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Associative and semantic priming effects occur at very short stimulus-onset asynchronies in lexical decision and naming

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Abstract

Prior research has found significant associative/semantic priming effects at very short stimulus-onset asynchronies (SOAs) in experimental tasks such as lexical decision, but not in naming tasks (however, see Lukatela and Turvey, 1994). In this paper, the time course of associative priming effects was analyzed at several very short SOAs (33, 50, and 67 ms), using the masked priming paradigm (Forster and Davis, 1984), both in lexical decision (Experiment 1) and naming (Experiment 2). The results show small—but significant—associative priming effects in both tasks. Additionally, using the masked priming procedure at the 67 ms SOA, Experiments 3 and 4 show facilitatory priming effects for both associatively and semantically (unassociative) related pairs in lexical decision and naming tasks. That is, automatic priming can be semantic. Taken together, our data appear to support interactive models of word recognition in which semantic activation may influence the early stages of word processing. ©1997 Elsevier Science B.V.

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1. Introduction

1.1. Associative and semantic priming effects occur at very short SOAs in lexical decision and naming

Word recognition is a rapid and efficient cognitive process in which contextual information facilitates the processing of subsequent words. One of the best known

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phenomena in this context is that of semantic/associative facilitation (Meyer and Schvaneveldt, 1971): a word such as *dog* (the target word) is recognized more quickly when it is preceded by a related word (e.g. the prime word *cat*) than when it is preceded by an unrelated word (*key*). Undoubtedly, knowledge of the effects of associative/semantic priming is important for understanding the structure and organization of the mental lexicon.

Unfortunately, the influence of strategic or expectancy-based processes in experiments using long stimulus-onset asynchronies (SOAs) between primes and targets makes it difficult to analyze the components of semantic/associative facilitation (for a comprehensive review, see Neely, 1991). As Neely pointed out, a useful strategy to minimize such factors to isolate automatic priming effects is using very short SOAs and forward masked primes. Obviously, using brief forward masked primes does not necessarily imply the absence of a subsequent processing of the prime. As Fischler and Goodman (1978) pointed out, ''there is a tendency to assume that the effects of a prime, by definition, must occur only before the onset of the event to be primed'' (p. 468). Additionally, since semantic encoding areas may be activated rapidly (as soon as 90 ms) once the visual input is presented (see Posner and Carr, 1992), it is likely that semantic information from semantically related word primes might facilitate the lexical access of the target word.

The most popular explanation of associative/semantic priming effects is in the context of spreading-activation theories (e.g. Collins and Loftus, 1975; Neely, 1977; but see Ratcliff and McKoon (1988, 1994) for an alternative account). In these theories, prime activation spreads automatically along the paths of associatively/semantically related nodes. Since related pathways in semantic memory have been partially activated, related targets can be processed more rapidly than unrelated targets. It has been suggested that activation can spread along the paths of associatively related words at the lexical level, because of the frequent co-occurrence of associated words (Lupker, 1984; Plaut, 1995; Shelton and Martin, 1992), although other authors claim that the locus of associative effects is the semantic level (e.g. de Groot and Nas, 1991). Similarly, parallel distributed models (e.g. Masson, 1995; Plaut, 1995; Rueckl, 1990; Seidenberg and McClelland, 1989) also assume the existence of facilitation in related pairs by means of the connections between an orthographic level and a semantic level. However, in this case, the spread of activation is not between concepts but between features.

Within this theoretical framework, the first aim of this study is to analyze whether or not there are automatic associative effects in lexical decision and naming at very short SOAs (Experiments 1–2). As is discussed in the next section, previous studies have consistently found associative effects in the lexical decision task at very short SOAs, but not in the naming task. If the pattern of effects is similar in both tasks, that would mean that associative priming is a real and interesting effect and not an experimental curiosity. The second aim of the study is to analyze whether or not automatic priming can be due to semantic relations rather than associative relations (as measured in free-production association norms), since a recent study (Shelton and Martin, 1992) concluded that automatic priming is not semantic. As in Experiments 1–2, we will use both lexical decision and naming tasks.

1.2. Associative and semantic priming effects at short SOAs

Associative priming effects seem to occur at very brief SOAs in the lexical decision task. Fischler and Goodman (1978) found an associative priming effect at a 40 ms SOA (Experiment 2), but not at a 90 ms SOA (Experiment 1, using a 40 ms prime presentation followed by a 50 ms mask). However, in Experiment 1, subjects were instructed not only to make a lexical decision but also to recall the prime. This additional task could have induced processes that interfered with the facilitation of primes. Actually, when subjects were not instructed to recall the prime, Beauvillian and Seguí (1983) found similar associative effects at the 40 and 70 ms SOAs. More recently, using the masked priming paradigm (Forster and Davis, 1984), in which briefly presented primes (60 ms) are preceded by a 500 ms mask and followed by the target, not only have associative effects been found within a language (de Groot and Nas, 1991; Sereno, 1991) but also between languages (although restricted to cognates, de Groot and Nas, 1991).

However, associative priming effects in the lexical decision task could have been due to task-specific effects (e.g. a post-lexical familiarity stage), in which associatively related primes bias to a word/nonword decision rather than influence the sensitivity to the target (see Hodgson, 1991; Sereno, 1991). In contrast, the naming task is not supposed to involve post-lexical familiarity effects, since the prime does not provide information about the pronunciation of the target word. Actually, the evidence of associative priming effects in the naming task at very short SOAs is inconclusive. Warren (1977) presented word primes for 75–225 ms, followed immediately by a mask covering the prime and a target word. Although he failed to find associative effects at the briefer SOAs (75 and 112.5 ms), there was a slight increase in facilitation from the 75 ms to the 150 ms SOA. More recently, using the masked priming paradigm, Sereno (1991) (Experiment 4) failed to find an associative priming effect at a 60 ms SOA (although there was a nonsignificant 7 ms trend). Because Sereno found a significant priming effect (41 ms)—using the same materials and SOA—with the lexical decision task, she interpreted her lexical decision results in terms of post-lexical familiarity processes. However, the statistical power in her naming experiment was rather small (less than 0.35). As a consequence, in the naming task, we may be dealing with the controversial issue of choosing the null hypothesis. In fact, a recent study by Lukatela and Turvey (1994) has shown small—but reliable—associative priming effects at a 50 ms SOA in the naming task.

In addition, there is the question of the existence of automatic semantic priming effects. In fact, the previous studies used associative word pairs that were, in many cases, categorically related. To our knowledge, only a few published studies have examined the effects of semantic (not associative) priming at very short SOAs. Using a variety of semantic dimensions, in which primes and targets were loosely associated, Hodgson (1991) found overall facilitatory semantic priming effects at the 83 and 150 ms SOA in a lexical decision task with unmasked primes, but he failed to find a significant priming effect in the naming task. Recently, at a 60 ms SOA with the masked priming technique in the lexical decision task, Williams (1994) found reliable cross-language priming effects not only for pairs that were translation equivalents (Experiment 2B) but also for highly similar pairs (Experiment 2A).

2. Experimental

2.1. Brief description of the experiments

The main aim of Experiments 1 and 2 is to shed some light on the time course of associative priming effects at very short SOAs (33, 50, and 67 ms) in lexical decision (Experiment 1) and naming (Experiment 2). In both experiments, primes were presented after a 500 ms forward mask and the SOA varied from 33 to 67 ms. SOA was manipulated between subjects [a similar procedure can be seen in Ferrand and Grainger (1993)] in order to prevent subjects from knowing the existence of related pairs as well as to avoid any problems with repetition of the same targets to the same subjects. We will not, however, analyze the controversial question of ''subliminal'' priming (e.g. see Carr and Dagenbach, 1990; Dietrich and Theios, 1992; Hirshman and Durante, 1992). Nonetheless, the percentage of correctly identified primes with the masked priming technique is considerably low (e.g. see Forster and Davis, 1984; Forster et al., 1987; Grainger et al., 1991; de Groot and Nas, 1991) and there is very little usable information that one can obtain from the prime (Forster and Davis, 1984; Forster et al., 1987).

Experiments 3 and 4 were designed to analyze the role of automatic semantic, unassociative priming at a very short SOA in lexical decision (Experiment 3) and naming (Experiment 4). According to Shelton and Martin (1992), there is no such thing as automatic semantic priming effects (see also Lupker, 1984). In their experiments, Shelton and Martin used the single-presentation lexical decision task, in which subjects are required to make lexical decisions for each presented item. However, although this paradigm is thought to reflect only automatic processes, recently Moss et al. (1995) have found that the pattern of results in this type of task can vary with minor changes in presentation timing. Obviously, more research using the single-presentation lexical decision task is needed before strong conclusions about this paradigm can be made.

2.2. Experiment 1

2.2.1. Method

2.2.1.1. Subjects

Sixty-six students from introductory psychology courses at the Universitat de València participated in the experiment either to earn an extra course credit or to fulfil a course requirement. All were native speakers of Spanish.

2.2.1.2. Materials

A set of 64 Spanish words with their primary associates were compiled from the Algarabel et al. (1986) Spanish associative norms. The probability of the associative responses ranged from 0.20 to 0.68 with a mean of 0.35 (see Appendix A). Target words were five or six letters long and prime words were from four to six letters long. A list of 64 unrelated prime words matched in word frequency and length to the related primes was also generated. In order to avoid the onset effect (Forster and Davis, 1991) in the naming task (Experiment 2), primes and targets always differed in the first phoneme (i.e. a pair such as bread–BUTTER could not have been selected). For each subject, the computer program selected at random 32 related word pairs and 32 unrelated word pairs. That is, each subject received a different random sample of pairs, thereby eliminating the need for item analyses.[1] For word–nonword trials, a set of 64 words and 64 orthographically legal nonwords of similar length to those of word trials was selected. Orthographically legal nonwords were produced by changing one letter in words other than those selected in the experimental set.

2.2.1.3. Design

SOA (33, 50, and 67 ms) was varied between subjects (22 subjects in each SOA condition) and prime–target relatedness was varied within subjects. Each subject was given a total of 128 experimental trials: 64 word trials (32 related and 32 unrelated pairs) and 64 nonword trials.

2.2.1.4. Procedure

Subjects were tested individually in a quiet room. Presentation of the stimuli and recording of latencies were controlled by an Apple Macintosh Plus microcomputer. The routines for controlling stimulus presentation and reaction time collection were obtained from Lane and Ashby (1987) and from Westall et al. (1986), respectively. In each trial, a forward mask (######) was presented for 500 ms on the center of the screen. Next, a lowercase prime word was presented in the center of the screen for 33, 50, or 67 ms. Primes were immediately replaced by an uppercase target. Subjects were instructed to press one of two buttons on the keyboard (‘‘;’’ for yes and ‘‘z’’ for no) to indicate whether the uppercase letter string was a Spanish word or not. This decision had to be done as rapidly and as accurately as possible. When the subject responded, the target disappeared from the screen. The inter-trial interval was 1500 ms. Subjects were not informed of the presence of lowercase words. Each subject received a total of 20 practice trials prior to the 128 experimental trials. The whole session lasted approximately 11 min.

[1] Since every subject received a randomized list of prime–target pairs, there is no need to conduct item analyses. Other recent experiments in this field have also used a similar procedure with randomized lists (e.g. Kroll and Stewart, 1994, Experiment 1). However, as two reviewers pointed out, by using this procedure, we cannot know if the priming effects can be attributed to certain items and not others.

2.2.2. Results and discussion

Incorrect responses and reaction times less than 300 ms or greater than 1200 ms (less than 3.4% of the data[2]) were omitted from the latency analysis. Mean reaction times and error data were then submitted to separate analyses of variance (ANOVAs), with SOA (33, 50, and 67 ms) as a between-subjects factor and associative relatedness (related, unrelated) as a within-subjects factor. The mean reaction time and error rate on the word targets in each experimental condition are shown in Table 1.

The ANOVA on latency data revealed a main effect of associative relatedness ($F(1,63) = 17.46$, $p < 0.001$) in which targets preceded by associatively related primes were responded to faster than those preceded by unrelated primes (678 vs. 690 ms). The other effects were not reliable. Planned comparisons showed that relatedness was significant at the 67 ms SOA ($F(1,21) = 4.71$, $p < 0.05$) and at the 50 ms SOA ($F(1,21) = 19.07$, $p < 0.001$) but not at the 33 ms SOA ($F(1,21) = 1.62$).

The analysis of the error rates showed a main effect of relatedness ($F(1,63) = 6.40$, $p < 0.02$) in which related targets were identified better than unrelated targets (1.4% vs. 2.7% of errors). No other effects were significant.

As expected, the present experiment has confirmed the existence of small—but significant—associative priming effects at very brief SOAs in the lexical decision task (Beauvillian and Seguí, 1983; de Groot and Nas, 1991; Fischler and Goodman, 1978; Sereno, 1991). The magnitude of the associative priming effect (7, 17, and 11 ms, at the 33, 50, and 67 ms SOAs, respectively) was slightly smaller than that obtained by Beauvillian and Seguí (1983) with unmasked primes (19 and 22 ms, at the 40 and 70 ms SOAs, respectively).

Table 1
Mean lexical decision times (in ms), percentage of errors (in parentheses), and percentage of excluded correct responses (in italics) on word targets in Experiment 1

	Stimulus-onset asynchrony (in ms)		
	33	50	67
Related targets:	677 (1.8) *3.8*	683 (0.9) *3.3*	675 (1.6) *3.3*
Unrelated targets:	684 (2.5) *3.1*	700 (3.2) *4.4*	686 (2.3) *2.6*
U − R:	7 (0.7)	17 (2.3)	11 (0.7)

Note: U − R refers to the difference between unrelated targets and related targets.

[2] In order to avoid the influence of outliers, we used a cut-off of 1200 ms for the lexical decision task (Experiments 1 and 3), and a cut-off of 900 ms for the naming task (Experiments 2 and 4). In the lexical decision task, we assumed that responses longer than 1200 ms reflected the low-familiarity with the stimulus word or a subject's distraction rather than lexical access. Further, both the accuracy analysis and other cut-off procedures on the latency data also yielded an analogous pattern of results (see Ratcliff, 1993).

2.3. Experiment 2

2.3.1. Method

2.3.1.1. Subjects

A total of sixty-six students from the same population of subjects as in Experiment 1 participated as subjects. None of the subjects had taken part in the previous experiment.

2.3.1.2. Design and materials

The design and stimuli were the same as in the previous experiment with the exception that nonword trials were not used.

2.3.1.3. Procedure

The procedure was identical to that in Experiment 1 except that subjects were instructed to read aloud the uppercase word as rapidly and as accurately as possible. Naming latencies were collected by a microphone connected to a voice-activated key (Algarabel et al., 1989) interfaced with a digital I/O port of the microcomputer. Subjects' naming errors (both mispronunciations and hesitations) were recorded by hand. Each subject received a total of 10 practice trials prior to the 64 experimental trials. The whole session lasted approximately 7 min.

2.3.2. Results and discussion

Incorrect responses and reaction times less than 300 ms or greater than 900 ms (less than 1.5% of the data, typically caused by extraneous sounds or failures of the voice key) were excluded from the latency analysis. As in Experiment 1, mean reaction times and error data were submitted to separate ANOVAs, with SOA (33, 50, and 67 ms) as a between-subjects factor and associative relatedness as a within-subjects factor. The mean reaction time and error rate on the targets in each experimental condition are presented in Table 2.

The statistical analysis on the latency data showed that relatedness was significant at the 67 ms SOA (8 ms, $F(1,21)=7.43$, $p<0.02$), but not at the 50

Table 2
Mean lexical decision times (in ms), percentage of errors (in parentheses), and percentage of excluded correct responses (in italics) on word targets in Experiment 2

	Stimulus-onset asynchrony (in ms)		
	33	50	67
Related targets:	543 (1.5) *1.7*	551 (0.7) *1.0*	544 (0.4) *1.6*
Unrelated targets:	543 (1.2) *1.4*	555 (0.7) *1.3*	552 (0.7) *1.4*
U − R:	0 (−0.3)	4 (0.0)	8 (0.3)

Note: U − R refers to the difference between unrelated targets and related targets.

ms SOA (4 ms, $F(1,21)=3.21$, $p<0.10$) or the 33 ms SOA (0 ms, $F<1$). The analysis of the error rates did not show any reliable effects.

This experiment has shown a pattern of results similar to that of Experiment 1. The result is straightforward: associatively related primes do facilitate target pronunciation at very short SOAs. Moreover, the associative priming effect found at the 50 and 67 ms SOA (4 and 8 ms, respectively) is similar to that obtained by Sereno (1991) at the 60 ms SOA (7 ms).

Possibly, when the primes are masked and the SOA is extremely brief (less than 30–35 ms), the activation caused by the related prime is not sufficient to facilitate semantic target processing compared with unrelated primes. Even at SOAs of about 60–70 ms, the magnitude of the associative priming effect seems to be less than 30 ms in the lexical decision task (see Beauvillian and Seguí, 1983; de Groot and Nas, 1991; however, Sereno (1991) found a 41 ms priming effect) and it is even smaller in the naming task (see Lukatela and Turvey, 1994; Sereno, 1991; Warren, 1977), possibly because subjects pronounce the target via a non-lexical pathway on a certain proportion of the trials.

2.4. Experiment 3

In Experiments 1 and 2, we examined the role of associative priming at very short SOAs. However, most of the associatively related pairs in Experiments 1–2 were also categorically related (52 out of 64).[3] As a result, it is possible that the associative priming effect could have been caused by a number of semantically related pairs rather than by associative relatedness per se.

Experiments 3 and 4 were carried out in order to examine if automatic priming can be semantic. Specifically, we analyzed the effects of associatively and semantically (unassociated) related pairs in the lexical decision task (Experiment 3) and in the naming task (Experiment 4) at the 67 ms SOA. This SOA was selected on the basis of Experiments 1–2, since we found reliable associative priming effects at that SOA in both experimental tasks.

Because it has been suggested that semantic priming effects could be limited to a small pool of very similar words (e.g. Lupker, 1984; Seidenberg et al., 1984; Tanenhaus and Lucas, 1987; Williams, 1994), we chose highly similar prime–target pairs (i.e. synonyms) that were not associated. Actually, prior research has shown some facilitatory trend for synonyms at very short SOAs (see Hodgson, 1991; Warren, 1977; Williams, 1994). In addition, Dagenbach et al. (1990) found significant priming effects for experimentally paired synonyms that were originally unassociated, but not for two well-known words previously unrelated.

[3] Twelve of the pairs were not categorically related (e.g. shepherd–SHEEP; pastor–OVEJA). Although some studies have considered this kind of pairs as if they do not have any semantic relations, it seems that the meaning of the prime (e.g. shepherd) is probably semantically linked to the target (sheep) (see Moss et al., 1995).

2.4.1. Method

2.4.1.1. Subjects

A total of twenty-six students from the same population of subjects as in Experiments 1–2 participated as subjects. None of them had taken part in the previous experiments.

2.4.1.2. Materials

A set of 32 words with their corresponding synonyms was compiled from the University of Valencia's computerized word pool (Algarabel et al., 1988). None of the 32 target words were listed as associated with their primes in the Spanish associative norms (Algarabel et al., 1986). As a further check, we asked five subjects to generate three words that first came to mind when reading the 32 selected prime words, and none of them generated any of the synonyms compiled. Additionally, a set of 32 associatively related prime–target pairs was selected from the stimuli of Experiment 1 (see Appendix B). A list of 64 unrelated prime words matched in word frequency and length was also generated. In order to avoid the onset effect in the naming task (Experiment 4), 60 prime–target pairs always differed in the first phoneme and 4 prime–target pairs shared the first phoneme (both related and unrelated pairs: *punta–PINCHO* and *patio–PINCHO*). For each subject, the computer program selected at random 16 semantically related word pairs and 16 unrelated word pairs from the set of 32 semantically related pairs. Likewise, the computer selected at random 16 associatively related word pairs and 16 unrelated word pairs from the set of 32 associatively related pairs.

2.4.1.3. Design

Both type (associative or semantic) and prime–target relatedness were varied within subjects. In the lexical decision tasks, each subject was given a total of 128 experimental trials: 64 word trials (16 semantically related and 16 unrelated pairs from the semantic set; 16 associatively related and 16 unrelated pairs from the associative set) and 64 nonword trials.

2.4.1.4. Procedure

The procedure was similar to Experiment 1 except that prime duration was set to 67 ms.

2.4.2. Results and discussion

As in Experiment 1, incorrect responses and reaction times less than 300 ms or greater than 1200 ms (less than 4.4% of the data) were excluded from the latency analysis. Mean reaction times and error data were then submitted to separate ANOVAs, with type of pair (associative vs. semantic) and associative relatedness (related vs. unrelated) as within-subjects factors. The mean reaction time and error rate on the targets in each experimental condition are presented in Table 3.

The ANOVA on the latency data revealed that the effect of type of relation was significant ($F(1,25) = 89.32$, $p < 0.001$): latencies for the associative pairs and

Table 3
Mean lexical decision times (in ms), percentage of errors (in parentheses), and percentage of excluded correct responses (in italics) on word targets in Experiment 3

	Prime–target relationship	
	Associated	Similar
Related targets:	651 (0.5) *2.8*	710 (3.2) *6.0*
Unrelated targets:	665 (2.4) *3.6*	727 (4.7) *5.0*
U − R	14 (1.9)	17 (1.5)

Note: U − R refers to the difference between unrelated targets and related targets.

their controls were faster than those for the semantic pairs and their controls (658 vs. 718 ms), possibly because of a higher usage frequency of the targets in the associative condition. The effect of relatedness was also significant ($F(1,25) = 7.99$, $p < 0.01$): related targets were responded to faster than unrelated targets. Specifically, there were effects of 14 and 17 ms for associatively and semantically related pairs compared with their respective controls. The interaction between type and relatedness was not significant ($F < 1$).

The analysis of the error rates showed an effect of type of relation ($F(1,25) = 17.97$, $p < 0.001$), the accuracy being worse for the semantic pairs and their controls than for the associative pairs and their controls (6.5% vs. 3.2%). Again, the effect of relatedness was statistically reliable ($F(1,25) = 5.29$, $p < 0.04$), which reflected that the accuracy was worse for the unrelated targets than for the related targets (4.7% vs. 3.2%). The interaction between type and relatedness was not reliable ($F < 1$).

It seems that not only do associatively related primes facilitate target processing at very short SOAs but semantically (non-associated) related primes do as well. The size of the facilitatory priming effects was similar for associatively and semantically related pairs (14 and 17 ms, respectively). Furthermore, these effects appeared in both the response time and the accuracy data.

2.5. Experiment 4

2.5.1. Method

2.5.1.1. Subjects

A total of twenty-six students from the same population of subjects as in Experiments 1–3 participated as subjects. None of them had taken part in the previous experiments.

2.5.1.2. Design and materials

The design and stimuli were the same as in Experiment 3 with the exception that nonword trials were not used.

2.5.1.3. Procedure

The procedure was identical to that in Experiment 2 except that prime duration was set to 67 ms.

2.5.2. Results and discussion

Incorrect responses and reaction times less than 300 ms or greater than 900 ms (less than 1.5% of the data) were excluded from the latency analysis. Mean reaction times and error data were then submitted to separate ANOVAs, with type (associative vs. semantic) and associative relatedness as within-subjects factors. The mean reaction time and error rate on the targets in each experimental condition are presented in Table 4.

The ANOVA on the latency data revealed that the effect of type was significant ($F(1,25) = 26.57$, $p < 0.001$): response latencies for the associative pairs and their controls were faster than those for the semantic pairs and their controls (562 vs. 586 ms), possibly because of the lower usage frequency of the targets in the semantic condition. The effect of relatedness was also significant ($F(1,25) = 5.28$, $p < 0.04$), reflecting that related targets were responded to faster than unrelated targets (8 and 10 ms facilitation for associatively and semantically related pairs, respectively). The interaction between type and relatedness was not significant ($F < 1$).

The analysis of the error rates showed an effect of type ($F(1,25) = 5.23$, $p < 0.04$), in which the semantic pairs were responded to less accurately than the associative pairs (0.1% vs. 0.9%). The other effects were not reliable.

As in Experiment 3, we found similar effects for associatively and semantically related pairs at a very short SOA. Thus, these effects appear to be consistent across lexical decision and naming tasks. In contrast to Shelton and Martin's (Shelton and Martin, 1992) claim, automatic priming effects can be semantic.

Another possibility is that the semantic priming effects could have been due to associative relations between the target and the prime (i.e. backward priming) that apparently can affect both lexical decision and naming tasks under some circumstances (see Peterson and Simpson, 1989). However, backward priming effects are possibly minimized when subjects cannot identify the prime word (see Sereno, 1991) and there is no empirical evidence for backward priming effects in the masked priming technique.

Table 4
Mean naming times (in ms), percentage of errors (in parentheses), and percentage of excluded correct responses (in italics) on word targets in Experiment 4

	Prime–target relationship	
	Associated	Similar
Related targets:	558 (0.0) *1.0*	581 (1.4) *1.9*
Unrelated targets:	566 (0.3) *1.0*	591 (0.5) *1.7*
U − R	8 (0.3)	10 (−0.9)

Note: U − R refers to the difference between unrelated targets and related targets.

3. General discussion

The results indicate that—even at very brief SOAs—associative and semantic priming effects may influence not only the lexical decision on the subsequent target (Beauvillian and Seguí, 1983; Fischler and Goodman, 1978; Hodgson, 1991; Sereno, 1991) but also its pronunciation. In fact, other investigations have also shown semantic/associative priming effects with other paradigms at very short SOAs (e.g. four-field technique, Evett and Humphreys, 1981; fast priming technique, Sereno and Rayner, 1992) and there is an increasing amount of evidence in favor of semantic facilitation without conscious identification (e.g. Dietrich and Theios, 1992; Hirshman and Durante, 1992). Even with the single-presentation lexical decision task—which is supposed to reflect automatic priming processes—there is recent evidence for priming effects for semantically (un-associative) related pairs in latency data (Moss et al., 1995) and event-related brain potentials (Kotz and Holcomb, 1996).

Furthermore, both associative and semantic relations were equally effective in supporting priming in lexical decision and naming tasks. That is, a strong prime–target association according to free-association production probabilities is not essential for automatic priming to occur. In fact, a number of previous studies have reached the same conclusion (e.g. Fischler, 1977; Hines et al., 1986; Hodgson, 1991; McKoon and Ratcliff, 1992; Warren, 1977; Williams, 1994). In addition, there is some agreement that automatic priming effects can occur for words with a substantial semantic overlap, perhaps via spreading activation from the prime to a small subset of highly similar words (see Lupker, 1984; Seidenberg et al., 1984; Tanenhaus and Lucas, 1987; Warren, 1977; Williams, 1994; however, see McKoon and Ratcliff, 1992). Actually, in a recent study (Perea et al., 1996), we failed to find a significant priming effect using unassociated semantic pairs in the lexical decision task at the 67 ms SOA, in which the pairs were members of the same semantic category (e.g. arm–NOSE), whereas we found reliable priming effects for associatively related words (both semantically related, doctor–NURSE, and non-categorically related, cradle–BABY).[4] However, semantically related pairs in that study were of much lower semantic similarity than those used in Experiment 3 (see Williams (1994) for a similar argument concerning Shelton and Martin's stimuli).

Recently, Plaut (1995) proposed a connectionist model that can differentiate between associative effects and semantic effects: associative effects occur at the lexical level and semantic effects occur at the semantic level (see Lupker (1984); Shelton and Martin (1992) for a similar proposal). Plaut's model predicts stronger effects for associative priming than for semantic priming, although semantic priming effects may appear at very short SOAs. In addition, semantic priming

[4] In that study we used a sample of the words used by Chiarello et al. (1990), in which they found reliable effects for nonsemantic associates at a 575 ms SOA with a low-proportion of related pairs in both lexical decision and naming.

effects will be stronger for pairs with a high similarity (i.e. synonyms) and, apparently, the results in the model can be generalized to both lexical decision and naming. However, the magnitude of the semantic priming effect in our experiments was similar to that of the associative priming effect. While these findings are inconsistent with the current version of Plaut's model, it may be possible to reconcile the two by imposing a different training regimen on the network.

Other explanations in terms other than of spreading activation or connectionist models are also possible, but with a number of problems. On the one hand, the compound cue model (Ratcliff and McKoon, 1988) assumes that subjects can use a compound cue consisting of both the prime and target in the access to lexical memory even at short SOAs. Specifically, familiar compound cues (e.g. pairs semantically related) can be responded to faster than unfamiliar compound cues (unrelated pairs). This model can explain the facilitatory priming effects found in the lexical decision task, providing that masked primes enter the compound cue. However, this assumption is admittedly ad hoc (see Ratcliff and McKoon, 1988, p. 392) and the question is how subjects can use the masked prime to create a context when they ordinarily claim not to see the primes (see Neely, 1991). In addition, this model does not account for the naming task, and we wonder how the related prime can facilitate the pronunciation of the target in an appealing way (see Masson (1995) for a recent proposal). In any case, McKoon and Ratcliff (1992); Ratcliff and McKoon (1994) have recently suggested a comprehensive model of naming in future research, possibly related to a new version of the Seidenberg and McClelland (1989) model in which the semantic layer is implemented explicitly. Only time will tell whether this synthesis will succeed. On the other hand, context-checking models (e.g. Norris, 1986) assume that the recognition criterion for related word targets are lower than those for unrelated word targets. This mechanism is similar both in lexical decision and naming tasks so that priming effects should appear in both tasks (although in the naming task such effects could be smaller because of the existence of the non-lexical route). However, as with the compound cue theory, it is not clear how masked primes can be used to create a context for the targets at very short SOAs. Nevertheless, as a reviewer pointed out, we must note that these theories were not formulated with unaware primes in mind, and somehow the lexical processor itself must have information about the prime for facilitation to occur.

To summarize, it appears that associatively/semantically related masked primes affect a common stage—probably automatic—in lexical decision and naming tasks. As Ratcliff and McKoon (1988) pointed out, ''lexical decision and naming processes may be more similar than previously believed'' (p. 393). Moreover, the present research has shown the utility of the combined use of the masked priming paradigm at short SOAs with different experimental tasks to study automatic priming processes in semantic memory. By using these procedures, future research on automatic semantic/associative priming could focus on issues such as, for example, the time course of the different prime–target pair types (see Warren, 1977) or the relationships between morphological and semantic effects (see Grainger et al., 1991; Napps, 1989).

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Appendix A

Associated word pairs from Experiments 1 and 2

Prime	Target	Prime	Target
sitio	(site)	lugar	(place)
pastor	(shepherd)	oveja	(sheep)
temor	(dread)	miedo	(fear)
marco	(frame)	cuadro	(picture)
auto	(auto)	coche	(car)
suma	(sum)	resta	(subtract)
prosa	(prose)	verso	(verse)
nieto	(grandson)	abuelo	(grandfather)
banco	(bank)	dinero	(money)
texto	(text)	libro	(book)
bosque	(forest)	árbol	(tree)
frío	(cold)	calor	(heat)
azar	(chance)	suerte	(luck)
muro	(wall)	pared	(wall)
mesa	(table)	silla	(chair)
doctor	(doctor)	médico	(physician)
mujer	(woman)	hombre	(man)
llave	(key)	puerta	(door)
latín	(Latin)	griego	(Greek)
cobre	(copper)	metal	(metal)
puerto	(port)	barco	(boat)
julio	(July)	agosto	(August)
negro	(black)	blanco	(white)
marzo	(March)	abril	(April)
joven	(young)	viejo	(old)
tabla	(board)	madera	(wood)
gato	(cat)	perro	(dog)
ritmo	(rhythm)	música	(music)
núcleo	(nucleus)	centro	(center)
playa	(beach)	arena	(sand)
humo	(fume)	fuego	(fire)

error	(error)	fallo	(mistake)
punta	(tip)	lápiz	(pencil)
gusto	(taste)	sabor	(flavor)
dama	(lady)	señora	(madam)
conde	(count)	duque	(duke)
cara	(face)	rostro	(visage)
hoja	(sheet)	papel	(paper)
modo	(mode)	forma	(way)
diente	(tooth)	muela	(molar)
pena	(grief)	dolor	(pain)
norma	(norm)	regla	(rule)
plazo	(term)	tiempo	(time)
hora	(hour)	reloj	(clock)
venta	(sale)	compra	(purchase)
mancha	(stain)	sucio	(dirty)
país	(country)	nación	(nation)
jefe	(chief)	mando	(command)
pueblo	(town)	ciudad	(city)
trozo	(piece)	pedazo	(bit)
campo	(field)	verde	(green)
tarde	(evening)	noche	(night)
genio	(genius)	sabio	(savant)
suelo	(floor)	techo	(ceiling)
villa	(village)	pueblo	(town)
grupo	(group)	gente	(people)
moro	(Moor)	árabe	(Arab)
casa	(house)	hogar	(home)
arroz	(rice)	comida	(food)
baile	(ball)	fiesta	(festivity)
capa	(cloak)	espada	(sword)
duro	(hard)	blando	(soft)
causa	(cause)	efecto	(effect)
drama	(drama)	teatro	(theater)

Appendix B

Associated and similar pairs from Experiments 3 and 4

Associated				Similar			
Prime		Target		Prime		Target	
sitio	(place)	lugar	(place)	casa	(house)	morada	(dwell)
pastor	(shepherd)	oveja	(sheep)	hijo	(son)	vástago	(offspring)
temor	(dread)	miedo	(fear)	autor	(author)	creador	(creator)
marco	(frame)	cuadro	(picture)	país	(country)	comarca	(region)
auto	(auto)	coche	(car)	madre	(mother)	señora	(madam)
suma	(sum)	resta	(subtract)	fuerza	(strength)	energía	(energy)
prosa	(prose)	verso	(verse)	campo	(field)	terreno	(terrain)
nieto	(grandson)	abuelo	(grandfather)	cambio	(change)	permuta	(barter)

banco	(bank)	dinero	(money)	falta	(offense)	pecado	(sin)
texto	(text)	libro	(book)	dolor	(pain)	molestia	(discomfort)
bosque	(forest)	árbol	(tree)	letra	(letter)	signo	(sign)
azar	(chance)	suerte	(luck)	jardín	(garden)	vergel	(orchard)
muro	(wall)	pared	(wall)	raza	(race)	casta	(caste)
mesa	(table)	silla	(chair)	barco	(boat)	buque	(ship)
doctor	(doctor)	médico	(physician)	obra	(work)	trabajo	(labor)
mujer	(woman)	hombre	(man)	hoja	(leaf)	pétalo	(petal)
llave	(key)	puerta	(door)	lente	(lens)	cristal	(glass)
latín	(Latin)	griego	(Greek)	culpa	(guilt)	delito	(crime)
julio	(July)	agosto	(August)	hambre	(hunger)	apetito	(appetite)
negro	(black)	blanco	(white)	rayo	(beam)	chispa	(spark)
marzo	(March)	abril	(April)	broma	(joke)	burla	(mockery)
joven	(young)	viejo	(old)	punta	(tip)	pincho	(prick)
tabla	(board)	madera	(wood)	lluvia	(rain)	aguacero	(shower)
gato	(cat)	perro	(dog)	calor	(heat)	fuego	(fire)
ritmo	(rhythm)	música	(music)	cobre	(copper)	alambre	(wire)
núcleo	(nucleus)	centro	(center)	cuello	(neck)	pescuezo	(neck)
playa	(beach)	arena	(sand)	peso	(weight)	gravedad	(gravity)
error	(error)	fallo	(mistake)	humo	(fume)	vapor	(steam)
conde	(count)	duque	(duke)	tienda	(shop)	comercio	(store)
cara	(visage)	rostro	(face)	ramo	(bunch)	manojo	(handful)
diente	(tooth)	muela	(molar)	favor	(favor)	servicio	(service)
hora	(hour)	reloj	(clock)	virtud	(virtue)	santidad	(sanctity)

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