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Semantic Facilitation and Lexical Competition in Picture Naming

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Four experiments are reported to study lexical access in picture naming. Interference was found when semantically related word primes were presented, but no effect was obtained using picture primes (Experiment 1). In Experiments 2a, 2b and 3, we introduced a new technique: Double-priming. The technique requires naming a picture target after presentation of two stimuli: a preprime stimulus and a picture prime. The results showed that the presentation of a semantically related preprime word slowed picture naming (Experiments 2a and 3). The interference was not due to the single effect of the preprime nor to the prime's lexical processing since related primes by themselves (Experiment 1), and primes preceded by unrelated word preprimes (Experiment 2b and 3) did not produce the effect. This pattern of results suggests that lexical access in picture naming involves two types of processes. The first is excitatory and semantic in nature; the second involves competitive lexical selection.

Lexical selection processes have been explored by investigating semantic interference in priming and stroop-like interference paradigms (Alario, Segui, & Ferrand, 2000; Cutting & Ferreira, 1998; Starreveld & La Heij, 1996). In the word-picture interference paradigm, pairs of stimuli are presented (distractor and target). Participants are asked to perform naming responses to the picture targets and to ignore the distractor word. Despite these instructions, participants automatically process the distractor words so that words that are semantically related interfere with picture naming (Caramazza & Costa, 2000, 2001; Rosinski, Golinkoff, & Kukish, 1975). In priming procedures, participants are also asked to name the picture targets and, although they may be unaware of a briefly presented prime, the presence of a related prime word slows picture naming (Alario et al., 2000; Bajo,

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Puerta-Melguizo, & Macizo, 2003). A second interesting finding is that while this effect consistently appears with word primes or distractors, the effect disappears (Bajo et al., 2003; Irwin & Lupker, 1983) or become facilitatory (Durso & Johnson, 1979) when picture primes are presented. For example, Irwin and Lupker used semantically related prime-target pictures in naming and categorization tasks. When picture targets had to be named, there was no significant effect of relatedness. When picture targets had to be categorized, a facilitation effect was found with picture primes.

The presence of interference with word primes is easily explained by models of lexical selection. Interference is the result of the extra activation of the prime's lexical representations. The lexical node for the word prime would receive, (a) direct activation from the word prime, and (b) activation descending from the related picture target (e.g., the picture target "ear" - concept EAR- would activate the prime EYE at the conceptual level and this, in turn, would send activation to the lexical entry for *eye*)[1]. Thus, the prime's lexical representation (*eye*) would receive extra-activation and would interfere and compete with responses involving the target's lexical representation (*ear*) (Levelt, Roelofs, & Meyer, 1999; Starreveld & La Heij, 1996).

However, it is not obvious why interference should disappear when the nature of the prime is changed and pictures are presented as primes. The absence of interference with picture primes could be explained if two types of processes were assumed: 1) excitatory connections among units at the conceptual level (e.g., Glaser & Glaser, 1989), 2) competitive processes among units at the lexical level (Damian, Vigliocco, & Levelt, 2001). When the prime is a word, competitive processes would prevail and produce lexical interference: The prime would directly activate its lexical representation. This representation also receives activation from the conceptual representation of the picture target. As a result the lexical representation of a word prime would be strongly activated and compete with the lexical representation of the target. The word prime would not necessarily activate its conceptual representation since words can directly activate their lexical representation without accessing their meaning (Bajo, 1988; Glaser & Glaser, 1989). However, when the prime is a picture, semantic processing would be heavily involved. When the picture prime "eye" is presented, its representation would directly activate its semantic representation (EYE) and this activation would spread to other semantically related units through the excitatory connections present at the conceptual level. Thus, if the picture target is related to the prime ("ear"), it would receive activation from the previous activation of the prime. Semantic processing of the target would be facilitated by the processing of the prime (EYE → EAR). The presence of these excitatory conceptual connections would explain the facilitation effects obtained in picture-picture categorization tasks (Dell'Aqua & Grainger, 1999; Irwin & Lupker, 1983). However, when the task is picture naming, lexical processing is also involved and competitive

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

processes would also take place. Facilitation and competition could cancel each other out and produce null results. Thus, the absence of effect with picture primes can be explained as the result of these opposing forces.

This account would predict that the presentation of a picture prime could interfere with picture naming in conditions where lexical competition increases. The present experiments try to test this hypothesis. In Experiments 2a, 2b and 3, we introduced the double-priming paradigm: A sequence of three stimuli was presented, (1) a preprime word, (2) a picture prime; and (3) a picture target. The preprime was included to increase competitive processes among related lexical candidates. The presentation of a preprime word ("foot") would activate its lexical representation (*foot*) and would induce competitive processes among related lexical units (e.g., *eye*, *ear*). The purpose of Experiment 1 was to replicate in a single experiment the presence of interference with word primes (Alario et al., 2000) and the absence of it with picture primes (Irwin & Lupker, 1983). Conditions were set so that the chances of obtaining interference were maximized. For example, the Stimulus-Onset- Asynchrony (SOA) is an important variable for obtaining picture-word interference effects. Starreveld and La Heij (1996) showed that the presence of semantic interference depends on the SOA used. Thus, they found semantic interference effect at SOAs ranging from 0 ms to + 200 ms. Moreover, Bajo et al. (2003; Experiment 1) showed an interference effect with related word primes presented for 100 ms (SOA = 114ms) and a lack of effect at 50 and 75 ms. Therefore, in order to increase the chances of obtaining interference, in the experiments to follow the SOAs were set at 114 ms.

EXPERIMENT 1

METHOD

Participants. Sixty psychology students at the University of Granada with normal or corrected–to-normal vision participated in the experiment. They received course credit for their participation.

Materials. Thirty two black and white simple pictures were employed as targets (see Appendix A). Ten additional pictures were used for practice. For each picture target two types of primes were selected[2], (a) primes that were semantically related (belonged to the same category, dog-cat); and (b) primes that were semantically unrelated (knife-cat). The pictures were selected from the norms of Puerta-Melguizo, Bajo, and Gómez-Ariza (1998). These

[2] In order to replicate the conditions to obtain a semantic interference effect with SOA = 114 ms, cited by Alario et al. (2000), ours related prime-target pairs were selected so that they were from the same category and as much as possible coordinated pairs.

norms were obtained by selecting 580 concept pairs that could be drawn as some of the objects depicted in the Snodgrass and Vanderwart (1980) norms and as some of the experimental materials used by Bajo and Cañas (1989). The selected objects belonged to nine different categories (animals, kitchen, parts of the body, fruits, tools, toys, pieces of furniture, musical instruments, and articles of clothing). Within a category, all possible combinations of pairs of items were formed. These pairs were presented to a group of 270 students that 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). In the related condition the mean visual similarity for related pairs was 2.82 (SD = 0.9) and their mean functional similarity was 4.47 (SD = 1.14). Although in language production lexical frequency has an effect at the phonological level (e.g., Jescheniak & Levelt, 1994) and the locus of semantic interference is located at a different level of processing (e.g., lemma level; Levelt et al., 1999), to avoid possible confounding related and unrelated primes were equated for frequency. Thus, the mean frequency (Alameda & Cuetos, 1995) for the prime pictures in the related condition was 68.23 (SD = 84.22), the mean frequency for the unrelated prime pictures was 72.87 (SD = 112.19).

Each participant was presented with 32 prime-target pairs, 16 in each relatedness condition. To avoid repetitions, 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. Although the primes were repeated, they were never presented twice in the same experimental list. For example, the unrelated prime word "suitcase" appeared in the pairs "suitcase-gun" and "suitcase-banana", but theses pairs were presented in different experimental lists.

Assignment of target to the related condition was carried out so that across participants each target appeared an equal number of times in the related and in the unrelated condition. The order of the pairs was randomized so that each participant received a different order. In addition, two versions of the primes were created, one as pictures and one as words. One group of participants received the picture version and the other half received the word version.

Procedure and Design. The type of prime (picture or word) was manipulated between groups (within items) and the prime-target relation (semantically related or unrelated) was manipulated within-participants (within items). In all cases the primes were presented for 100 ms. The prime-target Inter-Stimuli-Interval was 14 ms (ISI = 14 ms = mask duration), and the SOA was 114 ms.

All the stimuli appeared in the centre of the screen of a personal computer (PC 486). All the details of stimulus presentation were controlled throughout the ERTS program. Pictures were black on a white background and covered a visual angle of approximately 0.87º. 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 centre of the

screen and to name the pictures as fast and as accurately as possible. However, they were not informed about the presence of the prime stimuli. Naming times were registered by an external microphone and the experimenter registered the naming errors when they occurred.

Before the experiment the participants were presented with a set of cards. Each card contained one of the picture targets 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 a sequence of four stimuli: (a) a mask was presented for 500 ms, (b) a prime (word or picture) presented for 100 ms, (c) the mask for another 14 ms, (d) the picture target was presented in the centre of the screen and remained there until the participants's responses. The interval between trials was 2 s.

RESULTS AND DISCUSSION

For the analysis in this and the remaining experiments, two ANOVAs were performed, one with participants as the random variable ($\underline{F}_1$), and another with items as the random variable ($\underline{F}_2$). In the participant analysis, the mean reaction time (RT) within each condition was calculated for each participant and treated as a single score. In the item analysis, the mean RTs for each target across participants were treated as single scores. Only correct responses were included in the analyses of the RT 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; or (d) a machine error occurred. Only trials falling into categories a, b and c, were considered as errors for the error analyses. Since the error rates were not sensitive to the experimental manipulations across the experiments, error analyses will not be reported. Following the criteria explained above, 3.9% of the data points of Experiment 1 were excluded from the RT analyses. A level of .05 was used as the criterion for significance in this and all other statistical analyses. Table 1 presents the mean RT, percentage of errors and standard deviations for each condition of the Experiment 1.

Analyses of the data indicated that the type of prime-target relation was significant, $\underline{F}_1(1, 58) = 3.96$, $\underline{MSE} = 373.1$, $\underline{p} < .05$; $\underline{F}_2(1, 30) = 5.02$, $\underline{MSE} = 917.3$, $\underline{p} < .03$. When the prime and target were semantically related, naming was slower (747.5 ms) than when they were unrelated (740.4 ms). The effect of type of prime was also significant in the item analysis, $\underline{F}_1(1, 58) = 0.22$, $\underline{MSE} = 5944.6$, $\underline{p} < .64$; $\underline{F}_2(1, 30) = 5.64$, $\underline{MSE} = 675.4$, $\underline{p} < .02$. This effect indicated that naming was faster when the prime was a word (737.4 ms in the item analysis) than when the prime was a picture (748.5 ms in the item analysis) suggesting that visual processing of pictures is more complex than that of words. In addition the interaction between the two variables was

significant, $F_1(1, 58) = 7.36$, MSE = 373.1, $p < .009$; $F_2(1, 30) = 4.05$, MSE = 993.6, $p < .05$. When the prime was a picture there was no difference between related and unrelated primes, $F_1(1, 58) = 0.26$, MSE = 373.1, $p < .61$; $F_2(1, 30) = 0.01$, MSE = 999.8, $p < .92$. However, when the prime was a word, the differences between related and unrelated primes were significant, $F_1(1, 58) = 11.06$, MSE = 373.1, $p < .002$; $F_2(1, 30) = 9.47$, MSE = 911.2, $p < .004$. Therefore, the results of this analysis indicated that semantic interference appeared when the prime was a word, but not when the prime was a picture. This pattern is consistent with previous results (Alario et al., 2000; Irwin & Lupker, 1983) and with the hypothesis that picture primes induced both semantic facilitation and lexical competition[3]. The results of the two processes cancel each other out. In this experiment lexical competition was enough to cancel the facilitatory effect of semantic activation, but insufficient to override it. In Experiment 2, we explored whether semantic interference can be obtained in conditions where lexical competition is increased.

Table 1. Mean reaction time (RT, in ms), percentage of errors (%Error) and standard deviation (in parenthesis) in Experiment 1, as a function of prime-target relation (semantically related or unrelated) and type of prime (word, picture).

	Related		Unrelated	
Type of Prime	RT	%Errors	RT	%Errors
Word	748 (75)	4.4	732 (65)	3.4
Picture	745 (38)	3.7	748 (34)	4.4

EXPERIMENT 2

EXPERIMENT 2A

Experiment 2a explored the effect of semantically related picture primes when lexical competition has already acted through the presentation of semantically related word preprimes. As mentioned, lexical competition would increase when lexical representations other than the target receive extra-activation from presentation of a related context. We introduced the double-priming paradigm. In Experiment 2a, the preprimes were always related words and the relatedness of the prime-target pairs was varied. If the lack of interference with picture primes is due to the opposing effects of semantic activation and lexical competition, the presentation of a related preprime would make competition greater than facilitation and semantic interference should

[3] The absence of interference with picture primes has been replicated by the authors with a different set of materials (see Bajo, Puerta-Melguizo, & Macizo, 2003).

appear. In Experiment 2b the preprimes were always unrelated words and again the relatedness of the prime-target pairs was varied. In this experiment, we expected that the type of prime would not produce an effect since the preprimes were always unrelated.

The presence of interference in Experiment 2a and the absence of it in Experiment 2b would suggest that interference in the double-prime procedure depends on the preprime and prime semantic relation. When both stimuli are related lexical competition would increase and interference would be evident.

METHOD

Participants. A total of thirty psychology students at the University of Granada participated in the experiment. They had normal or corrected-to-normal vision and received course credit for their participation.

Materials. A new set of stimuli was added to the materials of Experiment 1 to conform the new experimental conditions (see Appendix B). All the preprimes were semantically related to the targets. For each preprime, two primes were used: (a) a semantically related picture, and (b) a neutral stimulus (a row of asterisks). Related primes were selected so that they would yield the maximum possible value of visual and functional similarity. Thus, the mean visual similarity for the thirty primes and preprimes in the Experiment was 1.78 (SD = 0.78) and the mean functional similarity was 3.73 (SD = 1.47). The prime-target related pictures yielded the maximum possible value of visual (2.64, SD = 1.09) and functional (4.64, SD = 1.25) similarity. Finally, the mean visual similarity between the preprimes and targets was 2.64 (SD = 1.09) and the mean functional similarity was 4.64 (SD = 1.25). Preprimes, primes and targets were equated for lexical frequency. Thus, the mean frequency (Alameda & Cuetos, 1995) for the preprimes was 50.90 (SD = 64.74), the mean frequency for the primes was 97.79 (SD = 198.91), and the mean frequency for the targets was 123.55 (SD = 221.57).

Procedure and Design. The type of prime relation (semantically related vs. neutral) was manipulated within-participants. Each participant was presented with 30 preprime-prime-target experimental sequences: 15 preprimes were followed by semantically related picture primes and targets and 15 neutral preprimes were followed by the neutral primes and the targets. To avoid repetitions, participants were divided into two groups so that pairs assigned to the related condition in one group were assigned to the neutral condition in the second group. Thus, although some of the related primes were repeated, they were never presented twice in the experimental list. For example, the picture prime "tie" appeared in the triads "scarf-tie-hat" and "skirt-tie-shoe", but theses pairs were presented in different experimental lists. If the "scarf-tie-hat" combination was assigned to one list, "skirt-****-shoe" would also be assigned to that list. Each group received a

particular combination of 30 preprime-prime-target sequences; 15 in each relatedness condition. The time of presentation of the preprimes was 100 ms (SOA 114 ms).

The procedure was identical to that in Experiment 1 with the only difference that a preprime was presented. The preprime was preceded by a 500 ms mask and followed by a 14 ms mask (see Figure 1).

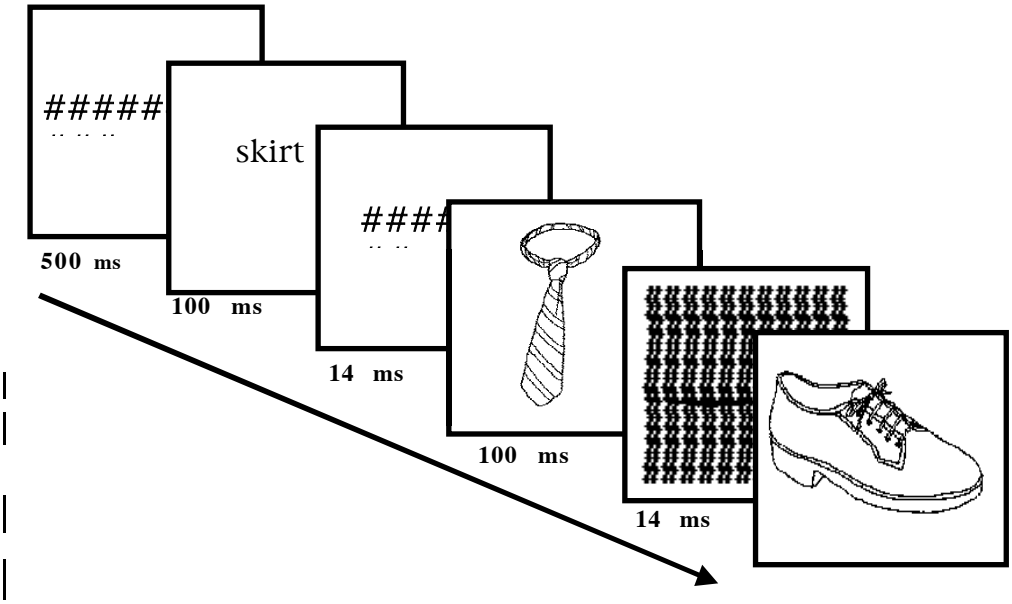

Figure 1. Sequence of events on each trial of Experiments 2a, 2b and 3 using the double-priming paradigm.

RESULTS

Table 2 shows the mean response latencies and error rates (10.3%) of this experiment. The results of the ANOVAs on the RT data indicated that the type of relation of the prime was significant, $\underline{F}_1(1, 29) = 7.71$, $\underline{MSE} = 4952.1$, $\underline{p} < .009$; $\underline{F}_2(1, 29) = 17.2$, $\underline{MSE} = 2460.3$, $\underline{p} < .001$.

Thus, targets preceded by related picture primes were named slower (788.6 ms) than targets preceded by neutral primes (738.1 ms) indicating that in the double-priming paradigm interference is also due to the related picture primes and it cannot simply be due to lexical competition from the preprimes. This suggests that increments in lexical competition by the presentation of a related word preprime produces interference when picture primes are involved.

Table 2. Mean reaction time (RT, in ms), percentage of errors (%Error) and standard deviation (in parenthesis) in Experiment 2a, as a function of prime-target relation (semantically related or neutral). All the preprimes were semantically related words.

	Related	Neutral
RT	788 (120)	738 (113)
%Errors	9.1	11.5

EXPERIMENT 2B

In Experiment 2b, the preprimes were always unrelated and the relatedness of the prime was varied. In this experiment, we expected that the type of prime would not produce an effect. Lexical competition for the related prime condition would be roughly equivalent to that present in Experiment 1 and interference should not appear.

METHOD

Thirty new students participated in this experiment. The materials were identical to those used in Experiment 2a. The unrelated preprimes were formed by mixing the preprimes of Experiment 2a, so that none of them was related to the prime and target. All other details regarding materials and procedure were identical to those in the previous experiments.

RESULTS

Table 3 shows the mean response latencies and error rates (1.9%) of this experiment. The results of the ANOVAs on the RT data indicated that the type of relation of the prime was not significant, $\underline{F}_1(1, 29) = 1.19$, $\underline{MSE} = 4758.4$, $\underline{p} < .284$; $\underline{F}_2(1, 29) = 0.47$, $\underline{MSE} = 11183.4$, $\underline{p} < .47$.

Table 3. Mean reaction time (RT, in ms), percentage of errors (%Error) and standard deviation (in parenthesis) in Experiment 2b, as a function of prime-target relation (semantically related or neutral). All the preprimes were semantically unrelated words.

	Related	Neutral
RT	811.9 (83)	792 (105)
%Errors	1.5	0.4

This result suggests that the presentation of a preprime word is not a sufficient condition to produce semantic interference. That is, the preprime has to be related to the prime-target pairs to obtain an interference effect with picture primes.

DISCUSSION OF EXPERIMENTS 2A AND 2B

The results of Experiment 2a and 2b show that (a) interference effects with related picture primes appear when a related word preprime is previously presented, (b) interference is due to the joint effect of the preprime and target semantic relation: related picture primes and related word preprimes are needed to observe the effect.

Since words have direct access to the lexical system, this pattern of results is consistent with the hypothesis that increments in lexical competition can override semantic facilitation and produce interference effects. When a related preprime is presented, lexical competition is increased relative to semantic facilitation, producing a delay in naming of the target. However, some methodological aspects of the reported experiments made us exercise caution. In Experiments 2a and 2b the effect of the type of prime was assessed by comparing related and neutral primes and holding the type of preprime constant (related in Experiment 2a and unrelated in Experiment 2b). As predicted, the results showed that naming responses were slower when the preprimes and primes were related to the target (Experiment 2a) relative to unrelated preprime conditions (Experiment 2b). However, this conclusion was reached by comparing conditions involving different experiments with different groups of participants. This comparison is somewhat problematic since overall RTs and error rates for the experiments varied significantly. For example, participants in Experiment 2a produced faster responses (763.3 ms) but higher error rates (10.3 %) than participants in Experiment 2b, who produced slower (802.2 ms) but more accurate responses (1 %). These overall differences may be due to a shift in the speed-accuracy trade-off function between the experiments. The reason for this shift is not evident, but made direct comparison between the two experiments difficult.

Hence, the aim of Experiment 3 was to assess directly the relative influence of the semantic relation of the word preprimes and the picture primes in the double-priming paradigm. Thus, in Experiment 3 the type of relation of the preprime (related and unrelated) and the type of relation of the prime (related and unrelated) were manipulated, yielding four experimental conditions: 1) related word preprimes- related picture primes, 2) related word preprimes- unrelated picture primes, 3) unrelated word preprimes- related picture primes, 4) unrelated word preprimes- unrelated picture primes. Note that the neutral prime baseline condition was composed by unrelated pictures instead that a row of asterisks used in Experiments 2a,b. In this way, the type of prime manipulation was more comparable to that in Experiment 1. If related preprimes are required to obtain semantic interference with picture primes, the two variables (type of prime and type of preprime) should interact, so that

interference would only be observed in the condition involving related word preprimes and related picture primes.

EXPERIMENT 3

METHOD

Participants. Thirty-six new psychology students at the University of Granada participated in the experiment.

Materials. Thirty-six pictures were used as targets and thirty-six pictures as primes. Twelve additional pictures were used for practice. Thirty six triads of stimuli were generated. Each of the triads involved a word preprime, a picture prime and a picture target. For each of the picture targets, four types of triads were constructed: (a) the word preprimes, the picture primes and the picture targets were related (related-related condition) (b) the word preprimes and the picture primes were related, but the picture primes and the picture targets were unrelated (related-unrelated condition), (c) the word preprimes and the picture primes were unrelated, but the picture primes and the picture targets were related (unrelated-related condition), and (d) the word preprimes, the picture primes and the picture target were unrelated (unrelated-unrelated condition). See (Table 4).

Table 4. Example of the experimental conditions used in Experiment 3. Preprime were words, prime and target were pictures (see Appendix C for the complete list of stimuli).

Condition	Preprime	Prime	Target
Related - Related	screw	nut	tile
Related - Unrelated	watermelon	grapes	tile
Unrelated - Related	watermelon	nut	tile
Unrelated - Unrelated	screw	grapes	tile

The mean visual similarity for the related preprime-prime pairs was 2.6 (SD = 0.93) and their mean functional similarity was 4.5 (SD = 1.12). For the related prime-target pairs these values were 1.8 (SD = 0.66) and 3.6 (SD = 1.24), respectively. Finally, the mean visual similarity between the preprimes and targets in the related-related condition was 1.6 (SD = 0.49) and the mean functional similarity was 3.6 (SD = 1.30). Preprimes, primes and targets were equated for lexical frequency. Thus, the mean frequency (Alameda & Cuetos, 1995) for the preprimes was 78.86 (SD = 187.91), the mean frequency for the

primes was 68.34 (SD = 102.94), and the mean frequency for the targets was 79.23 (SD = 156.36).

To avoid repetitions, four experimental lists were created. Each list was composed of nine unrelated-unrelated triads, nine unrelated-related triads, nine related-unrelated triads and nine related-related triads. Across participants each picture target appeared an equal number of times in each experimental condition. Participants named thirty six picture targets, nine in each of the four conditions. Appendix C shows the experimental materials used for this experiment.

Procedure and Design. The type of word preprimes (semantically related or unrelated) and the type of picture primes (semantically related or unrelated) were manipulated within participants and within items. The design conformed a 2 x 2 factorial model. Thus, there were four conditions in the experiment: 1) related word preprimes- related picture primes, 2) related word preprimes- unrelated picture primes, 3) unrelated word preprimes- related picture primes, 4) unrelated word preprimes- unrelated picture primes. Each participant was presented with a random sequence of 36 trials, nine trials in each of the four experimental conditions. All other details of the procedure were identical to those in Experiments 2a and 2b.

RESULTS AND DISCUSSION

Table 5 shows the mean response latencies and error rates (15.2%) for the conditions of the experiment. Note that reaction times in this experiment were slower than those in Experiment 1 and Experiment 2a and 2b. This overall increment in latencies is possibly due to the presence of preprimes (compared to Experiment 1) and to changes in the baseline line condition (asterisks in Experiment 2a and 2b and unrelated pictures in Experiment 3). In both cases analyses of the data indicated that the type of prime-target relation was significant, $F_1(1, 35) = 5.90$, MSE = 13831.8, $p < .02$; $F_2(1, 34) = 7.83$, MSE = 11301.0, $p < .008$. When the prime and target were semantically related, naming was slower (961.35 ms) than when they were unrelated (913.73 ms).

The effect of type of preprime was not significant, $F_1(1, 35) = 0.25$, MSE = 11938.19, $p > .62$; $F_2(1, 34) = 0.31$, MSE = 15479.0, $p > .58$. However, the interaction between the two variables was reliable, $F_1(1, 35) = 6.18$, MSE = 7223.7, $p < .02$; $F_2(1, 34) = 4.13$, MSE = 6586.5, $p < .05$. When the preprime was unrelated there was no difference between related and unrelated primes, $F_1(1, 35) = 0.30$, MSE = 9300.23, $p > .59$; $F_2(1, 34) = 1.05$, MSE = 8325.40, $p > .31$. However, when the preprime was a related word, the effect of the prime was significant, $F_1(1, 35) = 10.50$, MSE = 11755.28, $p < .002$; $F_2(1, 34) = 11.19$, MSE = 9562.07, $p < .002$. Therefore, the results indicated that related pictures primes produced semantic interference only when they were preceded by related word preprimes. These results replicate those reported in Experiment 2a and 2b.

Table 5. Mean reaction time (RT, in ms), percentage of errors (%Error) and standard deviation (in parenthesis) in Experiment 3 as a function of word preprime, picture prime and picture target semantic relation.

Preprime	Prime	RT	% Errors
Related	Related	974 (160)	15.4
Related	Unrelated	891 (133)	17.6
Unrelated	Related	948 (111)	13.9
Unrelated	Unrelated	935 (141)	13.8

On the other hand, when the prime was a related picture, the effect of the preprimes was not significant , $F_1(1, 35) = 0.06$, MSE = 11625.18, $p > .31$; $F_2(1, 34) = 0.30$, MSE = 15425.33, $p > .59$. However, when the prime was an unrelated picture, the effect of the preprimes was significant , $F_1(1, 35) = 4.69$, MSE = 7536.75, $p < .04$; $F_2(1, 34) = 4.14$, MSE = 6640.15, $p < .05$. This unexpected pattern may be the result of a speed-accuracy trade off since the faster responses in the related-unrelated condition were accompanied by an increase in the error rates (17.6 vs 13.8 % in the related and unrelated preprime condition). However, the main point in this experiment is that semantic interference appears only when the related picture primes were preceded by word preprimes.

GENERAL DISCUSSION

Results suggest that spreading activation at a conceptual level and competition at the lexical level may be the cause of picture-word interference effects (Glaser & Glaser, 1989; Roelofs 1992; Starreveld & La Heij, 1996). Experiment 1 indicated that interference is present with word primes but disappears when the nature of the prime enhances semantic processing (picture primes). Semantic activation from a word prime would be small relative to the semantic activation produced by a picture prime. When the prime is a picture, semantic processing would be heavily involved before processes of lexical selection take place. Conceptual activation from word primes would be less heavily involved since lexical access can be achieved directly (Bajo, 1988; Glaser & Glaser, 1989; Potter & Faulconer, 1975; Roelofs, 1992). Hence, if picture-word interference is due to the direct activation of the lexical representation by the prime word and by competition among related lexical nodes (e.g., Glaser & Glaser, 1989), the lack of effect in the picture-picture procedure could be explained by the additional activation of the conceptual representation of the prime. This strong semantic activation may override the interference produced by competing lexical representations. Specifically, the presentation of the picture primes activates their conceptual

nodes and this activation spreads to related nodes. Thus, when the prime is related to the target, the target's conceptual node is also activated, facilitating processing of the target. However, once the target is presented, activation from its conceptual node spreads down to related lexical nodes and, therefore, both the prime and target lexical nodes are activated and lexical competition between active units slows lexical selection. The absence of picture-picture interference effect is caused by the opposing effects of semantic facilitation and lexical competition.

Results of Experiments 2a and 3 indicated that interference can also be present with picture primes if a related word preprime is introduced. Lexical competition was increased by presenting related word preprimes in double-priming and interference was obtained. This interference cannot be due to the single effect of the preprime or the prime's lexical processing. First, related primes by themselves (Experiment 1) and primes preceded by unrelated word preprimes (Experiment 2b and 3) did not produce interference. Therefore, the presence of a related picture prime is not sufficient to produce the effect. Second, related preprimes followed by unrelated primes did not slow down naming the picture targets relative to the unrelated preprime-prime condition (Experiments 2a,b and 3) indicating that the preprime alone cannot be the cause of the effect.

Interference, then, seems to be due to the joint effect of conceptual and lexical processing from the preprime and prime stimuli. Depending on the relative weight of the conceptual and lexical requirements, facilitation, interference or null effects could be found. These joint conceptual and lexical effects could take several forms. First, the presentation of the preprime word could activate its lexical representation (without conceptual activation). When the picture prime is presented its conceptual representation would be activated and this activation would spread to other related representations and to their lexical nodes. Hence, the lexical representation of the preprime would receive activation from both the visual presentation of the preprime and the prime's conceptual representation. In addition, the lexical representation of the prime would receive activation from both the prime and target conceptual nodes. Therefore, when a related preprime is presented, strong competition would be induced by the prime and preprime lexical representations and this could override the possible facilitation from the conceptual activation of the target representation by the picture prime. Second, the presentation of the preprime may activate its lexical and conceptual representation. Thus, when the preprime is related, the conceptual representation of the prime would receive activation from the preprime and target representations. This strong activation would spread to the prime's lexical representation and produce strong competition to the target. This mechanism correctly predicts facilitation in normal priming conditions: 1) When the task does not require lexical selection, (e.g., lexical decision; categorization) (Dell'Acqua & Grainger, 1999; Perea & Gotor, 1997), 2) when the time from the prime to the target is too long for the target conceptual representation to affect the conceptual representation of the prime (Duaney, 2000, Experiment 2). Activation of the prime conceptual representation would spread to related concepts so that when

the target is presented, its representation would already be active, facilitating the response. However, facilitation effects from word primes are not always present (e.g., Alario et al., 2000; Experiment 1) indicating that conceptual activation does not always occur or that this activation is weaker than the activation produced by pictorial primes. Thus, although some conceptual activation may be present with word primes, lexical competition would be stronger than semantic facilitation and would produce interference.

In any case, these mechanisms seem to be based on the activation level achieved by the competing lexical representations (Levelt et al., 1999; Roelofs, 1997; Starreveld & La Heij, 1996). This competition between lexical representations is against models that explain interference effects as the result of competing semantic representations (Glaser & Düngelhoff, 1984; Lupker & Katz, 1981; Smith & Magee, 1980). In contrast, our data provide support to explanations of interference based on the presence of competition at the lexical level: Lemma access (e.g., Levelt et al., 1999; Roelofs, 1992;) or lexeme selection (Humphreys et al., 1995; Starreveld & La Heij, 1996). This lexical competition can be articulated either as a balance between activated lemmas (Levelt et al., 1999) or as due to inhibitory connections at the lexical level (Berg & Schade, 1992; Sternberger, 1992). In addition, results of Experiment 1, 2a, 2b and 3 suggest that lexical competition may oppose semantic facilitation, so that the presence of interference, facilitation or null effect would depend on the result of these opposing forces. Results of recent experiments conducted in our laboratory (Bajo, Macizo, & Soriano, in preparation) have shown that the introduction of a related picture preprime in the double-priming paradigm produced facilitation relative to conditions where the picture prime was related to the target but the picture preprime was unrelated. The presence of a related picture preprime induces spreading activation at the semantic level that overrides lexical competition.

The proposal of opposite effects of conceptual facilitation and lexical competition when picture primes are presented in picture naming is also consistent with the results of some experiments showing facilitation effects with picture primes when the task involves conceptual activation without lexical selection (e.g., categorization tasks, Dell'Acqua & Grainger, 1999; Irwin & Lupker, 1983), when the picture primes are presented too briefly prior to the target (SOAs less than 60 ms) to allow lexical activation (Bar & Biederman, 1998; Dell'Acqua & Grainger, 1999) or when a picture preprime is presented prior to the picture prime (Bajo, Macizo, & Soriano, in preparation). Macizo, Bajo, and Puerta-Melguizo (2003) reported facilitation effects with pictures primes when the participants were asked to categorised the picture target (Experiment 2) and when they were encouraged to use semantic processing in picture naming (Experiment 3). These effects were not present in regular picture-picture naming. Hence, procedures that induce semantic processing (categorization, instruction toward semantic processing) increase semantic activation and produce facilitation.

In contrast, procedures enhancing lexical processing of the picture primes seem to produce interference. Humphreys, Lloyd-Jones, and Fias (1995, Experiments 1 and 2) presented two pictures simultaneously. After a

delay, participants were signalled which picture to name. Hence, the lexical representations of the two pictures were strongly activated. In these conditions semantically related pictures produced slower naming responses than unrelated pairs.

Finally, the results of our experiments clearly indicate that the effects produced in the double-priming paradigm are the joint product of prime and preprime processing, so manipulations regarding these two types of stimuli can provide information about how different types of processing interact. Models of lexical access (Rapp & Goldrick, 2000; for a review) differ in the type of relation that they propose among the different level of representation (semantic, lexical, articulatory). The double-priming paradigm may provide a useful means to explore the relation between these different types of representation.

RESUMEN

Facilitación Semántica y Competición Léxica en Denominación de Dibujos. En el artículo se presentan cuatro experimentos que estudian los procesos de acceso léxico en denominación de dibujos. Los resultados del Experimento 1 muestran que cuando se utilizan palabras prime que están semánticamente relacionadas con el dibujo target se producen efectos de interferencia, sin embargo, este efecto no aparece cuando se utilizan dibujos prime. En el Experimento 2a, 2b y 3, se introduce una nueva técnica: Priming-doble. Esta técnica requiere que el participante nombre un dibujo (target) después de la presentación de dos estímulos: preprime y un dibujo prime. Los resultados muestran que la presentación de una palabra preprime relacionada semánticamente hizo más lenta la denominación del dibujo target (Experimentos 2a y 3). Este efecto de interferencia no se debía al efecto separado del procesamiento léxico de los primes, ya que los estímulos prime por sí mismos no produjeron el efecto (Experimento 1), tampoco lo hicieron cuando estaban precedidos por una palabra preprime no relacionada (Experimento 2b y 3). Este patrón de resultados sugiere que el acceso léxico implica dos tipos de procesos. El primero es excitatorio y de naturaleza semántica; el segundo implica procesos competitivos de selección léxica.

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APPENDIX A

Stimulus Materials Used in Experiment 1

	Prime Type	
Target	Related	Unrelated
brazo[arm]	pierna[leg]	cuchillo[knife]
caballo[horse]	burro[donkey]	piano[piano]
cerdo[pig]	vaca[cow]	mesa[table]
cisne[swan]	pato[duck]	escalera[stairs]
coche[car]	autobús[bus]	bota[boot]
copa[cup]	botella[bottle]	oveja[sheep]
corona[crown]	reina[queen]	escalera[stairs]
dedal[thimble]	aguja[needle]	sartén[frying-pan]
elefante[elephant]	oso[bear]	cenicero[ashtray]
estrella[star]	luna[moon]	limón[lemon]
gato[cat]	perro[dog]	cuchillo[knife]
hacha[axe]	sierra[saw]	cometa[comet]
jirafa[giraffe]	cebra[zebra]	sartén[frying-pan]
lámpara[lamp]	bombilla[bulb]	rama[branch]
libro[book]	lápiz[pencil]	violín[violin]
mariposa[butterfly]	mosca[fly]	cenicero[ashtray]
muñeca[doll]	pelota[ball]	vaso[glass]
ojo[eye]	labios[lips]	bota[boot]
oreja[ear]	nariz[nose]	piano[piano]
pantalón[trousers]	corbata[tie]	violín[violin]
pera[pear]	manzana[apple]	rama[branch]
pipa[pipe]	cigarro[cigarette]	cometa[comet]
pistola[gun]	escopeta[shotgun]	maleta[suitcase]
plátano[banana]	naranja[orange]	maleta[suitcase]
puerta[door]	ventana[window]	taza[cup]
radio[radio]	televisor[television]	limón[lemon]
serpiente[snake]	cocodrilo[crocodile]	mesa[table]
sobre[envelope]	sello[stamp]	oveja[sheep]
sofá[sofa]	mecedora[rocker]	vaso[glass]
tenedor[fork]	cuchara[spoon]	sombrero[hat]
tomate[tomate]	cebolla[onion]	sombrero[hat]
vestido[dress]	falda[skirt]	taza[cup]

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

APPENDIX B

Stimulus Materials Used in Experiment 2a,b

Target	Related Preprime	Prime
brazo[arm]	pierna[leg]	cabeza[head]
cama[bed]	sofá[sofa]	cuadro[picture]
camello[camel]	caballo[horse]	conejo[rabbit]
cerdo[pig]	vaca[cow]	rana[frog]
gato[cat]	perro[dog]	pato[duck]
guante[glove]	calcetín[sock]	chaleco[vest]
guitarra[guitar]	violín[violin]	tambor[drum]
mano[hand]	dedo[finger]	pie[foot]
mesa[table]	taburete[stool]	armario[closet]
oreja[ear]	ojo[eye]	pie[foot]
sandía[watermelon]	manzana[apple]	uvas[grapes]
silla[chair]	mecedora[rocker]	sillón[armchair]
sombrero[hat]	bufanda[scarf]	corbata[tie]
trompeta[trumpet]	flauta[flute]	tambor[drum]
tuerca[nut]	tornillo[screw]	destornillador[screwdriver]
cocodrilo[crocodile]	jirafa[giraffe]	conejo[rabbit]
coche[car]	camión[truck]	bicicleta[bicycle]
elefante[elephant]	zorro[fox]	rana[frog]
fresa[strawberry]	piña[pineapple]	cereza[cherry]
hacha[axe]	alicates[pliers]	destornillador[screwdriver]
naranja[orange]	limón[lemon]	uvas[grapes]
oso[bear]	serpiente[snake]	pato[duck]
piano[piano]	arpa[harp]	acordeón[accordion]
sartén[frying pan]	cuchara[spoon]	tenedor[fork]
martillo[hammer]	sierra[saw]	tijeras[scissors]
tren[train]	avión[plane]	bicicleta[bicycle]
vaso[glass]	taza[cup]	plato[plate]
muñeca[doll]	patín[skate]	pelota[ball]
pantalón[trouser]	vestido[dress]	chaleco[vest]
zapato[shoe]	falda[skirt]	corbata[tie]

Note. Stimuli were presented in Spanish. Approximate English translations are given in brackets. Related = Semantically related.

APPENDIX C
Stimulus Materials Used in Experiment 3

Target	Preprime Type		Prime Type	
	Rel-Rel Unrel-Unrel	Rel-Unrel Unrel-Rel	Rel-Rel Unrel-Rel	Rel-Unrel Unrel-Unrel
cuchillo	cafetera	caballo	cuchara	camello
[knife]	[coffee pot]	[horse]	[spoon]	[camel]
cebra	caballo	cafetera	camello	cuchara
[zebra]	[horse]	[coffe pot]	[camel]	[spoon]
ciruela	piña	avión	plátano	tren
[plum]	[pineapple]	[airplane]	[banana]	[train]
barco	avión	piña	tren	plátano
[ship]	[airplane]	[pineapple]	[train]	[banana]
tenedor	cazo	serpiente	sartén	cocodrilo
[fork]	[saucepan]	[snake]	[frying pan]	[crocodile]
ardilla	serpiente	cazo	cocodrilo	sartén
[squirrel]	[snake]	[saucepan]	[crocodile]	[frying pan]
hacha	sierra	fresa	pala	pera
[axe]	[saw]	[strawberry]	[spade]	[pear]
nuez	fresa	sierra	pera	pala
[nut]	[strawberry]	[saw]	[pear]	[spade]
plato	copa	perro	vaso	gato
[plate]	[wineglass]	[dog]	[glase]	[cat]
mosca	perro	copa	gato	vaso
[fly]	[dog]	[wineglass]	[cat]	[glass]
corbata	manopla	acordeón	guante	violín
[tie]	[gauntlet]	[acordion]	[glove]	[violin]
piano	acordeón	manopla	violín	guante
[piano]	[accordion]	[gauntlet]	[violin]	[glove]
avestruz	oso	pierna	conejo	brazo
[ostrich]	[bear]	[leg]	[rabbit]	[arm]
cabeza	pierna	oso	brazo	conejo
[head]	[leg]	[bear]	[arm]	[rabbit]
banco	silla	camión	taburete	coche
[bench]	[chair]	[trunck]	[stool]	[car]
bicicleta	camión	silla	coche	taburete
[bicycle]	[truck]	[chair]	[car]	[stool]
alicates	tornillo	sandía	tuerca	uvas
[tile]	[screw]	[watermelon]	[nut]	[grapes]
melocotón	sandía	tornillo	uvas	tuerca
[peach]	[watermelon]	[screw]	[grapes]	[nut]
jirafa	león	ojo	elefante	oreja
[jiraffe]	[lion]	[eye]	[elephant]	[ear]
nariz	ojo	león	oreja	elefante
[nose]	[eye]	[lion]	[ear]	[elephant]
cinturón	bufanda	mecedora	calcetín	sofá
[belt]	[scarf]	[rocker]	[sock]	[couch]
armario	mecedora	bufanda	sofá	calcetín
[closet]	[rocker]	[scarf]	[couch]	[sock]

salero	jarra	vaca	taza	cerdo
[salt cellar]	[jar]	[cow]	[cup]	[pig]
oveja	vaca	jarra	cerdo	taza
[sheep]	[cow]	[jar]	[pig]	[cup]
pato	rana	mano	tortuga	pie
[duck]	[frog]	[hand]	[turtle]	[foot]
dedo	mano	rana	pie	tortuga
[finger]	[hand]	[frog]	[foot]	[turtle]
arpa	trompeta	bota	flauta	zapato
[harp]	[trumpet]	[boot]	[flute]	[shoes]
sombrero	bota	trompeta	zapato	flauta
[hat]	[boot]	[trumpet]	[shoes]	[flute]
camisa	vestido	muñeca	falda	pelota
[shirt]	[dress]	[doll]	[skirt]	[ball]
patín	muñeca	vestido	pelota	falda
[skate]	[doll]	[dress]	[ball]	[skirt]
guitarra	tambor	jarrón	pandereta	lámpara
[guitar]	[drum]	[vase]	[tambourine]	[lamp]
cuadro	jarrón	tambor	lámpara	pandereta
[picture]	[vase]	[drum]	[lamp]	[tambourine]
blusa	chaleco	hamaca	pantalón	cama
[blouse]	[vest]	[hammock]	[trousers]	[bed]
mesa	hamaca	chaleco	cama	pantalón
[table]	[hammock]	[vest]	[bed]	[trousers]
tijeras	martillo	limón	destornillador	naranja
[scissors]	[hammer]	[lemon]	[screwdriver]	[orange]
cereza	limón	martillo	naranja	destornillador
[cherry]	[lemon]	[hammer]	[orange]	[screwdriver]

Note. Stimuli were presented in Spanish. Approximate English translations are given in brackets. Rel = Semantically related. Unrel = Not semantically related. Stimuli are organized according to the experimental condition in which they were used.

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