Memory & Cognition
2003, 31 (8), 1271-1283

Lexical competition in phonological priming: Assessing the role of phonological match and mismatch lengths between primes and targets

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In five experiments, we examined lexical competition effects using the phonological priming paradigm in a shadowing task. Experiments 1A and 1B replicate and extend Slowiaczek and Hamburger's (1992) observation that inhibitory effects occur when the prime and the target share the first three phonemes (e.g., /bʀiz/–/bʀik/) but not when they share the first two phonemes (e.g., /bʀɛz/–/bʀik/). This observation suggests that lexical competition depends on the length of the phonological match between the prime and the target. However, Experiment 2 revealed that an overlap of two phonemes is sufficient to cause an inhibitory effect provided that the primes mismatched the targets only on the last phoneme (e.g., /bɔl/–/bɔt/). Conversely, with a three-phoneme overlap, no inhibition was observed in Experiment 3 when the primes mismatched the targets on the last two phonemes (e.g., /bagɛt/–/bagaʒ/). In Experiment 4, an inhibitory effect was again observed when the primes mismatched the targets on the last phoneme but not when they mismatched the targets on the last two phonemes when the time between the offset of overlapping segments in the primes and the onset of overlapping segments in the targets was controlled for. The data thus indicate that what essentially determines prime–target competition effects in word-form priming is the number of mismatching phonemes.

Word recognition from the acoustic signal constitutes an important aspect of speech comprehension. Contemporary models postulate that spoken word recognition involves the activation of a set of lexical candidates and the selection of the best match within the candidate set. The time course of word recognition can thus be understood with reference to the set of lexical competitors from which a target word must be discriminated.

There is now ample evidence from various experimental paradigms that multiple lexical candidates are activated and compete with one another during target word processing (Allopenna, Magnuson, & Tanenhaus, 1998; Dahan, Magnuson, Tanenhaus, & Hogan, 2001; Goldinger, Luce, & Pisoni, 1989; Goldinger, Luce, Pisoni, & Marcario, 1992; Luce, Goldinger, Auer, & Vitevitch, 2000; Luce & Large, 2001; McQueen, Norris, & Cutler, 1994; Norris, McQueen, & Cutler, 1995; Soto-Faraco, Sebastián-Gallés, & Cutler, 2001; Vitevitch & Luce, 1998, 1999; Vroomen & de Gelder, 1995). However, the precise mechanism by which competition among lexical candidates is supposed to arise remains controversial. In some models, such as TRACE (McClelland & Elman, 1986) and Shortlist (Norris, 1994), lexical competition is caused by lateral inhibitions. By this mechanism, the target word tries to inhibit its competitors, but the competitors themselves also send inhibition to the target word and thus reduce its activation level, causing slower recognition. The degree to which a competitor inhibits a target word is also supposed to be a function of its activation level. The more a competitor is activated, the more inhibition the target word receives. Conversely, in the Cohort model (Marslen-Wilson, 1987; Marslen-Wilson, Moss, & van Halen, 1996) or the neighborhood activation model (NAM; Luce, Pisoni, & Goldinger, 1990), lexical competitors have no direct influence on the activation level of a target word, but competition effects are mediated at the decision stage, at which the presence of close competitors slows down the process of discrimination among lexical candidates. For example, in the Cohort model recognition takes place when the difference in activation between the target word and its most activated competitor has reached a fixed value. Thus, a competitor can influence the recognition of a target word by delaying the moment at which this critical difference is reached.

One way to study competition processes consists in measuring target performance after the presentation of one of the target's lexical competitors. What makes the phonological priming paradigm interesting for the study of lexical competition is that a competitor is explicitly presented and its effect on performance can be measured. Regardless of the mechanism by which competition is supposed to arise, all current models predict that priming a target word by one of its competitors should slow down its recognition. Indeed, preactivation of the competitor should increase its inhibitory influence during target processing in models such

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We thank Jay Rueckl, Dennis Norris, Louisa Slowiaczek, and one anonymous reviewer, who provided helpful comments on earlier versions of this manuscript. Correspondence concerning this article should be addressed to S. Dufour, LEAD–CNRS, Université de Bourgogne, Pôle AAFE, BP 26513, 21065 Dijon Cedex, France (e-mail: sophie.dufour@leadserv.u-bourgogne.fr).

as TRACE and Shortlist. It should also take longer for the activation level of the target word to exceed that of its competitors in the Cohort model. Surprisingly, however, the literature on phonological priming reports very few inhibitory effects, and several authors have also described either facilitation or null effects (see Monsell & Hirsh, 1998, and Radeau, Morais, & Segui, 1995, for reviews). The aim of the present study was to resolve some of the inconsistencies among the existing data. More specifically, we tried to assess under which conditions the expected competition effect can be consistently demonstrated.

Competition Effects in Phonological Priming

Although interference effects have not been systematically observed, some form-priming studies have reported them. Slowiaczek and Hamburger (1992) asked participants to perform a shadowing task[1] on monosyllabic targets preceded by primes sharing zero phonemes (e.g., *clump–green*), one phoneme (e.g., *goals–green*), two phonemes (e.g., *grope–green*), or three phonemes (e.g., *grief–green*) with the target words. It was found that responses were faster when primes and targets shared one phoneme than when there was no phonemic overlap between them. In addition to this *low similarity facilitation effect*, a *high similarity interference effect* was observed when the one-, two-, and three-phoneme overlap conditions were compared, with naming latencies being slowest for the three-phoneme overlap. In an attempt to determine the locus of these effects, Slowiaczek and Hamburger manipulated both the lexicality (word vs. nonword) and the modality (auditory vs. visual) of the primes. They found that the lexical status of the primes influenced the interference effect but not the facilitation effect. High-similarity interference was observed only with word primes, whereas low-similarity facilitation emerged for both word and nonword primes. On the other hand, prime modality affected the facilitation effect but not the interference effect. Low-similarity facilitation was present only with auditory primes, whereas high-similarity interference was observed with both auditory and visual primes. This pattern of results led Slowiaczek and Hamburger to conclude that low-similarity facilitation was a prelexical effect due to phonemic similarity between the primes and the targets. In contrast, high similarity interference was assumed to reflect competition between the lexical representations of the target and of the prime. Note, however, that response latencies were not reliably longer with a three-phoneme overlap than with a zero-phoneme overlap between the primes and the targets. Thus, the evidence for competition between lexical candidates consists in the observation that naming latencies increased as the phonemic overlap between primes and targets increased from one to three phonemes.

To account for the data, Slowiaczek and Hamburger (1992) proposed that facilitation results both from preactivation of the target's phonemes at a prelexical level and from partial activation of the target word at a lexical level. Interference, on the other hand, would arise when highly activated lexical units compete and inhibit each other. In the case of a large phonemic overlap between the prime and the target, the prime word would be strongly reactivated during target processing and would act as a strong competitor, thereby slowing down target recognition. Conversely, in the case of a single-phoneme overlap, the reactivation of the prime would not be sufficient to cause processing cost. Such an account is also compatible with the architecture of the TRACE model (McClelland & Elman, 1986), which postulates both excitatory connections between phonemes and lexical units and inhibitory connections at the lexical level. Consequently, both facilitation and inhibitory effects are predicted by TRACE, although the exact combination of these two effects remains unclear in the absence of simulation studies. Finally, the observation that an interference effect occurs only in the case of a large overlap between the primes and the targets is also compatible with the Cohort model (Marslen-Wilson et al., 1996), which does not postulate lateral inhibition but predicts that the strongest competitors are the words that diverge latest from the target word. Note that the inhibitory priming effects are restricted to words overlapping at their onsets (Monsell & Hirsh, 1998; Radeau et al., 1995). When the same kind of overlap occurs at offset, facilitation tends to be found (Dumay, Benraïss, Barriol, Colin, Radeau, & Besson, 2001; Monsell & Hirsh, 1998; Radeau et al., 1995; Slowiaczek, McQueen, Soltano, & Lynch, 2000), although the effect in the lexical decision task appears to be modulated by strategic bias (Norris, McQueen, & Cutler, 2002).

Investigating the role of strategic processes in initial-overlap phonological priming, Hamburger and Slowiaczek (1996) reported a reliable inhibitory effect with a three-phoneme overlap only when the strategic factors were discouraged by a low proportion of related pairs (21%) and a short (50-msec) interstimulus interval (ISI). When a high proportion of related pairs (75%) and a long (500-msec) ISI were used, the interference effect was negligible, thus indicating that strategic processes do not cause inhibitory priming effects but, rather, counteract them. Despite this observation, it was claimed that Hamburger and Slowiaczek's (1996) findings of inhibition when primes and targets shared three phonemes did not reflect a "true" lexical competition effect. Rather, it would be the result of response biases developed by participants when they noticed the presence of related prime–target pairs. In a replication of Hamburger and Slowiaczek's (1996) experiment, Goldinger (1999) attempted to provide evidence for response biases by examining how performance on control trials developed over the course of the experiment. He reasoned that if participants develop strategic processes intended to maximize performance on related trials, a cost should be systematically observed on control trials. This was in fact what Goldinger found. Reaction times (RTs) on control trials became slower as the experiment progressed for both the high and the low proportions of related prime–target pair conditions. The slowdown on control trials was nonetheless weaker when a low proportion of related pairs was used. Because

Goldinger observed that RTs increased even in a condition that reduced the likelihood of strategic processes, he argued that the inhibition observed when primes and targets shared three phonemes is the result of an "inefficient bias." Hence, according to Goldinger, inhibitory priming effects occur because participants "avoid anticipating more prime phonemes than targets truly contain" (p. 350). Although in a reanalysis of Hamburger and Slowiaczek's (1996) data, Hamburger and Slowiaczek (1999) also showed that biases were reduced but not eliminated by the use of a low proportion of related trial pairs, they maintained that the three-phoneme overlap inhibition reflects competition between the lexical representations of the primes and of the targets. This is because inhibition is stronger when strategic biases are weaker, thus making it unlikely that response biases cause inhibitory priming effects.

Taken together, the results described by Slowiaczek and Hamburger (1992) suggest that the likelihood that an inhibitory priming effect will emerge is dependent on the number of shared initial phonemes. Inhibitory effects are more likely to occur with an overlap of three phonemes than with an overlap of two phonemes between the primes and the targets. Nevertheless, such a finding is incompatible with the data obtained by Radeau et al. (1995) using monosyllabic words. With a 20-msec ISI and primes of lower frequency than the targets, Radeau et al. (1995) reported an inhibitory effect in a shadowing task despite the fact that the primes and the targets shared only the first two phonemes (e.g., *bouche* /buʃ/–*boule* /bul/).[2] This observation is particularly interesting because it may indicate that the number of matching phonemes is not the only factor in determining the competition effect in phonological priming.

Why did Radeau et al. (1995) observe an inhibitory effect with an overlap of two phonemes, whereas Slowiaczek and Hamburger (1992) did not? An examination of Slowiaczek and Hamburger's materials reveals that the phonological *mismatch* length between primes and targets covaried with the size of the phonological *match*. In their studies, Slowiaczek and Hamburger used four- or five-phoneme monosyllabic words. This implies that in the case of an overlap of two phonemes, the primes mismatched the targets on at least the last two phonemes (e.g., *drill*–*dread*). In contrast, in Radeau et al.'s (1995) study, three-phoneme monosyllabic words were used, meaning that with the same overlap, the primes mismatched the targets only on the last phoneme (e.g., *bouche* /buʃ/–*boule* /bul/). It is thus likely that the amount of inhibition exerted by a competitor on target word recognition is a function of the size of the phonological mismatch. Such a hypothesis seems to follow naturally from the sequential nature of the speech signal. When a competitor differs from the target only on the last phoneme, it should be strongly reactivated during the processing of the target word, since its activation will rise until the last phoneme of the target is processed. As a result, a late-diverging word should compete strongly with target recognition. In contrast, when a competitor mismatches the target on the last two phonemes, its inhibitory influence should be considerably reduced, since it mismatches the lexical representation of the target word earlier and its activation quickly stops increasing during the processing of the target. Thus, primes differing from the targets on the last two phonemes should constitute less effective competitors and should have less influence on the recognition of the target words. The present study was undertaken to provide an empirical examination of this prediction.

Five experiments were carried out in order to examine whether variations in the number of mismatching phonemes cause variations in the competition effect between prime and target words. In each experiment, the primes and the targets were presented auditorily and the participants performed a shadowing task. The stimulus lists included a weak proportion of related pairs (25%) to minimize the influence of strategic factors that could counteract the expected inhibitory effects (Hamburger & Slowiaczek, 1996). Except in Experiment 4, a short (50-msec) ISI was used to prevent the residual activation of the prime from dissipating before target presentation. Because it had previously been observed that low-frequency primes produce more inhibition than high-frequency primes do (Radeau et al., 1995; see also Luce et al., 2000, for a similar observation in phonetic priming), the less frequent of the words in each of the prime–target pairs was always used as the prime.[3] The conditions used in each experiment are illustrated with examples in Table 1.

As in Slowiaczek and Hamburger's (1992) study, the amount of initial overlap was manipulated in Experiments 1A and 1B to assess the generality of their effects with French materials. In Experiment 1A, CCVC monosyllabic target words were used. Primes and targets shared zero phonemes (e.g., *moine* /mwɑn/–*brique* /bʀik/), two phonemes (e.g., *braise* /bʀɛz/–*brique* /bʀik/), or three phonemes (e.g., *brise* /bʀiz/–*brique* /bʀik/). The amount of initial overlap also covaried with the number of mismatching phonemes between the primes and the targets. In the case of an overlap of two phonemes, the primes mismatched the targets on the last two phonemes. In contrast, in the case of an overlap of three phonemes, the primes and the targets differed only on the last phoneme. Because the use of CCVC target words makes it unavoidable that related prime–target pairs share the vowel for the three-phoneme overlap but not for the two-phoneme overlap, Experiment 1B was conducted to ensure that it is not the vocalic overlap that is responsible for the inhibitory effect. Thus, CVCC target words were used in Experiment 1B so that primes and targets shared the vowel in both the two-phoneme (e.g., *carpe* /kaʀp/– *casque* /kask/) and the three-phoneme (e.g., *corne* /kɔʀn/–*corde* /kɔʀd/) overlap conditions. So, in Experiments 1A and 1B, the stimuli were four phonemes long, with three initial matched phonemes and one mismatched final phoneme, two initial matched phonemes and two mismatched final phonemes, or zero matched phonemes. In Experi-

Table 1
Priming Conditions Used in the Experiments

Experiment	Priming Condition	Examples	Initial Overlap	Final Mismatch
1A	Two-phoneme	/bʀɛz/–/bʀik/	2	2
	Three-phoneme	/bʀiz/–/bʀik/	3	1
	Control	/mwɑn/–/bʀik/	0	4
1B	Two-phoneme	/kaʀp/–/kask/	2	2
	Control	/guʀd/–/kask/	0	4
	Three-phoneme	/kɔʀn/–/kɔʀd/	3	1
	Control	/bɛlʒ/–/kɔʀd/	0	4
2	Two-phoneme	/bɔl/–/bɔt/	2	1
	Control	/luʃ/–/bɔt/	0	3
3 and 4	Three-phoneme	/bagɛt/–/bagaʒ/	3	2
	Four-phoneme	/bagaʀ/–/bagaʒ/	4	1
	Control	/flokɔ̃/–/bagaʒ/	0	5

ment 2, the primes and targets shared the first two phonemes and mismatched only on the last phoneme (e.g., *bol* /bɔl/–*botte* /bɔt/), as was the case in Radeau et al.'s (1995) experiment. Thus, the stimuli were three phonemes long with two initial matched phonemes and one mismatched final phoneme, or with zero matched phonemes. Despite the small overlap between primes and targets, primes should constitute strong competitors because they mismatched the lexical representations of the targets only on the last phoneme. In consistency with Radeau et al.'s (1995) observation, an interference effect was expected. In Experiment 3, an overlap of three phonemes was again used, to examine whether inhibition could still be observed when the primes and the targets differed on the last two phonemes. Because it was not possible to select monosyllabic primes that shared three phonemes with the targets but mismatched the targets on the last two phonemes, bisyllabic primes and targets were used. Primes and targets shared zero phonemes (e.g., *flocon* /flokɔ̃)/–*bagage* /bagaʒ/), three phonemes (e.g., *baguette* /bagɛʀ/–*bagage* /bagaʒ/), or four phonemes (e.g., *bagarre* /bagaʀ/–*bagage* /bagaʒ/). In the case of the three-phoneme overlap, the primes mismatched the targets on the last two phonemes. In contrast, in the case of the four-phoneme overlap, the primes differed from the targets only on the last phoneme. Thus, the stimuli were five phonemes long with three initial matched phonemes and two mismatched final phonemes, four initial matched phonemes and one mismatched final phoneme, or zero matched phonemes. As in Experiment 1, an inhibitory effect was expected only when the primes mismatch the targets on the last phoneme. Because the number of mismatching phonemes bore a direct correlation to the time that elapsed between the offset of overlapping segments in the primes and the onset of overlapping segments in the targets, Experiment 4 was aimed at replicating Experiment 3 while keeping this variable constant.

EXPERIMENT 1A

Experiment 1A consisted of a partial replication of the Slowiaczek and Hamburger (1992) experiment. Primes and targets shared zero phonemes (e.g., /mwan/–/bʀik/), two phonemes (e.g., /bʀɛz/–/bʀik/), or three phonemes (e.g., /bʀiz/–/bʀik/). Following Slowiaczek and Hamburger, an inhibitory effect was expected only for the three-phoneme overlap because the high similarity between primes and targets should cause the prime words to be strongly reactivated during target processing. Conversely, no inhibitory effect should emerge when the primes and the targets share two phonemes, because the low similarity between primes and targets should prevent the primes from being sufficiently reactivated during target presentation and thus interfering with target recognition.

Method

Participants. Fifty-four students at the University of Bourgogne participated in the experiment for course credits. All were native speakers of French and reported no hearing or speech disorders.

Materials. Forty-two monosyllabic target words with a CCVC syllabic structure were selected from BRULEX, a lexical database for the French language (Content, Mousty, & Radeau, 1990). Each of these 42 target words was paired with three monosyllabic prime words. Two primes were phonologically related to the target: One shared the first two phonemes with the target and mismatched the target on the last two phonemes (e.g., *braise* /brɛz/–*brique* /brik/), and the other shared the first three phonemes with the target and differed from the target only on the last phoneme (e.g., *brise* /briz/–*brique* /brik/). A third prime having no phoneme in common with the target was used as a control (e.g., *moine* /mwan/–*brique* /brik/). The prime–target pairs are provided in Appendix A.

The targets had a mean logarithmic frequency of 3.45. The mean logarithmic frequencies of the primes were 2.48 for the two-phoneme primes, 2.63 for the three-phoneme primes, and 2.51 for the control primes. The average duration of the targets was 462 msec. The average duration of the primes was 458 msec for the two-phoneme primes, 450 msec for the three-phoneme primes, and 453 msec for the control primes.

Because each target was paired with three different primes (two-phoneme, three-phoneme, and control) and no participant was to be presented with the same target more than once, three experimental lists were created. Each list included the 42 target words, and within each list each type of prime preceded 14 target words. The lists were counterbalanced so that each target was preceded by the three types of prime. To attain a proportion of related prime–target pairs of 25%, 70 filler pairs without any relation between the primes and the targets were added to each list.

Procedure. The stimuli were recorded by a female native speaker of French on a digital audio tape recorder. The items were digitized at a sampling rate of 44 kHz with 16-bit analog-to-digital recording. The participants were tested individually in a quiet room. The presentation of the items was controlled by a computer. RTs were collected via a voice key connected to the computer. The primes and the targets were presented over headphones at a comfortable sound level. A 50-msec ISI separated the offset of the prime and the onset of the target. Each participant was asked to repeat the target as quickly and accurately as possible. The participant's response and the onset of the prime of the following trial were separated by a 2-sec silence. The naming latencies were measured from the onset of the target to the participant's response. Each participant was tested on only one experimental list and began the experiment with a block of 16 practice trials.

Results and Discussion

Two items that gave rise to an error rate of more than 20% were excluded from the analyses. For each participant, both RTs longer than 1,200 msec and those greater than 2.5 standard deviations above and below the overall response time were removed from the analyses. Incorrect responses were also removed from the latency analyses. A response was considered incorrect in case of hesitation or when at least one phoneme of the target was mispronounced. With these criteria, only 2.96% of the data were rejected. The mean RTs and error rates in each priming condition are presented in Table 2. Because few errors occurred, analyses were performed on RTs only. Analyses of variance (ANOVAs) by participants (F_1) and by items (F_2) were conducted, with prime type (two-phoneme, three-phoneme, and control) as the variable. In order to reduce interindividual variability, the variable list was also included in the analyses (see Pollatsek & Well, 1995). Only the results concerning the variable of interest (prime type) are reported below.

The main effect of prime type was significant [$F_1(2,102) = 10.21, p < .001; F_2(2,74) = 8.93, p < .001$]. Planned comparisons were conducted to test for differences across prime type. Responses to targets were significantly slower (15 msec on average) when they were preceded by the three-phoneme primes in comparison with the control primes [$F_1(1,51) = 7.42, p < .01; F_2(1,37) = 5.47, p < .05$]. No significant difference was observed between the two-phoneme primes and the control primes [$F_1(1,51) = 2.78, p = .10; F_2(1,37) = 1.99, p = .17$].

EXPERIMENT 1B

Because in the three-phoneme overlap condition primes and targets shared the vowel, Experiment 1B was carried out to ensure that the vocalic overlap is not the primary vehicle for inhibitory priming effects. Therefore, CVCC monosyllabic words were used so that primes and targets shared the vowel in both the two- and the three-phoneme overlap conditions. If the vocalic overlap, rather than the amount of overlap between primes and targets, explains the inhibition observed when primes and targets shared three phonemes, no difference in magnitude of the priming effect is expected between the two- and the three-phoneme overlap conditions when vowel overlap is controlled. Because it was not possible to select two related primes for a given target word, two sets of targets were selected. For one set, the related primes shared two phonemes with the targets, and for the other the related primes shared three phonemes with the targets. What is so critical in this experiment is the interaction between prime type and overlap.

Table 2
Mean Reaction Times (RTs, in Milliseconds, With Standard Deviations) and Percentage of Errors (%Error) as a Function of the Number of Shared Phonemes Between the Primes and the Targets in Experiment 1A

Prime Type	RT	*SD*	%Error
Control	825	87	2.78
Two-phoneme overlap	817	91	1.39
Three-phoneme overlap	840	90	0.97

Method

Participants. Fifty students were recruited from the same pool as in Experiment 1A.

Materials and Procedure. Two sets of 18 monosyllabic target words with a CVCC syllabic structure were selected. For the first set, the related primes shared the first two phonemes with the targets and mismatched the targets on the last two phonemes (e.g., *carpe* /kaʀp /–*casque* /kask/). For the second set, the related primes shared the first three phonemes with the targets and differed from the targets only on the last phoneme (e.g., *corne* /kɔʀn/– *corde* /kɔʀd/). All related primes had a CVCC syllabic structure. For each of the 36 target words, a CVCC control prime having no phoneme in common with the targets was selected.[4] The primes and targets are provided in Appendix B.

Both sets of targets were matched for word frequency, with mean logarithmic frequencies of 3.49 for the two-phoneme overlap condition and 3.52 for the three-phoneme overlap condition. The mean logarithmic frequencies of related and control primes were 2.54 and 2.26, respectively, for the two-phoneme overlap condition. The corresponding respective values for the three-phoneme overlap condition were 1.87 and 2.22. The average durations of the targets were 560 and 556 msec for the two- and the three-phoneme overlap conditions, respectively. In the two-phoneme overlap condition, the average durations of related and control primes were 554 and 575 msec, respectively. In the three-phoneme overlap condition, the corresponding respective values were 555 and 551 msec. Because each target was paired with two different primes (related and control), two experimental lists were created. To attain a proportion of related prime–target pairs of 25%, 36 filler pairs without any relation between the primes and the targets were added to each list. The procedure was the same as in Experiment 1A.

Results and Discussion

The RT data were analyzed according to the same criteria as in Experiment 1A. One item was excluded from the analyses because it was subject to frequent miscomprehension. The percentage of rejected data was 3.14. The mean RTs and error rates in each condition are presented in Table 3. Because few errors occurred, analyses were performed on RTs only. ANOVAs were conducted with prime type (related, control) and overlap (two-phoneme, three-phoneme) as variables.

The main effect of prime type was significant [$F_1(1,48) = 9.23, p < .01; F_2(1,31) = 5.14, p < .05$]. The main effect of overlap was not significant [$F_1(1,48) =$

Table 3
Mean Reaction Times (RTs, in Milliseconds, With Standard Deviations) and Percentage of Errors (% Error) for Control and Related Primes as a Function of Overlap in Experiment 1B

	Overlap					
	Two-Phoneme			Three-Phoneme		
Prime Type	RT	*SD*	%Error	RT	*SD*	%Error
Control	834	107	2.89	824	117	0.47
Related	840	112	2.22	844	111	1.41

0.75, $p > .20$; $F_2(1,31) = 0.00$, $p > .20$]. The interaction between prime type and overlap was significant [$F_1(1,48) = 5.25$, $p < .05$; $F_2(1,31) = 6.49$, $p < .05$].

Planned comparisons were conducted to assess the effect of priming within each overlap condition. A priming effect was observed only in the three-phoneme overlap condition. Responses to targets were 20 msec slower when they were preceded by the related primes in comparison with the control primes [$F_1(1,48) = 12.37$, $p < .001$; $F_2(1,31) = 11.24$, $p < .01$]. No priming effect was observed in the two-phoneme overlap condition [$F_1(1,48) = 1.28$, $p > .20$; $F_2(1,31) = 0.04$, $p > .20$]. Overall, the results suggest that the inhibitory effect previously observed in the three-phoneme overlap condition is due to more than simple vocalic overlap between primes and targets.[5]

To summarize, Experiments 1A and 1B replicate the results previously described by Slowiaczek and Hamburger (1992) and indicate that an inhibitory priming effect occurs when the primes and the targets share three phonemes but not when they share two phonemes. Hence, as was suggested by Slowiaczek and Hamburger, the amount of inhibition exerted by the primes on the processing of the target words appears to be a function of the number of matching phonemes between primes and targets. Primes sharing more than two phonemes with the targets would constitute strong competitors and, therefore, slow down the recognition of the target words.

EXPERIMENT 2

An alternative account of the present findings could be that what determines competition between lexical candidates is not the size of the phonological match, but the number of mismatching phonemes between primes and targets. As was mentioned above, in both Experiment 1 and Slowiaczek and Hamburger's (1992) study, the size of the phonological match varied together with the number of mismatching phonemes between the primes and the targets. This characteristic might be critical because, given the sequential nature of the speech signal, it could be that competition depends on the number of mismatching phonemes. Primes that mismatch the targets only on the last phoneme, as was the case in the three-phoneme overlap, might constitute strong competitors not because of the size of the phonological match per se, but rather because such prime words are reactivated until the last phoneme of the target is processed. The lack of interference with two-phoneme overlap primes might thus be related to the higher phonological mismatch between primes and targets. When the prime mismatches the target on the last two phonemes, its activation quickly stops increasing during target processing, thus strongly reducing its inhibitory influence. According to this hypothesis, the effectiveness of a prime word in slowing down target recognition would be dependent on a weak mismatch with the target word. In accordance with the result described by Radeau et al. (1995), such an account leads to the prediction that an inhibitory priming effect should again occur with an overlap of two phonemes when the primes mismatch the targets only on the last phoneme. Experiment 2 was designed to test this prediction. Although this condition was included in the Radeau et al. (1995) study, the interference effect did not reach significance in the by-item analysis, perhaps because of the small number of items involved.

Method

Participants. Forty students were recruited from the same pool as in Experiment 1.

Materials and Procedure. Forty-two monosyllabic target words with a CVC syllabic structure were selected. Each of the 42 target words was paired with two monosyllabic prime words. One prime shared the first two phonemes with the target and mismatched the target on the last phoneme (e.g., *bol* /bɔl/–*botte* /bɔt/). The other was used as a control and had no phonemes in common with the target (e.g., *louche* /luʃ/–*botte* /bɔt/). The targets and primes are provided in Appendix C.

The targets had a mean logarithmic frequency of 3.61. The mean logarithmic frequencies of the primes were 2.55 for the related primes and 2.59 for the control primes. The average durations were 480 msec for the targets, 458 msec for the related primes, and 497 msec for the control primes. Since the targets were paired with two different primes, two experimental lists were created. To attain a proportion of related prime–target pairs of 25%, 42 filler pairs without any relation between the primes and the targets were added to each list. The procedure was the same as in Experiment 1.

Results and Discussion

Two items that gave rise to an error rate of more than 20% were excluded from the analyses. The RT data were analyzed according to the same criteria as in Experiment 1. The percentage of rejected data was 2.75. The mean RTs and error rates in each condition are presented in Table 4. Because few errors occurred, only RTs were submitted to ANOVAs.

The ANOVAs revealed a main effect of prime type [$F_1(1,38) = 6.74$, $p < .05$; $F_2(1,38) = 5.34$, $p < .05$].

Table 4
Mean Reaction Times (RTs, in Milliseconds, With Standard Deviations) and Percentage of Errors (% Error) for Control and Related Primes in Experiment 2

Prime Type	RT	*SD*	%Error
Control	798	113	0.88
Related	808	107	1.38

Responses to targets were 10 msec slower when they were preceded by the related primes in comparison with the control primes. Although small in magnitude, this inhibition observed with a two-phoneme overlap appears to be robust, since a similar, 18-msec effect was also observed by Radeau et al. (1995) using different stimuli.

Taken together, the results of Experiments 1 and 2 reveal that for the same initial overlap, the inhibitory influence of the prime words is not equal. Two shared phonemes in Experiment 1 did not lead to inhibition, but two shared phonemes in Experiment 2 led to significant inhibition. These results indicate that the amount of inhibition produced by a prime word on the processing of a target word depends on the length of the phonological mismatch between the prime and the target. A prime will have a strong impact on target word recognition only when it mismatches the target on the last phoneme. When a prime mismatches the target on the last two phonemes, as was the case in Experiment 1, its inhibitory influence is considerably reduced, with the result that it no longer influences target word recognition.

EXPERIMENT 3

Both Experiment 2 and Radeau et al.'s (1995) results indicated that an inhibitory priming effect can be observed even in the case of a reduced initial overlap between primes and targets. At first sight, these findings appear to conflict with the data reported both in Experiment 1 and in Slowiaczek and Hamburger's (1992) study. Indeed, in Experiment 1 an inhibitory effect was found only when the initial overlap was of three phonemes. The results of Experiment 2 suggest, therefore, that the lack of an interference effect in Experiment 1 for the two-phoneme overlap follows from a high level of mismatch between the primes and the targets. It seems that a prime sharing the first two phonemes with the target can slow down the recognition of the target word only when it mismatches the target on the last phoneme. A more thorough examination of the role of the number of mismatching phonemes would consist of assessing whether an initial overlap of three phonemes is still sufficient to cause inhibition when the primes mismatch the targets on the last two phonemes. This was the purpose of Experiment 3.

In this experiment, bisyllabic primes and targets were used. The primes and the targets shared zero phonemes (e.g., /flokɔ̃/–/bagaʒ/), three phonemes (e.g., /bagɛt/–/bagaʒ/), or four phonemes (e.g., /bagaʀ/–/bagaʒ/). In the case of a three-phoneme overlap, the primes mismatched the targets on the last two phonemes. In contrast, in the case of a four-phoneme overlap, the primes mismatched the targets only on the last phoneme. As in Experiments 1 and 2, an inhibitory effect was expected only when the primes mismatched the targets on the last phoneme.

Method

Participants. Fifty-four students were recruited from the same pool as in Experiments 1 and 2.

Materials and Procedure. Forty-two bisyllabic target words, five phonemes in length, were selected. Each of these 42 target words was paired with three bisyllabic prime words, five phonemes in length. Two primes were phonologically related to the target. One shared the first three phonemes with the target and mismatched the target on the last two phonemes (e.g., *baguette* /bagɛt/–*bagage* /bagaʒ/). The other shared the first four phonemes with the target and differed from the target only on the last phoneme (e.g., *bagarre* /bagaʀ/–*bagage* /bagaʒ/). The third prime was used as a control and had no phoneme in common with the target (e.g., *flocon* /flokɔ̃)/–*bagage* /bagaʒ/). The prime–target pairs are provided in Appendix D.

The targets had a mean logarithmic frequency of 3.37. The mean logarithmic frequencies of the primes were 2.26 for the three-phoneme primes, 2.33 for the four-phoneme primes, and 2.58 for the control primes. The average duration of the targets was 584 msec. The average durations of the primes were 619 msec for the three-phoneme primes, 606 msec for the four-phoneme primes, and 552 msec for the control primes. As in the previous experiments, since the targets were paired with three different primes, three experimental lists were created. To attain a proportion of related prime–target pairs of 25%, 70 filler pairs without any relation between the primes and the targets were added to each list. The procedure was the same as in Experiments 1 and 2.

Results and Discussion

The RT data were analyzed according to the same criteria as in Experiments 1 and 2. The percentage of rejected data was 2.87. The mean RTs and error rates in each condition are presented in Table 5. Because few errors occurred, only RTs were submitted to ANOVAs.

The main effect of prime type was reliable [$F_1(2,102) = 11.53, p < .001$; $F_2(2,78) = 7.59, p < .001$]. Planned comparisons were conducted to test for differences across prime type. Responses to targets were significantly slower (23 msec on average) when they were preceded by four-phoneme primes in comparison with the control primes [$F_1(1,51) = 17.36, p < .001$; $F_2(1,39) = 10.84, p < .01$]. No significant difference was observed between three-phoneme primes and control primes [$F_1(1,51) = 2.27$, $p = .14$; $F_2 < 1$].

As in Experiments 1 and 2, a competition effect was consistently demonstrated when the primes mismatched the targets on the last phoneme (e.g., /bagaʀ/–/bagaʒ/). No significant inhibition was observed with an overlap of three phonemes when the primes mismatched the targets on the last two phonemes (e.g., /bagɛt/–/bagaʒ/). Thus, unlike in Experiment 1, it appears that an initial overlap of three phonemes is no longer sufficient to cause inhibition. The contrasting outcomes of Experiments 1 and 3 are probably related to a higher mismatch in Experiment 3, which considerably reduces the com-

Table 5

Mean Reaction Times (RTs, in Milliseconds, With Standard Deviations) and Percentage of Errors (%Error) as a Function of the Number of Shared Phonemes Between the Primes and the Targets in Experiment 3

Prime Type	RT	*SD*	%Error
Control	862	85	1.32
Three-phoneme overlap	869	87	0.26
Four-phoneme overlap	885	71	0.79

petition between primes and target words. This finding supports our claim that the number of mismatching phonemes between primes and targets is a critical variable in determining inhibition during target word recognition.

EXPERIMENT 4

To sum up, the results of the previous experiments indicate that the inhibitory influence of a prime word is considerably reduced when it mismatches the target on the last two phonemes. Nonetheless, a potentially important factor directly related to the number of mismatching phonemes is the time elapsed between the offset of overlapping segments in the primes and the onset of overlapping segments in the targets. Because it is well known that an activation-based priming effect rapidly diminishes as a function of time, it might be that the larger inhibition effect in the case of a one-phoneme mismatch than in that of a two-phoneme mismatch results from a shorter delay in the former than in the latter. Therefore, in Experiment 4 the same materials were used as in Experiment 3, and the time elapsed between the offset of overlapping segments in the primes and the onset of overlapping segments in the targets was controlled for. Controlling for the offset–onset delay in the different priming conditions necessarily requires a longer ISI for the smaller mismatch. Thus, in order to have equivalent time durations between the offset of overlapping segments in the primes and the onset of overlapping segments in the targets, a larger mismatch was compensated by a shorter ISI. Consequently, the ISI was still 50 msec in the two-phoneme mismatch condition, whereas it was increased to 211 msec in the one-phoneme mismatch condition. Although it has been shown that inhibitory effects occurred when a 50-msec ISI was used but not when a 500-msec ISI was used (Goldinger et al., 1992), to our knowledge the effects of using such an intermediate ISI have not been examined in any study.

Method

Participants. Fifty-four students were recruited from the same pool as in the previous experiments.

Materials and Procedure. The materials were the same as in Experiment 3. The durations of the mismatching segments in the primes were measured. On average, they were 327 msec in the two-phoneme mismatch condition (e.g., the segment /ɛt/ for the prime /bagɛt/ in the prime–target pair /bagɛt/–/bagaʒ/) and 166 msec in the one-phoneme mismatch condition (e.g., the segment /ʀ/ for the prime /bagaʀ/ in the prime–target pair /bagaʀ/–/bagaʒ/). The procedure was the same as in the previous experiments except that the ISI was increased from 50 to 211 msec in the one-phoneme mismatch condition. Thus, the delay between the offset of overlapping segments in the primes and the onset of overlapping segments in the targets was 377 msec for both the two-phoneme and the one-phoneme mismatch conditions. To prevent the participants from developing strategies, the ISI was also increased to 211 msec for half of the control and filler pairs.

Results and Discussion

One item that gave rise to an error rate of more than 20% was excluded from the analyses. The RT data were analyzed according to the same criteria as in the previous experiments. The percentage of rejected data was 1.45. The mean RTs and error rates in each condition are presented in Table 6. Because few errors occurred, only RTs were submitted to ANOVAs.

The main effect of prime type was reliable [$F_1(2,102) = 66.17, p < .001$; $F_2(2,76) = 59.29, p < .001$]. Planned comparisons were conducted to test for differences across prime type. Responses to targets were significantly slower (43 msec on average) when they were preceded by one-phoneme-mismatch primes in comparison with the control primes [$F_1(1,51) = 87.16, p < .001$; $F_2(1,38) = 77.03, p < .001$]. No significant difference was observed between two-phoneme-mismatch primes and control primes [$F_1(1,51) = 2.57, p = .12$; $F_2(1,38) = 1.64, p > .20$].

When the time duration between the offset of overlapping segments in the primes and the onset of overlapping segments in the targets was controlled for, a competition effect was again consistently demonstrated when the primes mismatched the targets on the last phoneme (e.g., /bagaʀ/–/bagaʒ/) but not when they mismatched the targets on the last two phonemes (e.g., /bagɛt/–/bagaʒ/). Thus, it appears that the lack of inhibitory priming effect in the case of a two-phoneme mismatch cannot be attributed to a longer time elapsed between overlapping segments in the primes and the targets.[6] Moreover, the results show that increasing the ISI from 50 to 211 msec did not eliminate the inhibitory priming effect, suggesting that such an ISI did not allow enough time for activation of the prime to dissipate before target presentation.

What is surprising, however, is the fact that the inhibitory priming effect did not diminish with an increase in ISI. Indeed, the inhibitory effect was twice as large when the 211-msec ISI was used than when the 50-msec ISI was used. Because it is usually claimed that greater priming for long than for short ISIs indicates bias contamination (Goldinger et al., 1992; Radeau et al., 1995), the possibility of strategic involvement cannot be discarded. As will be discussed below, Pitt and Shoaf (2002) recently argued that as participants become aware of the presence of related prime–target pairs, they use information about primes to maximize fast responses at least on related trials, thus masking inhibitory priming effects (but see Dufour & Peereman, 2003, for conflicting evidence). Nonetheless, the observation of a larger priming effect at longer ISIs seems to argue against such a position. Indeed, because a longer ISI should provide a better opportunity to engage such strategic processing, a smaller inhibitory priming effect should have occurred.

Table 6
Mean Reaction Times (RTs, in Milliseconds, With Standard Deviations) and Percentage of Errors (%Error) as a Function of the Number of Mismatching Phonemes Between Primes and Targets in Experiment 4

Prime Type	RT	*SD*	%Error
Control	803	84	0.54
Two-phoneme mismatch	808	83	0.14
One-phoneme mismatch	846	84	0.81

Of particular interest are the shorter RTs in Experiment 4 in comparison with those in Experiment 3. They would suggest that fast participants are more affected than slow participants by the prior presentation of related primes. Additional analyses performed on the RTs in Experiment 4 confirm this suggestion. The slowest participants showed an inhibitory priming effect of 34 msec, whereas the fastest participants showed an inhibitory priming effect of 53 msec [$F(1,48) = 4.02, p = .05$].[7] Thus, it is likely that the difference in the magnitude of the priming effect between Experiments 3 and 4 is related to the overall speed of the participants.

GENERAL DISCUSSION

All competitive activation models predict that priming a target word by one of its competitors should delay its recognition. However, as we have pointed out, reviews of published studies (Monsell & Hirsh, 1998; Radeau et al., 1995) indicate that inhibitory priming effects have been reported only occasionally. The aim of the present study was to try to resolve some of the inconsistencies among the existing data. As we have mentioned above, previous studies have generally focused on the size of the phonological match, and they have not systematically considered the phonological mismatch length between primes and targets. As a result, the number of mismatching phonemes was generally left to covary with the number of phonemes shared between the primes and the targets. The present study was designed to examine whether such a variable is critical in determining the magnitude of inhibitory priming effects.

Experiment 1A replicated Slowiaczek and Hamburger's (1992) observation of an inhibitory priming effect with a prime–target overlap of three phonemes but not with an overlap of two phonemes. Importantly, Experiment 1B indicated that differential priming effects were still observed when the vocalic overlap between primes and targets was controlled for. Such a finding seems to indicate that the amount of inhibition exerted by a prime word on target word processing is a function of the number of initial phonemes that match the target. Experiment 2 revealed, however, that the lack of an interference effect in Experiment 1 for the two-phoneme overlap was due to the size of the phonological mismatch between primes and targets. It appeared that a prime sharing the first two phonemes with a target can also slow down the recognition of the target word, provided that the prime mismatches the target only on the last phoneme. Examining this hypothesis further, we predicted that a three-phoneme overlap would no longer be sufficient to cause inhibitory effects when the primes mismatch the targets on the last two phonemes. The results of Experiment 3 confirmed this prediction. An inhibitory effect was again observed in Experiment 4 when the primes mismatched the targets on the last phoneme but not when they mismatched the targets on the last two phonemes when the time duration between the offset of overlapping segments in the primes and the onset of overlapping segments in the targets was controlled for. Overall, the present results suggest that the number of mismatching phonemes is a relevant factor in determining the amount of competition between lexical candidates. Inhibitory priming effects consistently occurred even in the case of a reduced initial overlap whenever the primes mismatch the targets on the last phoneme. When the primes mismatch the targets on the last two phonemes, their inhibitory influence is considerably reduced.

An alternative explanation of the present findings might be that what is important in determining competition effects is not the absolute number of mismatching phonemes per se but the ratio between the number of matching and mismatching phonemes. Indeed, when the results are viewed in terms of percentage of overlap, competition effects were found when there was an overlap of 67% (two phonemes out of three in Experiment 2), 75% (three phonemes out of four in Experiment 1), and 80% (four phonemes out of five in Experiments 3 and 4). Conversely, no competition effect was reported when there was 50% (two phonemes out of four in Experiment 1) or 60% (three phonemes out of five in Experiments 3 and 4) overlap. Although this alternative seems to offer a coherent account of the present data, additional work is required to examine this hypothesis further.

It was recently claimed that the inhibition observed with an initial overlap reflects a surprise effect (Pitt & Shoaf, 2002). Examining the emergence of biases by comparing the magnitude of the priming effects at various points during the experimental session, Pitt and Shoaf reported an inhibitory effect only for targets presented at the beginning of the experiment. No inhibition was observed for the targets presented at the end of the testing session. Again, it was suggested that priming effects are contaminated by response biases developed by participants when they become aware of the presence of related pairs (see also Goldinger, 1999). In addition, it was argued that inhibitory priming effects are due to participants' surprise when they encounter the first related trial. We believe, however, that the present inhibition cannot be attributed to the participants' surprise. Indeed, our experimental setting also included related trials in the training session (4 related trials out of a total of 16) so that any surprise effect should be manifested during the training session, not during the experimental session. Moreover, such an account does not explain the modulation of inhibitory priming effects as a function of lexical factors such as the lexicality (Slowiaczek & Hamburger, 1992) or frequency (Radeau et al., 1995) of the primes. In accordance with this view, we have recently found that inhibitory priming effects also vary as a function of the neighborhood density of the target words (Dufour & Peereman, 2003). Hence, it seems that an explanation of inhibitory effects in terms of an automatic competition between lexical candidates is the more appropriate. Neither response biases nor surprise effects should modulate as a function of lexical factors.

The basic finding of the present study is that the competition effect that is predicted by competitive activation models can be consistently observed when primes and targets differ on the last phoneme—that is, when the prime words mismatch the lexical representations of the targets later. We believe that our results are consistent with the Cohort model (Marslen-Wilson et al., 1996). In this model, competition effects are mediated at the decision stage, where the presence of a close competitor slows down the process of discrimination among lexical candidates. Indeed, recognition is supposed to occur when the difference in activation between the target word and its most activated competitor reaches a fixed value. Assuming that the prime is still activated at target onset, an inhibitory effect can be predicted because of the reactivation of the prime during target processing. Moreover, the later a prime word diverges from the target word, the longer it will act as a strong competitor of the target word, and the more it will delay the moment at which the target word can be reliably identified.

Our results also appear to be compatible with models such as TRACE (McClelland & Elman, 1986) and Shortlist (Norris, 1994) that assume lateral inhibitions between lexical candidates. In TRACE, all the lexical nodes are potential candidates for recognition, continuously increasing or decreasing in activation as a function of their match with the incoming signal. Unlike the Cohort model, the lexical competitors directly affect the activation level of the target word. In addition, the degree to which a competitor tries to inhibit the target word is a function of its activation level. The more a competitor is activated, the more inhibition the target word will receive. Because competitors are activated in proportion with their matches with the incoming signal, stronger competition should arise for large prime–target overlap. Thus, in consistency with our findings, a competitor such as /bagaʀ/ should have more influence on the recognition of the target word /bagaʒ/ than on that of a word such as /bagɛt/. Indeed, in the latter case, the competitor /bagɛt/ overlaps the target word by a smaller number of phonemes, and it should therefore compete less with the target word. Nonetheless, our data also indicate that the number of mismatching phonemes is a key determinant of the emergence of inhibition priming effects. So, priming occurred for a prime–target overlap of three phonemes in the case of a one-phoneme mismatch but not in the case of a two-phoneme mismatch. Similarly, a two-phoneme overlap caused inhibition only when primes and targets differed by one phoneme, but not when they differed by two. In the absence of simulation work, it is presently unclear how the TRACE model could predict differential inhibition effects for prime–target words sharing the same number of phonemes but differing on mismatch length.

Unlike TRACE, competition in Shortlist takes place within a small list of word candidates. This model involves two distinct stages of processing. In the first stage, a short list of candidates that are roughly consistent with the incoming signal is derived. Only the candidates that match the input to some preset criterion are allowed to enter into a second stage of competition similar to that assumed by TRACE. Shortlist also predicts a stronger competition between lexical candidates that have a large phonological overlap. Thus, the competitor /bagaʀ/ should have a greater impact on recognition of the target word /bagaʒ/ than on that of the word /bagɛt/ because it overlaps more with the target word. An interesting feature of the Shortlist model is that the activation of words that mismatch the input decreases through bottom-up inhibition. In accordance with this feature, some evidence in the literature indicates that bottom-up inhibition plays a role during auditory word processing. In a cross-modal priming study, Marslen-Wilson, Gaskell, and Older (1991) found that the nonword *apricod* failed to prime *fruit*, whereas the nonword *aprico* produced a priming effect similar to that of the real word *apricot*. Thus, it appears that a deviation between the input (i.e., the /d/ in *apricod*) and the critical word (i.e., the /t/ in *apricot*) was sufficient to eliminate cross-modal priming. Such a result seems incompatible with the TRACE model, which does not incorporate a bottom-up inhibition mechanism. Indeed, because in TRACE the elimination of mismatching word candidates is only lexically mediated, the nonword *apricod* should also prime *fruit* due to the lack of corresponding lexical nodes to generate inhibition on the real word *apricot*. The assumption that mismatching candidates have their activation decreased via bottom-up inhibition is also supported by more recent studies using different experimental paradigms, such as the cross-modal fragment priming paradigm (Cutler & van Donselaar, 2001; Soto-Faraco et al., 2001) and the phoneme monitoring task (Frauenfelder, Scholten, & Content, 2001). These findings, together with our results, suggest that both bottom-up inhibition and lexical competition are involved in the word recognition process. Hence, a possible explanation for the lack of competition when the primes differed from the targets by the last two phonemes would be that competitors are rapidly inhibited—through bottom-up inhibition—when mismatching phonemes are detected. As a result, the earlier a mismatching phoneme between a target word and its competitor is detected, the faster the activation of the competitor is turned off, thus strongly reducing its inhibitory influence during target word processing. Further studies are nevertheless required to examine whether the absence of a competition effect in the case of two diverging phonemes is due to a bottom-up inhibition mechanism.

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NOTES

1. The term *shadowing* was used by the authors (see also Radeau et al., 1995) to refer to the experimental procedure in which the target had to be repeated by the participants. Although not all stimuli had to be pronounced (participants were not instructed to repeat the prime), we will continue to use the same term in order to adhere to common usage in phonological priming studies.

2. Note, however, that no effect was observed in the lexical decision task, a result that the authors attributed to the involvement of postlexical processes (see also Radeau, Morais, & Dewier, 1989).

3. The observation of stronger inhibitory priming effects with low-frequency primes does not necessarily exclude the explanation proposed by Slowiaczek and Hamburger (1992) that inhibition operates during target presentation. Indeed, according to the NAM model, frequency is not coded at the resting level of word units but acts in biasing decision processes. Because decisions would be made less quickly for low-frequency than for high-frequency primes, this model predicts that low-frequency primes should produce more inhibition, since they begin to return to a resting level later than high-frequency primes do (Luce et al., 2000; Luce et al., 1990). Moreover, Eberhard (1994) argued that both the Cohort and TRACE models predict a stronger competition effect from low-frequency primes.

4. Note that several stimulus words ended in a schwa (i.e., /ə/), whose pronunciation is optional in French and generally absent at the normal speaking rate. To keep a constant length of four phonemes across all stimuli, these words were recorded without realization of the optional vowel. The resulting pronunciation corresponds to a monosyllable.

5. The third phoneme of all the primes and targets in the three-phoneme overlap condition was /ʀ/, whereas such was not the case in the two-phoneme overlap condition, in which /ʀ/ occurred either in the primes or in the targets. Because of the /r/-coloring of the vowel in English, it could be argued that the vowels in the primes and targets are more similar in the three-phoneme than in the two-phoneme overlap condition. However, in contrast with the case of the English language, there is no similar /r/-coloring phenomenon in French. Hence, the lack of an inhibitory priming effect in the two-phoneme overlap condition is likely not caused by mismatching information in the vowels of the primes and targets.

6. Unavoidably, the number of mismatching phonemes is also directly related to the number of intervening and potentially interfering segments between the offset of overlapping segments in the primes and the onset of overlapping segments in the targets. It remains difficult, however, to discard this confounded factor because manipulating the number of mismatching phonemes necessarily causes variations in the number of interfering segments.

7. The participants were categorized as slow or fast according to their RTs on control trials.

APPENDIX A
Stimuli for Experiment 1A

	Primes				Primes		
Targets	Two-Phoneme Overlap	Three-Phoneme Overlap	Controls	Targets	Two-Phoneme Overlap	Three-Phoneme Overlap	Controls
blague	bled	blatte	trompe	graine	grange	graisse	film
bref	brute	brèche	sport	grappe	grêle	grade	snob
brique	braise	brise	moine	grave	gril	gramme	couette
bronze	brasse	bronche	diète	grève*	grotte	greffe	moelle
brosse	bride	broche	lynx	griffe	groin	grippe	talc
brume	brave	brune	parc	grille	grog	grive	test
classe	clown	claque	fraude	liasse	liège	liane	chouette
cloche	club	cloque	douane	miel*	mioche	miette	toise
crâne	crampe	crabe	toast	pièce	pioche	piège	cuisse
crème	crasse	crèche	viol	place	planque	plage	sphère
crête	cruche	crêpe	pionne	plaire	plume	plaine	fuite
crise	crawl	crime	bloc	plante	plaque	planche	nièce
cro°te	crosse	croupe	myope	prise	prune	prime	golf
flamme	flair	flaque	chienne	proche	presse	prof	foire
flèche	flic	flemme	spot	stade	stand	stage	frime
fleur	fl°te	fleuve	poil	stock	star	store	plinthe
flotte	flash	flore	scout	trace	trône	trappe	duel
fraise	fringues	fraîche	volt	tranche	traire	transe	poire
frère	frange	frêne	drogue	trêve	truffe	tresse	coiffe
frite	frappe	friche	score	tripe	troc	trique	loir
globe	glande	glotte	match	troupe	trame	trousse	plaid

*Items excluded from the analyses.

APPENDIX B
Stimuli for Experiment 1B

	Two-Phoneme Overlap			Three-Phoneme Overlap	
Targets	Related Primes	Control Primes	Targets	Related Primes	Control Primes
barbe	basque	toast	borne	borgne	leste
buste	bulbe	derme	bourse	bourde	self
calme	carte	zest	corde	corne	belge
carne	calque	surf	charge	charte	norme
casque	carpe	gourde	courbe	courte	bisque
charme	chaste	test	forme	forte	pulpe
garde	galbe	volt	fourche	fourbe	box
geste	germe	barque	larme	larve	merle
gorge	golfe	match	marche	marque	liste
masque	marne	culte	morgue	morse	vulve
pacte	palme	corse	morne	morve	film
peste	perle	disque	perte	perche	lourde
poste	porche	cirque	source	sourde	kyste
secte	cerne	darne	tarte	tarse	fisc
serpe	celte	caste	course	courge	talc
sorte	solde	berge	terme*	terne	garce
vaste	valve	nurse	torse	torche	piste
veste	verge	farce	verbe	verte	tact

*Items excluded from the analyses.

APPENDIX C
Stimuli for Experiment 2

	Primes	
Targets	Related	Control
bac	bave	taupe
bague	baffe	plot
base	batte	lotte
botte	bol	louche
bouche	bouc	dose
boule	boum	cake
bulle	buse	mite
cage	cache	figue
case*	caille	dinde
cave	cap	puce
chasse	chatte	fugue
choc	chope	fève
col	cotte	menthe
cure	cube	pelle
dalle	dard	cèpe
douche	douille	lobe
gare	gaffe	biche
goutte	gousse	jars
guerre	guêpe	loupe
juge	jupe	char
lac	lame	dette
laine	laisse	pince
langue	lange	tube
ligne	lime	gomme
lune	luge	gag
manche	mangue	râpe
mouche	moule	rhume
mur	mule	sauce
nappe	natte	bille
note	noce	bec
page	paille	caisse
quille	quiche	mâche
rage	rail	code
riche	ride	singe
rire	rime	châle
robe	roche	sel
rude*	ruche	digue
soupe	souche	niche
tige	tic	chauve
vague	vache	linge
ville	vigne	banque
vol	vote	ronce

*Items excluded from the analyses.

APPENDIX D
Stimuli for Experiments 3 and 4

	Primes		
Targets	Three-Phoneme Overlap	Four-Phoneme Overlap	Control
bagage	baguette	bagarre	flocon
baleine	balise	balèze	méduse
banale	bannir	banane	farine
banquette	banquise	bancaire	pruneau
baraque	baril	barrage	copine
baroque	barème	baronne	capuche
bataille	baptême	bâtard	support
bourrique	bourrage	bourriche	poireau
canal	caniche	canard	vernis
cannelle	canine	canette	perruche
cantique	cantal	cantine	gourdin
caresse	carafe	carême	volcan
carrosse	carence	carotte	goudron
cigare	cigogne	cigale	punaise
colère	colombe	collège	légume
colline	collage	colique	blouson
colonne	collyre	colosse	garage
comique	comète	comices	plumeau
complet	compote	complot	palace
conseil	consigne	concert	marteau
contrée	contour	contrat	narine
coquille	coquette	coquine	dicton
délire	déluge	délice	cachette
dentelle	dentier	dentaire	biberon
famille	fameuse	famine	crayon
galère	galante	galette	rapace
livrer*	livide	livret	piéton
malaise	malice	mallette	copier
manège	manier	manette	culotte
métal	métro	méthane	cornet
minute	mineur	minus	fardeau
montagne	monture	montage	congrès
parade	parier	parages	briquet
pareil	parure	paresse	buisson
patron	patate	patrie	lunette
pétale	pétanque	pétard	trousseau
police	polaire	polir	girafe
radio	radar	radieux	pollen
salive	salade	salir	lézard
semaine	semence	semelle	labeur
tonnerre	tonus	tonnelle	frelon
valise	valence	valide	pédale

*Item excluded from the analyses in Experiment 4.

(Manuscript received June 25, 2002;
revision accepted for publication August 6, 2003.)