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The locus of semantic interference in picture naming

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Masked priming was used to study the locus of the semantic interference effect. This effect was studied by varying the nature of the task (naming and gender decision) and the type of prime-target relation (semantic and phonological). The time of presentation of the prime was also varied. Results indicated that semantic interference appears in naming (Experiment 1) and gender decision (Experiment 2) when the time of presentation of the prime was 100 ms. This replicates results by others and extends them to gender decision. In contrast, phonological facilitation was not present in gender decision (Experiment 3). This pattern suggests that semantic interference is the result of processes occurring at the lemma level and that gender decision is not influenced by phonological activation.

Theories of language production distinguish between several levels of representation that have to be accessed in order to produce an utterance. Specifically, when an object or a picture of an object is named, several processes have occurred. First, the picture contacts its semantic representation; that is, the picture is recognised and understood. Second, the lexical representation of the picture is accessed. Depending on the theory, lexical access occurs in one or two steps. In two-step models of lexical access, lexicalization starts by accessing a lemma level of representation with the semantic and syntactic specifications of the words (e.g., Dell & O'Seaghdha, 1992; Levelt, Roelofs, & Meyer, 1999). This first step is followed by access to the phonological (lexeme) representation of the word. Access to the lemma level is eliminated in one step models of lexical access (Caramazza, 1997; Humphreys, Lloyd-Jones, & Fias, 1995; Starreveld & La

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Heij 1995, 1996a, 1996b; Stemberger, 1985). Finally, an articulatory level is accessed where all the motor programs to pronounce the word are activated.

A procedure that is widely used to study word production and to explore the nature of the processes involved has been the picture-word interference paradigm. In this task, participants perform naming responses to picture targets depicting simple objects. At the same time, they are presented with distractor words that are visually embedded in the picture. Participants are instructed to name the picture as fast as possible and to ignore the distractor word. Despite these instructions, participants seem to automatically process the distractor words and as a consequence, words that are semantically related to the pictures slow down naming responses compared to unrelated words (Rosinski, Golinkoff, & Kukish, 1975). In contrast, when the distractor words are orthographically/phonologically related, they speed up naming times compared to unrelated words (Rayner & Posnansky, 1978).

Several theoretical explanations have been offered for the interference effects found when the relationship between the distractor and the target is manipulated in picture naming (Levelt et al., 1999; Starreveld & La Heij, 1995, 1996a). These explanations differ in where they locate the effect within the representational levels. Thus, the effect is explained as the result of competing semantic activations (Glaser & Düngelhoff, 1984; Lupker & Katz, 1981; Smith & Magee, 1980), and as the result of lemma (Roelofs, 1992, 2001; Levelt et al., 1999) or lexeme selection (Humphreys et al., 1995; Starreveld & La Heij, 1996a).

For example, Lupker and Katz (1981) and Rayner and Springer (1986) proposed that interference from semantically related distractors is located at a semantic level. Distractor words access their semantic information, and when words and pictures are semantically related, precise semantic classification (evaluation) of the pictures becomes more difficult. Although the semantic explanation can account for many of the semantic interference and phonological facilitation effects (see Glaser & Glaser, 1989; and Rayner & Springer, 1986), it has run into difficulties because a number of experiments have shown that semantic interference is reduced and may even disappear whenever the task used does not require a naming response (Humphreys et al., 1995; Schriefers, Meyer, & Levelt, 1990).

Alternative accounts have located the effect at a lexical level of representation. Within this view it is possible to distinguish between the phonological retrieval account (Glaser & Glaser, 1989; La Heij, 1988; Starreveld & La Heij, 1995, 1996a) and the lemma selection hypothesis (Dell, 1986; Dell, Schwartz, Martin, Saffran, & Gagnon, 1996; Levelt, 1989; Levelt et al., 1999; Roelofs, 1992; Schriefers et al., 1990). According to the phonological retrieval view, when the distractor word is presented, this word is processed first at a phonological level. Naming of the picture target, however, first requires semantic processing. Hence, naming the picture implies that its semantic representation has been activated. This activation would spread to semantically related representations and these, in turn, would send activation to their name representations at the phonological level. As a result of these activation processes, a word that is semantically related to the picture would receive extra-activation at the phonological level. This extra-activation comes back from the picture-target to the word-distractor semantic representations and induces competition at the phonological level.

For example, according to the phonological retrieval view, a briefly presented distractor word such as “dog”[2] will be first processed at a phonological level and therefore its name representation would be activated. If a picture representing the concept CAT is then presented as target and participants have to name it, this picture would activate first its semantic representation. Activation spreading from CAT would reach a semantically related concept such as “dog”, first at the semantic level (DOG) and then at the phonological one (dog). As a consequence the phonological representation for “dog” would be extra-activated and would compete with the name to be produced “cat”. This extra-activation would not be present with unrelated primes, since backward activation from the target would not reach them.

The alternative lexical hypothesis offers a very similar explanation of semantic interference, but locates it in the process of lemma selection. Semantic interference is the result of a trade-off between activation of the distractor’s lemma node by the picture and the target’s lemma node by the distractor word. In the model proposed by Roelofs (1992)**,** the lemmas are connected to a semantic level and activation flows up and down from the conceptual to the lemma level of representation. In the picture-word interference paradigm, when a semantically related distractor word is presented, it will activate its lemma node and also the target’s lemma node via the semantic level. Put another way, the word’s lemma node will activate its conceptual representation which will spread to related nodes that in turn will activate their corresponding lemmas. Similarly, the picture target will activate its concept node which, in turn, will activate related concept nodes and their corresponding lemmas (therefore the distractor

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[2] Following the notation used by Roelofs (1992) words in capital letters denote conceptual representation, words in italics and in lowercase represent lexical nodes, and words in quotations represent either the picture or the prime words.

lemma node will be activated by the target). Because the path from the picture to the distractor's lemma node (activation of the target concept node CAT ⇒ activation spreads to related concept nodes DOG ⇒ the concept node DOG activates the lemma node dog) is shorter than the path from the distractor to target's lemma node (activation of the distractor lemma node dog ⇒ activation of the conceptual node DOG ⇒ activation spreads to related concept nodes CAT ⇒ the concept node CAT activates the lemma node cat), the target will activate the distractor's lemma node more quickly than the distractor word will activate the target's lemma node and, therefore, semantic interference will occur. (Note that in the unrelated condition the distractor's lemma node will not receive activation from the target and therefore the distractor lemma will be less activated than the target lemma, and so interference will not occur).

The experiments that we present in this paper make use of masked priming procedures to study the locus of the semantic interference effect. Masked priming procedures have proven useful in investigating picture naming and lexical processing (Carr, McCauley, Sperber, & Parmelee, 1982; Ferrand & Grainger, 1992; Ferrand, Grainger, & Segui, 1994; Ferrand, Segui, & Grainger, 1995; Forster & Davis, 1984, 1991; Forster & Veres, 1998; Grainger & Ferrand, 1994; Hines, Czerwinski, Sawyer, & Dwyer, 1986; Jacobs, Grainger, & Ferrand, 1995; Perea & Gotor, 1997; Sereno, 1991). In this paradigm, a stimulus (the prime) is presented visually for relatively short durations (29-100 ms), and is both forward and backward masked. This procedure has the advantage that it is free of attentional influences because the primes are processed automatically (the primes are presented for a short period) and because visual processing of prime and targets do not overlap (Ferrand & Grainger, 1992; Jacobs et al., 1995). However, the predictions of the different theoretical accounts can be tested since the conditions are similar to those in the picture-word interference paradigm.

In our experiments we used masked priming paradigms in two tasks: naming and gender decision. Naming has been widely used to investigate lexical access during language production (Alario et al., 2000; Bajo, 1988; Forster, 1998; Lukatela & Turvey, 1994; Perea & Gotor, 1997). To name an object the complete course of lexical processing is required, semantic, syntactic and phonological information must be retrieved. Gender decision has been used to study the processes involved at the lemma level of representation (Jescheniak & Levelt, 1994, Experiments 5a, b) and according to Jescheniak and Levelt it is independent of phonological processing. Therefore, its use permits the isolation of lemma-related variables.

The purpose of the first experiment reported here was to replicate the semantic interference effect using masked priming in picture naming. In addition, Experiments 2 and 3 explored if the locus of the semantic interference effect was linked to the processes involved in lemma selection.

EXPERIMENT 1

The purpose of Experiment 1 was to replicate the interference effects normally found in the word-picture interference paradigms by using the masked priming procedure with different times of exposure to the primes. Thus, the prime was semantically related to the target or unrelated. The primes were presented for 50, 75 or 100 ms. Alario et al. (2000) found that interference in priming procedures is dependent on the time of presentation of the prime (interference appeared at a 100 ms exposure to the prime). Therefore, we expected to find interference at 100 ms exposures, but we were also interested in finding the minimum time for the effect to appear so that automatic processing was involved.

METHOD

Participants. A total of thirty students participated in the experiment. All were students of Psychology at the University of Granada and they presented normal or corrected-to-normal vision. For their participation they received course credits.

Design. The experimental design conformed a 3 x 2 within-participants model. The type of relation between the prime and target (semantic vs. unrelated) and the time of presentation of the primes (50, 75, 100, ms) were manipulated within-participants.

Materials. Thirty pictures were selected from the competitor norms of Puerta-Melguizo, Bajo, and Gómez-Ariza, (1998) to be part of the experimental materials. These pictures were employed as targets. Ten more pictures were selected for the practice list. The norms were obtained by selecting 580 concept pairs that could be drawn as some of the objects depicted in the Snodgrass and Vanderwart (1980) nozms and as some of the experimental materials used by Bajo and Cañas (1989). The selected objects belonged to 9 different categories (animals, kitchen utensils, parts of the body, fruits, tools, toys, pieces of furniture, musical instruments, and articles of clothing). Within any one category, all possible combinations of pairs of items were formed. These pairs were presented to a group of 270 students who judged them for their functional and visual similarity on a scale of 1 to 7 (1 meant lack of similarity and 7 very high similarity).

For each picture selected as a target in the present experiment two types of word primes were selected: (a) a semantically related word from the norms (e.g., dog-cat) and (b) an unrelated word (e.g., knife-cat). Related primes were selected so that they would yield the maximum possible value of visual and functional similarity. The mean visual similarity for the thirty related pairs in the experiment was 3.18 (SD = .89) and the mean functional similarity was 5.11 (SD = .75). Unrelated primes were also selected from objects in the competitor norms but for each target the selected prime belonged to a different category. Unrelated pairs were formed by interchanging primes and targets within the related set. Each participant was presented with 30 prime-target pairs, of which 15 of the picture targets were preceded by semantically related word primes and 15 were preceded by unrelated primes. To avoid repetition of the picture targets (paired with semantically related words and paired with unrelated words), we counterbalanced the prime-target pairs. Participants were divided into two groups so that picture targets assigned to the related condition in the first group were assigned to the unrelated condition in the second group. In addition, the time of presentation of the prime (50, 75 and 100 ms) was blocked and the order of the blocks varied across participants. Thus, each group received a particular combination of prime-target pairs, so that each time of presentation appeared an equal number of times in each position. Each participant was presented with a total of 30 prime-target pairs, five in each Relatedness x Time condition. The order of the pairs within the blocks was randomised for each participant. Appendix A shows the experimental material used for this experiment.

Procedure. Students participated in individual sessions. Before beginning the naming task, participants were presented with a set of 40 cards. Each card contained one of the pictures in the experimental list and the name designating it. Participants were told to examine the pictures and study their names because they would have to name the pictures later on. After this study phase, instructions for the naming task were presented. Each trial consisted of the following sequence of events: (a) a visual mask appeared in the center of the screen for 500 ms, (b) a prime word (related or unrelated) was presented for 50, 75 or 100 ms, (c) the mask was presented again for 14 ms, (d) the target picture was presented and remained on the screen until the participant's naming response. Note that the Interstimulus Interval (ISI) was fixed (14ms), whereas the time of presentation of the prime varied from 50, 75 to 100 ms. Hence, in the experiment we used three Stimulus-Onset-Asynchronies (SOAs): 64, 89 and 114 ms, respectively. The next trial started after a period of 2 s following the participant's response.

All the stimuli appeared in the center of the screen of a personal computer (PC 486). Pictures and words were black on a white background. The pictures covered a visual angle of approximately 0.87º . The size of the words covered 0.38º of visual angle. Participants were seated facing the computer at a distance of 60 cm from the screen. Participants were instructed to look at the center of the screen and to name the pictures as fast and as accurately as possible. However, they were not informed of the presence of the prime stimuli. Naming times were registered by an external microphone and the experimenter registered the naming errors when they occurred.

RESULTS

For the analysis in this and the remaining experiments, two ANOVAs were performed, one with participants as the random variable (F_1), and another with items as the random variable (F_2). In the participants analysis, the mean reaction time (RT) within each condition was calculated for each subject and treated as a single observation. In the item analysis, the mean RTs for each target across participants was treated as single a score. Only correct responses were included in the analyses of the RTs data. Thus, data points were excluded from the RT analyses if: (a) the participants stuttered or hesitated in naming the target, (b) the participant misnamed or failed to name the target; (c) the naming latency was 2.5 standard deviations above or below the mean for that participant in that particular condition; (d) a machine error occurred (this was not included in the error analysis). Since the error rates were not sensitive to most experimental manipulations across the experiments, error analyses will not be reported unless they showed significant effects. Whenever an effect was significant for both the participants and item analyses, comparisons among conditions were carried out for the participant analysis. However, if the effect was significant only for items, it was further analysed. A level of .05 was used as the criterion for significance in this and all other statistical analyses. Table 1 presents the mean RTs, percentage of errors and standard deviations for each condition of the experiment (relatedness and time of presentation). Following the criteria mentioned above, 2.8% of the data points were excluded from the RT analyses.

Table 1. Mean reaction time (RT, in ms), percentage of errors (%Errors) and standard deviation (SD, in parenthesis), in Experiment 1 as a function of prime-target relation (semantically related or unrelated) and exposure to the prime (50, 75 and 100 ms) in the Naming Task.

	50 ms		75 ms		100 ms	
	RT	%Errors	RT	%Errors	RT	%Errors
Related	716.8 (72.7)	13.0 (0.4)	738.5 (59.4)	10.2 (0.4)	754.1 (62.2)	17.0 (0.4)
Unrelated	739.2 (89.9)	7.5 (0.3)	733.3 (70.8)	20.0 (0.4)	724.6 (65.6)	17.4 (0.4)

Analysis of these data indicated that the main effects of time of presentation $\underline{F}_1(2, 58) = .59$, $\underline{MSE} = 3437.9$, $\underline{p} = .56$; $\underline{F}_2(2, 58) = .35$, $\underline{MSE} = 3694.1$, $\underline{p} = .70$ and prime target relation $\underline{F}_1(1, 29) = .29$, $\underline{MSE} = 2578.1$, $\underline{p} = .59$; $\underline{F}_2(1, 29) = .07$, $\underline{MSE} = 5420.4$, $\underline{p} = .79$ were not significant. However, the interaction between relatedness and time of presentation was significant $\underline{F}_1(2, 58) = 3.72$, $\underline{MSE} = 2730.8$, $\underline{p} = .03$; $\underline{F}_2(2, 58) = 3.06$, $\underline{MSE} = 2678.5$, $\underline{p} = .05$. This interaction indicated that there were no differences between related and unrelated primes when the primes were presented for 50 ms ($p > .05$), nor for 75 ms ($p > .05$). However, when the primes were presented for 100 ms the previous presentation of a related prime produced a slower response relative to the previous presentation of an unrelated prime $\underline{F}_1(1, 29) = 6.83$, $\underline{MSE} = 1915.0$, $\underline{p} = .01$; $\underline{F}_2(1, 29) = 5.71$, $\underline{MSE} = 2203.6$, $\underline{p} = .02$. Inspection of Table 1 clearly shows that a related prime interferes with the naming response to the picture target when the related prime was presented for 100 ms.

DISCUSSION

As we expected, the results of Experiment 1 with 100 ms primes showed the semantic interference effect that is typically found in the word-picture interference paradigm using short presentations of the primes (about 100ms). Thus, the presence of a semantically related prime slowed picture naming compared to conditions in which the prime was unrelated. In addition, the results of this experiment indicated that the presence of interference was a function of the time available to process the information coming from the prime. When the prime was presented from 50 to 75 ms, the presence of a semantically related prime did not affect picture naming. However, when word primes were presented for 100 ms, naming latencies depended on the existence of a semantic relation between the prime and the target. Thus, picture naming was slower when the picture was preceded by a semantically related word. As we mentioned, these results are consistent with those found with the word-picture interference paradigm when a semantically related visual distractor is presented before the picture target (Starreveld & La Heij, 1996a). They are also consistent with those reported by Alario et al. (2000) where semantic interference from competitor primes was found at 100 ms presentation of the prime.

The lack of effect at 50 and 75 ms cannot be explained by assuming that participants cannot recognize the stimuli at 50 ms, whereas they can do so at 100 ms. As indicated by Forster, Davis, Schoknecht, and Carter (1987), with short exposures to masked primes (100 ms or below), participants can usually tell that something preceded the target stimuli, but they are unable to identify what it was. Also, the effect obtained with primes presented for 100 ms but not for 50 or 75 ms cannot be explained assuming differences in automatic vs. controlled processing of the prime. Exposures to the primes were equal or below 100 ms, and many studies have established that priming effects at 250 ms or below are automatic and limited to lexical internal processing (De Groot, 1984; Den Heyer, Briand, & Dannenbring, 1983; Neely, 1977). This is more so when the instructions did not mention the presence of the prime. In addition, the absence of effects with 50 ms primes is unlikely to be due to lack of processing of the prime, since Perea and Gotor (1997, Experiment 2) found semantic facilitation with 50 ms masked primes. Hence, the absence of interference at 50 and 75 ms and its presence at 100 ms is probably related to the time needed to extract the information needed for the effect. That is, primes presented for 50 ms could be processed at the semantic level, but this semantic analysis is not sufficient to produce the interference effect.

As we mentioned above, several explanations have been offered for the interference effect in the Stroop-like paradigm (Glaser & Düngelhoff, 1984; Glaser & Glaser, 1989; Starreveld & La Heij, 1995, 1996a). This interference has been interpreted in terms of competition between the word and the picture name at a semantic level (Lupker & Katz, 1981; Rayner & Springer, 1986; Smith & Magee, 1980) at a lemma level (Dell, 1986; Levelt et al., 1999; Roelofs, 1992; Schriefers et al., 1990) and at a phonological level (La Heij, 1988; Starreveld & La Heij, 1995). The results of Experiment 1 do not allow us to completely rule out any of these possible explanations. The pattern of interference suggests only that the activation coming from the prime and the target converge at any of these representational networks to produce the effect.

Theoretical accounts locate the effect at a lexical level (Dell, 1986, La Heij, 1988, Levelt et al., 1999). However, it is not clear whether the lemma selection processes or the processes related to name retrieval are producing the effect. In the next experiment we tried to explore whether semantic interference is linked to the processes involved in lemma selection by manipulating semantic relatedness in a gender decision task. If semantic interference implies processing of the stimuli at the lemma level, the effect should appear in tasks that require activation of information at this level (e.g., gender decision).

EXPERIMENT 2

The purpose of Experiment 2 was to introduce a task that required lemma selection. Thus, participants performed a gender decision task. This task was introduced by Jescheniak and Levelt (1994, Experiments 5a, b) to study lemma related variables. Gender has been proposed to be a syntactic feature linked to the lemma level of representation (Jescheniak & Levelt, 1994, p. 831). Hence, gender decision was used to study the processes involved at this level of representation. Although we do not discard the possibility that metalinguistic components could be implied in the gender decision task, this task has been used recently by several authors to study syntactic processing in lexical production (Rodriguez-Fornells, Schmitt, Kutas, & Münte, submitted; Schmit, Schiltz, Zaake, Kutas, & Münte, 2001; Van Turennout, Hagoort, & Brown, 1998; Van Turennout, Hagoort, & Brown, 1999; Versace, & Allain, 2001). In addition, Jescheniak and Levelt suggest that the activation of information at this level is previous to, and independent of, accessing the phonology of the stimuli. Thus, we assume that responding to whether or not a determiner and a depicted object are grammatically congruent requires activation of syntactic information, the gender of the pictured object. Hence with this task, we explored access to the lemma. In the gender decision task, participants were presented with a masculine (EL-the$_{masc}$) or feminine (LA-the$_{fem}$) article and a masculine (e.g., coche-car$_{masc}$) or feminine (e.g., naranja-orange$_{fem}$) picture target. Participants were asked to decide if the picture name was of the same gender as the previously presented article. They gave a yes response when the article and the target matched in gender (EL-coche, the$_{masc}$-car$_{masc}$; LA-naranja, the$_{fem}$-orange$_{fem}$). They gave a no response when the picture target was of different gender to the previously presented article (EL-naranja, the$_{masc}$-orange$_{fem}$; LA-coche, the$_{fem}$-car$_{masc}$). Between the article and the picture a masked word prime was presented that was semantically related or unrelated to the picture target. If semantic interference occurs at a lemma level of representation, the presence of a semantically related prime should interfere with gender decision relative to the condition where the prime was unrelated.

METHOD

Participants. A total of 40 students participated in the experiment. All were students of Psychology at the University of Granada and they presented normal or corrected-to-normal vision. For their participation they received course credits.

Design. The experimental design conformed a 2 x 2 within-participants model. The time of presentation of the prime (50 or 100 ms) and the type of prime-target relation (related or unrelated) were manipulated. The time of presentation was reduced to two levels (50 and 100 ms) compared to the previous experiment which included a third level (75 ms), because of the lack of significant differences between the 50 and 75 ms conditions.

Materials. Fifty simple pictures were selected for this experiment. Ten were used for the practice trials and forty were used as targets in the experimental trials. As in the previous experiment, two words were selected as primes for each picture target, (a) a word unrelated to the picture target (e.g., camel-truck) (b) a word semantically related to the picture target (e.g., car-truck). As in the previous experiment, semantically related words were selected from the normative data of Puerta-Melguizo et al. (1998), so that the prime and target had high visual and functional similarity values. (Mean visual similarity = 2.53, SD = 1.01; Mean functional similarity = 4.77, SD 1.18). Half the primes in the experimental list were semantically related and half were unrelated. At the beginning of each trial, the determiner article EL-the_{masc} or LA-the_{fem} was presented (both articles appeared approximately an equal number of times). In order to avoid that the target's gender was predicted by the article, we introduced in the materials masculine stimuli not ended in /o/ (e.g., tren) and feminine stimuli not ended in /a/ (e.g., mano). Within an experimental list half of the targets were of the same gender as the article presented at the beginning of the trial (yes responses) and half were of a different gender (no responses). In addition, the primes were of the same or different gender to the target approximately an equal number of times. Each target appeared once in the experimental list and it was preceded either by the related or the unrelated prime. Across participants the targets appeared an equal number of times in the related and unrelated conditions. As in the previous experiment, the time of presentation of the prime (50 and 100 ms) was blocked. The order of the blocks was balanced so that they appeared an equal number of times in each position. Each block was composed of 20 prime-target pairs representing all relatedness and type of response conditions Within each block, the order of presentation of the pairs was randomized so that each participant received a different order. All the conditions were counterbalanced, so that across participants, all the prime-target pairs appeared an equal number of times in the different exposure to the prime, relatedness and type of response conditions. A complete list of the stimuli for Experiment 2 is presented in Appendix B.

Procedure. As in previous experiment, the session started with participants being shown the experimental pictures with their corresponding names. Once they had studied them, they received instructions for the gender decision task (see Figure 1). They were told that they would be presented with the articles EL-the$_{masc}$ or LA-the$_{fem}$, and that they should say as fast as possible if the name of the picture and the presented article shared the same gender. Hence, at the beginning of each trial the article EL-the$_{masc}$ or LA-the$_{fem}$ appeared in capital letters at the center of the screen. The article remained on for 1500 ms. Immediately after the article a visual mask appeared for 500 ms followed by a prime word that remained on for 50 or 100 ms depending of the time of presentation condition. The prime was written in lower-case letters and was followed by a visual mask that remained on the screen for 14 ms. The picture target appeared immediately and stayed on until the participant responded. Thus, in the experiment, two SOAs (64 and 114 ms) were used that corresponded to the 50 and 100 exposures to the primes plus the 14 ms masks. The participants had to indicate their responses by pressing the appropriate keys on the computer keyboard. After each trial there was a 2 second blank interval after which the sequence of events of a new trial started.

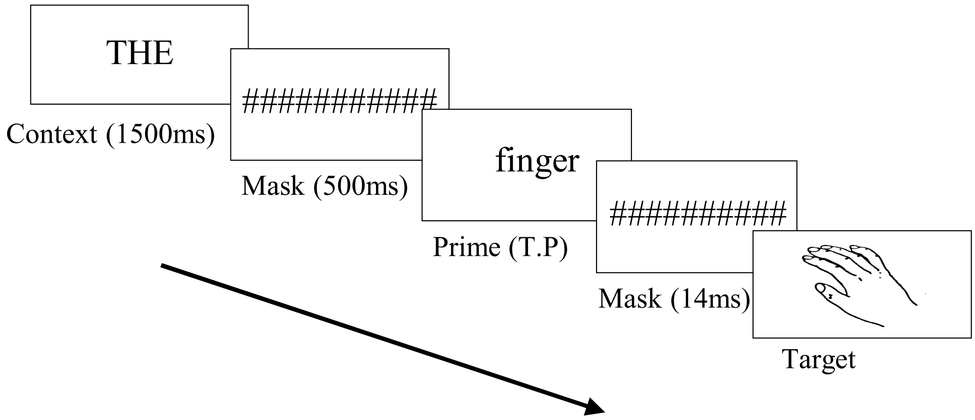

Figure 1. Procedure used in the gender decision task. Notations: Context: Article The_{masc}/ The_{fem}; TP: time of presentation to the prime. See text for comment.

RESULTS

Table 2 shows the mean latencies, percentage of errors and standard deviations as a function of the type of prime-target relation and the time of presentation. In this Experiment, 9.9% of the data point were excluded from the RT data (following the criteria stated above). Yes and no responses were analysed separately. However since the analyses for no responses did not show any significant effect, they will not be discussed further. The lack of sensitivity of the no responses to the experimental manipulations is not surprising if we assume that the participants adopted a strict criterion for responding no (e.g., an exhaustive search through related lemmas). If that were the case, participants would make a much slower response and this may have obscured any possible effect. The slower no responses (1358.2 ms) relative to yes responses (1257.2 ms) supports this assumption ($F_1(1, 39) = 17.96$, $MSE = 45505.4$, $p = .0001$; $F_2(1, 39) = 14.02$, $MSE = 72240.8$, $p = .0005$)[3].

[3] To try to understand the differences between positive and negative responses in Experiment 2 we performed an additional experiment in which the materials, conditions and procedure were identical to those of Experiment 2, except that participants were asked to name the picture target. Naming is not supposed to be influenced by decisional factors and therefore, if these factors were the underlying cause of the differences, once they were eliminated, the differences should disappear. To capture possible differences between matching article-noun conditions (positive responses) and non-matching conditions (negative responses), matching condition was introduced as a factor in the analyses of variance. The results of this new experiment showed significant effects of type of prime-target relation in both participant and item analyses ($p < .001$ and $p = .003$) and article-

Table 2. Mean reaction time (RT, in ms), percentage of errors (%Errors) and standard deviation (SD, in parenthesis), in Experiment 2 as a function of prime-target relation (semantically related or unrelated) and exposure to the prime (50 and 100 ms) in the Gender Decision Task.

	50 ms		100 ms	
Gender Match	RT	%Errors	RT	%Errors
Related	1225.4 (240.9)	11.5 (0.6)	1354.6 (266.5)	8.0 (0.7)
Unrelated	1192.2 (224.1)	7.5 (0.7)	1256.4 (226.9)	9.5 (0.7)

Analyses of the reaction time data showed a significant main effect of time of presentation in both participant and item analyses $F_1(1, 39)= 16.15$, $MSE = 23150.9$, $p = .0002$; $F_2(1, 39) = 7.72$, $MSE = 50716.6$, $p = .008$, indicating that gender decisions were faster when the prime was presented for 50 ms (1208.8 ms) than when it was presented for 100 ms (1305.4 ms).

The main effect of type of relation was also significant $F_1(1, 39) = 11.27$, $MSE =15303.1$, $p = .002$; $F_2(1, 39) = 4.75$, $MSE = 36970.6$, $p = .03$. When the prime and target were semantically related, participants took longer to decide about the gender of the target (1290.0 ms) than when the primes were unrelated (1224.3 ms). The interaction between time of presentation and relatedness was not significant $F_1(1, 39) = 1.49$, $MSE = 28429.8$ $p < .23$; $F_2(1, 39) = 0.80$, $MSE = 32433.6$, $p = .38$. However, since in Experiment 1 we found that the interference effect depended on the time of presentation and we expected to find the same pattern in this experiment, we performed planned comparisons between the related and unrelated conditions for each time of presentation. Results of these analyses showed that the difference between the related and unrelated primes was significant when the primes were presented for 100 ms in both participant and item analyses, $F_1(1, 39) = 6.84$, $MSE = 28170.0$, $p = .01$; $F_2(1, 39) = 7.80$, $MSE = 21505.3$, $p = .008$; but not for 50 ms primes F_1 and $F_2 < 1$. Hence, this

picture gender match (type of response in Experiment 2), ($p < .001$ $p < .001$). However, the interaction between type of relation and gender match was not significant ($p > .05$ in the participants and item analyses), suggesting that the differences between type of response in Experiment 2 were due to decisional factors. The elimination of these factors in this new experiment made these differences disappear.

indicated that the interfering effect produced by related primes was mainly present when the primes were presented for 100 ms. Thus, an effect similar to that found in the picture naming task of Experiment 1 appeared in the gender decision task.

DISCUSSION

The results of Experiment 2 indicated that the presence of a related prime could interfere with the gender decision response. Thus, the presence of a semantically related prime produced slower responses. This interference effect appeared more strongly when the related prime was presented for 100 ms. The presence of this effect in the gender decision task with the same temporal parameters as those found in the naming task seems to suggest that activation at the lemma level is the cause of interference in both gender decision and picture naming. According to Levelt et al. (1999), the prime word directly activates its lemma level, whereas the picture target would directly activate its semantic representation at a conceptual level. This activation would spread to related concepts which, in turn, would send activation to their lemma representations. Thus, the prime's lemma would receive extra activation from its representation at the conceptual level. Although both prime and target would be activated at a lemma level, the representation of the prime would be more activated than the target, since the conceptual node of semantically related targets would send activation to the lemma of the word prime. This extra activation of the prime's lemma would interfere with responses involving the target's lemma, producing the interference effect in our experiments. However, the name retrieval hypothesis could still work if we assume that activation of phonological information at a lexeme level can influence syntactic processing (Caramazza, 1997; Cutting & Ferreira, 1999; Dell et al., 1996). It is possible that the competing lexeme delayed name retrieval processes and that this delay carried over to the syntactic level. Experiment 3 attempts to explore this hypothesis.

EXPERIMENT 3

The results of Experiment 2 are consistent with the hypothesis that the interference effect occurs at a lexical/ lemma level. However, it is also possible that the effect was located at the level of phonological processing and this, in turn, influenced the syntactic processing of the words. As mentioned above, there are different theoretical positions regarding the relation between the lemma and lexeme level of representation. Interactive-type models propose that activation can spread to different representational levels in an interactive manner. Thus, activation does not only proceed from lemma to lexeme, but also activation of the phonological representation of a word or picture can spread back to the lemma level of representation (Cutting & Ferreira, 1999; Dell et al., 1996; Dell & O'Seaghdha, 1991). Hence, it is possible that interference is located at a phonological level and carries over to the syntactic level. That is, the effect may show in the gender task due to the connections from the phonological to the syntactic level. A prediction from these theories is that phonological effects should appear in syntactic tasks and interact with syntactic or semantic variables (Starreveld & La Heij, 1996a). Experiment 3 explored this prediction by introducing phonological primes (rhymes) in the gender decision task. If phonological activation spreads back to the lemma level of representation, phonological effects should appear in this task.

METHOD

Participants. Thirty two new students participated in the experiment. All of them received class credit for their participation.

Design. The experimental design was identical to that of Experiment 2 with the only exception that the type of prime (related vs. unrelated) involved phonological relations.

Materials. A new set of twenty pictures was selected to be used as targets in the experimental list. Eight more pictures were selected for the practice trials. Two words were selected as primes for each picture target, (a) a word unrelated to the picture target (e.g., tie-car); (b) a word that rhymed with the name of the picture target (e.g., tie-pie). The prime words were selected from the experimental materials used by Bajo and Cañas (1989). In that study phonologically related word-picture lists were taken from the Horta-Massanes (1981) dictionary of synonyms and rhymes, so that the word primes shared the last phonemes of the picture name (e.g., sillón-camión). These pairs were then presented to a group of twenty students who had to rate on a scale from 1 to 5 the degree to which both names were phonologically related (the mean relatedness was 4.4, SD = .33). The mean frequency for the related and unrelated primes was 135.7 (SD = 252.3) and 132.8 (SD = 253.5) respectively. Half the primes in the experimental list were phonologically (rhyme) related to the target and half were unrelated[4]. At the beginning of each trial, the article EL-the$_{masc}$ or LA-the$_{fem}$ was presented (both articles appeared approximately an equal number of times). Within an experimental list half the targets were of the same gender as the article presented at the beginning of the trial (yes responses) and half were of a different gender (no responses). In addition, the primes were of the same or of different gender than the target approximately an equal number of times. As in previous experiments, the time of presentation of the prime (50 and 100 ms) was blocked. All the conditions were counterbalanced, so that across participants all the prime-target pairs appeared an equal number of times in the different times of presentation of the primes, relatedness and type of response conditions. A complete list of the stimuli for Experiment 3 is presented in Appendix C.

Procedure. The experimental procedure was identical to that of Experiment 2. The only difference was that the type of relation between primes and targets was phonological instead of semantic.

RESULTS

Table 3 shows mean reaction times, percentage of errors, and standard deviations for the conditions of the experiment. The percentage of error for this experiment was 13.28 %. The results of the analyses of variance performed in the RT and error data indicated that there were not significant sources of variance with all Fs less than or close to unity. As in the previous experiment, participants were faster in positive trials (1177.31 ms) than

[4] We carried out a pilot study to make sure that the temporal parameters and the stimulus selection in this experiment were appropriate. In order to obtain a phonological effect in gender decision, the prime word had to be phonologically processed and this activation had to spread back to the lemma level of representation. Hence, it was important to show that the selected primes were able to activate their phonological representations and influence processing of the picture target when they were presented for 50 and 100 ms. The type of relation between the prime and target (phonologically related vs. unrelated) and the time of presentation of the primes (50, 75, 100, ms) were manipulated within-participants. Three exposure times were selected to explore the temporal parameters of phonological processing. The procedure was identical to that of Experiment 1 the only difference being that the primes were phonologically related. The results of the analyses of variance indicated that the main effect of relatedness (phonological relation vs. unrelated) was significant in the participant analysis ($p = .008$). The interaction between relatedness and time of exposure was not significant in either the participant or item analyses ($p > .05$) indicating that the differences between related and unrelated primes were independent of the time of presentation of the prime. Therefore, phonological information was extracted from the prime and was able to influence picture processing with prime exposures as short as 50ms.

they were in negative trials (1474.89 ms). Consistent with the RT data, participants made more errors in negative trials (15.3%) than in positive trials (14.1%).

Table 3. Mean reaction time (RT, in ms), percentage of errors (%Errors) and standard deviation (SD, in parenthesis), in Experiment 3 as a function of prime-target relation (phonologically related or unrelated) and exposure to the prime (50 and 100 ms) in the Gender Decision Task.

	50 ms		100 ms	
Gender Match	RT	%Errors	RT	%Errors
Related	1178.2 (279.4)	12.5 (0.6)	1149.8 (211.3)	16.2 (0.7)
Unrelated	1167.3 (309.0)	16.2 (0.3)	1213.9 (314.1)	11.2 (0.6)

DISCUSSION

The results of Experiment 3 indicated that the presence of a phonologically related prime did not facilitate the gender decision response. Thus, recovery of the syntactic features from a picture seems to proceed independently of phonology. As we mentioned, the absence of phonological facilitation can be interpreted as evidence against interactive-type models. According to these models (Cutting & Ferreira, 1999; Dell & O'Seaghdha, 1991; Dell et al., 1996) activation can spread to different representational levels in an interactive manner. Thus, activation would spread not only from the lemma to lexeme representations, but also from the phonological features of a word or picture to the lemma level of representation (Cutting & Ferreira, 1999; Dell & O'Seaghdha, 1991; Dell et al., 1996). Hence, phonological effects should appear in syntactic tasks such as the gender decision task used in our experiment and the absence of these effects can be interpreted against the interactive nature of lemma and lexeme processing.

The results of Experiment 3 contrast with some experiments by Starreveld and La Heij (2001) that found phonological facilitation in Stroop-like gender decision tasks. There are several reasons for the discrepancies between their experiments and ours. First, several differences in the procedures may produce the effect: the visual overlap between the prime and target, the type of decision (pressing different keys on the computer keyboard depending on the gender versus deciding if the gender of the noun was congruent with the gender of the article), the syntactic categories (common or neutral in Starreveld and La Heij's experiments versus feminine and masculine in our Experiment 3). Second, the relation between the phonological and syntactic features may be language dependent. For example, gender congruency effects have been found in Dutch picture naming (La Heij, Mak, Sander, & Willeboordse, 1998; Schriefers, 1993), but not in Italian naming (Miozzo & Caramazza, 1999). Since the rules associated to gender vary across languages, it is possible that different connections between the syntactic and phonological representations are established.

GENERAL DISCUSSION

The purpose of the series of experiments described here was to investigate the nature of the word-picture semantic interference effect. Although this phenomenon has been shown in many studies (La Heij, 1988; Schriefers et al., 1990; Starreveld & La Heij, 1995, 1996a), the level of linguistic processing (semantic vs. lexical) at which this effect occurs has not been clearly determined. The results of our first experiment indicated that it is possible to find semantic interference in masked priming paradigms. Thus, picture targets preceded by semantically related prime words were named slower than picture targets preceded by unrelated words. This effect is similar to those found by others in the Stroop-like interference paradigm using short prime-target intervals (Glaser & Düngelhoff, 1984; Glaser & Glaser, 1989; Starreveld & La Heij, 1996a). Some contradictory results obtained in the Stroop paradigm have been explained as the result of the additional processing that the prime may undergo while it remains on the screen, or of attentional shifts due to the presentation of the distractor when the target is being processed (Damian & Martin, 1999). Thus, the presence of semantic interference in masked priming suggests that this effect is not due to the overlap between the prime and target (as is the case of the distractor-target in the Stroop paradigm) or to attentional shifts when the prime is presented. The time of presentation of the primes was clearly within the range of automatic processing (50 to 100ms) and the primes did not overlap with the target.

The results of these experiments can easily be explained by theoretical accounts that locate the word-picture interference effect in the lexical system either at the lemma level (Roelofs, 1992; Levelt et al., 1999) or at the level where the phonological form is accessed (Glaser & Glaser, 1989; Starreveld & La Heij, 1996a). In Experiment 2, participants performed a gender decision task that required activation of the lemma representation. In this experiment semantic interference was found. That is, the presence of a semantically related prime slowed down the decisions regarding the gender of the object depicted by the target. The results of this experiment seem to suggest that interference effects occur at the lemma level. Thus, when the task necessarily requires activation of the lemma (gender decision), interference is present. However, it could be argued that interference in gender decision comes from previous phonological processing. Some researchers (Dell, 1986; Cutting & Ferreira, 1999) have proposed that the lexical system is interactive, and lemmas can become activated through ascending activation from the phonology of the stimuli. However, the results of Experiment 3 indicated that the phonological relation between the word prime and picture target had no influence in judging the gender of the picture target. The discrepancy between the Starreveld and La Heij's and our experiment is probably associated with differences in procedure or to differences in the target language. As we mentioned, it is possible that gender processing differs across languages and that the differences obtained in different experiments regarding gender selection may be attributed to these variations (for similar arguments see Miozzo & Caramazza, 1999).

In recent years the question of whether grammatical information is necessary to name a picture has been the subject of much discussion. From the lexical access model (Levelt et al., 1999; Roelofs, 1992), it is held that the lemma of a picture is a necessary step during pronunciation of the name of a picture, and we only activate the phonological form after selecting a given lemma. Caramazza (1997), and Caramazza and Miozzo (1997) indicate that the obligatory syntactic mediation hypothesis is not correct. They suggest that syntactic contents are only activated when they are necessary to carry out the task. It is possible that this flexibility also accounts for the relation between the phonological and syntactic processing. In the model proposed by Caramazza (1997, Caramazza & Miozzo, 1997, 1998) picture naming involves activation of syntactic and phonological representations in parallel. Phonological facilitation would be caused by activation of the phonological networks, whereas gender decisions would be taken with information in the syntactic network. Although lexeme nodes are connected to the syntactic layer so that gender decisions can be influenced by phonological information, it is not clear whether this connection is mandatory. Results obtained in Experiment 3 seem to suggest that retrieval of phonological information is not necessary during access to grammatical information. It is very possible that in a language such as Spanish where gender is not always phonologically linked, the connection between phonological and syntactic features is not used in gender decision. Although speculative at the moment, this conclusion is subject of further investigation.

RESUMEN

El locus del efecto de interferencia semántica en la denominación de dibujos. En los experimentos que se presentan se utilizó el procedimiento de priming enmascarado para explorar el locus del efecto de interferencia semántica. Para ello se manipuló la naturaleza de la tarea (denominación y decisión de género), el tipo de relación entre el prime y el target (semántica y fonológica) y el tiempo de presentación del prime. Los resultados indicaron que el efecto de interferencia semántica aparece en las tareas de denominación (Experimento 1) y de decisión de género (Experimento 2), con tiempos de presentación del prime de 100 ms. Este resultado replica el efecto encontrado por otros investigadores y lo extiende a la tarea de decisión de género. Por otro lado, el efecto de facilitación fonológica no apareció en la tarea de decisión de género (Experimento 3). Este patrón de resultados sugiere que el efecto de interferencia semántica es consecuencia de procesos que ocurren en el nivel de representación del lemma, y que la tarea de decisión de género no está influenciada por la activación fonológica.

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Appendix A. Stimulus Materials Used in Experiment 1.

	Prime Type	
Target	Related	Unrelated
bicicleta[bicycle]	patín[skate]	nariz[nose]
boca[mouth]	nariz[nose]	piña[pineapple]
brazo[arm]	pierna[leg]	cereza[cherry]
cama[bed]	sofá[sofa]	flauta[flute]
camello[camel]	caballo[horse]	tornillo[screw]
cerdo[pig]	vaca[cow]	bufanda[scarf]
coche[car]	camión[trunk]	mecedora[rocker]
cocodrilo[crocodile]	serpiente[snack]	arpa[harp]
fresa[strawberry]	cereza[cherry]	cuchara[spoon]
gato[cat]	perro[dog]	alicates[tile]
guante[glove]	calcetín[sock]	taza[cup]
guitarra[guitar]	violín[violin]	serpiente[snack]
hacha[axe]	sierra[saw]	limón[lemon]
mano[hand]	dedo[finger]	taburete[stool]
mesa[table]	taburete[stool]	dedo[finger]
naranja[orange]	limón[lemon]	sierra[saw]
oreja[ear]	ojo[eye]	cazo[saucepan]
pera[pear]	piña[pineapple]	patín[skate]
piano[piano]	arpa[harp]	pierna[leg]
sandía[watermelon]	manzana[apple]	falda[skirt]
sartén[frying-pan]	cazo[saucepan]	avión[aeroplane]
silla[chair]	mecedora[rocker]	perro[dog]
sombrero[hat]	bufanda[scarf]	vaca[cow]
tenedor[fork]	cuchara[spoon]	camión[trunk]
tijeras[scissors]	alicates[tile]	manzana[apple]
tren[train]	avión[aeroplane]	ojo[eye]
trompeta[trumpet]	flauta[flute]	sofá[sofa]
tuerca[nut]	tornillo[screw]	caballo[horse]
vaso[glass]	taza[cup]	calcetín[sock]
vestido[dress]	falda[skirt]	violín[violin]

Note. Stimuli were presented in Spanish. Approximate English translations are given in brackets. Related = semantically related. Unrelated = Not semantically/ phonologically related.

Appendix B. Stimulus Materials Used in Experiment 2

Article	Target	Prime Type	
		Related	Unrelated
EL	caballo[horse$_{masc}$]	camello[camel$_{masc}$]	coche[car$_{masc}$]
EL	camión[truck$_{masc}$]	coche[car$_{masc}$]	camello[camel$_{masc}$]
EL	león[lion$_{masc}$]	oso[bear$_{masc}$]	cazo[saucepan$_{masc}$]
EL	plato[plate$_{masc}$]	cazo[saucepan$_{masc}$]	oso[bear$_{masc}$]
EL	perro[dog$_{masc}$]	gato[cat$_{masc}$]	sofá[settee$_{masc}$]
EL	sillón[armchair$_{masc}$]	sofá[steel$_{masc}$]	gato[cat$_{masc}$]
EL	tren[train$_{masc}$]	barco[ship$_{masc}$U	pantalón[trousers$_{masc}$]
EL	vestido[dress$_{masc}$]	pantalón[trousers$_{masc}$]	barco[ship$_{masc}$]
EL	violín[violin$_{masc}$]	arpa[harp$_{masc}$]	calcetín[sock$_{masc}$]
EL	zapato[shoe$_{masc}$]	calcetín[sock$_{masc}$]	arpa[harp$_{masc}$]
EL	cuchillo[knife$_{masc}$]	cuchara[spoon$_{fem}$]	falda[skirt$_{fem}$]
EL	chaleco[vest$_{masc}$]	falda[skirt$_{fem}$]	cuchara[spoon$_{fem}$]
EL	dedo[finger$_{masc}$]	mano[hand$_{fem}$]	ardilla[squirrel$_{fem}$]
EL	elefante[elephant$_{masc}$]	ardilla[squirrel$_{fem}$]	mano[hand$_{fem}$]
EL	guante[glove$_{masc}$]	bufanda[scarf$_{fem}$]	oreja[ear$_{fem}$]
EL	ojo[eye$_{masc}$]	oreja[ear$_{fem}$]	bufanda[scarf$_{fem}$]
EL	piano[piano$_{masc}$]	guitarra[guitar$_{fem}$]	tijera[scissor$_{fem}$]
EL	martillo[hammer$_{masc}$]	tijera[scissor$_{fem}$]	guitarra[guitar$_{fem}$]
EL	tornillo[screw$_{masc}$]	tuerca[nut$_{fem}$]	jirafa[giraffe$_{fem}$]
EL	avestruz[ostrich$_{masc}$]	jirafa[giraffe$_{fem}$]	tuerca[nut$_{fem}$]
LA	cama[bed$_{fem}$]	mecedora[rocker$_{fem}$]	fresa[strawberry$_{fem}$]
LA	cereza[cherry$_{fem}$]	fresa[strawberry$_{fem}$]	mecedora[rocker$_{fem}$]
LA	flauta[flute$_{fem}$]	trompeta[trumpet$_{fem}$]	pistola[gun$_{fem}$]
LA	muñeca[doll$_{fem}$]	pistola[gun$_{fem}$]	trompeta[trumpet$_{fem}$]
LA	nariz[nose$_{fem}$]	boca[mouth$_{fem}$]	bicicleta[bicycle$_{fem}$]
LA	pelota[ball$_{fem}$]	bicicleta[bicycle$_{fem}$]	boca[mouth$_{fem}$]
LA	pera[pear$_{fem}$]	manzana[apple$_{fem}$]	tortuga[turtle$_{fem}$]
LA	rana[frog$_{fem}$]	tortuga[turtle$_{fem}$]	manzana[apple$_{fem}$]
LA	sartén[frying-pan$_{fem}$]	cafetera[coffeepot$_{fem}$]	uva[grape$_{fem}$]
LA	naranja[orange$_{fem}$]	uva[grape$_{fem}$]	cafetera[coffeepot$_{fem}$]
LA	pala[shovel$_{fem}$]	destornillador[screwdriver$_{masc}$]	armario[wardrobe$_{masc}$]
LA	mesa[table$_{fem}$]	armario[wardrobe$_{masc}$]	destornillador[screwdriver$_{masc}$]
LA	pierna[leg$_{fem}$]	pie[foot$_{masc}$]	plátano[banana$_{masc}$]
LA	piña[pineapple$_{fem}$]	plátano[banana$_{masc}$]	pie[foot$_{masc}$]
LA	serpiente[snake$_{fem}$]	cocodrilo[crocodile$_{masc}$]	hacha[axe$_{masc}$]
LA	sierra[saw$_{fem}$]	hacha[axe$_{masc}$]	cocodrilo[crocodile$_{masc}$]
LA	taza[cup$_{fem}$]	vaso[glass$_{masc}$]	cerdo[pig$_{masc}$]
LA	vaca[cow$_{fem}$]	cerdo[pig$_{masc}$]	vaso[glass$_{masc}$]
LA	silla[chair$_{fem}$]	taburete[stool$_{masc}$]	brazo[arm$_{masc}$]
LA	cabeza[head$_{fem}$]	brazo[arm$_{masc}$]	taburete[stool$_{masc}$]

Note. Stimuli were presented in Spanish. Approximate English translations are given in brackets. Related = semantically related; Unrelated = Not sematically/ phonologically related. Masc = Gender masculine; Fem = Gender femenine.

Appendix C. Stimulus Materials Used in Experiment 3.

		Prime Type	
Article	Target	Related	Unrelated
EL	camello[camel$_{masc}$]	sello[stamp$_{masc}$]	sartén[frying-pan$_{fem}$]
EL	cenicero[ashtray$_{masc}$]	sombrero[hat$_{masc}$]	sello[stamp$_{masc}$]
EL	zapato[shoe$_{masc}$]	gato[cat$_{masc}$]	caracol[snail$_{masc}$]
EL	sol[sun$_{masc}$]	caracol[snail$_{masc}$]	gato[cat$_{masc}$]
EL	tren[train$_{masc}$]	sartén[frying-pan$_{masc}$]	sombrero[hat$_{masc}$]
EL	piano[piano$_{masc}$]	mano[hand$_{fem}$]	cepillo[brush$_{masc}$]
EL	cazo[saucepan$_{masc}$]	brazo[arm$_{masc}$]	ventana[window$_{fem}$]
EL	rastrillo[rake$_{masc}$]	cepillo[brush$_{masc}$]	cama[bed$_{fem}$]
EL	violín[violín$_{masc}$]	calcetín[sock$_{masc}$]	cometa[comet$_{fem}$]
EL	cuchillo[knife$_{masc}$]	martillo[hammer$_{masc}$]	bandera[flag$_{fem}$]
LA	rama[branch$_{fem}$]	cama[bed$_{fem}$]	mano[hand$_{fem}$]
LA	campana[bell$_{fem}$]	ventana[window$_{fem}$]	brazo[arm$_{masc}$]
LA	calabaza[pumpkin$_{fem}$]	taza[cup$_{fem}$]	oveja[sheep$_{fem}$]
LA	raqueta[racket$_{fem}$]	cometa[comet$_{fem}$]	taza[cup$_{fem}$]
LA	ardilla[squirrel$_{fem}$]	silla[chair$_{fem}$]	calcetín[sock$_{masc}$]
LA	oveja[sheep$_{fem}$]	oreja[ear$_{fem}$]	silla[chair$_{fem}$]
LA	pera[pear$_{fem}$]	bandera[flag$_{fem}$]	trompeta[trumpet$_{fem}$]
LA	pelota[ball$_{fem}$]	bota[boot$_{fem}$]	tijera[scissors$_{fem}$]
LA	seta[mushroom$_{fem}$]	trompeta[trumpet$_{fem}$]	martillo[hammer$_{masc}$]
LA	escalera[stairway$_{fem}$]	tijera[scissors$_{fem}$]	bota[boot$_{fem}$]

Note. Stimuli were presented in Spanish. Approximate English translations are given in brackets. Related = phonologically related. Unrelated = Not phonologically related. Masc = Gender masculine; Fem = Gender femenine.