

Unconscious Congruency Priming From Unpracticed Words Is Modulated by Prime–Target Semantic Relatedness

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Participants performed a 2-choice categorization task on visible word targets that were preceded by novel (unpracticed) prime words. The prime words were presented for 33 ms and followed either immediately (Experiments 1–3) or after a variable delay (Experiments 1 and 4) by a pattern mask. Both subjective and objective measures of prime visibility were used in all experiments. On 80% of the trials the primes and targets belonged to different categories (incongruent trials), whereas in the remaining 20% (congruent trials) they could be either strong or weak semantically related category members. Positive congruency effects (reaction times faster on congruent than on incongruent trials) were consistently found, but only when the mask immediately followed the primes, and participants reported being unaware of the identity of the primes. Primes followed by a delayed mask (such that participants reported being aware of their identity) produced either nonreliable facilitation or reliable reversed priming (strategic), depending on whether the prime–target stimulus onset asynchrony was either short (200 ms; Experiments 1 and 4) or long (1,000 ms; Experiment 4). Facilitatory priming with immediate mask was found strong (a) even for participants who performed at chance in prime visibility tests; and (b) for high but not for weakly semantically related category coordinates, irrespective of category size (animals, body parts). These findings provide evidence that unconscious congruency priming by unpracticed words from large stimulus sets critically depends on associative strength and/or semantic similarity between category coexemplars.

Keywords: unconscious congruency priming, congruency priming from novel words, prime–target semantic relatedness

Can semantic information be extracted from unconsciously presented words and subsequently influence behavior? To address that question, one line of research frequently used over the last decade has employed binary categorization tasks. Participants are asked to categorize visible target words (e.g., animal vs. nonanimal) that are preceded by briefly flashed, visually masked primes whose category (and/or response) is either congruent or incongruent with the target (Dehaene et al., 1998; Greenwald, Klinger, & Schuh, 1995; Klauer, Eder, Greenwald, & Abrams, 2007; see Kouider & Dehaene, 2007; Van den Bussche, Van den Noortgate,

& Reynvoet, 2009, for reviews). A congruency priming effect occurs when target categorization on congruent trials (e.g., *lion–dog*) is faster and/or more accurate than on incongruent trials (*table–dog*). Such priming has been described as unconscious in nature when subjects reported being unaware of the identity of the prime (Ortells, Daza, & Fox, 2003), and they could not directly categorize the masked primes in a separate test of prime visibility (Dehaene et al., 1998).

Evidence for reproducible unconscious congruency priming has been accumulated across a variety of categorization tasks, such as positive versus negative valence judgments (Klauer et al., 2007), number classification (Dehaene et al., 1998; Naccache & Dehaene, 2001), size discrimination (Kiesel, Kunde, Pohl, & Hoffmann, 2006; Van den Bussche & Reynvoet, 2007), gender classification (Greenwald & Abrams, 2002; Klauer et al., 2007), and category exemplars versus nonexemplars (Forster, Mohan, & Hector, 2003; Van den Bussche & Reynvoet, 2007).

Recently, however, the mechanisms underlying unconscious congruency priming from words have attracted considerable interest and debate (Kang, Blake, & Woodman, 2011; Kouider & Dehaene, 2007; Van den Bussche, Van den Noortgate, & Reynvoet, 2009). One of the most straightforward ways to explain congruency priming from masked primes is that these stimuli are unconsciously categorized and processed semantically (e.g., Dehaene et al., 1998).

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Subsequent findings have suggested, however, that the observed results can be explained by alternative nonsemantic interpretations. On the one hand, many prior demonstrations of unconscious congruency priming have used a reduced stimulus set, with the undesirable consequence that the critical masked primes reappear as classified visible (conscious) targets in different trials (e.g., Dehaene et al., 1998; Draine & Greenwald, 1998; Greenwald, Draine, & Abrams, 1996). This repetition of items may allow the primes to be identified superficially, where the identification of isolated features (e.g., word fragments of one or more letters) could aid the retrieval of their identity without accessing semantic information. For example, the unconscious primes may activate the stimulus–response (S-R) links that were mapped and practiced with the conscious target stimuli (e.g., Damian, 2001; Neumann & Klotz, 1994) or even activate the practiced links between targets and a more abstract response-related representation, such as its response category (e.g., Abrams, Klinger, & Greenwald, 2002), curtailing the need for semantic processing of unconscious primes.

Another nonsemantic account of unconscious congruency priming has been developed by Kunde, Kiesel, and Hoffmann (2003). These authors assume that following task instructions, participants intentionally prepare action triggers for the stimuli they might receive later in the experiment. These action triggers create automatic associations between all expected stimuli and their appropriate responses. When a prime stimulus is included in the prepared action trigger set, it can automatically trigger the adequate response and evoke priming without the need to undergo semantic processing. Note that the action trigger hypothesis could effectively explain masked congruency priming effects not only for repeated primes but also for unpracticed primes, as long as they fell inside the expected stimulus range. In addition, a prediction from this account is that these action triggers would be more readily applied when a reduced stimulus set and/or a small category (e.g., months; animal farms) is used. Yet, as such a mechanism relies on the sustained expectancy of a number of individual instances, it seems unlikely (as acknowledged by Kunde et al., 2003) that subjects are able to form action triggers for all possible members of large task categories. This would also be particularly the case in categories that include many perceptually dissimilar members (e.g., small vs. large objects; positive vs. negative words; animals vs. nonanimals).

To decide between semantic and nonsemantic interpretations, one should consider whether subliminal stimuli from large categories and stimulus sets that are never presented as visible targets (i.e., novel or unpracticed primes) can elicit reliable congruency priming. If unpracticed primes remain ineffective despite their fit to the current task instructions, congruency priming would be restricted to acquired S-R mappings. By using pictures as prime stimuli, several prior studies (e.g., Dell'Acqua & Grainger, 1999; Van den Bussche, Notebaert, & Reynvoet, 2009; see also Pohl, Kiesel, Kunde, & Hoffmann, 2010) have reported reliable semantic congruity effects from subliminal primes that were part of a large stimulus set and never appeared as targets during the experiment. These findings provide a clear-cut demonstration of unconscious congruency priming at the semantic level, as they cannot be explained in terms of prime–target orthographic overlap, action triggers or stimulus–response mappings. In clear contrast, when prime stimuli consist rather of symbolic carriers such as words, the evidence of unconscious congruency priming with unpracticed

primes from large categories has been elusive so far.¹ Whereas some studies have reported reliable (although generally small) priming effects from unpracticed words (e.g., Kiesel et al., 2006; Klauer et al., 2007; Van den Bussche & Reynvoet, 2007), others have reported no effect at all (e.g., Abrams, 2008; Abrams & Greenwald, 2000; Damian, 2001; Forster et al., 2003), even under very similar task demands and stimulus presentation conditions (see, e.g., the opposite pattern of results reported by Forster et al., 2003, and Van den Bussche & Reynvoet, 2007, both using animal targets).

In an attempt to account for the discrepancies among studies, Abrams (2008) has recently explained that congruency priming effects from both practiced words and novel (unpracticed) words from small categories occur reliably, but both can be attributed to processing that does not entail full semantic access (e.g., subword level). In contrast, priming from unpracticed words grouped in large categories (which would involve extraction of whole-word meaning) occurs only under some circumstances. According to Abrams (2008), when the category size is large, the dependence of priming of semantic access apparently results in weaker effects that are highly sensitive to minor procedural differences (e.g., prime–target orthographic overlap, test power, type of masking, or prime duration). The present research was designed to test directly for reliable and consistent unconscious congruency priming in this set of words.

A difference between masked congruency priming and the more conventional semantic priming paradigm (Neely, 1991), which could be relevant here, concerns semantic similarity or association strength between prime and target words. Semantic similarity (e.g., McRae & Boisvert, 1998) reflects the similarity in meaning or the overlap in feature descriptions of two words (e.g., *whale–dolphin*). Association strength is a normative description of the probability that one word will call to mind a second word (e.g., Postman & Keppel, 1970). Although the degree of semantic similarity and associative strength between two words do not necessarily covary together, highly associated items tend to share more or stronger semantic relations than weakly associated members (e.g., Hutchison, 2003; Hutchison, Balota, Cortese, & Watson, 2008; McNamara, 2005; but see Coane & Balota, 2011). Accordingly, the term *semantic relatedness* has frequently been used in a wide sense to refer to category coexemplars that are both strongly associated and highly similar in semantic overlap.

This is the case in a standard semantic priming procedure, in which the semantically related trials traditionally consist of strongly associated and semantically similar word pairs. It is well documented that highly associated words from the same semantic category that share also a large semantic feature overlap (e.g., *cat–dog*; *bread–butter*) reliably prime each other in lexical decision, naming, and categorization tasks (Hutchison et al., 2008; McNamara, 2005). But the evidence for associative priming in the absence of semantic similarity is weaker by comparison (Lucas, 2000; but see Coane & Balota, 2011). Likewise, the evidence for “pure” semantic priming (i.e., defined only in terms of category

¹ As suggested by Kouider and Dehaene (2007; see also Kang et al., 2011), it remains possible that picture stimuli could have a more direct access to meaning representations, thus leading to stronger semantic effects under subliminal conditions than word stimuli.

co-membership) in the absence of associative relation is also weak (e.g., Abad, Noguera, & Ortells, 2003; Hutchison, 2003), and it is likely to mainly reflect task-dependent strategic processes such as the expectation of individual category members similar to the action triggers described earlier (Kunde et al., 2003). Consequently, automatic semantic priming (not modulated by strategies) seems to be due to both association strength and semantic feature overlap. But the very fact of being members of the same category does not seem to be enough to observe reliable automatic priming (Hutchison, 2003; see also McRae & Boisvert, 1998).

In clear contrast to the semantic priming literature, congruency priming is normally manipulated by selecting primes and targets that share (congruent) or not (incongruent) the same category, becoming an irrelevant aspect of these pairs whether they are more or less associatively and/or semantically related. This practice implicitly assumes that a congruency priming effect mainly results from a competition between the prime and target categories, thus reflecting category or response congruity instead of semantic priming in the classic sense of spreading activation theories (Collins & Loftus, 1975). But in a vast majority of masked congruency priming studies, the pairs presented on congruent trials consist of a random mixture of more and less related items in terms of associative norms and/or semantic feature overlap (e.g., *bull-fly*; *shark-donkey*; *ape-cat*; see, e.g., Van den Bussche & Reynvoet, 2007, Appendix B, p. 235).

On the basis of these considerations, it remains possible that prior congruency priming studies reporting null or inconsistent results have used category exemplars that were not sufficiently strongly related (in terms of association strength and/or semantic similarity) to produce robust priming effects. The use of more (e.g., *eagle-hawk*) or less closely related (e.g., *tiger-hawk*) category members in congruency priming might not be an issue when a reduced stimulus set is presented repeatedly, or even with unpracticed primes from small categories (e.g., months, numbers, farm animals). Yet, prime-target semantic relatedness could be critical when using a large set of unrepeated prime words from broader categories (e.g., animals). Under these circumstances, the different proportion of more versus less closely related word pairs used across studies could be critically responsible for substantial variations in the size and significance of their priming effects, even when using similar stimulus presentation conditions. A main goal of the present research was to examine whether congruency priming from unpracticed words could be modulated by prime-target semantic relatedness. Accordingly, we used in our experiments a modified congruency priming procedure that allows manipulating that factor.

Single Dissociation Versus Qualitative Differences for Demonstrating Unconscious Perception

The bulk of research on masked congruency priming has generally followed the tradition of demonstrating a single or classic (Schmidt, 2007) dissociation between two measures of perception of the critical stimulus: a *direct* (subjective or objective) measure that reflects the effect of a perceived stimulus on the instructed response to that stimulus, and thus indicates whether relevant stimulus information has been consciously perceived; and an *indirect* measure (e.g., priming) that reflects an uninstructed effect of the stimulus on behavior and is an indication of unconsciously

perceived information. Perception without awareness is demonstrated when the indirect measure is sensitive to stimulus information to which the direct index shows null sensitivity. Despite the straightforward logic underlying the single dissociation paradigm, it has proved a difficult and challenging task to provide uncontroversial evidence for perception without awareness.

A widely held assumption underlying the single dissociation paradigm is that to provide compelling evidence for unconscious perception, the direct measure must be assumed to be sensitive to all relevant conscious effects of stimuli (i.e., an exhaustiveness assumption) and should exhibit null sensitivity (a “zero-awareness” criterion; see Schmidt, 2007). If it is not, any dissociation between measures may indicate simply that the direct and indirect indexes are sensitive to different aspects of consciously perceived stimuli. In addition, the direct measure should exclusively reflect conscious influences. If a direct effect is sensitive to both consciously and unconsciously perceived information, then any attempt to establish null sensitivity for the direct measure could eliminate or underestimate evidence for unconscious perception. But requiring that direct measures reflect exclusively and exhaustively all relevant consciously perceived information may be too stringent a requirement for the demonstration of unconscious influences. As pointed out by Reingold and Merikle (1988, 1990; see also Merikle & Reingold, 1998), it seems more likely that any direct effect (like any indirect one) might stem from both conscious and unconscious contributions.

A further weakness of studies looking for single dissociations concerns the use of a facilitation paradigm, whereby unconscious perception produces the same pattern of results (e.g., facilitatory priming) as does conscious perception. Because both types of processes can contribute to performance in a similar way (i.e., by facilitating it), it is difficult to determine whether the supposedly unconscious influences might be partially or completely attributed to any residual conscious perception (Debnar & Jacoby, 1994).

An alternative and more powerful approach for establishing unconscious processing, which requires neither the use of exhaustive measures of awareness nor a convincing demonstration of a null effect, involves the demonstration of qualitatively different (or even opposite) behavioral effects (or double dissociations; see Schmidt, 2007) as a result of perceiving the critical stimulus with versus without conscious awareness (e.g., Daza, Ortells, & Fox, 2002; Merikle & Joordens, 1997; Merikle, Joordens, & Stolz, 1995; Ortells, Daza, & Fox, 2003; Ortells, Vellido, Daza, & Noguera, 2006; see also Joordens & Hockley, 2000, for the use of a similar qualitative differences logic in recognition memory tasks).

In a relevant application of this technique, Ortells et al. (2003) used a congruency priming procedure in which participants performed a categorization task on visible targets that were preceded by briefly presented (33 ms) masked prime words. The prime and target words were highly associated members of the same semantic category on 20% of trials (congruent) and belonged to different categories on the remaining 80% (incongruent). The likelihood that the prime was consciously perceived was manipulated by varying the interval between the prime word and a pattern mask that appeared either immediately or after a time delay following the prime offset (see also Daza et al., 2002; Merikle & Joordens, 1997). A dissociated priming pattern as a function of masking condition was consistently found: With a delayed mask, reaction

times (RTs) were slower on congruent (less frequent) than on incongruent trials. Such a reversed priming effect indicates that participants consciously identified the prime words and learned to use them in a strategic manner to anticipate the target category (Daza et al., 2002; Logan, Zbrodoff, & Williamson, 1984; Merikle & Joordens, 1997). The reversed priming effect was significant at a prime–target stimulus onset asynchrony (SOA) of 400 ms or longer, but never at the shorter intervals (e.g., 200 and 300 ms). These results were consistent with prior research showing that controlled processes build up more slowly (and are often more sustained) than automatic ones (e.g., Neely, 1977; Ortells, Abad, Noguera, & Lupiáñez, 2001; Posner & Snyder, 1975; Shenaut & Ober, 1996). By contrast, after an immediate mask, when participants systematically claimed to be unaware of the identity of the prime, the opposite pattern was obtained: RTs were faster on congruent than on incongruent trials. This facilitatory priming does not appear to reflect strategic influences, as it reached significance only at relatively short SOAs (less than 400 ms; see also Daza et al., 2002) and was unaffected by either practice (Ortells et al., 2003), or context manipulations (Ortells et al., 2006).

Note, however, that in all experiments conducted by Ortells and collaborators (Ortells et al., 2003, 2006), a small stimulus set was used (four animal and four body part words) in a way such that every visible (conscious) target reappeared on other trials as a masked prime. As outlined above, a representation including semantic information about the category of the target may be triggered by partial visual information (e.g., a masked fragment of the whole word), leading to categorical priming effects in the absence of a proper semantic analysis of prime words. We asked therefore whether the facilitatory congruency priming reported by Ortells and colleagues in the absence of prime awareness (i.e., immediate masking) could also be observed from unpracticed words that had not previously appeared as visible targets. To this end, the modified congruency-priming task by Ortells et al. (2003) was used in the present research.

Experiment 1

The procedure used in the present experiment was similar to that by Ortells et al. (2003, Experiment 2) but with three differences: First, we used a much larger stimulus set in which prime words never occur as targets. Second, the mask types (immediate vs. delayed) were randomized within subjects. Note that by adopting this procedure, we tried to prevent participants from using separate strategies for immediate and delayed masks in the different conditions. With this procedure we expected to obtain reliable facilitatory priming (i.e., RTs faster on congruent than on incongruent trials) in the absence of prime awareness (immediate masking) but not when participants could be aware of the identity of the prime (delayed masking). In the latter case, we expect to find at least a null priming effect (if not reversed), since the short SOA of 200 ms may not allow enough time to fully implement the strategic processes (Daza et al., 2002; Ortells et al., 2001; Ortells et al., 2003).

Last, in the aforementioned studies by Ortells and colleagues (Ortells et al., 2003, 2006), prime awareness was only assessed on the basis of introspective self-reports of conscious perceptual experiences (see also Daza et al., 2002; Merikle & Joordens, 1997). Note, however, that an increasing number of researchers over the years have preferred to use objective measures of conscious aware-

ness (i.e., the observer's inability to discriminate between alternative stimulus states). The underlying assumption is that they would provide a better method than the subjective measures to demonstrate perceptual awareness (e.g., Van den Bussche, Van den Noortgate, & Reynvoet, 2009). Accordingly, and despite using a double dissociation paradigm that would not require the use of objective measures of prime awareness (Merikle & Joordens, 1997), in all experiments presented here prime awareness was measured through both subjective and objective measures of perceptual discrimination on masked primes.

Method

Participants. Twenty-six undergraduate students at the University of Almería took part in the experiment, receiving course credit for their participation. All had normal or corrected-to-normal vision and were aged between 21 and 25 years ($M = 23$). All participants consistently reported being able to identify the prime words followed by a delayed mask on all or most of the trials, whereas they claimed to be unaware of identity of the prime on all (17 participants) or most (nine participants) of the immediate masking trials.

Apparatus and stimuli. The stimuli were presented on a PC connected to a VGA enhanced graphics monitor. Stimulus delivery and response recordings were controlled by E-Prime (Version 1.1).

All stimuli were displayed in gray color against a black background, appearing at the center of the screen at a viewing distance of approximately 60 cm. Each character was 0.29° wide and 0.49° high. A random string of seven grey letters (e.g., *MDGTKSN*), subtending about 2.46° horizontally and 0.49° vertically, was used as the pattern mask.

One hundred twenty concrete and familiar nouns of four to seven letters in length (60 animals and 60 body parts) were selected from the intracategorical associative norms published by Callejas, Correa, Lupiáñez, and Tudela (2003). From this set, 60 words (30 per category) were presented only as masked primes, and the remaining 60 (30 per category) were presented only as visible targets (see Appendix A; a different set of 20 words, 10 animals and 10 body parts not included in Appendix A, was presented during practice trials). For all experimental trials, the word pairs were matched on subjective familiarity (max. = 7; min. = 1; see Callejas et al., 2003) between the semantic categories (animals = 5.24; body parts = 5.94), and for both congruent (primes = 5.97; targets = 6.01) and incongruent trials (primes = 5.20; targets = 5.24). To minimize orthographic overlap between prime and target stimuli in this and the remaining experiments, neither congruent nor incongruent trials contained any target word that shared a first letter with any novel prime (see Appendix A). The prime–target pairs presented on congruent trials were always highly associated category members (i.e., the first ranked exemplar, on both forward and backward directions, in the norms of Callejas et al.; see Table 3). Participants had to indicate the category (animal vs. body part) of the target by pressing either the *M* or the *C* key on the computer keyboard. The mapping between categories and response keys was counterbalanced across participants.

Design and procedure. Participants were tested individually in a sound-damped, dimly lit room. General task instructions were displayed on the monitor and also delivered orally. The timing of

the events on immediate masking (prime-mask SOA of 33 ms) trials was as follows: (a) fixation display (*), presented for 500 ms; (b) prime word, in uppercase, presented for 33 ms; (c) pattern mask (e.g., *ZKDMLSM*), presented for 167 ms; (d) and a target word, in lowercase, presented until response. This sequence produced a prime–target SOA of 200 ms. The delayed masking (prime-mask SOA of 167 ms) trials contained a similar sequence of events, except that the offset of the prime word was now followed by a 34-ms blank screen and a 133-ms pattern mask, thus matching the 200-ms SOA of the immediate masking trials. The two masking conditions varied randomly within the experiment. Participants were asked to make a categorization judgment (animal or body part) on the target word. A correct response would trigger the onset of the following trial. If the response was incorrect, the following trial would start after a 500-ms beep. The intertrial interval was 1,000 ms.

Participants took part in a single session (lasting about 20 min) consisting of 40 practice trials followed by 240 experimental trials, 120 immediate masking trials, and 120 delayed masking trials. Within each masking condition, 80% were incongruent trials, in which the prime and target belonged to different semantic categories. The remaining 20% were congruent trials, in which the prime and target were always high associated category members (e.g., *COW–bull*; *HAND–finger*). Participants were asked to respond as fast as possible and were informed about the relative proportions of congruent and incongruent trials and encouraged to use this information to optimize their categorization performance. So, given a particular prime word, they should expect that the upcoming target would belong to a different semantic category, since the incongruent trials were much more frequent than the congruent trials (see Neely, 1977, for a similar procedure). After completing the computerized priming task, participants were questioned about the consciousness they had on the prime words preceding the masking pattern on both immediate and delayed masking trials. This was achieved by means of a Likert-type scale ranging from 1 (*prime fully unconscious on all the priming trials*) to 7 (*prime fully conscious on all the trials*; see Ruz, Madrid, Lupiáñez, & Tudela, 2003, for a similar procedure).

Following the priming task, participants did a test on prime visibility that began with 20 practice trials followed by 120 experimental trials (60 immediate and 60 delayed masking trials), with stimuli timings similar to those from the priming task. The only differences were the following:

1. Participants were instructed to categorize the masked prime and to press either the *M* or *C* keys, depending on whether the prime was either an animal or a body part (the response assignment to semantic categories was counterbalanced across participants). Participants were informed that the prime word could be either an animal or a body part with an identical probability (.50). If they were unable to categorize the prime, they were forced to guess (forced choice) without time limit.
2. When the masked prime disappeared, the category name *Animal?* was presented for half of participants and *Body part?* for the other half. In previous congruency priming studies using a prime visibility test, the presentation conditions of that test were usually the same as during the

priming task. Namely, the masked prime was followed by a target word, although participants were instructed to respond to the masked prime instead of the target. Note however that the incongruent trials in our research were much more frequent (80%) than the congruent ones (20%), and participants were informed of this. Under these circumstances, it is possible that presenting a target word on each trial of the visibility test could help participants to correctly guess the category of the preceding prime word, thus inducing an abnormally good performance in that test. For example, if the target word was a body part, then the probability that the preceding masked prime was an animal word was 0.8. Accordingly, to avoid the involvement of strategic-response biases in the visibility test, the mask offset was always followed by the same category name (*Animal* or *Body part*, depending on group), instead of a target word.

Results

Priming task. Trials containing an incorrect response (6.8% of total) or those with RTs falling more than 2.5 standard deviations from the overall mean RT (2.47% of trials) were removed from analyses. Mean RTs and percentage errors per participant and per condition were entered in two separate analyses of variance (ANOVAs) with target category (animals vs. body parts), masking condition (immediate vs. delayed), and prime–target congruency (congruent vs. incongruent) as within-subject variables. Mean RTs and mean error percentages as a function of masking condition and congruency are shown in Table 1.

No reliable effects were found in the analysis of error rates (all *F* values < 1). In the analysis of RTs, there was a significant main effect of target category, $F(1, 25) = 17.1, p < .001, \eta^2 = .41$, where body-part targets were responded to 37 ms slower than animal targets. As this factor did not interact with any of the others, the data were averaged across the categories for further analyses. There were significant main effects of masking condition, $F(1, 25) = 11.8, p = .01, \eta^2 = .32$, and congruency, $F(1, 25) = 12.8, p = .01, \eta^2 = .34$, and of more interest, a significant interaction between both variables, $F(1, 25) = 8.2, p = .01, \eta^2 = .25$. Further analyses of the interaction (see Table 1) showed significant facilitation priming on immediate masking trials, 38

Table 1
Mean RTs, Error Percentages, and Differences in RTs as a Function of Masking Condition and Congruency for Experiment 1

Condition	Incongruent	Congruent	Priming
Immediate mask			
RT in ms: <i>M</i> (<i>SD</i>)	707 (81.7)	669 (82.6)	
Error: % (<i>SD</i>)	7.1 (6.1)	5.5 (5.1)	
Difference in RTs (in ms)			+38*
Delayed mask			
RT in ms: <i>M</i> (<i>SD</i>)	714 (86.6)	707 (90.6)	
Error: % (<i>SD</i>)	7.6 (7.3)	6.8 (7.8)	
Difference in RTs (in ms)			+7

Note. RT = reaction time; + = facilitatory priming.
* $p < .05$.

ms, $t(25) = 7.48$, $p < .001$, but not on delayed masking trials, 7 ms, $t(25) = 0.65$, $p = .52$.

Most of the published reports of semantic priming tend to emphasize the mean level of priming observed, ignoring the individual variability that usually underlies the mean effect. Stolz, Besner, and Carr (2005; see also Waechter, Besner, & Stolz, 2010) recently took the opposite tack to examine whether the observed individual differences in semantic priming effects are systematic or rather arise from random processes. They examined test–retest (and split-half) reliability of semantic priming by presenting two comparable sets of prime–target pairs across two consecutive trial blocks in a series of lexical decision experiments that crossed relatedness proportion (RP: .25, .50, and .75) with prime–target SOA (200 ms, 350 ms, and 850 ms). Although robust and fairly similar priming effects across blocks were found, the correlations between participants' priming scores on the two blocks (i.e., test–retest reliability) were low and nonsignificant under conditions that maximized the impact of automatic processes (i.e., 200-ms SOA and a low RP of .25). According to Stolz et al. (2005), semantic priming effects under automatic conditions would be noisy and variable, perhaps reflecting inherently uncoordinated, rather than coherent, activity in participants' semantic memory.

The conclusion from Stolz et al. (2005) warrants concern for the current study, as we also presented the prime words under some conditions that highlighted automatic processing (i.e., immediate masking, short 200-ms SOA, 20% of related congruent trials). To examine test–retest reliability of congruency priming effects in our experiment, in which the same word set was presented across two consecutive trial blocks, we correlated the mean priming score from each participant in the first block with the mean priming score in the second block.

It is also important to note that in the Stolz et al. (2005) study the priming scores entered into the reliability tests were based on raw (or trimmed) RT means. Hutchison et al. (2008) demonstrated that applying a z -score transformation on raw RTs (i.e., each participant's RT is normalized with respect to its overall RT) has the potential to correct for individual differences in speed and variability across conditions (see also Faust, Balota, Spieler, & Ferraro, 1999). This transformation also reduces variability emerging from differences in baseline RTs. The results by Hutchison et al. (2008) showed that, compared to priming scores based on raw RTs, normalized scores increased the reliability of semantic priming effects.

On the basis of these considerations, for all experiments in this article we also analyzed standardized priming effects by converting each RT to a z -score based on the subject's overall mean and standard deviation (e.g., Hutchison et al., 2008; see also Faust et al., 1999).² In addition, we examined test–retest reliability on priming scores based on both raw means and z -score means.

The analyses on standardized RTs showed a very similar result pattern to that found on raw RTs. Namely, congruency priming was reliably greater on immediate masking trials, .26 ms, $t(25) = 7.76$, $p < .001$, than on delayed masking trials, .06 ms, $t(25) = 0.91$, $p = .37$, as revealed by a significant Congruency \times Masking Type interaction, $F(1, 25) = 8.55$, $p = .007$, $\eta^2 = .26$. Regarding test–retest reliability of congruency priming, in contrast to the weak and nonsignificant reliability reported by Stolz et al. (2005), we found significant correlations on both raw RTs ($r = .46$, $p = .017$) and standardized RTs ($r = .44$, $p = .028$). These reliability

indexes demonstrate that there is indeed some predictable variability in priming within each individual, even under conditions promoting automatic processing of primes (e.g., immediate masking; short prime–target SOA).

Prime visibility test. To assess prime visibility, we computed the signal detection measure d' for each participant. The measure was obtained by treating one level of the prime category (e.g., animal) as signal and the other level (e.g., body part) as noise. Overall discrimination for primes on delayed masking trials was $d' = 1.71$ (the mean hit rate was 77%, false alarm rate was 24%); for primes on immediate masking trials it was $d' = .55$ (mean hit rate = 58%, false alarm rate = 37%). Discrimination values deviated from zero for both the delayed, $t(25) = 7.64$, $p = .01$, and the immediate mask conditions, $t(25) = 5.65$, $p = .01$. Yet, the above-chance performance in the latter condition does not necessarily reveal conscious perception of the immediately masked primes. Indeed, all participants reported the subjective impression of having responded at chance on the immediate masking trials in the visibility task. Additionally, the d' measure and the index for the respective amount of priming did not correlate with each other for both immediate ($r = .14$, $p = .47$) and delayed mask conditions ($r = .19$, $p = .33$), indicating that the observed priming effects were unrelated to participants' perceptual sensitivity to the masked primes.

The lack of relation between priming effects and prime visibility measures is common in the unconscious priming literature (e.g., Damian, 2001; Kiesel et al., 2006; Van den Bussche, Van den Noortgate, & Reynvoet, 2009; Van den Bussche & Reynvoet, 2007). Finding no reliable correlation between both measures could partly reflect small reliability in either task due to, for example, high individual differences in baseline RTs (Hutchison et al., 2008). But in our experiment reliability in unconscious priming measures was significant for both raw and standardized RTs. We also found that d' measures across immediate and delayed masking trials significantly correlated with each other ($r = .44$, $p = .02$). Alternatively (although not incompatible with the previous explanation), the lack of relation between direct and indirect measures of prime processing is that both tasks performances could be influenced by different mechanisms or task demands (this issue will further be addressed in the General Discussion). Whereas in the priming task participants were encouraged to make fast (and accurate) discriminations to the target word, during the visibility test participants were asked to exclusively attend to the prime (ignoring the target), with emphasis on accuracy rather than on speed.

Despite the observed lack of correlation between direct and indirect measures, the usual practice in many recent studies is conducting linear regression analyses (e.g., Greenwald et al., 1996) in which priming effects are regressed on prime visibility indexes (e.g., Klauer et al., 2007; Van den Bussche, Van den Noortgate, & Reynvoet, 2009; Van den Bussche & Reynvoet, 2007). Finding a significant priming index at a zero prime visibility ($d' = 0$) intercept would reveal evidence of unconscious processing.

The linear regression method has the advantage of not relying on the acceptance of the null hypothesis of zero prime visibility in testing for priming effects in the absence of prime awareness. But

² We thank Keith A. Hutchison for making this suggestion.

in the absence of a correlation between direct (d') and indirect (priming) measures, the regression intercept index may simply reveal the overall mean sensitivity of the indirect measure (i.e., the mean priming effect; Doshier, 1998; Merikle & Reingold, 1998). Because we cannot completely rule out that possibility,³ in this and remaining experiments we applied an alternative strategy of splitting observers into two different groups based on their performance in the immediate mask trials of the visibility test.

Participants with a null or negative d' score on immediate masking trials in the prime visibility test ($N = 9$) were assigned to a "lower d' values" group. The remaining participants (17) were assigned to a second "higher d' values" group. Whereas the latter group showed a d' mean of .87 for the immediate mask condition that was reliably above chance, $t(16) = 10.20, p < .001$, the group with lower d' values showed a d' mean of $-.01$ that did not reliably differ from zero, $t(8) = -0.08, p = .94$. Importantly, significant facilitatory priming with the immediate but not with the delayed mask was observed in both groups: participants with higher discrimination [immediate = +40 ms; $t(16) = 6.54, p < .001$; delayed masking = +8 ms; $t(16) = 0.86, p = .40$], and more critical for our study, those performing at chance [immediate = +34 ms; $t(8) = 3.63, p = .006$; delayed = 5.2 ms; $t(8) = 0.19, p = .85$]. These latter results provide strong evidence for the unconscious nature of the masked priming effects in our experiment. The present findings also demonstrate that the use of suboptimal presentation conditions of prime words is not the reason why our priming effects are so large compared to other congruency priming studies (on average, about 10–15 ms; see Van den Bussche, Van den Noortgate, & Reynvoet, 2009, for a recent review). Indeed, positive priming effects remained substantial even for participants performing at chance in the prime visibility test.

Discussion

There were two main findings in the present experiment. First, by using a modified congruency procedure in which the congruent trials (less frequent, 20%) consisted of highly associated category coordinates, we replicated prior results showing that obtaining facilitatory priming with this task directly depends on whether the prime words are or are not consciously perceived (Ortells et al., 2003, 2006). When the primes were immediately followed by the mask, thus rendering them consciously unidentifiable, strong facilitatory priming was found, regardless of whether participants performed either at chance or above chance in a prime visibility posttest. In contrast, when the onset of the mask was delayed, thus making the primes clearly visible, facilitation effects did not reach significance, being also significantly smaller than those observed with an immediate mask. The finding that consciously perceived primes (delayed mask) produced nonreliable facilitation, rather than reversed (strategic) priming, replicates previous studies (Ortells et al., 2003, Experiment 1) that used a short 200-ms SOA. In a further replication not included here, also with a prime–target SOA of 200, the same stimulus set as that used in Experiment 1 was repeated several times across consecutive trial blocks. The results again showed a differential priming pattern under immediate versus delayed masking (i.e., reliable facilitatory priming vs. nonsignificant facilitation, respectively), clearly unaffected by task practice. Rather than being triggered by stimulus repetition, reversed priming from consciously perceived primes in this task appears to depend on using a prime–target SOA long enough to

allow strategic actions (400 ms or longer; see Daza et al., 2002; Ortells et al., 2001, 2003). Stronger evidence in support of that conclusion is provided by the results of Experiment 4.

Second, our results also add to the previous literature (e.g., Ortells et al., 2003, 2006) by showing reliable congruency priming from unconsciously presented primes never presented as targets, strongly demonstrating the robustness of congruency priming from unpracticed words from large categories (see also Van den Bussche & Reynvoet, 2007). The observed priming reliability estimates also demonstrate that, in contrast to the conclusions of Stolz et al. (2005), there is indeed predictable variability in semantic priming even under conditions that highlight automatic processing of prime words (i.e., immediate masking and short prime–target SOA).

The current findings are difficult to reconcile with a number of nonsemantic accounts of unconscious congruency priming. For instance, it cannot be explained by the preexistence of automated S-R mappings (Damian, 2001), as the unpracticed primes have never been mapped to a response before. Also, it is unlikely that these results emerge from subword processing of the primes (Abrams, 2008) resulting from orthographic overlap between prime and target words (see for example, Van den Bussche & Reynvoet, 2007, Experiment 1c), as such an orthographic overlap was minimal in our study (see also Klauer et al., 2007; Van den Bussche & Reynvoet, 2007, Experiments 2 and 3). Finally, the use of a large target set makes it unlikely that our results emerge from the strategic activation of action triggers that create associations between all expected stimuli and their appropriate responses (Kunde et al., 2003).

Kiesel et al. (2006) have recently extended the action trigger hypothesis to explain unconscious priming from novel words and large target sets. They suggest that when many targets from broad categories (e.g., animals) are presented, subjects could form an action trigger for the expected semantic categories, instead of for the individual expected stimuli. Accordingly, novel primes from large stimulus sets might elicit responding to the extent that they match these semantic categories, as would be the case when they belong to the target set's category. This extended action-trigger account might thus offer an alternative nonsemantic explanation of the facilitatory priming under immediate masking that we observed in the present experiment.⁴

It should be noted that unlike naming and lexical decision tasks, categorization tasks usually confound response congruency with semantic relatedness (as defined by category co-membership), in that related (congruent) pairs are associated with the same re-

³ In all the experiments presented here, regression analyses were conducted, which consistently showed a significant priming index at the $d' = 0$ intercept for the immediate masking condition [Experiment 1: 37 ms; $t(25) = 4.63, p < .001$; Experiment 2: 33 ms; $t(23) = 3.39, p = .003$; Experiment 3: 29 ms; $t(25) = 4.28, p < .001$]. But as the correlations between the priming scores and d' indexes were never significant, we did not include these data in the Results sections.

⁴ We agree with Van den Bussche, Van den Noortgate, and Reynvoet (2009) that the modified action-trigger account by Kiesel et al. (2006) should be considered less asemantic than originally assumed. If action triggers can be developed at an amodal categorical level, then they can only be semantic in nature. From our point of view, this type of category activation promoted by a subliminal prime is certainly a form of semantic processing.

sponse, whereas unrelated (incongruent) primes are associated with different responses (e.g., Forster, 2004; Wentura, 2000). Thus, one cannot be sure whether the congruency priming effects would mainly reflect response congruency, semantic relatedness, or both. Experiment 2 was designed to elucidate whether unconscious priming in our task could reflect the involvement of action triggers for the semantic categories (Kiesel et al., 2006) and/or result from the congruency of prime and target stimulus–response mappings (a “response priming” hypothesis).

Note also that in the current experiment, participants were aware that primes would be present and that in 80% of the trials they would be incongruent with the upcoming target. These task instructions could boost prime perceptibility, thus leading to larger priming effects and/or larger d' values in the visibility test than those usually reported. To check this possibility, participants in Experiment 2 were not informed about the presence of primes, which has been the common practice in unconscious priming literature.

Experiment 2

In the present experiment we used an immediate masking procedure similar to that of Experiment 1, but we also manipulated the degree of associative strength between congruent primes and targets. To achieve this, the experiment was carried out through two consecutive blocks of trials, with the order of blocks being counterbalanced across participants. In one block (high associates) the congruent trials consisted of strongly associated pairs (in both forward and backward directions, as in Experiment 1). In the other block (weak associates), we presented the same prime and target stimuli but pseudo-randomly combined them such that (a) the word target was never given as response to the prime (and vice versa) in the original norms published by Callejas et al. (2003); and (b) no target word shared a first letter with its corresponding prime, such that there was a similar (reduced) orthographic overlap to that of the highly associated pairs.

In the intracategorical norms published by Callejas et al. (2003), participants received a set of words belonging to different semantic categories, being asked to generate the first word from the same category that came to mind after reading each of the items. Given these task instructions, it is very likely that associative strength in that study could also reflect semantic similarity in terms of feature overlap. Namely, category coexemplars that were more strongly associated could also share a higher number of semantic features. To test this possibility and provide an additional objective dissociation between strong and weakly associated items, both types of prime–target pairs were screened in a similarity rating study.

A separate group of 60 subjects rated the similarity of category coexemplars from the animal and body-part categories (“How similar in terms of features in common are the things that these words refer to?”) on a 7-point scale (1 = *not at all similar*, 7 = *highly similar*; see McRae & Boisvert, 1998, for a similar task). As predicted, strongly associated pairs from each category showed much higher similarity ratings than weakly associated pairs (see Appendix B). The important point is that both strong and weak associates (rated as sharing more or less semantic features, respectively) did not differ either in terms of response activation, as both types of pairs contain the same response congruency between

primes and targets (opposite vs. same) or in terms of semantic relatedness defined in the narrow sense of category co-membership. For instance, if subjects form an action trigger for the expected semantic category “animal,” and the masked prime *TOAD* is presented, similar priming effects should be found for the target words *FROG* and *SHEEP*, as both words belong to the same semantic category. Therefore, both response priming and action-trigger (Kiesel et al., 2006) accounts would predict no difference between priming effects from strong and weak associate primes.

It is also important to note that during the prime visibility measure in Experiment 1, the target word was omitted and replaced by a category name to avoid strategic guessing. As the presentation conditions in the visibility task were not identical to those used during the priming task, one could argue that conscious perceptibility was higher during the latter, due to some form of retroactive semantic priming (e.g., Briand, den Heyer, & Dannenbring, 1988; Dark, 1988). To also evaluate that possibility, participants in the present experiment performed two different tests of prime visibility after the priming task. One test was the same as that used in Experiment 1. In a second test, participants received the same prime–target stimuli as in the priming task (i.e., the mask offset was followed by a target word on each visibility trial), but they responded to the masked primes rather than to the visible targets. If the presentation of a target word could affect conscious perceptibility of the prime word as a result of retroactive influences, then participants should show increased d' values in the prime–target visibility test compared to the prime-only test.

Method

Participants. Twenty-four undergraduate students at the University of Almería participated in the study, receiving extra course credit. All had normal or corrected-to-normal vision and were aged between 21 and 28 years ($M = 24$). All claimed to be unaware of the identity of the prime word on either all (17 participants) or most of the trials (seven participants).

Apparatus and stimuli. We used the same stimulus set (animals and body parts) as in Experiment 1, with half of prime and target stimuli being animal words and the other half body parts. Highly and weakly associated pairs from each category were presented to a separate group of 60 subjects, who rated the similarity of each prime–target pair on a 7-point scale (1 = *not at all similar*, 7 = *highly similar*). Overall mean rates were reliably larger, $F(1, 59) = 1,303.7$, for strongly ($M = 6.1$, $SE = 0.08$) than for weakly associated pairs ($M = 1.98$, $SE = 0.10$). Planned comparisons showed a similar pattern of differential ratings for strong and weak associates for the two semantic categories (see Appendix B): *animals*, strong: $M = 6.1$, $SE = 0.06$; weak: $M = 1.9$, $SE = 0.1$; $F(1, 59) = 1,181.1$; and *body parts*, strong: $M = 6.03$, $SE = 0.1$; weak: $M = 2.07$, $SE = 0.1$; $F(1, 59) = 739.9$. From each category, two lists of six congruent prime–target pairs each were created so that the same target word was paired with a strongly associated and highly semantically similar prime in one list, and with a weakly associated (and less similar) prime in the other list. These lists were then presented as highly versus weakly associated congruent trials.

Design and procedure. These were similar to the immediate masking procedure of Experiment 1, with the following exceptions:

1. Participants were not informed about the presence of primes during the priming task.
2. Participants received two blocks of experimental trials (the order of blocks was counterbalanced across participants) with the only difference between the two blocks concerning the congruent trials: In one block (high associates) all the prime–target pairs presented as congruent trials were highly associated (and highly similar) co-exemplars. The other block (weak associates) contained exactly the same stimuli, but the primes and targets presented on congruent trials were pseudo-randomly combined, such that all of them were weak associates rated as less similar pairs in the rating study.
3. After the priming task, participants completed two different tests of prime visibility. In one test the mask was replaced by either the category name *Animal?* for half the participants or *Body part?* for the other half, as in Experiment 1. In the second test, we presented the same prime–target pairs as in the priming task, in which the mask was replaced by the target word, but participants were instructed to categorize the masked prime instead of the target. The order of the tests, with 80 trials each one, was counterbalanced across participants.

Results

Priming task. Trials containing an incorrect response (5.5% of total) or those with RTs falling more than 2.5 standard deviations from the overall mean RT (3.07% of trials) were removed from analyses. Mean RTs from correct responses were submitted to a repeated measures analysis of variance with target category (animal vs. body part), association strength (strong, highly semantically similar vs. weak associates) and congruency (congruent vs. incongruent) as within-subject factors. Mean RTs and mean error rates as a function of congruency and association strength are shown in Table 2.

No reliable effects were found in the analysis of error rates (all $F_s < 1$). The analysis of RTs revealed again a main effect of congruency [congruent = 753 ms; incongruent = 785 ms; $F(1, 23) = 13.7, p = .01, \eta^2 = .37$], and more interestingly, congruency priming was modulated by the associative strength (and/or semantic similarity) between prime and target, $F(1, 23) = 6.4, p = .05, \eta^2 = .22$. This interaction revealed greater congruency effects for strong and highly semantically similar items, 48 ms; $t(23) = 3.89, p < .001$, than for weak associates, 16 ms; $t(23) = 1.89, p = .08$.

The analyses on standardized RTs showed a very similar result pattern to that found on raw RTs. Congruency priming for strongly related pairs, .25 ms, $t(23) = 4.23, p < .001$, was reliably greater than that for weakly related pairs, .10 ms, $t(23) = 2.33, p = .028$, as revealed by a significant congruency by association strength interaction, $F(1, 23) = 6.12, p = .021, \eta^2 = .21$.

Given that in this and remaining experiments, associative strength between congruent primes and targets was manipulated

across different trial blocks, test–retest reliability of congruency priming effects was examined by correlating in each experiment the mean priming score from each participant in the strong-associates block with their mean priming score in the weak-associates block. The results of these correlations showed a marginally significant reliability on raw RTs ($r = .35, p = .09$), further confirmed by significant reliability on standardized RTs ($r = .41, p = .05$).

Prime visibility test. Of special relevance for this experiment, there were no significant differences between the two tests of prime visibility, $t(46) = 0.52, p = .6$, with the overall prime discrimination being $d' = .45$ (mean hit rate = 62%, false alarm rate = 37%) for the prime-only test, and $d' = .31$ (mean hit rate = 53%, false alarm rate = 40%) for the prime–target test. The overall discrimination of primes averaged across the two tests was $d' = .38$ (hit rate = 57%, false alarm rate = 39%), which deviated from zero, $t(23) = 2.58, p = .05$. Yet, as observed in Experiment 1, participants consistently reported the subjective impression of having responded at chance during the two visibility tests. Also, the individual averaged d' values and the size of the priming effects did not correlate with each other ($r = .08, p = .69$). As in Experiment 1, we split participants in two subgroups based on their d' scores in the prime visibility test (i.e., $d' = 0$ or negative vs. $d' > 0$): a “higher discrimination” group (nine participants) with an overall d' mean of 1.16 that deviated from zero, $t(8) = 6.97; p < .001$; and a “lower discrimination” group (15 participants) with an overall d' mean of $-.005$ that did not reliably differ from zero, $t(14) = -0.47, p = .65$. As in Experiment 1, both groups showed a similar performance in the priming task, with strong priming effects from high but not from weak associates for both, participants who performed above chance in the visibility test [strong = 52 ms; $t(8) = 2.20, p = .05$; weak = 11 ms; $t(8) = 0.79, p = .45$], as well as for those who did not discriminate the primes better than chance [strong = 44 ms; $t(14) = 3.19, p = .006$; weak = 20 ms; $t(14) = 1.71, p = .11$].

Discussion

The results from the present experiment replicate those from Experiment 1 in showing strong and reliable unconscious congruency priming by unpracticed masked words from large target sets drawn from broad (animals) or smaller (body parts) semantic categories. The relatively large priming effects in our experiments cannot be due to the fact that participants were informed about the presence of primes, as that information was not given in the current experiment.

Interestingly, the congruency priming effects were reliable only when congruent trials consisted of highly normatively associated and semantically similar word pairs. By contrast, congruency priming did not reach significance for unassociated and less semantically similar exemplars (see Abad et al., 2003, for a similar data pattern with unmasked parafoveal words). These results demonstrate for the first time that unconscious congruency effects from unpracticed words are modulated by prime–target semantic relatedness. Indeed, they show a strong effect of unconscious congruency priming that is reliant on the associative strength and/or semantic similarity between the word pairs and that cannot be explained in terms of either action triggers (Kiesel et al., 2006) or response priming.

Table 2
Mean RTs, Error Percentages, and Differences in RTs as a Function of Prime–Target Semantic Relatedness, Congruency, and Prime–Target SOA for Experiments 2–4

Experiment and condition	Incongruent	Congruent	Priming
Experiment 2 (immediate masking)			
Strong associates			
RT in ms: <i>M</i> (<i>SD</i>)	786 (90.2)	738 (104.3)	
Error: % (<i>SD</i>)	5.8 (3.9)	5.9 (6.9)	
Difference in RTs (in ms)			+48*
Weak associates			
RT in ms: <i>M</i> (<i>SD</i>)	785 (65.9)	769 (81.6)	
Error: % (<i>SD</i>)	5.4 (3.7)	4.8 (4.3)	
Difference in RTs (in ms)			+16
Experiment 3 (immediate masking)			
Strong associates			
RT in ms: <i>M</i> (<i>SD</i>)	677 (68.9)	636 (65.6)	
Error: % (<i>SD</i>)	4.8 (4.2)	3.2 (3.3)	
Difference in RTs (in ms)			+41*
Weak associates			
RT in ms: <i>M</i> (<i>SD</i>)	669 (66.9)	658 (65.1)	
Error: % (<i>SD</i>)	5.6 (3.7)	5.5 (5.7)	
Difference in RTs (in ms)			+11
Experiment 4 (delayed masking)			
200-ms SOA			
Strong associates			
RT in ms: <i>M</i> (<i>SD</i>)	721 (95.5)	712 (106.2)	
Error: % (<i>SD</i>)	7.4 (5.3)	6.8 (5.8)	
Difference in RTs (in ms)			+9
Weak associates			
RT in ms: <i>M</i> (<i>SD</i>)	719 (88.2)	713 (101.2)	
Error: % (<i>SD</i>)	7.1 (5.3)	5.9 (6.4)	
Difference in RTs (in ms)			+6
1,000-ms SOA			
Strong associates			
RT in ms: <i>M</i> (<i>SD</i>)	642 (97.3)	694 (103.9)	
Error: % (<i>SD</i>)	2.6 (2.9)	6.8 (8.9)	
Difference in RTs (in ms)			–52*
Weak associates			
RT in ms: <i>M</i> (<i>SD</i>)	651 (97.5)	700 (95.9)	
Error: % (<i>SD</i>)	3.5 (4.4)	7.5 (10.4)	
Difference in RTs (in ms)			–49*

Note. RT = reaction time; SOA = stimulus onset asynchrony; + = facilitatory priming; – = reversed priming.

* $p < .05$.

Experiment 3

Prior research examining unconscious congruency priming from unpracticed words and large stimulus sets have usually presented the same primes and targets on both congruent and incongruent trials. This was clearly not the case in our study, as congruent and incongruent trials contained different prime–target pairs (see Appendix A). But in our experiments, unlike conventional congruency priming procedure studies presenting the same proportion of congruent and incongruent items (50%), the latter were much more frequent (80%) than the former (20%). Given such a differential proportion of congruent and incongruent trials, presenting every prime (and target) stimulus on both kinds of condition would necessarily increase the repetitions of each word. To avoid a relatively high item repetition, we decided to present different primes and targets on

congruent and incongruent trials. In either case, note that our congruent prime–target pairs were counterbalanced across immediate and delayed masking conditions (Experiment 1) and strong and weak associates (Experiments 2), so that the significant differences in priming effects that were observed as a function of both masking type and association strength could not be simply due to stimulus differences.

However, given the lack of counterbalancing across congruency, one could still argue that our congruency priming effects could at least partly be due to item differences. Whereas the mean subjective familiarity of our items was fairly similar for congruent and incongruent trials (5.22 and 5.98, respectively), they nevertheless showed a greater variation on incongruent ($SD = 0.86$) than on congruent trials ($SD = 0.59$). It is thus possible that this lack of counterbalancing of items across

congruency conditions in our experiments could explain the relatively large size of the priming effects compared to those generally reported elsewhere (for a review, see Van den Bussche, Van den Noortgate, & Reynvoet, 2009).

The main goal of the present experiment was to elucidate whether reliable priming effects from unpracticed words of a similar size to those found in Experiments 1 and 2 could still be obtained when the same word set was presented on both congruent and incongruent trials in our task in such a way that the findings could not be attributed to item differences across conditions.

Method

Participants. Twenty-six undergraduate students at the University of Almería participated in the study, receiving extra course credit. All had normal or corrected-to-normal vision and were aged between 20 and 27 years ($M = 23$). All claimed to be unaware of the identity of the prime word on either all (18 participants) or most (eight participants) of the priming trials.

Stimuli, design, and procedure. These were similar to those used in Experiment 2, except that the same prime and target words (eight pairs from each semantic category; see Appendix B) were presented on both congruent and incongruent trials. As in Experiment 2, participants were not informed about the presence of primes. Participants took part in a single session (lasting about 15 min) consisting of 40 practice trials followed by two blocks of 80 experimental trials each, with the order of blocks being counterbalanced across participants. The congruent trials in one block (high associates) consisted of highly associated coexemplars that also shared a large overlap in semantic features, whereas the other block (weak associates) contained weakly associated and less semantically similar items (see Appendix B). Within each trial block, each prime (and target) was presented five times, once followed by a related (congruent) target and four times followed by an unrelated (incongruent) target from the opposite category. After finishing the priming task, participants did a prime visibility test that contained the same prime–target pairs as in the priming task, but participants were instructed to categorize the masked prime instead of the target.

Results and Discussion

Priming task. Trials containing an incorrect response (4.5% of total) or those with RTs falling more than 2.5 standard deviations from the overall mean RT (3% of trials) were removed from analyses. Mean RTs from correct responses were submitted to a repeated measures analysis of variance with target category (animal vs. body part), association strength (strong vs. weak associates) and congruency (congruent vs. incongruent) as within-subject factors. Mean RTs and mean error rates as a function of congruency and association strength are shown in Table 2.

In the analysis of RTs, there was a significant main effect of target category, $F(1, 25) = 16.2$, $p < .001$, $\eta^2 = .39$, where body-part targets were responded to 26 ms slower than animal targets. As this factor did not interact with any of the others, the data were averaged across the categories for further analyses. There also were significant main effects of congruency [congruent = 647 ms; incongruent = 672 ms; $F(1, 25) = 20.6$, $p < .001$, $\eta^2 = .47$], and more interestingly, of the interaction between

congruency and association strength, $F(1, 25) = 25.85$, $p < .001$, $\eta^2 = .51$. As in Experiment 2, this interaction revealed reliable congruency effects for strong and highly semantically similar items, 41 ms; $t(25) = 6.36$, $p < .001$, but not for weak associates, 11 ms; $t(25) = 1.59$, $p = .12$. The analyses on standardized RTs showed a very similar result pattern to that found on raw RTs. Congruency priming was significant for strong associates, .27 ms, $t(25) = 7.45$, $p < .001$, but not for weak associates, .05 ms, $t(25) = 1.33$, $p = .195$, as revealed by a significant congruency by association strength interaction, $F(1, 25) = 25.55$, $p < .001$, $\eta^2 = .51$. Regarding test–retest reliability estimates, these were significant for both raw RTs ($r = .54$, $p = .003$) and standardized RTs ($r = .41$, $p = .046$).

In the analysis of accuracy data there was a significant main effect of target category, $F(1, 25) = 4.3$, $p = .047$, $\eta^2 = .15$, such that there were fewer categorization errors for animal (4.1%) than for body-part targets (5.5%). The main effect of association strength was also significant [strong = 4.0%; weak = 5.5%; $F(1, 25) = 4.6$, $p = .04$, $\eta^2 = .16$], but none of these factors interacted with any other variable.

The present results demonstrate that the relatively large congruency priming effects from unpracticed words that were observed in the previous experiments cannot be attributed to the lack of word counterbalancing across congruency conditions. The only difference between Experiment 2 and the current one is the presentation of either different words (Experiment 2) or the same prime and target words across congruent and incongruent trials. Importantly, a remarkably similar pattern was observed in both experiments: namely, reliably larger unconscious congruency priming with strong than with weak associates. To test for any influence of same versus different items across congruent and incongruent trials, we further conducted an ANOVA treating both experiments as a between-participants factor. As suspected, all previously found effects remained significant [main effect of congruency, $F(1, 48) = 32.04$, $p < .001$, $\eta^2 = .40$; interaction of congruency with association strength, $F(1, 48) = 21.2$, $p < .001$, $\eta^2 = .31$; and the evidence of greater effects for strong, 44 ms; $t(49) = 6.6$, $p < .001$, than for weak associates, 13 ms; $t(49) = 2.49$, $p = .016$]. Interestingly, there was also a significant main effect of experiment, $F(1, 48) = 31.4$, $p < .001$, $\eta^2 = .39$, showing faster responses on Experiment 3 (660 ms) than on Experiment 2 (769 ms). But this factor did not interact with any other variable, thus suggesting that congruency priming in our task was not affected by whether we used the same or different items across congruency conditions.

Prime visibility test. Overall discrimination for primes was $d' = .29$ (mean hit rate = 55%, false alarm rate = 44%), which significantly deviated from zero, $t(25) = 3.65$, $p = .001$. But as in Experiment 2, all participants reported the subjective impression of having responded at chance during the whole block of trials in the visibility task. Also, the individual averaged d' values and the size of the priming effects did not correlate with each other ($r = -.21$, $p = .31$). As in our prior experiments, we divided participants into two different groups based on their performance in the prime visibility test (i.e., null or negative vs. positive d' score): A “higher discrimination” group (10 of the total number of participants) with an overall d' mean of .77 that deviated from zero, $t(9) = 11.3$; $p < .001$; and a “lower discrimination” group (16 participants) showing

an overall d' mean of $-.012$ that did not reliably differ from zero, $t(15) = -0.197, p = .84$. As in Experiment 2, both groups showed a similar performance in the priming task, with strong priming effects from high but not from weak associates, for both participants who performed above chance in the visibility test [strong = 37 ms; $t(9) = 2.84, p = .019$; weak = 11 ms; $t(9) = 1.09, p = .30$] and those who did not discriminate the primes better than chance [strong = 42 ms; $t(15) = 6.35, p < .001$; weak = 9 ms; $t(15) = 1.13, p = .27$].

Experiment 4

By using a double dissociation procedure similar to that of the present research, several prior studies have reported opposite priming pattern as a function of prime awareness. Congruent pairs produced positive priming with the immediate mask and reversed negative priming with the delayed mask (e.g., Daza et al., 2002; Merikle & Joordens, 1997; Ortells et al., 2003, 2006). Namely, participants were able to strategically use the biased congruency manipulation (e.g., 20% congruent; 80% incongruent trials) to enhance their performance only when the primes were clearly visible. Indeed, in Experiment 1, reliable positive priming was observed with an immediate mask, but we did not observe a full reversal of the priming effect with the delayed mask. We suggested (see Discussion of Experiment 1) that this latter finding would be the expected result when a relatively short prime–target SOA (e.g., 200 ms) is used, as was the case in Experiment 1 (see also Ortells et al., 2003, Experiment 1), which would be not long enough to allow a full implementation of strategic actions. On the basis of this line of argument, the primes followed by a late mask should lead to a complete reversal of priming when the prime–target SOA was lengthened, thus allowing participants to fully develop the strategic action of generating the countervailing (opposite category) response. To test this possibility, we conducted an additional experiment in which the prime words were always followed by a delayed mask, but the prime–target SOA was manipulated between participants at 200 ms (as in Experiment 1) and 1,000 ms. As in the rest of the experiments, the prime words were never presented as targets, but (following the results from Experiment 3) the same primes and targets were presented on both congruent and incongruent trials. The prime–target association strength was again manipulated across different trial blocks.

The inclusion of both strong and weak associates allowed to us to also elucidate whether the impact of associative strength is comparable in a fully conscious condition to that previously found with unconscious primes.

Note that the results of our rating similarity study had shown that the weakly associated pairs presented on congruent trials in Experiments 2 and 3 were rated by participants as sharing fewer (or no) semantic features than the strongly associated pairs, although both types of pairs did not differ in terms of category co-membership. But, provided that we did not test the semantic similarity (in terms of feature overlap) of the incongruent prime–target pairs, it was not possible to fully demonstrate that semantic similarity was not at the basis of the reported effects. To illustrate this, the semantic similarity between weak associates, such as *lion* and *rabbit*, might not necessarily be any stronger than the one between some unrelated (incongruent) pairs, such as *tongue* and *camel* (see Appendix A). If both types of prime–target pairs really

had similar semantic similarity, one would not expect the responses to weakly associated word primes from the same category to be any faster than those to word targets preceded by incongruent primes from the opposite category. Indeed, this was generally the case in Experiments 2 and 3.

An additional advantage of using a long SOA interval of 1,000 ms was to further test these word pairs to definitely rule out that the lack of congruency effects with weak associates could be due to similar semantic similarity between weakly related (congruent) and incongruent word pairs. As primes were clearly visible, participants were encouraged to use the congruency manipulation to anticipate the target category (and they were given enough time to fully implement such strategy); we expected that responses would be reliably faster on incongruent trials than on the less expected congruent ones. This reversed priming effect should be much the same across strong and weak associates (i.e., no reliable interaction between association strength and congruency), as what mainly matters in observing reversed priming is whether the target belongs to the same or the opposite category.

On the contrary, if we assume that weak associates from the same category could have similar semantic similarity to that of the unrelated pairs, one would expect to obtain reversed priming with strong associates but no effect with weak associates, as was observed with the immediate mask in our prior experiments.

Method

Participants. Fifty-two (26 for each group) undergraduate students at the University of Almería participated in the study, receiving extra course credit. All had normal or corrected-to-normal vision and were aged between 21 and 26 years ($M = 23$). Participants in both delayed masking groups consistently reported being able to identify the prime words of all or most of the priming trials (all participants ranked their prime awareness in the Likert-type scale at 6 or above; max. = 7).

Stimuli, design, and procedure. These were similar to those used in Experiment 3, except that the 33-ms prime was followed by a blank screen presented for either 34 ms or 834 ms (depending on the group of participants), followed by a 133-ms pattern mask and the target, thus resulting in two different prime–target SOA conditions: 200 ms (as in Experiment 1) and 1,000 ms.

Results

Priming task. Trials containing an incorrect response (5.8% of total) or those with RTs falling more than 2.5 standard deviations from the overall mean RT (3.65% of trials) were removed from analyses. Mean RTs from correct responses and error percentages were entered in two $2 \times 2 \times 2 \times 2$ ANOVAs, with target category (animal vs. body part), association strength (strong vs. weak associates) and congruency (congruent vs. incongruent) as within-participant factors, and prime–target SOA (200 vs. 1,000 ms) as a between-participants factor. Mean RTs and mean error rates as a function of prime–target SOA, congruency, and association strength are depicted in Table 2.

In the analysis of RTs, there was a significant main effect of target category, $F(1, 50) = 6.78, p = .012, \eta^2 = .12$, where body-part targets were responded to 18 ms slower than animal targets, but this factor did not interact with any of the others. There

was also a significant effect of congruency, $F(1, 50) = 6.9$, $p = .011$, $\eta^2 = .12$, with responses slower on congruent (705 ms) than on the most frequent incongruent (683 ms) trials (i.e., a reversed priming effect). Interestingly, the interaction between congruency and prime–target SOA was also highly significant, $F(1, 50) = 12.03$, $p = .0011$, $\eta^2 = .19$, which revealed a differential priming pattern as a function of prime–target SOA. A nonreliable facilitation (7 ms; $F < 1$) was found at the short 200-ms SOA in line with the results observed in the delayed masking condition from Experiment 1. By contrast, reliable reversed priming was rather observed at the longer 1,000-ms SOA interval, -50 ms; $F(1, 25) = 12.63$, $p = .0015$, $\eta^2 = .34$. Importantly for our purposes, the associative strength did not interact with congruency, such that similar priming effects across strong and weak associates (see Table 2) were found at both, 200-ms SOA [strong = 9 ms; $t < 1$; weak = 6 ms; $t < 1$], and 1,000-ms SOA [strong = -52 ms; $t(25) = -2.81$, $p = .07$; weak = -49 ms; $t(25) = -3.43$, $p = .02$].

The analyses on standardized RTs revealed a fairly similar result pattern to that on raw RTs (see Table 2). A significant congruency by prime–target SOA interaction, $F(1, 50) = 14.21$, $p < .001$, $\eta^2 = .23$, revealed a differential priming pattern as a function of prime–target SOA: At 200-ms SOA, a nonreliable facilitation was found for both strong, $.07$ ms; $t(25) = 1.04$, $p = .31$, and weak associates, $.03$ ms; $t(25) = 0.49$, $p = .62$, whereas at the longer 1,000-ms SOA a reliable reversed priming was observed, which was similar for both strong, $-.24$ ms; $t(25) = -2.69$, $p = .012$, and weak associates, $-.27$ ms; $t(25) = -3.71$, $p < .001$. Regarding test–retest reliability estimates, these were significant for both raw RTs ($r = .42$, $p = .002$) and standardized RTs ($r = .36$, $p = .008$).

In the analysis of error rates there was a significant main effect of target category, $F(1, 50) = 7.04$, $p = .010$, $\eta^2 = .12$, showing fewer categorization errors for animal (5.0%) than for body-part targets (7.0%). The interaction between congruency and prime–target SOA was also significant [$F(1, 50) = 10.23$, $p = .002$, $\eta^2 = .17$], which revealed again an opposite priming pattern as a function of SOA: a marginally significant facilitatory priming at 200-ms SOA [incongruent = 7.0%; congruent = 6.0%; $F(1, 25) = 3.46$, $p = .07$, $\eta^2 = .12$], and reliable reversed priming at 1,000-ms SOA [incongruent = 3.0%; congruent = 7.0%; $F(1, 25) = 6.92$, $p = .014$, $\eta^2 = .22$].

Prime visibility test. As expected, all participants in the two delayed masking groups showed an above-chance discrimination for primes, with the overall mean d' significantly deviating from zero at both 200-ms SOA [$d' = 3.59$; hit rate = 91%, false alarm rate = 9%; $t(25) = 11.34$, $p < .001$], and 1,000-ms SOA [$d' = 4.26$; hit rate = 94%, false alarm rate = 7%; $t(25) = 13.89$, $p < .001$].

Discussion

The results of the present experiment replicate and extend those reported in some prior research with this task (e.g., Ortells et al., 2003) in showing that consciously perceiving a prime stimulus, though necessary, is not sufficient to obtain a complete reversal of priming in our congruency priming paradigm. A long-enough prime–target SOA should also be used to allow the full implementation of a strategic action.

In addition, the fact of obtaining a reversed priming effect similar in magnitude for both strong and weak associates (as

revealed by the lack of an interaction between association strength and congruency at 1,000-ms SOA on both raw and standardized RTs) clearly demonstrates that the weakly associated words presented on congruent trials had a different status in terms of semantic similarity than the incongruent pairs belonging to different categories. It seems clear that the nonsignificant facilitatory priming with weak associates that was generally observed with the immediate mask in our previous experiments cannot be explained in terms of a similar semantic status for both unrelated and weakly related items.

General Discussion

By using a modified congruency-priming task with a differential proportion of congruent (20%) and incongruent trials (80%) in which briefly presented unpracticed prime words were followed either immediately or after a delay by a pattern mask, the present research replicates and extends several previous findings with this task (e.g., Ortells et al., 2003, 2006; see also Daza et al., 2002; Merikle & Joordens, 1997) and provides further support for the utility of the qualitative differences (i.e., double dissociations) approach over the single dissociation paradigm.

When the onset of the mask was delayed and participants systematically reported being aware of the identity of the prime (Experiments 1 and 4), we found either nonreliable small positive priming (Experiments 1 and 4) or reliable reversed (strategic) priming (Experiment 4), depending on whether the prime–target SOA was short (200 ms; Experiments 1 and 4) or long (1,000 ms; Experiment 4). The nonsignificant facilitation by clearly visible primes at the short 200-ms SOA was expected, as this time interval is not long enough to allow a full implementation of strategies (e.g., Ortells et al., 2003; Experiment 1). When the prime–target SOA was lengthened (1,000 ms; Experiment 4), so participants had time to fully develop a strategic action, reliable reversed priming was found. The latter finding is consistent with prior research showing that controlled processes build up much more slowly (e.g., Neely, 1977; Ortells et al., 2001) and also demonstrates that to use a particular stimulus for an intentional action, two factors are jointly needed: First, the stimulus must carry enough activation strength for conscious access (i.e., delayed masking); and second, a time interval long enough to allow a full implementation of strategic processes must be used.

In contrast to the observed results with the delayed mask, when the prime words were immediately masked and participants systematically claimed to be unaware of their identity, substantial and robust facilitatory priming effects for both raw (trimmed) and standardized RTs were found in Experiments 1 to 3. To the extent that we used large target sets and unpracticed primes that were never presented as conscious targets, these findings cannot be attributed to nonsemantic influences based on automated S-R mappings (Damian, 2001) or action triggers (Kunde et al., 2003). Rather, our results agree with others previously reported by providing strong evidence of the unconscious semantic processing of the prime words in a congruency-priming paradigm (e.g., Klauer et al., 2007; Van den Bussche & Reynvoet, 2007).

The facilitatory priming found in the absence of prime awareness (immediate mask) was consistently observed in our research, irrespective of whether (a) participants performed at chance or above chance in the prime visibility tests; (b) participants were

aware (Experiment 1) or unaware (Experiments 2 and 3) that primes would be present during the priming task; (c) the same (Experiment 3) versus different words (Experiments 1–2) were presented on congruent and incongruent trials (thus demonstrating that priming effects cannot be attributed to item differences); and (d) the conditions for the visibility test were identical (Experiments 2–3) or different (Experiments 1–2) from those used in the preceding priming task. Indeed some authors (e.g., Briand et al., 1988; Dark, 1988) have previously argued that masked priming can result from the retroactive facilitation of the target word on the processing of the masked one. If this explanation is true, then the discriminability index must be enhanced when visibility conditions were identical (i.e., the prime–target test) as opposed to when they changed (the prime-only test). On the contrary, in Experiment 2 we found that performance in the prime–target test was worse (i.e., not different from chance) than that observed in the prime-only test. This finding clearly demonstrates that supplying explicit targets neither aided guessing nor retroactively facilitated masked primes.

A further relevant finding is that the observed between-participants differences in the size of these supposedly automatic priming effects showed to be quite consistent and reliable across Experiments 1 to 3, particularly when reliability estimates were computed on standardized (*z*-score transformations) priming scores. Against Stolz et al.'s (2005) proposal arguing that automatic semantic associations are inherently noisy and uncoordinated, the present results strongly suggest that there is indeed some explainable (predictable) variability in automatic semantic priming (see Hutchison et al., 2008, for a similar conclusion).

Subjective Versus Objective Direct Measures of Stimulus Awareness

In all of our experiments we included both subjective (i.e., based on participants' self-reports) and objective measures of prime awareness (i.e., based on participants' performance in a prime visibility test). Whereas considerable discussion has taken place regarding whether subjective or objective measures provide the more accurate method for demonstrating perception without awareness (e.g., Eriksen, 1960; Reingold & Merikle, 1990), a widely held view over the years is that objective measures of perceptual discrimination provide the most accurate method to determine awareness. In clear contrast to this point of view, our results demonstrate that unconscious priming depends on the phenomenological report of unawareness (i.e., a subjective measure) but not on how detectable the primes were in a binary-based visibility posttest (i.e., an objective measure). As noted before, an above-chance performance in a binary decision test, such as the one used in our experiments, does not necessarily reveal a conscious perception of the immediately masked words. First, participants always reported their subjective impression of having responded at chance during the immediate mask trials. Second, research on recognition memory has reported evidence that decisions on binary classification (i.e., old/new) tasks can be based on both conscious (i.e., recollection) and unconscious (i.e., familiarity) influences (e.g., Jacoby, 1991; see also Jacoby, Lindsay, & Toth, 1992; Joordens & Hockley, 2000). Third, whereas an above-chance identification certainly suggests that the immediately masked primes could be visible when participants are instructed to identify them in the visibility test, this does not necessarily imply that these primes were indeed seen (i.e., consciously

detected) on every trial on the priming task. Performance in the visibility task could be influenced by an attentional amplification toward the masked primes, which was not equally present during the priming task. Whereas in the former task subjects were asked to exclusively attend to the primes and to completely ignore the target, this was not the case during the priming task, in which participants were asked to also focus their attention on responding to the target (Kouider, Dehaene, Jobert, & Le Bihan, 2007).

The possibility that the indirect (priming) and direct (prime visibility) measures of prime processing might reflect different mechanisms and/or task demands could explain why no reliable correlation between both measures was ever found in any of our experiments. This has, in fact, been the usual finding in the literature. Despite that, a frequently used strategy in many recent studies is regressing priming scores on prime visibility indexes (*d'*) to provide stronger evidence for unconscious perception. As noted above (see also footnote 3), the regression technique is only valid if both the priming effects and the *d'* effects show high reliability. But this was not the case in the current research. Although the *d'* effects in Experiment 1 showed some reliability across immediate and delayed masking conditions, discrimination of immediately masked primes produced high within-participant variability across Experiments 1–3, with some participants showing null or negative *d'* scores and others showing higher *d'* scores, clearly above chance.

When the correlation between direct and indirect measures is zero, a significant priming score intercept can simply reflect the mean of the priming effect. This was the reason for which we used in our experiments an alternative median-split strategy, which consisted of dividing participants in two different groups (i.e., high vs. low visibility) based on their performance in the visibility test (i.e., at chance vs. better than chance). The use of that participant-splitting strategy allowed us to provide further support for reliable congruency priming at an objective threshold for stimulus awareness, as it also did the regression method. Of even more worth and relevance, it also allowed us to demonstrate that immediately masked primes, whose identity participants consistently claimed to be unaware of, led to facilitatory priming effects of a similar size, irrespective of whether the objective index of prime awareness revealed a null (or negative) discrimination or a discrimination above chance.

To sum up, whereas some researchers could still be inclined to refuse a subjective assessment of prime visibility as indicative of the unconscious nature of that stimulus, we are suggesting here that objective measures of awareness that rely on binary decisions may have been inadequately used. The demonstration in our experiments that unconscious priming was essentially the same, whether performance in the visibility test was at chance or above chance, allows us to take a stronger stand on the usefulness of subjective self-reports over binary-based objective measures of awareness, at least when the subjective measure is coupled with a qualitative differences approach, as was the case in the present research.⁵

⁵ We thank Steve Joordens for this suggestion.

On the Role of Associative/Semantic Relatedness in Congruency Priming Tasks

Masked congruency priming has become a well-established method to investigate whether unconsciously presented words can be processed and affect responding through conceptual meaning. Unconscious congruency priming has been shown to occur reliably when the masked words are presented as visible targets on other trials and/or when small categories or reduced stimulus sets are used. But as noted in the Introduction, these results could be explained in terms of either acquired stimulus–response (S-R) links between conscious targets and motor responses (Damian, 2001) or action triggers that create automatic associations between all expected stimuli and their appropriate responses (Kunde et al., 2003). Neither action triggers nor automated S-R mappings play a role in the generation of priming effects when unpracticed words from broad categories (which usually include many perceptually dissimilar members; e.g., animals vs. nonanimals) and large stimulus sets are used. Yet, unconscious congruency priming from large category of unpracticed words has usually resulted in weaker effects that are highly sensitive to minor procedural differences (Abrams, 2008). Contradicting results were even reported under similar stimulus presentation conditions (e.g., Forster et al., 2003; Van den Bussche & Reynvoet, 2007).

It is important to note that, unlike the case in conventional semantic priming studies, associative and/or semantic relatedness has not generally been controlled in congruency priming from unpracticed words.⁶ Rather, congruent trials usually consist of a random mixture of more or less closely related category coordinates (e.g., Van den Bussche & Reynvoet, 2007). Furthermore, a few studies have explicitly avoided semantic-associative relations between primes and targets (e.g., Damian, 2001). When a reduced stimulus set is repeatedly presented through the experiment, it is unlikely that the observed congruency priming effects depend on whether strong or weak associates from the same semantic category are presented on congruent trials. Indeed, the consolidation through repetition of the same S-R mappings would lead to response-based congruency effects. But we could be facing the opposite scenario when presenting prime words from large categories and stimulus sets. In this case, the size and reliability of the observed priming effects may critically depend on associative and/or semantic relatedness between primes and targets, as research on semantic priming has consistently demonstrated (e.g., Abad et al., 2003; Hutchison, 2003; Hutchison et al., 2008; McNamara, 2005; see also McRae & Boisvert, 1998).

The results of the present research are clear-cut. Unconscious congruency priming from unpracticed words from large categories has been shown to be reliably influenced by associative and/or semantic relatedness between congruent primes and targets: The overall effect size was systematically larger with highly associated and highly semantically similar category coexemplars than with weak associates and less semantically similar items for both raw and standardized priming scores, a finding difficult to explain in terms other than a semantic processing of subliminally presented words.

This is a very important result, as the most common and straightforward interpretation for congruency effects is in terms of the compatibility of their evoked responses. Certainly, in the categorization task primes and targets are associated with the same response on congruent trials, whereas they are associated with

different (opposite) responses on incongruent trials (e.g., Forster, 2004; Wentura, 2000). If congruency priming in our experiments only arises from this response congruency, then there should not be any difference between high and weak associates, as both conditions are identical in terms of S-R category congruency. But in contrast, the high associate pairs that also share a large overlap in semantic features produced far stronger congruency effects than weak associates with a lesser semantic feature overlap (Experiments 2–3). Note also that the differential priming pattern as a function of semantic relatedness cannot ever be explained in terms of action triggers for semantic categories (Kiesel et al., 2006), as both strong and weakly related pairs did not differ in terms of category co-membership.

The failure to find robust congruency priming effects with low association pairs in our study could however be interpreted as evidence against a conceptual (semantic) locus of these effects. Some authors have argued that the associative “boost” to priming is caused by nonsemantic associative relations that exist between words that co-occur frequently in experience (e.g., McKoon & Ratcliff, 1992). But as noted in the Introduction, evidence of associative priming in the absence of semantic similarity has generally been difficult to find (but see Coane & Balota, 2011). The results of our rating similarity study showed, in fact, a strong correlation between association strength and semantic feature overlap.

The use of strongly associated and highly semantically similar category coordinates could be the main reason for the relatively large size of the positive priming effects under immediate masking found in our experiments (about 40 ms, compared to 10–15 ms found under similar conditions; see the meta-analysis of Van den Bussche, Van den Noortgate, & Reynvoet, 2009). But there are other alternative explanations for such differences in the amount of priming effects. One could wonder whether the large and reliable priming effects would present only for the slowest participants (i.e., those participants whose average RT was more than one standard deviation above the mean; see, e.g., Lachter, Forster, & Ruthruff, 2004). To test for that possibility, we conducted further data analyses in which participants were classified on the basis of their overall raw RT, and the average amount of priming in the immediate masking trials for high and weak associates was examined as a function of the participant’s overall RT (mean cutoffs were 699 ms, 769 ms, and 660 ms for Experiments 1 to 3, respectively). As shown in Table 3, it seems clear that the slowest participants did not show larger priming effects than faster partic-

⁶ An exception is Kiesel et al.’s (2006) study. By using a size discrimination task (smaller or larger than a soccer ball), these authors found that masked congruency priming did reliably transfer to novel (unpracticed) prime words with a large target set. Interestingly, variation of semantic relatedness had no reliable impact on priming. Similar (nonsignificantly different) response times and error rates in the categorization task were found irrespective of whether the prime–target pairs were more (*fork–knife*) or less (*fork–button*) semantically related (Kiesel et al., 2006, Experiment 1). But, as acknowledged by Kiesel et al. (2006; footnote 4, p. 45), one has to be cautious with this analysis since there were only four different trials per subject and condition (i.e., *fork–knife*; *fork–button*; *chair–table*; and *chair–house*).

Table 3

Priming (in ms) in Experiments 1, 2, and 3 Broken Down by Participants' Overall Raw RTs for Strong and Weak Associates (Immediate Masking)

Relative mean RT	Associative strength	
	Strong associates	Weak associates
Experiment 1		
Faster than $M - 1SD$ ($n = 5$)	+35*	
Between $M - 1SD$ and M ($n = 8$)	+41*	
Between M and $M + 1SD$ and M ($n = 9$)	+43*	
Slower than $M + 1SD$ ($n = 4$)	+29†	
Experiment 2		
Faster than $M - 1SD$ ($n = 3$)	+59*	+29
Between $M - 1SD$ and M ($n = 9$)	+74*	+29
Between M and $M + 1SD$ and M ($n = 7$)	+42	+16
Slower than $M + 1SD$ ($n = 5$)	+17	-7
Experiment 3		
Faster than $M - 1SD$ ($n = 5$)	+35*	+14
Between $M - 1SD$ and M ($n = 8$)	+49*	+16
Between M and $M + 1SD$ and M ($n = 10$)	+43*	+5
Slower than $M + 1SD$ ($n = 3$)	+37	+12

Note. RT = reaction time.

* $p < .05$. † $p > .05$ and $p < .09$.

ipants in any of our experiments. Therefore we argue that obtaining these large and reliable congruency priming effects results mainly from using category exemplars that are strongly associated and highly semantically similar.

It is interesting that prior research on unconscious congruency priming have generally used prime–target SOA intervals that were shorter (i.e., 100 ms or less; see, e.g., Abrams, 2008; Klauer et al., 2007; Van den Bussche & Reynvoet, 2007) than the 200-ms SOA used with the immediate mask in our Experiments 1 to 3. One could argue that priming effects from weak associates could be more short-lived than those observed with strong associates. On the basis of that assumption, one could explain why the unconscious priming effects that we observed with weak associates were systematically smaller than those found with strong associates. Whether greater priming effects from strong than from weakly associated unconscious primes could also be observed at SOA intervals shorter than 200 ms remains an interesting matter for future research.

Because our strongly related pairs were both highly associated (Callejas et al., 2003) and rated as sharing a large feature overlap, the present research does not allow us to elucidate whether the observed priming effects from such items are due to associative relations (e.g., spreading activation; Collins & Loftus, 1975; Neely, 1991), semantic feature overlap, or even both (Hutchison et al., 2008). An interesting issue for future work would be to examine unconscious congruency priming from unpracticed words by using either highly semantically similar but unassociated items or strong associates sharing no feature overlap. But the point to be stressed here is that our results undoubtedly demonstrate that the mere existence of a categorical or response-based relationship between two words is not enough to find robust unconscious (automatic) congruency priming when using unpracticed words from large stimulus sets.

Conclusions

The results of the present research consistently show that subliminal congruency word priming is not due to response congruency, nor is it restricted to practiced words or to the use of small categories or target sets. Instead, the nature of these effects lies on the associative–semantic relationship between prime and target. In a recent review of masked priming studies, Van den Bussche, Van den Noortgate, and Reynvoet (2009) listed a series of different moderators that can influence the strength and reliability of congruency priming effects, such as the kind of task, prime novelty, category size, target set size, and so forth. Our study clearly demonstrates that semantic relatedness between primes and targets should be added to the list.

References

- Abad, M. F., Noguera, C., & Ortells, J. J. (2003). Influence of prime–target congruency on semantic priming effects from words in a lexical decision task. *Acta Psychologica, 113*, 283–295. doi:10.1016/S0001-6918(03)00034-9
- Abrams, R. L. (2008). Influence of category size and target set size on unconscious priming by novel words. *Experimental Psychology, 55*, 189–194. doi:10.1027/1618-3169.55.3.189
- Abrams, R. L., & Greenwald, A. G. (2000). Parts outweigh the whole (word) in unconscious analysis of meaning. *Psychological Science, 11*, 118–124. doi:10.1111/1467-9280.00226
- Abrams, R. L., Klinger, M. R., & Greenwald, A. G. (2002). Subliminal words activate semantic categories (not automated motor responses). *Psychonomic Bulletin & Review, 9*, 100–106. doi:10.3758/BF03196262
- Briand, K., den Heyer, K., & Dannenbring, G. L. (1988). Retroactive semantic priming in a lexical decision task. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 40*, 341–359.
- Callejas, A., Correa, A., Lupiáñez, J., & Tudela, P. (2003). Normas asociativas intracategoriales para 612 palabras de seis categorías semánticas en Español [Associative intracategory norms for 612 words in six semantic categories in Spanish]. *Psicológica, 24*, 185–214.
- Coane, J. H., & Balota, D. A. (2011). Face (and nose) priming for book: The malleability of semantic memory. *Experimental Psychology, 58*, 62–70. doi:10.1027/1618-3169/a000068
- Collins, A. M., & Loftus, E. F. (1975). A spreading activation theory of semantic processing. *Psychological Review, 82*, 407–428. doi:10.1037/0033-295X.82.6.407
- Damian, M. F. (2001). Congruity effects evoked by subliminally presented primes: Automaticity rather than semantic processing. *Journal of Experimental Psychology: Human Perception and Performance, 27*, 154–165. doi:10.1037/0096-1523.27.1.154
- Dark, V. J. (1988). Semantic priming, prime reportability, and retroactive priming are interdependent. *Memory & Cognition, 16*, 299–308. doi:10.3758/BF03197040
- Daza, M. T., Ortells, J. J., & Fox, E. (2002). Perception without awareness: Further evidence from a Stroop priming task. *Perception & Psychophysics, 64*, 1316–1324. doi:10.3758/BF03194774
- Debner, J. A., & Jacoby, L. L. (1994). Unconscious perception: Attention, awareness, and control. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*, 304–317. doi:10.1037/0278-7393.20.2.304
- Dehaene, S., Naccache, L., Le Clec'h, G., Koehlin, E., Mueller, M., Dehaene-Lambertz, G., . . . Le Bihan, D. (1998). Imaging unconscious semantic priming. *Nature, 395*, 597–600. doi:10.1038/26967
- Dell'Acqua, R., & Grainger, J. (1999). Unconscious semantic priming from pictures. *Cognition, 73*, B1–B15. doi:10.1016/S0010-0277(99)00049-9
- Dosher, B. A. (1998). The response-window regression method—Some

- problematic assumptions: Comment on Draine and Greenwald (1998). *Journal of Experimental Psychology: General*, *127*, 311–317. doi:10.1037/0096-3445.127.3.311
- Draine, S., & Greenwald, A. (1998). Replicable unconscious semantic priming. *Journal of Experimental Psychology: General*, *127*, 286–303. doi:10.1037/0096-3445.127.3.286
- E-Prime (Version 1.1) [Computer software]. Sharpsburg, PA: Psychology Software Tools.
- Eriksen, C. W. (1960). Discrimination and learning without awareness: A methodological survey and evaluation. *Psychological Review*, *67*, 279–300. doi:10.1037/h0041622
- Faust, M. E., Balota, D. A., Spieler, D. H., & Ferraro, F. R. (1999). Individual differences in information-processing rate and amount: Implications for group differences in response latency. *Psychological Bulletin*, *125*, 777–799. doi:10.1037/0033-2909.125.6.777
- Forster, K. I. (2004). Category size effects revisited: Frequency and masked priming effects in semantic categorization. *Brain and Language*, *90*, 276–286. doi:10.1016/S0093-934X(03)00440-1
- Forster, K. I., Mohan, K., & Hector, J. (2003). The mechanics of masked priming. In S. Kinoshita & S. J. Lupker (Eds.), *Masked priming: The state of the art* (pp. 3–37). New York, NY: Psychology Press.
- Greenwald, A. G., & Abrams, R. L. (2002, November). *Visual masking reveals two qualitatively different levels of unconscious cognition*. Paper presented at the 43rd Annual Meeting of the Psychonomic Society, Kansas City, KS.
- Greenwald, A. G., Draine, S. C., & Abrams, R. L. (1996). Three cognitive markers of unconscious semantic activation. *Science*, *273*, 1699–1702. doi:10.1126/science.273.5282.1699
- Greenwald, A. G., Klinger, M. R., & Schuh, E. S. (1995). Activation by marginally (“subliminal”) stimuli: Dissociation of unconscious from conscious cognition. *Journal of Experimental Psychology: General*, *124*, 22–42. doi:10.1037/0096-3445.124.1.22
- Hutchison, K. A. (2003). Is semantic priming due to association strength or feature overlap? A microanalytic review. *Psychonomic Bulletin & Review*, *10*, 785–813. doi:10.3758/BF03196544
- Hutchison, K. A., Balota, D. A., Cortese, M. J., & Watson, J. M. (2008). Predicting semantic priming at the item level. *The Quarterly Journal of Experimental Psychology*, *61*, 1036–1066. doi:10.1080/17470210701438111
- Jacoby, L. L. (1991). A process dissociation framework: Separating intentional from automatic uses of memory. *Journal of Memory and Language*, *30*, 513–541. doi:10.1016/0749-596X(91)90025-F
- Jacoby, L. L., Lindsay, D. S., & Toth, J. P. (1992). Unconscious influences revealed: Attention, awareness, and control. *American Psychologist*, *47*, 802–809. doi:10.1037/0003-066X.47.6.802
- Joordens, S., & Hockley, W. E. (2000). Recollection and familiarity through the looking glass: When old does not mirror new. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*, 1534–1555. doi:10.1037/0278-7393.26.6.1534
- Kang, M.-S., Blake, R., & Woodman, G. F. (2011). Semantic analysis does not occur in the absence of awareness induced by interocular suppression. *The Journal of Neuroscience*, *31*, 13535–13545. doi:10.1523/JNEUROSCI.1691-11.2011
- Kiesel, A., Kunde, W., Pohl, C., & Hoffmann, J. (2006). Priming from novel masked stimuli depends on target set size. *Advances in Cognitive Psychology*, *2*, 37–45. doi:10.2478/v10053-008-0043-y
- Klauer, K. C., Eder, A. B., Greenwald, A. G., & Abrams, R. L. (2007). Priming of semantic classifications by novel subliminal prime words. *Consciousness and Cognition*, *16*, 63–83. doi:10.1016/j.concog.2005.12.002
- Kouider, S., & Dehaene, S. (2007). Levels of processing during nonconscious perception: A critical review of visual masking. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *362*, 857–875. doi:10.1098/rstb.2007.2093
- Kouider, S., Dehaene, S., Jobert, A., & Le Bihan, D. (2007). Cerebral bases of subliminal and supraliminal priming during reading. *Cerebral Cortex*, *17*, 2019–2029. doi:10.1093/cercor/bhl110
- Kunde, W., Kiesel, A., & Hoffmann, J. (2003). Conscious control over the content of unconscious cognition. *Cognition*, *88*, 223–242. doi:10.1016/S0010-0277(03)00023-4
- Lachter, J., Forster, K. I., & Ruthruff, E. (2004). Forty-five years after Broadbent (1958): Still no identification without attention. *Psychological Review*, *111*, 880–913. doi:10.1037/0033-295X.111.4.880
- Logan, G., Zbrodoff, N. J., & Williamson, J. (1984). Strategies in the color-word Stroop task. *Bulletin of the Psychonomic Society*, *22*, 135–138.
- Lucas, M. (2000). Semantic priming without association: A meta-analytic review. *Psychonomic Bulletin & Review*, *7*, 618–630. doi:10.3758/BF03212999
- McKoon, G., & Ratcliff, R. (1992). Spreading activation versus compound cue accounts of priming: Mediated priming revisited. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *18*, 1155–1172. doi:10.1037/0278-7393.18.6.1155
- McNamara, T. P. (2005). *Semantic priming: Perspectives from memory and word recognition*. New York, NY: Psychology Press. doi:10.4324/9780203338001
- McRae, K., & Boisvert, S. (1998). Automatic semantic similarity priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *24*, 558–572. doi:10.1037/0278-7393.24.3.558
- Merkle, P. M., & Joordens, S. (1997). Parallels between perception without attention and perception without awareness. *Consciousness and Cognition*, *6*, 219–236. doi:10.1006/ccog.1997.0310
- Merkle, P. M., Joordens, S., & Stolz, J. A. (1995). Measuring the relative magnitude of unconscious influences. *Consciousness and Cognition*, *4*, 422–439. doi:10.1006/ccog.1995.1049
- Merkle, P. M., & Reingold, E. M. (1998). On demonstrating unconscious perception: Comment on Draine and Greenwald. *Journal of Experimental Psychology: General*, *127*, 304–310. doi:10.1037/0096-3445.127.3.304
- Naccache, L., & Dehaene, S. (2001). Unconscious semantic priming extends to novel unseen stimuli. *Cognition*, *80*, 215–229. doi:10.1016/S0010-0277(00)00139-6
- Neely, J. H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. *Journal of Experimental Psychology: General*, *106*, 226–254. doi:10.1037/0096-3445.106.3.226
- Neely, J. H. (1991). Semantic priming effects in visual word recognition: A selective review of current findings and theories. In D. Besner & G. W. Humphreys (Eds.), *Basic processes in reading: Visual word recognition* (pp. 264–336). Hillsdale, NJ: Erlbaum.
- Neumann, O., & Klotz, W. (1994). Motor responses to nonreportable, masked stimuli: Where is the limit of direct parameter specification? In C. Umiltá & M. Moscovitch (Eds.), *Attention and Performance: Vol. 15. Conscious and nonconscious information processing* (pp. 123–150). Cambridge, MA: MIT Press.
- Ortells, J. J., Abad, M. J. F., Noguera, C., & Lupiáñez, J. (2001). Influence of prime–probe stimulus onset asynchrony and prime precuing manipulations on semantic priming effects with words in a lexical decision task. *Journal of Experimental Psychology: Human Perception and Performance*, *27*, 75–91. doi:10.1037/0096-1523.27.1.75
- Ortells, J. J., Daza, M. T., & Fox, E. (2003). Semantic activation in the absence of perceptual awareness. *Perception & Psychophysics*, *65*, 1307–1317. doi:10.3758/BF03194854
- Ortells, J. J., Vellido, C., Daza, M. T., & Noguera, C. (2006). Semantic priming effects with and without perceptual awareness. *Psicológica*, *27*, 225–242.
- Pohl, C., Kiesel, A., Kunde, W., & Hoffmann, J. (2010). Early and late selection in unconscious information processing. *Journal of Experimental Psychology: Human Perception and Performance*, *36*, 268–285. doi:10.1037/a0015793

- Posner, M. I., & Snyder, C. R. R. (1975). Facilitation and inhibition in the processing of signals. In P. M. A. Rabbit & S. Dornic (Eds.), *Attention and performance: Vol. V* (pp. 669–681). London, England: Academic Press.
- Postman, L., & Keppel, G. (1970). *Norms of word associations*. New York, NY: Academic Press.
- Reingold, E. M., & Merikle, P. M. (1988). Using direct and indirect measures to study perception without awareness. *Perception & Psychophysics*, *44*, 563–575. doi:10.3758/BF03207490
- Reingold, E. M., & Merikle, P. M. (1990). On the inter-relatedness of theory and measurement in the study of unconscious processes. *Mind & Language*, *5*, 9–28. doi:10.1111/j.1468-0017.1990.tb00150.x
- Ruz, M., Madrid, E., Lupiáñez, J., & Tudela, P. (2003). High density ERP indices of conscious and unconscious semantic priming. *Cognitive Brain Research*, *17*, 719–731. doi:10.1016/S0926-6410(03)00197-6
- Schmidt, T. (2007). Measuring unconscious cognition: Beyond the zero-awareness criterion. *Advances in Cognitive Psychology*, *3*, 275–287. doi:10.2478/v10053-008-0030-3
- Shenaut, G. K., & Ober, B. A. (1996). Methodological control for semantic priming in Alzheimer's disease. *Psychology and Aging*, *11*, 443–448. doi:10.1037/0882-7974.11.3.443
- Stolz, J. A., Besner, D., & Carr, T. H. (2005). Implications of measure of reliability for theories of priming: Activity in semantic memory is inherently noisy and uncoordinated. *Visual Cognition*, *12*, 284–336. doi:10.1080/13506280444000030
- Van den Bussche, E., Notebaert, K., & Reynvoet, B. (2009). Masked primes can be genuinely semantically processed: A picture prime study. *Experimental Psychology*, *56*, 295–300. doi:10.1027/1618-3169.56.5.295
- Van den Bussche, E., & Reynvoet, B. (2007). Masked priming effects in semantic categorization are independent of category size. *Experimental Psychology*, *54*, 225–235. doi:10.1027/1618-3169.54.3.225
- Van den Bussche, E., Van den Noortgate, W., & Reynvoet, B. (2009). Mechanisms of masked priming: A meta-analysis. *Psychological Bulletin*, *135*, 452–477. doi:10.1037/a0015329
- Waechter, S., Besner, D., & Stolz, J. A. (2010). Visual word recognition: On the reliability of repetition priming. *Visual Cognition*, *18*, 537–558. doi:10.1080/13506280902868603
- Wentura, D. (2000). Dissociative affective and associative priming effects in the lexical decision task: *Yes* versus *no* responses to word targets reveal evaluative judgment tendencies. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*, 456–469. doi:10.1037/0278-7393.26.2.456

Appendix A

Stimuli Used in Experiments 1 and 2 (and English Translations)

Primes	Targets
Congruent trials (strong associates)	
CABRA (GOAT)	oveja (sheep)
PERRO (DOG)	gato (cat)
LEON (LION)	tigre (tiger)
LIEBRE (HARE)	conejo (rabbit)
SAPO (TOAD)	rana (frog)
TORO (BULL)	vaca (cow)
BOCA (MOUTH)	labios (lips)
CARA (FACE)	ojos (eyes)
CODO (ELBOW)	brazo (arm)
MANO (HAND)	dedos (finger)
MUSLO (THIGH)	pierna (leg)
PELO (HAIR)	cabeza (head)
Incongruent trials	
ABEJA (BEE)	pies (feet)
AVISPA (WASP)	dorso (back)
BALLENA (WHALE)	senos (bosoms)
BUHO (OWL)	tronco (trunk)
BUITRE (VULTURE)	cejas (eyebrows)
CIERVO (DEER)	muela (molar)
DELFIN (DOLPHIN)	pestaña (eyelash)
FOCA (SEAL)	nervio (nerve)
GALLO (ROOSTER)	vagina (vagina)
GANSO (GOOSE)	ombligo (navel)
GUSANO (WORM)	mejilla (cheek)
HALCON (HALCON)	vientre (tummy)
JABALI (BOAR)	pulmon (lung)
JIRAFÁ (GIRAFFE)	hombro (shoulder)

(Appendices continue)

Appendix A (*continued*)

Primes	Targets
LINCE (LYNX)	higado (liver)
LORO (PARROT)	riñon (kidney)
MONO (MONKEY)	rodilla (kneel)
MULA (MULE)	diente (tooth)
PALOMA (DOVE)	oreja (ear)
PANTERA (PANTHER)	corazon (heart)
POTRO (FOAL)	coclea (cochlea)
TOPO (MOLE)	craneo (skull)
VIBORA (VIPER)	barriga (belly)
ZORRO (FOX)	uña (nail)
BARBA (BEARD)	cuervo (raven)
BIGOTE (MOUSTACHE)	tiburón (shark)
CADERA (HIP)	pavo (turkey)
CUELLO (NECK)	hiena (hyena)
CEREBRO (BRAIN)	puma (puma)
CABELLO (HAIR)	araña (spider)
ESPALDA (BACK)	Mosca (fly)
FEMUR (FEMUR)	yegua (mare)
FOVEA (FOVEA)	ratón (mouse)
FRENTE (FOREHEAD)	lobo (wolf)
HUESO (BONE)	lechuza (owl)
IRIS (IRIS)	avispa (wasp)
LENGUA (TONGUE)	camello (camel)
MUSCULO (MUSCLE)	grillo (cricket)
UÑA (NAIL)	gallina (hen)
NUCA (NAPE)	gaviota (gull)
OIDO (EAR)	piraña (piranha)
POMULO (CHEEKBONE)	gacela (gazelle)
PECHO (CHEST)	gorila (gorilla)
PIEL (SKIN)	erizo (hedgehog)
TALON (HEEL)	buey (ox)
TIBIA (SHINBONE)	gorrión (sparrow)
TOBILLO (ANKLE)	cisne (swan)
TORAX (CHEST)	coyote (coyote)

Appendix B

Mean Similarity Rates (and Standard Errors) in the Rating Similarity Study for Strongly and Weakly Associated Prime–Target Pairs in Experiments 2, 3, and 4

Primes	Targets	<i>M</i>	<i>SE</i>	%AS
Strong associates				
CABRA (GOAT)	oveja (sheep)	5.7	.15	73.4
PERRO (DOG)	gato (cat)	6.5	.08	89.6
LEON (LION)	tigre (tiger)	6.4	.09	84.4
LIEBRE (HARE)	conejo (rabbit)	5.2	.19	89.2
SAPO (TOAD)	rana (frog)	6.2	.10	96.2
TORO (BULL)	vaca (cow)	6.4	.09	92.3
BOCA (MOUTH)	labios (lips)	6.5	.11	50.0
CARA (FACE)	ojos (eyes)	5.6	.19	38.2
CODO (ELBOW)	brazo (arm)	5.9	.16	66.7
MANO (HAND)	dedos (finger)	6.2	.15	58.3
MUSLO (THIGH)	pierna (leg)	5.9	.16	62.4
PELO (HAIR)	cabeza (head)	6.0	.14	60.0
CISNE (SWAN)	pato (duck)	6.3	.09	86.3
GORILA (GORILLA)	mono (monkey)	6.4	.08	84.2

(Appendices continue)

Appendix B (*continued*)

Primes	Targets	<i>M</i>	<i>SE</i>	%AS
NUCA (NAPE)	cuello (neck)	5.8	.15	50.8
MUELA (MOLAR)	diente (tooth)	6.2	.11	66.4
Weak associates				
CABRA (GOAT)	tigre (tiger)	1.6	.10	
PERRO (DOG)	vaca (cow)	1.8	.14	
LEON (LION)	conejo (rabbit)	2.0	.14	
LIEBRE (HARE)	gato (cat)	1.9	.13	
SAPO (TOAD)	oveja (sheep)	1.9	.15	
TORO (BULL)	rana (frog)	1.8	.17	
BOCA (MOUTH)	pierna (leg)	1.6	.14	
CARA (FACE)	dedos (finger)	2.0	.17	
CODO (ELBOW)	labios (lips)	1.8	.16	
MANO (HAND)	cabeza (head)	2.1	.15	
MUSLO (THIGH)	brazo (arm)	2.3	.17	
PELO (HAIR)	ojos (eyes)	2.5	.19	
CISNE (SWAN)	mono (monkey)	1.8	.16	
GORILA (GORILLA)	pato (duck)	1.7	.14	
NUCA (NAPE)	diente (tooth)	1.9	.17	
MUELA (MOLAR)	cuello (neck)	1.8	.16	

Note. 1 = *not at all similar*; 7 = *highly similar*. %AS = associative strength scores (in forward direction) for strongly associated pairs from Callejas et al.'s (2003) norms. Associative strength in Callejas et al.'s norms refers to the percentage of participants that gave the word target as the first response to the corresponding prime word. In Experiment 2 only the first 12 prime-target pairs (six pairs from each category) from strong and weak associates lists were presented.

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