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Is unconscious identity priming lexical or sublexical? ☆

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Abstract

We examined unconscious priming in a stem-completion task with both identity and form-related primes. Participants were given exclusion instructions to avoid completing a stem (e.g., ca- - -) with a briefly flashed masked word (e.g., candy). In Experiment 1, priming of around 7% occurred for both identity (e.g., candy) and form-based (e.g., windy) primes at a 33 ms exposure duration. When examining only trials in which the participants failed to identify the prime, this effect increased to 12% for identity primes, but remained the same for form-based primes. In Experiment 2, priming without prime identification was 9% for identity primes, 4% for homophone primes, and 3% for orthographic control primes. Although identity priming was greater than form priming in both experiments, regression analyses revealed that orthographic and phonological overlap alone between the flashed primes and targets could completely account for unconscious identity priming. Hence, we conclude that masked words may only activate their sublexical orthographic and phonological representations and not their lexical representations.

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1. Introduction

The existence of unconscious perception has fueled perhaps the most controversial debate in experimental psychology for over 100 years (see Greenwald, 1992, for a review). The problem facing researchers is how to avoid relying solely on participants' subjective "introspection" as to whether or not an object was consciously perceived. Early behaviorists denounced such introspective methodology because it is impossible to ascertain how accurately one can monitor the contents of one's own consciousness.

Because of this, a need for an objective criterion for conscious/unconscious perception has emerged, with the most common procedure being the "task dissociation" paradigm. This paradigm includes both a direct task (such as conscious stimulus identification) and an indirect task (such as repetition or semantic priming). The underlying logic is that priming during the indirect task is due to unconscious perception if the stimulus producing such priming is not consciously identified during the direct identification or detection task (Balota, 1983; Carr, McCauley, Sperber, & Parmelee, 1982; Cheesman & Merikle, 1986; Draine & Greenwald, 1998; Fiscler & Goodman, 1978; Forster & Davis, 1984; Fowler, Wolford, Slade, & Tassinary, 1981; Greenwald, Draine, & Abrams, 1996; Kemp-Wheeler & Hill, 1988; Marcel, 1983).

Forster, Booker, Schacter, and Davis (1990) used the task dissociation procedure to investigate unconscious priming in a stem-completion task. Forster et al. (1990, Experiment 1) used items presented for a short (60 ms) duration, from which Forster and Davis (1984) previously found identity priming in a lexical decision task in the absence of conscious identification. In their experiment, Forster et al. (1990) asked participants to fill in a three-letter word stem (e.g., ela- - ->) with the first word that came to mind. The percentage of trials in which participants completed the three-letter word stem with a particular target (e.g., elastic) was 15% when the preceding 60 ms masked prime was unrelated to the target item (e.g., lattice). However, this percentage rose to 33% when the preceding prime was related to the target by identity (e.g., elastic) and to 27% when the preceding prime was related to the target by form (e.g., plastic). Forster et al. concluded that both form-based and identity-based priming effects could occur under masked prime conditions by unconsciously activating the lexical representation of the target item.

However, there are methodological limitations to using the task dissociation paradigm as a measure of unconscious perception. Holender (1986) pointed to differences in dark adaptation, response bias, and task sensitivity as factors that could produce different measured levels of conscious perception across the direct and indirect tasks. In addition, studies with separate direct and indirect phases have no way of demonstrating the extent to which any particular item was consciously perceived during the priming task. Finally, as noted by Debner and Jacoby (1994), the most serious concern with the task dissociation procedure is that conscious and unconscious processes work in cooperation to increase the size of priming effects. As a result, the extent to which each process contributes to performance is unknown because both conscious and unconscious perception would lead to the same pattern of responding (i.e., priming). Measures of unconscious perception can therefore be contaminated by consciously mediated responding and measures of conscious performance could be contaminated by unconscious priming that increases the accuracy of guessing.

To circumvent this problem, Debner and Jacoby (1994) used the "process dissociation" procedure (Jacoby, 1991; Jacoby, Toth, & Yonelinas, 1993) designed to separate the effects of conscious and unconscious perception. This procedure involves the assumption that conscious and unconscious processes make independent contributions to performance. To distinguish between the two processes, the process dissociation procedure uses both an inclusion and an exclusion task. The inclusion task is designed to make conscious awareness contribute to priming effects by asking participants to "try to complete the stem with the flashed item." By contrast, the exclusion task is designed to make conscious awareness eliminate priming effects by asking participants to "try *not* to complete the stem with the flashed item." By examining priming effects under inclusion and exclusion conditions, researchers are able to identify the contributions of both conscious and unconscious processes to performance.

In the present research, the interest is not in obtaining the precise magnitude of unconscious priming, but rather to show that such priming does indeed exist. For this reason, results from Debner and Jacoby's (1994) exclusion task are of the most importance because in this task any contamination due to conscious awareness should work against obtaining such priming. Debner and Jacoby (1994) found that the percentage of trials in which participants completed the stem with a particular target word was 34% when the stem was preceded by an unrelated item. Under exclusion instructions, this percentage dropped to only 10% when the flashed identity prime was presented for a duration long enough for conscious awareness (e.g., 500 ms), demonstrating that participants were following the exclusion instructions. Of critical importance, this percentage rose to 50% when the identity prime was presented for only 50 ms. This 16% identity priming effect under exclusion instructions was taken as strong evidence for unconscious perception.

Merikle, Joordens, and Stolz (1995, Experiment 1) replicated Debner and Jacoby's (1994) unconscious priming effect under exclusion instructions. As did Debner and Jacoby (1994), Merikle et al. presented participants with stems (e.g., cha- -) preceded by masked primes identical to one of the possible completions (e.g., chair). However, unlike Debner and Jacoby, Merikle et al. did not include any unrelated primes, but instead measured baseline performance under conditions in which the masked prime was presented for 0 ms. In the 0-ms baseline condition, participants completed the stem with the target word on 14% of the trials. Replicating Debner and Jacoby's results, this percentage was *reduced* by 6% at the long 214 ms exposure duration, yet was *increased* by 4, 5, and 2% at the intermediate 43, 57, and 71 ms exposure durations, respectively.

1.1. Unresolved issues

Although the Debner and Jacoby (1994) and Merikle et al. (1995) exclusion-task results support unconscious activation, the "level" at which this activation occurs is unknown. These results are equally consistent with unconscious priming occurring at a sublexical level. For instance, given the stem "ca- - -" and the prime "candy," one could obtain priming based on the activation of the concept CANDY, the lexical entry "candy," or instead simply from the activation of any of the component letters "n, d, or y." Indeed, in their stem-completion task, Forster et al. (1990) found nearly as much priming from orthographically similar primes as from identity primes.

In addition, recent studies using a two-alternative semantic classification task suggest that unconscious priming may indeed occur at a sublexical, rather than lexical, level (Abrams & Greenwald, 2000; Abrams, Klinger, & Greenwald, 2002; Klinger, Burton, & Pitts, 2000). In Draine and Greenwald's (1998) and Greenwald et al.'s (1996) "response window" modification of the traditional task dissociation paradigm, participants first receive practice classifying clearly presented items (e.g., classifying the word "bunny" as evaluatively positive or negative) and are later given these items as masked primes when classifying new targets under conditions of extreme time pressure in which to respond (hence the name "response window"). The original finding by Greenwald et al. (1996) and Draine and Greenwald (1998) was that the evaluative category of the prime influenced the categorization response given to the target. Greenwald and colleagues argued for an unconscious spread of activation from the representation of the prime to the representations of categorically similar items. However, further experiments by Abrams and Greenwald (2000), Klinger et al. (2000), and Abrams et al. (2002) demonstrated that priming in this task primarily occurs by the association between sub-word components of the masked prime and the appropriate classification response. For instance, Abrams and Greenwald (2000, Experiment 2) created "offspring" primes from sub-word components of previously categorized "parent" targets of the opposite valence (e.g., "tumor" from the parents "tulip" and "humor"). The interesting finding was that these "offspring" primes (e.g., "tumor") primed opposite-valence targets (e.g., "love") which had the same valence as their parent constituents ("tulip" and "humor"), rather than priming same-valence targets (e.g., "war") which had the opposite valence as their parent constituents. This shows that priming was produced by the unconscious (or perhaps conscious) perception of letter clusters that activated a specific intra-experimentally associated categorization response, rather than by unconscious spreading activation across lexical or semantic networks. This claim is further supported by Klinger et al.'s (2000) finding that standard unconscious semantic priming effects are not obtained under conditions that yield unconscious evaluative priming effects. Thus, there is reason to wonder whether the unconscious identity priming effects that Debner and Jacoby (1994), Forster et al. (1990), and Merikle et al. (1995) obtained were due to the perception of individual letters, rather than to the unconscious activation of whole words.

Another issue concerns the extent to which participants in the Debner and Jacoby (1994) and Merikle et al. (1995) studies were following exclusion instructions. In both studies, the long exposure duration condition was chosen to provide evidence that participants were following instructions under clearly visible conditions. However, in both studies, participants showed less than 100% compliance. Participants still completed the stem on 10% of the exclusion trials in Debner and Jacoby's experiment and 8% of the exclusion trials in Merickle et al.'s experiment when primes were presented for 500 and 214 ms, respectively. If it is assumed that participants in these conditions actually saw 100% of the long duration primes, a plausible account of these data is that participants either forgot or ignored the exclusion instructions about 10% of the time. If it is assumed that such occasional noncompliance also occurred in the shorter duration conditions, in which items are infrequently seen, such noncompliance could actually produce spurious priming effects. Thus, the occasional noncompliance at long durations actually brings into question whether the priming was due to unconscious activation of any sort. Alternatively, perhaps subjects let their attention lapse on 10% of the trials and hence either did not consciously perceive the long duration primes on some trials or forgot them by the time the stem appeared. Unfortunately, without some online measure of prime identification, noncompliance and attentional lapses cannot be separated.

1.2. Current investigation

There were two main goals of the current study. The first was to address the compliance issue raised above by asking participants to report the flashed prime word on each trial. The addition of prime-report improves upon earlier paradigms in three ways: (1) it permits a trial-by-trial measure of prime identification, thereby ameliorating many of Holender's (1986) concerns about differences that occur when direct and indirect tests are given in different blocks. (2) Prime report also allows us to determine if the failure to exclude a long-duration prime is due to an attentional lapse (no prime report) or to noncompliance with the instructions (prime reported). (3) As described by Debner and Jacoby (1994), "performance in an [unconditionalized] exclusion condition underestimates the contribution of unconscious perception" (p. 308). This occurs because unconscious priming is partially offset by the effects of conscious perception. Therefore, the use of an online prime report on each trial provides a more accurate assessment of the influence of unconscious priming by examining the percentage of target completions when the participant was unable to report the prime. These trials give a "purer" measure of unconscious priming because they eliminate those trials in which participants consciously identified the prime and hence intentionally avoided using it to complete the stem.

The second goal of the current study is to replicate the unconscious identity priming obtained by Debner and Jacoby (1994) and Merikle et al. (1995) and compare this to priming from form-related primes. In Experiment 1, we compared priming from identity primes to primes matched in letter overlap with the missing letters of a stem word. If the priming occurs only because participants use individually perceived letters to complete the stem, then as much priming should occur from masked primes sharing the letters necessary to complete the stem "ca- - -" (e.g., wi*ndy*) as from an identical prime (e.g., ca*ndy*). However, to the degree that unconscious identity priming occurs at the lexical level, priming from the identity prime should be greater than priming from the form-related prime when neither prime can be reported. In Experiments 2a and 2b, we presented either an identity prime (e.g., right, ri- - -), a homophone prime (e.g., write, ri- - -), or an orthographic control prime (e.g., trial-ri- - -) that contains the same letter-overlap with the target as the homophone prime. Any increase in priming from the homophone prime relative to the orthographic prime should reflect a phonological contribution to unconscious priming.

2. Experiment 1

In the first experiment, we were primarily interested in determining whether identity priming occurs at the lexical level or the letter level. Priming effects were compared between identity primes (e.g., candy-ca- - -) and primes sharing orthographic overlap with the missing letters in a stem (e.g., windy-ca- - -).

2.1. Method

2.1.1. Design

Each target stem (e.g., c a - - -) was preceded by a masked prime that shared either the target's identity (e.g., candy) or a masked form prime that shared the target's last three letters (e.g., windy). The identity primes were presented for either 0, 33, or 200 ms and the letter-overlap primes were presented for either 0 or 33 ms. The 200 ms exposure duration for identity primes was used to assess whether participants were following the exclusion instructions and the 0 ms exposure duration was used to measure the baseline completion rate of the word stem in the absence of a prime. Because there was only an artificial distinction between the 0 ms identity condition and the 0 ms letter-overlap condition, responses in these two conditions were combined for all analyses. The data are reported from the four within-subjects conditions of interest: 0 ms baseline, 33 ms letter-overlap, 33 ms identity, and 200 ms identity.

2.1.2. Stimuli

The MRC Psycholinguistic Database (Coltheart, 1981) was used to select 200 words four to eight letters in length that contained at least three valid completions when the last three letters were eliminated (e.g., ca- - -). These 200 words were used to select 100 pairs of words in which the last three letters were identical (e.g., candy and windy). The letter-overlap words were approximately matched in word frequency, with average Kucera and Francis (1967) printed word frequencies of 91.5 and 81.8 between the first and second member of each pair—$t(99) = -.83$, $p > .40$. (A list of these pairs is given in Appendices B and C.) Five different 100-item test lists were constructed with items counterbalanced across the five priming conditions (0 ms letter-overlap, 0 ms identity, 33 ms letter-overlap, 33 ms identity, or 200 ms identity), yielding 20 observations in each condition within a list. In these five lists, whether a stem served in the identity or letter-overlap condition was determined by the prime that preceded it (e.g., for the stem "ca- - -," the identity conditions used the "candy" prime and the letter-overlap conditions used the "windy" prime). Another parallel set of five lists was created by replacing each prime and stem (e.g., windy, ca- - -) with its pairmate (e.g., candy, wi- - -). Thus, across the 10 lists each word in the pair was assigned once to each of the five priming conditions. Each participant was tested on only one list.

2.1.3. Procedure

Participants were individually tested in one of four soundproof testing rooms and seated approximately 60 cm away from a VGA monitor. Participants read a set of task instructions displayed on the monitor and then heard them paraphrased by the experimenter. Each trial contained the following events: A 500 ms fixation point (*), a 500 ms forward pattern mask (XXXXXXXX), a prime word displayed for a variable duration (0, 33, or 200 ms), a 167 ms backward pattern mask (&&&&&&&), a variable inter-stimulus interval (233, 200, or 33 ms), and the target word-stem. The inter-stimulus-interval (ISI) was varied to maintain an overall prime-target SOA of 400 ms. Each visual event was centered around the center point on the video monitor. Each participant was given a separate answer sheet and asked to write down the flashed prime word (if visible). Next to the space provided for the prime word, participants were asked to complete each target word stem with any English word of appropriate length that was *not identical* to the flashed prime. They were told that if they did not see a prime, they should complete the stem with the first word of the appropriate length that came to mind. Participants were instructed to press the space bar to start each new trial. A 2000 ms blank screen preceded each trial and self-paced rest breaks were given every 33 trials.

2.1.4. Participants

A total of 60 University at Albany undergraduates participated for partial completion of a research requirement for an introductory psychology class, with each of the 10 test lists being tested on six different people. All participants were native English speakers with normal or corrected-to-normal vision.

2.2. Results

Data from two participants who failed to follow the exclusion instructions were eliminated from the statistical analyses. Unless otherwise noted, each effect called statistically significant is associated with a two-tailed $p < .05$.

2.2.1. Prime identification

The mean prime identification percentages are presented in Fig. 1A. In the 200-ms identity condition, participants correctly identified the prime on 94% of the trials, suggesting that an attentional lapse occurred on 6% of the trials. In contrast, participants correctly reported the 33 ms masked prime on only 6% of the letter-overlap trials and 22% of the identity trials. This 15.6% ± 4.8% difference [$t(57) = 6.58$] between the 33 ms letter-overlap and identity conditions suggests that participants may have used the stem to make an educated guess as to the identity of the target. (When reporting an $X \pm Y$ ms effect, Y refers to the 95 % confidence interval.) For instance, on some proportion of the "candy" prime trials, participants may have seen "n," "d," and/or "y" but failed to see "ca." When "ca- - -" is presented as the stem, they now correctly say "candy" was the prime. To test this "guessing" hypothesis, we examined for the letter-overlap condition (e.g., windy, ca- - -) and the 0 ms baseline condition (e.g., &&&&, ca- - -) the percentage

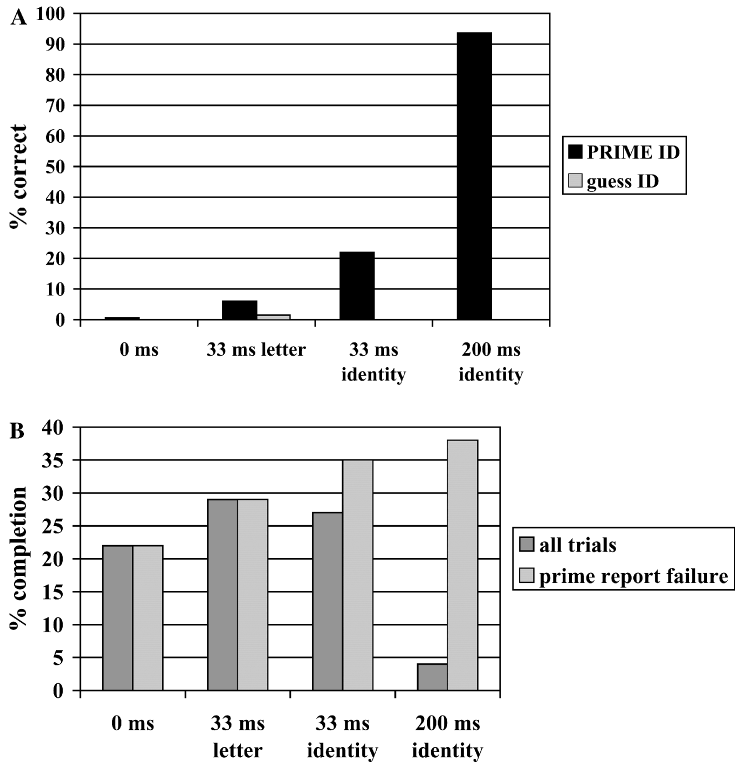

Fig. 1. Mean percentage correct (prime ID) and incorrect (guess ID) prime identification (A) and target stem completion (B) across the 0 ms baseline, 33 ms letter-overlap, 33 ms identity, and 200 ms identity conditions.

of trials on which the identity prime (e.g., candy) was incorrectly guessed as having been flashed as the prime. As shown in Fig. 1A, this occurred on only 1.5% of the trials in the letter-overlap condition and only 0.6% of the time in the baseline condition, suggesting that participants were seldom using the stem to guess the prime. A second possibility is that participants generated a few potential candidates based upon the initial letter of the flashed prime (e.g., candy, candle, crazy, and Cindy) and then used the remaining letters of the stem (e.g., ca- - -) to guess from the set of appropriate candidates, thereby increasing the probability of reporting the identity prime. Indeed, there is evidence that initial letters play a critical role in the identification of masked primes (Balota & Rayner, 1991) and that clearly presented target words can be used retrospectively to identify masked primes (Kahan, 2000). This candidate-generation explanation could explain the 16% difference in prime report between the identity and letter-overlap conditions, because none of the potential candidates generated by the letter-overlap prime (e.g., windy, wimpy, and Wendy) would be congruent with the stem (ca- - -).

2.2.2. Overall target stem completion

The mean percentages of target completion across conditions are presented in Fig. 1B. For the 0 ms primes, the baseline percentage of target completions was 22%. Consistent with Merikle et al. (1995), this percentage dropped to only 4% for the 200-ms identity primes—$t(57) = 14.19$. Thus, participants were following the exclusion instructions on trials in which the prime was presented long enough to be consciously identified. The shorter duration identity primes also replicated Merikle et al. (1995). Specifically, the percentage of target completions increased to 27% following the 33 ms identity primes, yielding a significant 4.5% ± 3.5% unconscious identity priming effect—$t(57) = 2.56$. However, the probability of target completion was increased to 29% following letter-overlap primes, yielding a significant 6.9% ± 3.6% unconscious letter priming effect—$t(57) = 3.90$.

Taken at face value, the equivalence of the overall identity and letter-overlap priming suggests that both effects may be entirely due to unconscious activation at the sublexical level. However, as was discussed in the introduction, by including completion performance on those trials in which the prime was reported and therefore excluded, one artificially underestimates the amount of unconscious identity priming relative to unconscious letter-overlap priming. Hence, we must also examine the data from only those trials in which the prime was not reported.

2.2.3. Target completion following prime report failure

To assess more directly the influence of unconscious priming, we examined the percentage of target completions when the participant failed to report the prime. Although rare, we also excluded the 1.5% of letter-overlap and 0.6% of baseline trials in which participants used the stem (e.g., ca- - -) to incorrectly guess that the target word (e.g., candy) was flashed. We eliminated these trials because they should also lead to the exclusion of the target word. Following the 33 ms identity primes, the target completion rate rose to 34%, yielding a significant 12.4% ± 4.3% priming effect—$t(57) = 5.79$. However, target completions following the 33 ms letter-overlap primes remained at 29%, yielding a significant 7.2% ± 3.7% priming effect [$t(57) = 3.77$] that was not different from the 6.9% overall letter-overlap priming effect—$t(57) < 1$. Most importantly, the 12.4% identity priming effect was now significantly greater than the 6.9% letter-overlap priming effect—$t(57) = 2.57$. For the identity 200 ms condition, the data support the attentional lapse explanation of noncompliance in Debner and Jacoby (1994) and Merikle et al. (1995). Specifically, the target completion rate rose to 38% during the 6% of the trials that participants failed to report the prime. In contrast, in the 94% of the trials in which participants identified the primes, the target completion rate was only 0.3%. Thus, the participants were likely to complete the stem with the target only in those cases in which they consciously missed the flashed prime word.

2.3. Discussion

The most critical finding was that unconscious priming occurred for both identity and letter-overlap primes, but was significantly greater for identity primes. This pattern suggests that unconscious priming may indeed occur at the lexical level. For 33 ms identity primes, our overall 4.5% priming effect replicated the 4–5% identity priming effect Merikle et al. (1995) found with their 43- and 57-ms primes. However, when we examined only the 78% of trials in which participants failed to report the prime word (such that conscious prime identification would not be offsetting the effects of unconscious activation), identity priming increased from 4.5 to 12.4% above baseline. For letter-overlap primes, however, we did not find any difference in priming between the 7.2% obtained from all trials and the 6.9% obtained from the 94% of trials in which the participants were unable to report the prime word. This is as would be expected, because participants were not told to avoid completing the stem with letter-overlap primes. In summary, the results of Experiment 1 reveal a lexical unconscious priming effect that occurs above and beyond any letter-level priming.

One potential problem with this general conclusion is that "extra" priming for identity primes may have been due to their sharing more phonological features with the target than the letter-overlap primes. Indeed, psycholinguistic researchers have long argued for an automatic phonological contribution to masked priming (Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994; Pollatsek, Lesch, Morris, & Rayner, 1992; Rayner, Sereno, Lesch, & Pollatsek, 1995; Van Orden, 1987). For instance, according to Van Orden's (1987) verification model a letter string initially activates a set of phonological candidates that are later compared to the actual stimulus for orthographic verification. If a match occurs, than the lexical entry is selected; otherwise the next candidate is compared. Van Orden suggested that masking a stimulus disrupts only the second, verification, process thereby allowing multiple phonological candidates to remain active. Researchers have since found evidence to support this model using homophonic prime-target pairs (e.g., towed-toad) that shared the same phonology yet differed in spelling (Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994). In these studies, priming in pronunciation tasks from homophones equals that of identity primes at short SOAs, yet is substantially reduced at long SOAs supporting both an automatic activation and a slower verification process.

Van Orden's verification model can also explain the nearly 16% increase in prime report for identity primes, relative to letter-overlap primes, when presented at 33 ms. That is, if the briefly presented masked prime activated a list of potential phonological candidates, when the stem was presented, it may have been used to select a phonologically active candidate for report.

To test whether phonology influenced target completion in the current study, we separated the letter-overlap items into rhyming pairs (e.g., shape-grape, indicated by an asterisk in Appendix A) and nonrhyming pairs (e.g., windy–candy). When participants failed to report the prime (94% of trials), for the non-rhyming pairs ($N = 65$), target completion in the letter-overlap condition increased 4.2% ± 3.9% above baseline (i.e., from 28–33%) and 11.2% ± 4.6% above baseline in the identity condition (i.e., from 28 to 39%). In contrast, target completion for rhyming pairs ($N = 35$) increased 13.0% ± 5.6% above baseline in the letter overlap condition (i.e., from 11 to 24%) and 12.2% ± 6.2% above baseline in the identity condition (i.e., from 11 to 23%). When we entered the between-item variable condition (rhyme vs. nonrhyme) and the within-item condition of prime type (letter-overlap vs. identity) into a two-way mixed ANOVA, the interaction between rhyme and prime type was significant—$F(1, 98) = 4.13$, $MSE = 205$. Specifically, for nonrhyming items target completion was higher in the identity condition (39%) than the letter-overlap condition (33%) whereas target completion for rhyming items was equivalent in these two prime type conditions (24 and 23%).

These data are supportive of a strong phonological contribution to unconscious priming. Indeed, there may be as much priming from items sharing letter + sound overlap (rhyming items in the letter-overlap condition) as from items sharing the same identity. However, because this analysis was based upon a post hoc grouping of items, the rhyming and nonrhyming pairs differed in many respects that may have influenced the observed differences in priming. These potentially important differences include length ($p < .001$), number of orthographic neighbors ($p < .001$), number of higher frequency orthographic neighbors ($p < .005$), number of possible stem completions ($p < .001$), baseline stem completion probability ($p < .05$), and percent letter overlap ($p < .001$). As a result, any one (or combination) of these factors could account for the difference in priming between the rhyme and nonrhyme conditions.

The difference in letter overlap between rhyming and nonrhyming items is particularly important because it suggests the greater priming for rhyming items could potentially be due to orthographic, rather than phonological, similarity. Indeed, as with phonological activation, researchers have argued for the unconscious activation of orthographic information in masked priming (Evett & Humphreys, 1981; Ferrand & Grainger, 1996; Fleming, 1993; Grainger & Ferrand, 1994; Lee, Rayner, & Pollatsek, 1999). For instance, Ferrand and Grainger (1996) found more priming from pseudohomophones with similar orthography than from pseudohomophones with dissimilar orthography. In addition, Lee et al. (1999) found evidence for early effects of both phonological and orthographic priming using an online eye-tracking paradigm with five different prime durations between 29 and 41 ms. Lee et al. found orthographic priming across all durations, but phonological priming only at the middle durations, and concluded that orthographic information influences both the early activation of phonology and the later spelling verification processes. Finally, Masson and Isaak (1999) showed as much priming from orthographic similarity (lenk and lend) as morphological similarity (lent and lend) in a naming task, leading them to question whether masked identity priming actually has an orthographic, rather than lexical, basis.

3. Experiments 2a and 2b

One implication of Experiment 1's results is that unconscious priming may be due to shared phonology and/or orthography, rather than identity. In Experiment 2 we test this hypothesis by comparing the probabilities of target stem completion following masked identity primes (e.g., right, ri- - -) and masked homophonic primes (e.g., write, ri- - -). If unconscious priming is due to lexical activation, then priming should be greater for identity primes than homophonic primes.

However, if the activated unconscious code is phonological, homophone priming should be equivalent to identity priming.

For a subset of the homophone primes used in Experiment 2a, we were able to construct matched orthographic control primes (i.e., primes that share an identical amount of letter overlap with the target word). This subset of Experiment 2a homophone primes was presented in Experiment 2b along with these matched orthographic control primes, allowing us to separate priming due to phonological overlap from priming due to orthographic overlap.

3.1. Method

3.1.1. Design

The design was identical to that of Experiment 1 with the following exceptions. In both Experiments 2a and 2b a 33 ms masked homophonic prime (e.g., write, ri- - -) condition was used instead of the 33 ms letter-overlap condition (e.g., windy, ca- - -) of Experiment 1. Also, in Experiment 2b an additional 33 ms masked orthographic control prime was added to the other conditions. The data are therefore reported from four within-subject conditions in Experiment 2a (0 ms baseline, 33 ms homophone, 33 ms identity, and 200 ms identity) and from five within-subject conditions in Experiment 2b (0 ms baseline, 33 ms homophone, 33 ms orthographic control, 33 ms identity, and 200 ms identity).

3.1.2. Experiment 2a stimuli

Seventy-two homophone pairs were selected for Experiment 2a. The two words in each pair were randomly chosen to be in Set A and Set B. When using these words to construct stems, a rule was adopted to eliminate as many of the final letters as possible with the constraints that: (1) the resulting stem could not be completed with the homophone word or orthographic control and (2) that the resulting stem could be completed with at least one word other than the identity target. The items in the two sets were approximately matched in word frequency (65 vs. 54, $p > .60$), length (4.6 vs. 4.4, $p > .08$), and number of valid completions (13.5 vs. 13.5, $p > .95$). (A list of these pairs is given in Appendix B.)

Four different 72-item test lists were constructed with items counterbalanced across four priming conditions (0 ms baseline, 33 ms homophone, 33 ms identity, or 200 ms identity), yielding 18 observations in each condition within a list. In these four lists, whether a stem served in the identity or homophone condition was determined by the prime word that preceded it (e.g., for the stem "ri- - -," the identity conditions used the "right" prime and the homophone conditions used the "write" prime). As in Experiment 1, another parallel set of four lists was created by replacing each prime and stem (e.g., write, ri- - -) with its pairmate (e.g., right, wr- - -). Thus, across the eight lists, each word in the pair was assigned once to each of the four priming conditions. Each participant was tested on only one list.

3.1.3. Experiment 2b stimuli

A subset of the homophone pairs from Experiment 2a were selected for Experiment 2b. Homophone pairs were included only if an orthographic control word could be obtained that both: (1) matched one of the homophones in letter overlap with the other homophone designated as the target and (2) could not be used as a valid completion to the stem (e.g., dew, due, die, for the identity, homophone, and orthographic primes, respectively, to the stem de-). Forty-six out of the 144 possible targets from Experiment 2a met this criterion. An additional four homophone–orthographic–identity triplets were generated by the authors according to the same criteria.[1] The orthographic primes were matched to the homophone primes in word frequency (81 vs. 93, $p > .75$), length (4.5 vs. 4.5, $p > .99$), number of initially overlapping letters with the identity prime (1.49 vs. 1.47, $p > .32$), overall number of shared letters with the identity prime (2.90. vs. 2.86, $p > .15$), and number of shared letters by position with the identity prime (2.06 vs. 2.06, $p > .99$). (A list of these triplets is given in Appendix C.)

Five different 50-item test lists were constructed with items counterbalanced across five priming conditions (0 ms baseline, 33 ms identity, 33 ms homophone, 33 ms orthographic, or 200 ms identity), yielding 10 observations in each condition within a list. As in Experiments 1 and 2a, each participant was tested on only one list.

3.1.4. Procedure

The procedures were identical to Experiment 1.

3.1.5. Participants

A total of 69 University at Albany undergraduates (30 in Experiment 2a and 39 in Experiment 2b) and 77 Washington University undergraduates (34 in Experiment 2a and 43 in Experiment 2b) participated for partial completion of a research requirement for an introductory psychology class. No student participated in both experiments. All participants were native English speakers with normal or corrected-to-normal vision.

3.2. Results

Data from seven participants (2 in Experiment 2a and 5 from Experiment 2b) who failed to follow the exclusion instructions were eliminated from the statistical analyses.

3.2.1. Prime identification

The mean prime identification percentages across conditions are presented in Figs. 2A and B for Experiment 2a and 2b, respectively. In the 200 ms identity condition, participants correctly identified the prime on 94 and 97% of the trials in Experiments 2a and 2b, respectively (indicating a 6 and 3% attentional lapse rate). At 33 ms, correct prime report dropped to 15% (Experiment 2a) and 10% (Experiment 2b) for identity primes, to 3% (both Experiments 2a and 2b) for homophone primes, and to 1% for orthographic primes. The $12.2\% \pm 3.5\%$, $6.8\% \pm 3.0\%$, and $8.9\% \pm 2.8\%$ advantages in prime identification for identity primes relative to homophone primes in Experiment 2a [$t(61) = 7.00$, $p < .001$], homophone primes in 2b [$t(77) = 4.44$, $p < .001$], and orthographic primes in Experiment 2b [$t(77) = 6.43$, $p < .001$], respectively, are similar to that obtained in Experiment 1. As described in Experiment 1, this difference suggests a verification process similar to that proposed by Van Orden (1987) in which a masked prime activates a list of

[1] Due to an experimental error, the pair "poor-pore" was accidentally used in two different triplets. As a result, one of the triplets (poor-pore-pork) was removed from the list immediately prior to running participants such that each list contained 49 items.

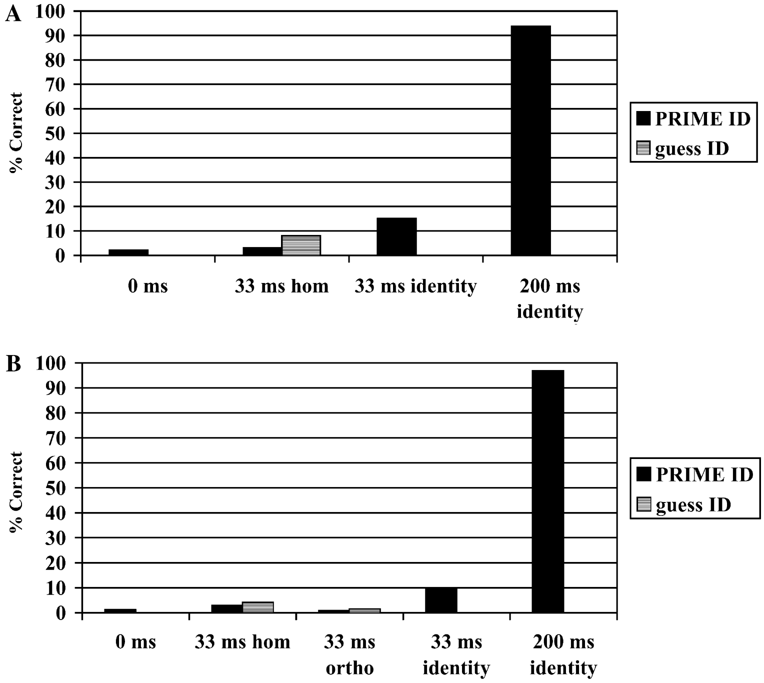

Fig. 2. Mean percentage correct (prime ID) and incorrect (guess ID) prime identification across the 0 ms baseline, 33 ms homophone, 33 ms orthographic, 33 ms identity, and 200 ms identity conditions in Experiments 2a and 2b.

potential phonological candidates that are then matched to the stem prior to conscious awareness. If indeed Van Orden's model is correct, then both the prime item (e.g., right) and its homophone (e.g., write) would receive the same amount of phonological activation. During the verification stage, the homophone that is consistent with the visual stem (e.g., wr- - -) should be selected to reach conscious awareness.

To test the hypothesis that people will report "seeing" whichever homophone is most consistent with the later stem, we examined the percentage of trials in which participants incorrectly guessed that they had seen the identity prime (e.g., write) that is consistent with the stem (e.g., wr- - -) when actually shown the homophone (e.g., right). As shown in Figs. 2A and B, participants incorrectly guessed the identity prime on 8 and 4% of the trials in which they were shown the homophone in Experiments 2a and 2b, respectively. In contrast, participants only guessed the identity prime on 2% of the baseline trials in Experiment 2a, 1% of the baseline trials in Experiment 2b, and 1% of the orthographic control trials in Experiment 2b. Remarkably, across Experiments 2a and 2b, participants in the homophone prime condition were twice as likely to "see" something that was not presented (the identity prime) than they were to see the presented homophone—$t(140) = 2.9$, $p < .01$. This provides strong support for Van Orden's (1987) verification model of masked prime identification.

3.2.2. Overall target stem completion

The mean percentage of target stem completion across conditions is presented in Figs. 3A and B. For the 0 ms primes, the baseline percentage of target completions was 20% in Experiment 2a

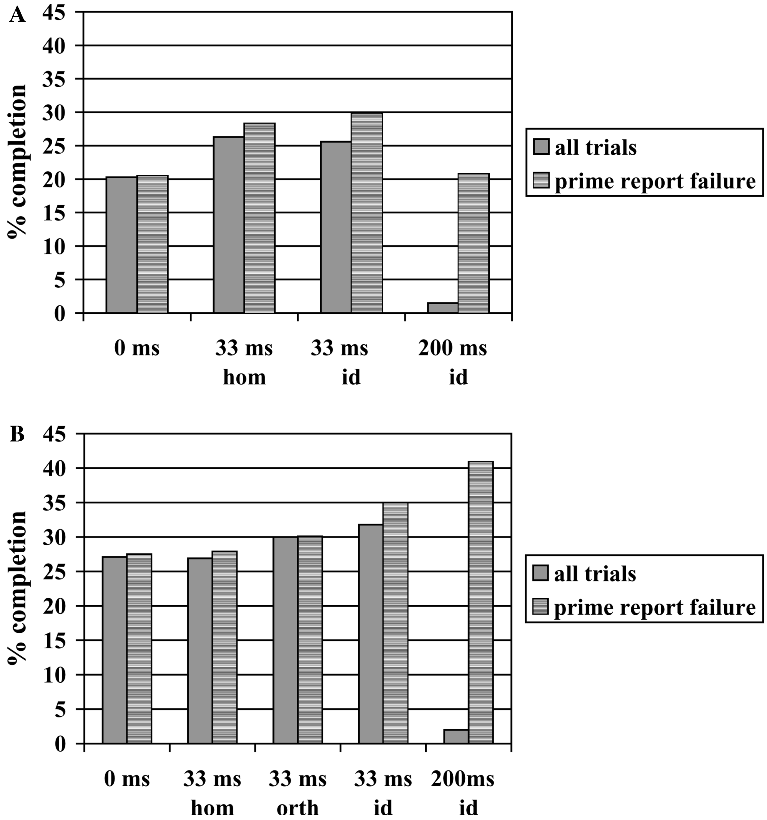

Fig. 3. Mean percentage target stem completion across the 0 ms baseline, 33 ms homophone, 33 ms orthographic, 33 ms identity (ID), and 200 ms identity conditions in Experiments 2a and 2b.

and 27% in Experiment 2b. Consistent with Experiment 1, this percentage was reduced to only 2% in both experiments following 200 ms identity primes—$t(61) = 12.62$; $t(77) = 14.09$ in Experiments 2a and 2b, respectively. For identity primes presented for 33 ms, the percentage of target completions increased to 26% in Experiment 2a and to 32% in Experiment 2b, yielding significant unconscious identity priming effects of 5.4% ± 4.4% and 4.7% ± 4.3% —$t(61) = 2.43$; $t(77) = 2.09$. For homophone primes, the probability of target completion also increased to 26% in Experiment 2a, but did not increase above baseline in Experiment 2b. Thus, there was a significant 6.0% ± 4.3% unconscious homophone priming effect [$t(61) = 2.71$] effect in Experiment 2a, but no hint of homophone priming (−0.2% ± 4.0%) in Experiment 2b—$t(77) < 1$. In Experiment 2b, although there was a hint of priming for orthographic primes, this 2.8% ± 4.7% increase failed to reach significance—$t(77) < 1$.

3.2.3. Target completion following prime report failure

As was done in Experiment 1, to obtain a more accurate measure of unconscious priming we examined the percentage of target completions for trials in which the participant failed to report the prime. We also excluded the homophone, orthographic, and baseline trials in which participants used the stem (e.g., wr- - -) to guess that the target word (e.g., write) was flashed. The baseline target completion was 21% in Experiment 2a and 27% in Experiment 2b. Following the 33 ms identity primes, the target completion rate rose to 30% in Experiment 2a and to 35% in Experiment 2b, yielding significant priming effects of 9.4% ± 4.6% and 7.5% ± 4.7%, respectively—$t(61) = 4.10$; $t(77) = 3.18$. For homophones, target completions rose to 28% in both Experiments 2a and 2b, yielding a significant 7.8% ± 4.6% priming effect in Experiment 2a [$t(61) = 3.38$], but a nonsignificant 0.4% ± 4.1% priming effect in Experiment 2b—$t(77) < 1$. When combined, the resulting 3.7% ± 3.1% homophone priming effect was significant—$t(139) = 2.38$. However, as with Experiment 1, this 3.7% "form"-based effect was significantly less than priming in the identity condition—$t(139) = 3.01$. The 2.7% ± 4.7% increase in priming from orthographic primes in Experiment 2b failed to differ from baseline ($p > .25$). For the identity 200 ms condition, the target completion rate was 23% during the 6% of the trials that participants failed to report the prime in Experiment 2a and 41% during the 3% of the trials that participants failed to report the prime in Experiment 2b. In contrast, in the 94 and 97% (Experiments 2a and 2b, respectively) of the trials in which participants identified the primes, the target completion rates were only 1.4% (Experiment 2a) and 0.7% (Experiment 2b), suggesting once again that participants completed the stem with the target only when they consciously missed the flashed prime word.

3.2.4. Comparing the homophonic priming effects in Experiments 2a and 2b

One potential concern in Experiment 2 was the failure to obtain significant homophone priming in Experiment 2b even though 46 of the 49 items came from the larger pool of items used in Experiment 2a. Perhaps item differences between the 144 stems used in Experiment 2a (72 pairs, with both pairmates appearing as stems across subjects) and the 46 stems selected for Experiment 2b caused the difference in priming. Indeed, a post hoc analysis revealed that the 46 stems selected for Experiment 2b differed significantly from the remaining 98 stems used in Experiment 2a in length (4.6 vs. 4.3, $p < .03$), the number of shared letters with the target (3.4 vs. 2.9, $p < .01$), and the percentage of overlapping letters with the target (74 vs. 67%, $p < .03$). In order to test whether the failure to replicate was due to the specific items selected for Experiment 2b, we examined only the 46 stems used in both experiments. From these items, the percent target completion following prime report failure was 22, 31, and 36% for the baseline, 33 ms homophone, and 33 ms identity conditions in Experiment 2a and 27, 28, and 34% for the baseline, 33 ms homophone, and 33 ms identity conditions in Experiment 2b. When we averaged the unweighted means for these 46 items across the two experiments, we obtained priming of 5.3% ± 4.0% following homophone primes [$t(45) = 2.7$] and 11.0% ± 4.5% following identity primes—$t(45) = 4.9$. The resulting 5.7% ± 4.6% difference in priming between identity and homophone primes was significant—$t(45) = 2.5$. This pattern of priming based solely upon the items used in both Experiments 2a and 2b converges with the overall pattern we obtained, with significant priming following identity primes and significant, yet reduced, priming following homophone primes.

3.2.5. Letter and phonemic overlap in Experiments 1, 2a, and 2b

One of the goals of the current investigation was to ask whether phonological overlap and/or orthographic overlap alone could explain unconscious priming. To investigate this, we performed a regression analysis across all 396 items including the letter-overlap items in Experiment 1, the homophones in Experiments 2a and 2b, and the orthographic controls in Experiment 2b to see how much unconscious priming would be predicted based upon letter- and phonemic-overlap alone.

For our measure of phonemic overlap, we used the MOBY lexicon project website (http://etext.icewire.com/moby/mpron/) which lists the phonemes that constitute 177,267 English words. For instance, the target "adult" (/@/'d/@/lt) shares one of its four phonemes with its letter-overlap prime "fault" (f/O/lt). By contrast, the target "worry" ('w/[@]/r/i/) shares three of its four phonemes with the letter-overlap prime "hurry" ('h/[@]/r/i/). This allowed us to provide a more objective measure of phonemic overlap (e.g., 75 vs. 25%) than simply using a dichotomy such as "rhyme vs. nonrhyme." It also allowed us to compare phonological overlap across all 396 form-related pairs in the current study. In each case, we calculated a "percent phonemic overlap" as the number of overlapping phonemes in the prime and target divided by the total number of phonemes in the target. The percentage phonemic overlap in these experiments was 48% for letter-overlap primes in Experiment 1, 91% for homophones in Experiment 2a and 2b, and 39% for the orthographic controls in Experiment 2b. Across all items, the correlation between phonemic overlap and unconscious form priming was only .056 ($p > .25$). However, this may be because nearly one-third of the items (115/396) had 100% overlap. Indeed, when these 115 homophones are left out of the analysis, the correlation between percent phonemic overlap and form-based unconscious priming was .138 ($p < .03$).[2]

For orthography, we could not create a 100% letter overlap condition akin to the 100% phonemic overlap condition from homophones. As a result, the identity primes always had more letter overlap with the target than the orthographic primes. We calculated percent letter overlap in a similar fashion as percent phonemic overlap, with number of overlapping letters divided by the total number of letters in the target. The percentage letter overlap for the form-related conditions across the experiments was 64% for the letter-overlap items in Experiment 1, 71% for the homophones of Experiment 2a, 67% for the homophones of Experiment 2b, and 67% for the orthographic control items of Experiment 2b. Because the rhyming items (Experiment 1) and homophone items (Experiments 2a and 2b) tended to share a high degree of letter overlap as well as phonemic overlap, some of the seemingly phonological effects may actually have been due to overlapping orthography.

3.2.6. Regression analysis

A regression analysis based upon all 396 items in Experiments 1, 2a, and 2b was run using phonemic overlap and letter overlap to predict form-based unconscious priming. Not surprisingly, there was a significant positive correlation between percentage of letter and phonological overlap in the current study ($r = +.238$, $p < .001$). When both letter and phonemic overlap were entered into the regression analysis, the resulting equation was "$y = .027$ (% phonemic overlap) + .08 (% letter overlap) – .007. According to this equation, if phonemic overlap was 0% and letter-overlap

[2] There were 32 homophones with less than perfect phonemic overlap [e.g., the pair "mall" (m/O/l) and "maul" (m/A/l) differ in their middle phoneme]. Importantly, the participants in Experiments 2a and 2b showed the same pattern of results when these 32 imperfect homophones were removed from the analyses. Specifically, across Experiments 2a and 2b, participants showed 8% priming for identity items and 3% priming for homophone items. These effects were significantly different from both each other [$t(139) = 3.19$] and from baseline—$t(139) = 4.42$, $t(139) = 1.72$ for the identity and homophone priming effects, respectively.

Table 1
Target stem completion in the identity and form conditions across high (>66%) and low (<67%) levels of letter overlap and phonemic overlap conditions

	Low letter		High letter	
	Low phone	High phone	Low phone	High phone
# Items	93	60	86	158
Identity	.42	.24	.37	.28
Form	.33	.18	.34	.29
ID-form	*.09**	*.06**	*.03*	*−.01*

Note. Phone., phonemic overlap, ID, identity.
$^{*}p < .05$.

was 100% then form priming should be 7.3%. Alternatively, if phonemic overlap was 100% and letter-overlap was 0% then form priming should be 2.0%. A one-sample *t* test was then conducted to see if *identity* priming across all items was greater than predicted by letter- or phonemic-overlap alone (7.3 or 2.0%). There were a total of 348 items in the identity condition. [3] The 10% priming effect for identity primes was significantly greater than both the 7.3% predicted based upon 100% letter overlap alone [$t(348) = 2.08$] and the 2.0% predicted based upon 100% phonemic overlap alone—$t(348) = 6.73$. However, when both phonemic and letter overlap were assumed to be 100% in this model, the regression equation predicted priming of 10%, the exact amount of priming observed in the identity condition!

One cautionary note is that roughly 1/3rd of the form-related items had 100% phonemic overlap. Thus, phonological overlap could not predict differences in priming among these items, resulting in a reduced influence of phonemic overlap. Indeed, when these items were removed, the resulting regression equation was "$y = .119$ (% phonemic overlap) + .08 (% letter overlap) − .042," suggesting a larger role of phonology. For this equation, one would predict a 15.7% identity priming effect. Once again, the observed 11% identity priming effect from these items is NOT larger than that predicted based upon the combined 100% contributions of orthography and phonology.

3.2.7. Median-split analysis

In order to explore the possible interactive effects of letter and phonemic overlap across our items, we performed an ANOVA comparing target completion following identity primes to target completion following form-based primes with letter overlap (high vs. low) and phonemic overlap (high vs. low) as between-item variables. The results from this analysis are shown in Table 1. We found a large effect of condition [$F(1, 392) = 10.39$, $MSE = 290.6$] with 4.1% ± 2.6% greater target completion following identity primes than form primes. However, this effect of condition interacted significantly with letter overlap [$F(1, 392) = 7.23$, $MSE = 290.6$] such that there was a 7.6% ± 3.9% advantage of identity primes over form primes at low levels of letter overlap, but only a nonsignificant 0.7% ± 3.2% advantage at high levels of letter overlap. This same pattern occurred numerically for the phonemic overlap conditions, with a 5.9% ± 3.6% advantage of

[3] This is less than in the form condition because in Experiment 2b the same 49 targets were preceded by both homophone and orthographic primes.

identity primes over form primes at low levels of phonemic overlap, but a nonsignificant 2.3% ± 3.6% advantage at high levels of phonemic overlap. However, this time the interaction between condition and phonemic overlap did not reach significance ($p > .16$).

In a second ANOVA using only the homophones with 100% phonemic overlap, we again found a letter-overlap × condition interaction [$F(1, 112) = 7.93$, $MSE = 186.2$] such that there was a 9.0% ± 7.0% advantage of identity primes over form primes at low levels of letter overlap, but only a nonsignificant 2.5% ± 4.2% advantage at high levels of letter overlap. This pattern confirms the necessity of both shared orthography and phonology to unconscious priming.

3.3. Discussion

Identity priming in Experiment 2 was significantly greater than priming from either homophones or orthographic controls. When Experiments 2a and 2b were combined, the overall 5% priming effect (unconditionalized on prime report) replicated both the 4.5% identity priming effect in Experiment 1 and the 4–5% identity priming effects Merikle et al. (1995) found with their 43- and 57-ms primes. When we examined only the approximately 87% of trials in which participants failed to report the prime word, identity priming increased from 5 to 8% above baseline. However, when we eliminated both the prime identification and guessing trials, homophone priming from the remaining 91% of the trials only increased from 3 to 4% above baseline. This pattern suggests a lexical contribution to unconscious priming that occurs above and beyond the contribution of phonology. However, additional analyses, which we revisit in Section 4, showed that identity priming was no greater than would be expected based on the combined priming effects from sublexical orthographic and phonological similarity.

4. General discussion

The two experiments reported in this article examined the possible roles of orthographic and phonological activation in accounting for unconscious identity priming. In Experiment 1, we found a significant effect of orthography on unconscious priming. Specifically, priming was produced by items that contained the missing letters of the stem (e.g., windy, ca- - -). In a post hoc analysis it was revealed that this form-priming was much greater if the prime and target shared phonological rhymes (e.g., shape, gr- - -). These rhyming items showed a 13% priming effect while the non-rhyming items showed a smaller, yet still significant, 4% effect. When combined, however, the 7% form priming was less than the 12% priming obtained by identity primes. In Experiment 2a, we matched the identity and form primes on phonological overlap with the target by using either identity primes (e.g., write, wr- - -) or homophone primes (e.g., right, wr- - -). In addition, we included orthographically matched primes in Experiment 2b to separate out phonological priming from letter priming. We obtained priming from homophones and orthographic primes of 4 and 3%, respectively, though the orthographic effect failed to reach significance. In contrast, the 9% identity priming was significantly greater than both homophone and orthographic priming.

The initial results from Experiments 1, 2a, and 2b lead to three main points. First, the inclusion of trial-by-trial prime report revealed that participants followed instructions by not completing the stem with consciously perceived primes. Although participants did occasionally complete the stems with the flashed word even at long durations, as they did in Merikle et al. (1995) and Debner and Jacoby (1994), our data showed that this happened only on the rare trials in which they failed to report the flashed prime. The second point is that unconscious priming is not entirely due to letter-overlap between the prime word and the *missing letters* of the stem. If this were so, then we should have obtained as much priming in Experiment 1 from our letter overlap primes (e.g., windy for the stem ca- - -) as from our identity primes (e.g., candy for the stem ca- - -). Thus, based upon our Experiment 1, it is likely that previous findings of unconscious identity priming by Debner and Jacoby (1994), Merikle et al. (1995), and Forster et al. (1990) were not entirely due to people using the final letters of the prime to complete the stem. The third point from these studies is that unconscious priming is not entirely due to phonological overlap between the prime word and the stem word. If this were the case, then we should have observed as much priming from homophones (e.g., right, wr- - -) as from identity primes (e.g., write-wr- - -). When combining data from Experiments 2a and 2b, we obtained a 4% homophone priming effect that was significantly less than our obtained 9% identity priming effect.

A regression analysis investigating the combined effects of orthography and phonology confirmed the above argument that unconscious identity priming is greater than that predicted by either letter-overlap or phonemic overlap alone. However, this analysis revealed that when both letter and phonemic overlap are high, form-based priming is as great as identity priming. This pattern was later confirmed in an ANOVA in which items were split into low and high levels of phonemic and letter-overlap. Across both analyses, identity priming was not greater than that predicted based purely upon sublexical letter and phonemic overlap. This implies that masked identity priming in a stem-completion task may be due solely to letter and phonemic overlap from identity primes, rather than the unconscious activation of lexical/semantic representations.

4.1. Methodological issues

4.1.1. Task dissociation vs. exclusion

The traditional task dissociation paradigm measures priming in an indirect task from items shown by a direct conscious identification task to be presented "below threshold." However, differences in dark adaptation, response bias, task sensitivity, and even individual and item differences in prime perceptibility all render this procedure suspect.

The current study adds another potential problem, i.e., differences in prime perceptibility across conditions, associated with the task dissociation paradigm. Specifically, participants in the current experiments were significantly more accurate at identifying the prime in the identity condition than in the letter-overlap condition, homophone condition, or orthographic control conditions. Thus, providing a stem (e.g., ca- - -) allowed participants to identify a flashed prime (e.g., candy) that would have gone undetected in a direct conscious identification task. Had we used the traditional task dissociation method, any facilitation in priming produced by peoples' conscious identification of these items would have been called "unconscious" facilitation. Similarly, any inhibition produced by peoples' conscious identification of these items would have been called an unconscious inhibition of surrounding items (Carr & Dagenbach, 1990). Indeed, Kahan (2000) recently described how a clearly presented target can help "retrieve" a masked prime and the situations in which this should lead to either facilitation or inhibition. Using exclusion instructions should reduce this problem because these retrospective priming trials (Durante & Hirshman,

1994) are both identified and eliminated from the unconscious priming analysis. Thus, the current study both demonstrates the inherent problem of task dissociation studies and provides a much cleaner demonstration of unconscious priming, in which differences in prime perceptibility across conditions should not contribute to priming.

4.1.2. Implications of participants' guessing

Although the current study improves upon the task dissociation procedure, the "retrospective priming" for identity primes may still present a problem. Perhaps participants actually "saw" many of the primes, but did not report them unless they were sure. This possibility could explain the 16% difference in prime report between the identity and letter-overlap conditions. For instance, a participant guessing that the word "candy" was flashed would be more confident in his/her report if the stem "ca- - -" immediately followed. A related possibility, is that flashed words activate multiple possible candidates (i.e., candy, candle, cindy, camping, etc...) and the stem is used to select the correct one.[4] This explanation differs from Van Orden's (1987) in that the verification process would occur consciously based upon partial information rather than prior to conscious awareness as suggested by Van Orden.

A potential problem occurs when one considers the implications of this "partial awareness" for both form and identity unconscious priming. Perhaps participants were partially aware of form primes (e.g., windy, wendy, wordy, or, whimsy), but not confident enough to report them after seeing the unrelated stem (e.g., ca- - -). Their partial awareness of these items could influence stem completion (Indeed, this was actually one of the reasons for including the form-related condition in the first place, because people may have conscious knowledge of seeing "n," "d," and "y" without being able to report the word.).[5] Unfortunately, this could work to artificially inflate unconscious form-related priming since the near 16% difference in prime report could potentially represent such trials in which participants have only "partial awareness" of form-related primes. If such contamination occurred, this leaves room for the possibility of unconscious lexical activation. However, although not perfect, we believe the exclusion task improves upon most of the problems inherent in the task-dissociation paradigm and our results still question the need for invoking lexical activation.

5. Conclusions

There are five general conclusions stemming from the current study. The first, and most important, conclusion is that unconscious identity priming does exist and is not due to participants'

[4] In support of this "candidate activation" hypothesis (see Forster, 1998), there was a significant negative −.122 ($p < .02$) correlation between the number of orthographic neighbors (other English words that can be obtained by replacing 1 letter) a form-related prime word has and its likelihood of being correctly reported, when averaging across all current experiments.

[5] One possible way to correct this problem in the exclusion task would be to tell people not to use "any of the individual letters that were flashed to complete the stem." However, it could be argued that forcing participants to attend to individual letter level (rather than whole word level) may influence the amount of semantic activation obtained (see Chiappe, Smith, & Besner, 1996, for such an activation-blocking account).

occasionally ignoring instructions. The second conclusion is that the task dissociation paradigm is unequipped to study unconscious priming, as effects from these paradigms are contaminated by conscious identification. The third conclusion, as shown in Experiment 1, is that unconscious identity priming is not due to shared letters between the flashed word and the *missing letters* of the stem. The fourth conclusion is that there is evidence for both phonological and orthographic contributions to unconscious priming. The fifth conclusion is that there is no evidence of a lexical contribution to priming above what would be predicted based upon overlapping letters and sound alone. Perhaps unconscious priming of "candy" is due solely to the unconscious activation of the letters (e.g., c, a, n, d, & y) and sound (e.g., 'k/&/nd/i/), rather than the activation of an abstract word form or meaning. Notwithstanding our acknowledging that the "absence of evidence" is not the same as "evidence of the absence," we believe that our results provide a challenge to 40 years of research that has argued for the existence of unconscious activation of lexical (and even semantic) information. Thus, we prefer to align ourselves with recent claims made by Abrams and Greenwald (2000), Abrams et al. (2002), Klinger et al. (2000) and Masson and Isaak (1999) that unconscious priming is not based on lexical or semantic activation.

It is unclear whether such a strong claim would hold in reaction-time tasks such as naming, lexical decision, or semantic categorization because stem-completion may be less sensitive to lexical/semantic activation than these tasks (although we see no reason to assume this). However, Masson and Isaak (1999) have already questioned the role of unconscious lexical activation in naming so perhaps lexical/semantic effects only emerge in tasks such as lexical decision or semantic categorization in which participants base their decisions on lexical or semantic information. Unfortunately, because such information is used in the decision process in these latter tasks, it is extremely difficult to rule out conscious post-lexical use of such information as an explanation for priming (see Hutchison, 2003; Neely & Keefe, 1989, for discussions). Nevertheless, at least in the stem completion task, we currently see no need for invoking the unconscious activation of a lexical representation when such priming can be explained by the activation of sublexical orthographic and phonological codes.

Appendix A. Identical and letter primes in Experiment 1

Set A	KF	# Comp	Set B	KF	# Comp
accuse	10	6	refuse	16	10
adult	25	11	fault	23	27
ample	16	11	purple	13	7
answer	152	1	flower	23	9
apple	9	6	maple	7	39
apply	56	6	reply	42	30
battle*	87	5	cattle	97	3
beast	7	33	coast	61	49
beauty	71	9	deputy	17	8
belly	9	33	ally	23	64
bible	59	13	double	56	5
blade*	13	32	grade	35	44
blown	9	32	drown	3	31
boost	15	39	ghost	11	3
border	20	4	elder	15	7
bright	87	11	caught	98	5

Appendix A (*continued*)

Set A	KF	# Comp	Set B	KF	# Comp
build	86	32	child	213	41
cabana*	4	4	banana	4	10
cancer	25	16	saucer	0	1
candy	6	45	windy	2	20
captain	85	4	contain	45	8
carpet	13	14	puppet	6	2
change	240	15	orange	23	3
choose	50	11	oppose	15	1
class*	207	32	glass	99	16
cold*	171	106	gold	52	80
command*	72	7	demand	102	4
concern	98	9	modern	198	4
cough	7	49	tough	36	27
cramp	2	44	swamp	5	23
create	54	12	locate	16	5
crime*	34	44	prime	45	21
custom	14	1	bottom	88	4
cycle	24	2	uncle	57	13
dance	90	18	since	630	24
desire	79	4	entire	149	4
east	183	34	past	281	118
explain	64	4	certain	313	2
false	29	27	pulse	9	11
female	50	1	morale	17	12
fence*	30	15	hence	58	21
finger	40	9	danger	70	7
flush*	11	41	brush	44	35
food	147	94	wood	55	78
forget	54	16	target	45	6
gentle	27	8	rattle	5	6
glory*	21	16	story	153	70
ground*	186	11	around	561	3
guitar	19	6	nectar	3	1
heart*	173	21	start	154	70
honey*	25	29	money	265	39
hurry*	36	9	worry	55	18
imagine	61	3	marine	55	15
insect*	14	8	affect	35	4
insist	27	8	resist	22	10
juice	11	11	slice	13	26
keep*	264	29	deep	109	94
kill*	63	29	hill	72	96
laugh	28	31	rough	41	37
light*	333	29	night	411	6
limp*	12	107	shrimp	2	10
memory	76	3	theory	129	5
might*	672	25	right	613	16
milk*	49	87	silk	12	166
minute	53	9	salute	3	13
mother	216	7	rather	373	6
never	698	11	river	165	16
north	206	16	earth	150	9
order	376	4	under	707	13

Appendix A (*continued*)

Set A	KF	# Comp	Set B	KF	# Comp
piece*	129	22	niece	8	6
pitch	22	22	watch	81	34
police	155	8	notice	59	4
prince	33	14	glance	40	6
quick*	68	17	thick	67	7
rank*	24	91	tank	12	110
real*	260	91	deal	142	94
reason	241	7	person	175	6
scared*	21	6	hatred	20	2
scent	6	22	agent	44	8
secure	30	6	assure	37	9
shape*	85	53	grape	3	44
shower	15	11	drawer	8	8
silly	15	24	jelly	3	10
sister	38	1	butter	27	5
sorry	48	21	carry	88	45
spider	2	9	wonder	67	1
spread*	83	9	thread	15	16
strike*	50	27	pike	41	118
student	131	5	present	377	6
sugar	34	13	cigar	10	9
team*	83	110	seam	9	167
treat*	26	36	wheat	9	18
tuner	0	13	diner	0	24
upper	72	3	paper	157	35
vague	25	8	argue	29	16
venus	11	13	minus	8	25
vote*	75	29	note	127	43
wealth*	22	9	health	105	16
wish*	110	78	fish	35	94
yell*	9	18	bell	18	124

Note. KF, Kucera and Francis word frequency (per million), Comp #, number of valid English completions for the word stem when the last three letters are removed. An * indicates rhyming pairs.

Appendix B. Homophone pairs in Experiment 2

Set A	KF	Stem	# Comp	Set B	KF	Stem	# Comp
bear	57	be- -	24	bare	29	ba- -	27
beach	61	bea- -	9	beech	6	bee- -	5
break	88	bre- -	4	brake	9	bra- -	9
build	86	bu- - -	32	billed	3	bil- - -	2
bury	6	bu- -	21	berry	9	be- - -	32
carrot	1	car- - -	14	karat	—	ka- - -	3
chute	2	ch- - -	41	shoot	27	sh- - -	53
claws	3	cla- -	8	clause	9	cla- -	6
cord	6	co- -	33	chord	7	cho- -	7
creak	1	crea-	2	creek	14	cree-	3
dough	13	dou- -	2	doe	1	do-	4
due	142	du-	4	dew	3	de-	2
ewe	1	e- -	15	you	3286	y- -	6

Appendix B (*continued*)

Set A	KF	Stem	# Comp	Set B	KF	Stem	# Comp
except	181	exc- - -	7	accept	72	ac- - - -	22
fare	7	far-	2	fair	77	fai-	2
feet	283	fee-	4	feat	6	fea-	2
ferry	11	fe- - -	15	fairy	4	fa- - -	27
flower	23	flow- -	2	flour	8	flo- -	10
fur	13	fu-	2	fir	2	fi-	5
great	665	gre- -	5	grate	3	gra- -	17
hare	1	har-	5	hair	148	hai-	2
heal	2	hea-	5	heel	9	hee-	2
heard	247	hea- -	8	herd	22	her-	5
heir	7	h- - -	96	air	257	ai-	3
higher	160	hig- - -	2	hire	15	hi- -	13
horse	117	hor- -	3	hoarse	5	hoa- - -	2
jean	—	j- - -	28	gene	9	g- - -	80
knight	18	kni- - -	2	night	411	ni- - -	6
loan	46	loa-	3	lone	8	lon-	2
mail	47	mai-	3	male	37	mal-	4
manner	124	man- - -	18	manor	5	man- -	3
maul	—	mau-	2	mall	3	mal-	3
meet	148	mee-	2	meat	45	mea-	4
metal	61	met- -	3	medal	7	med- -	2
miner	1	mine-	3	minor	58	min- -	8
oar	—	oa-	6	ore	3	or-	2
pail	4	pai-	4	pale	58	pal-	4
pane	3	pan-	2	pain	88	pai-	4
pause	21	pau- -	2	paws	3	paw-	2
peace	198	pe- - -	23	piece	129	pi- - -	22
pear	6	pe- -	18	pare	2	pa- -	29
peer	8	pe- -	18	pier	3	pi- -	17
petal	—	pet- -	3	pedal	4	ped- -	2
plain	48	plai-	2	plane	114	plan-	4
poor	113	poo-	2	pore	2	por-	3
prophet	5	prop- - -	3	profit	28	pro- - -	11
reign	7	re- - -	30	rain	70	ra- -	22
root	30	r- - -	91	route	43	rou- -	5
scent	6	sc- - -	22	cent	158	c- - -	109
seize	6	se- - -	28	seas	10	se- -	19
sight	86	si- - -	24	cite	7	c- - -	108
soared	4	soa- - -	2	sword	7	sw- - -	23
some	1617	so- -	24	sum	45	su-	4
sore	10	soe-	2	soar	—	soa-	2
soul	47	sou-	3	sole	18	sol-	5
stare	14	star-	4	stair	2	stai-	3
steal	5	stea-	4	steel	45	stee-	4
suite	27	su- - -	13	sweet	70	sw- - -	23
sun	112	su-	5	son	166	so-	5
surf	1	su- -	13	serf	—	se- -	19
tacks	—	ta- - -	27	tax	197	ta-	7
time	1599	ti- -	14	thyme	—	th- - -	23
toad	4	to- -	25	towed	1	tow- -	4
vein	25	ve- -	10	vane	—	va- -	7
wail	3	wa- -	24	whale	—	wh- - -	18
warn	11	wa- -	24	worn	23	wo- -	12

Appendix B (*continued*)

Set A	KF	Stem	# Comp	Set B	KF	Stem	# Comp
where	938	whe- -	4	wear	36	we- -	12
wine	72	wi- -	20	whine	4	wh- - -	18
witch	5	wi- - -	20	which	3562	wh- - -	18
wore	65	wo- -	12	war	464	wa-	4
would	2714	wou- -	2	wood	55	woo-	2
write	106	wr- - -	13	right	613	ri- - -	16

Appendix C. Homophone pairs and orthographic controls in Experiment 3

Target	KF	Stem	# Comp	Homophone	KF	Orthographic	KF
air	257	ai-	3	heir	7	stir	7
beech	6	bee- -	5	beach	61	bench	35
billed	3	bil- - -	2	build	86	behind	258
cite	7	c- - -	108	sight	86	giant	23
clause	9	cla- - -	6	claws	3	claps	2
dew	3	de-	2	due	142	die	73
doe	1	do-	4	dough	13	doing	163
fair	77	fai-	2	fare	7	farm	127
fairy	4	fa- - -	27	ferry	11	furry	—
feat	6	fea-	2	feet	283	feel	216
fir	2	fi-	5	fur	13	far	427
foul	4	fou-	2	fowl	1	foil	20
gene	9	g- - -	80	jean	23	amen	19
hair	148	hai-	2	hare	1	hark	3
higher	160	hig- - -	2	hire	15	hiker	—
karat	—	ka- - -	3	carrot	1	barret	—
lone	8	lon-	2	loan	46	line	298
male	37	mal-	4	mail	47	maze	6
metal	61	met- -	3	medal	7	meal	30
mite	1	mit-	1	might	672	midst	19
ore	3	or-	2	oar	—	our	1252
paced	11	pac- -	2	paste	10	panic	22
pail	4	pai-	4	pale	58	palm	22
pain	88	pai-	4	pane	3	pant	—
paws	3	paw-	2	pause	21	pansy	6
petal	—	pet- -	3	pedal	4	penal	1
piece	129	pi- - -	22	peace	198	price	108
plane	114	plan-	4	plain	48	plate	22
poor	113	poo-	2	pore	2	port	21
profit	28	pro- - -	11	prophet	5	protest	23
rain	70	ra- -	22	reign	7	ring	47
right	613	ri- - -	16	write	106	trial	134
root	30	r- - -	91	route	43	roast	10
seas	10	se- -	19	seize	6	serge	5
shoot	27	sh- - -	53	chute	2	chant	2
soar	—	soa-	2	sore	10	sofa	6
sole	18	sol-	5	soul	47	soil	54
son	166	so-	5	sun	112	sin	53
stair	2	stai-	3	stare	14	start	154

Appendix C (*continued*)

Target	KF	Stem	# Comp	Homophone	KF	Orthographic	KF
sum	45	su-	4	some	1617	same	686
sweet	70	sw- - -	23	suite	27	spite	51
sword	7	sw- - -	23	soared	4	soured	—
tax	197	ta-	7	tacks	—	tangy	—
time	1599	ti- -	14	thyme	—	tame	5
towed	1	tow- -	4	toad	4	tone	78
vain	10	va- -	8	vein	25	vent	10
war	464	wa-	4	wore	65	wire	42
whale	—	wh- - -	18	wail	3	waltz	1
you	3286	y- -	6	ewe	1	eel	2

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