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Negative semantic priming from consciously vs. unconsciously perceived single words

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The present research explores whether obtaining semantic negative priming from a single ignored word depends on whether that word is either consciously or unconsciously perceived. On each trial a prime word was briefly displayed and followed either immediately or after a delay by a pattern mask. The mask offset was followed by a probe display containing a single target word that participants were required to either categorize or identify. Participants were instructed to attend to the target while ignoring the prime word. On half of trials the prime-target pairs were highly associated words belonging to the same semantic category, whereas on the remaining half they belonged to different semantic categories. A differential priming pattern as a function of the masking condition was found: Semantic negative priming when the mask presentation was delayed, and positive priming when the prime word was immediately masked, thus preventing its conscious identification. These results suggest that masking type, which supposedly affects prime awareness, would be a critical factor to obtain negative semantic priming from single words. They also provide evidence that perceiving a stimulus with or without awareness can lead to qualitatively different behavioral consequences, which reflect the contribution of controlled and automatic components, respectively.

Visual selective attention refers to the ability to respond selectively to a portion of the surrounding environment while not responding to competing irrelevant sources of information. It is assumed that in order for selective responding to occur, relevant (i.e., target) stimuli must be processed to a greater extent than irrelevant stimuli. There are two non-

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exclusive ways for this to occur. First, the processing of relevant stimuli may be facilitated; second, the processing of irrelevant stimuli may be inhibited. Traditional models of selective attention have viewed selection of a target from a distractor as relying primarily on further (enhanced) processing of attended (relevant) information, with the irrelevant information being assumed to passively decay (e.g., Broadbent, 1982; Van der Heijden, 1981). More recently, however, several models have been proposed that emphasize a dual process, where the excitatory mechanism of attention would be supplemented by an active inhibition of the processing of irrelevant stimuli (e.g., Houghton & Tipper, 1994; Neill & Westberry, 1987; Tipper, 1985).

Evidence for selection through inhibition mainly concerns the observation that responses to a recently ignored object are often slower or less accurate than responses to new objects. That response slowing was termed *negative priming* (NP) by Tipper (1985) to contrast it with the *positive priming* (PP) effect, which is the demonstration that attending to an object facilitates subsequent responding to that stimulus (e.g., Scarborough, Cortese, & Scarborough, 1977). The NP effect has commonly been demonstrated in "selective attention" tasks, in which the to-be-ignored object is "selected against" a concurrent target to which participants have to attend and/or respond in each of two consecutive prime and probe displays (for reviews see Fox, 1995; May, Kane & Hasher, 1995; Neill, Valdes & Terry, 1995; Tipper & Milliken, 1996). Thus, in a typical NP experiment, two trials are presented in rapid succession; the first is generally called the prime trial, and the second is called the probe trial. In both trials, the observer usually attends (and/or responds) to one item while attempting to ignore other distracting items (the critical probe trials are those in which the previously ignored prime distractor is presented as the to-be-responded-to target stimulus). It makes sense then, that NP has widely been attributed to an inhibitory mechanism of attention acting on selected-against prime distractors (e.g., Houghton & Tipper, 1994; Tipper, 1985; Tipper & Cranston, 1985; but see Milliken, Joordens, Merikle & Seiffert, 1998; Neill & Valdes, 1992; Neill & Mathis, 1998, for alternative accounts of NP).

There are, however, a series of recent NP findings that result particularly challenging for inhibitory accounts, in that reliable NP is observed even when no selective attention appears to be required during presentation of the prime stimulus (e.g., Frings & Wentura, 2005; Milliken et al., 1998; Neill & Kahan, 1999; Neill, Kahan, & Ver Wys, 1996; Wood & Milliken, 1998). For example, in an elegant series of experiments, Milliken et al. (1998) presented at fixation (for 200 ms or less, depending on the experiment) a single white prime word followed by a to-be named red target word, which was presented either alone or superimposed over a

green distracting word (depending on the experiment). When participants were asked to attend to the prime word (Experiment 4), positive priming (PP) occurred for an identical (relative to a different) target word. In experiments in which participants were instructed to ignore the prime word, PP was again found when the target was presented alone in the probe display (i.e., ‘‘non-conflict’’ probe trials), but an opposite and reliable NP effect was observed when the probe task required selection between target and distractor (‘‘conflict’’ probe trials), thus suggesting that selective attention on probe (but not on prime) trials may be a crucial component to cause NP. The NP effect was also observed even when the prime was presented for 33 ms and pattern masked (Experiment 2), such that most participants reported to be unaware of the identity of the single primes.

At first sight, obtaining single negative priming would run counter the traditionally accepted assumption that such an effect occurs because of a reaction to distractor interference in selective attention situations. As pointed out by Milliken et al. (1998), since selection was not required during presentation of a single prime stimulus (i.e., there was no target to which participants responded during prime presentation), the prime was not selected against, and hence not inhibited. But several observations are, however, relevant here. First, in an experimental procedure requiring participants to "ignore" the first (i.e., the prime) of two stimuli presented in a rapid temporal sequence, the act of ignoring the prime word might involve the same inhibitory mechanisms that can actively suppress distracting items presented at irrelevant spatial locations on more conventional NP tasks (see also Tipper, 2001, for a similar line of argument).

Second, the dependence of NP effects on the presence of distractor stimuli in the probe display has been showed only for a number of tasks, such as letter-identification (e.g., Moore, 1994) or word (or colour) naming (e.g., Milliken et al., 1998; Neill & Kahan, 1999). When a (perhaps more demanding) binary task, such as lexical decision or semantic categorization is used on probe trials, there are several reports of reliable NP even if probe distractors are permanently absent (e.g., Abad, Noguera & Ortells, 2003; Ortells, Abad, Noguera, & Lupiáñez, 2001; Ortells & Tudela, 1996; Richards, 1999; Yee, 1991).

Finally, further research on single NP has also yielded somewhat mixed and apparently contradictory findings, with that effect being observed in some studies but not others. For example, Neill and Kahan (1999) conducted a series of experiments that closely replicated the Milliken et al.’s procedure, with the difference that the presence versus absence of a distractor on probe trials was manipulated in a within-participants (random) design, rather than across different experiments, as in

Milliken et al.'s study. In their Experiment 1a, in which the single prime word was briefly presented for 33 ms and followed by a masking pattern, an identical pattern of results as that of Milliken et al. (1998) was found. Namely, reliable NP when the to-be named target word was accompanied by a distractor (conflict probe trials), and PP when the target word was presented alone (non-conflict probe trials). Yet, such NP findings were not replicated in their Experiment 1b, despite of displaying again the masked prime word for 33 ms. Interestingly, when the exposure of the masked prime word was lengthened to 200 ms (Experiment 2), thus making the prime clearly visible, the NP effect disappeared and reversed to PP, regardless of the presence or absence of a distracting word on probe trials (see also Neill et al., 1996, Experiment 2). According to Neill and Kahan (1999), as no explicit instructions regarding the prime word were given to participants, it is possible that they chose to attend to that stimulus when it was presented for 200 ms, thus explaining the emergence of positive instead of NP for that prime duration (a similar argument was suggested to account for the lack of NP from a 33-ms prime in Experiment 1b). Yet, attentional instructions were not manipulated in their study.

Further evidence that manipulations affecting prime processing, such as the prime duration, could be more influential than the presence of probe distractors to obtain single NP, has been provided by Ortells, Fox, Noguera and Abad (2003; see also Noguera, Ortells, Abad, Daza & Carmona, 2007), who also manipulated attentional instructions in a within-participants (random) design such that participants were required to either "attend and remember" or "ignore" the single prime word, with both instructions varying randomly from trial to trial. A consistent finding in these experiments was that attentional instructions did modulate the magnitude and even the direction of priming effects. Thus, instructing participants to "attend and remember" a single prime word always produced an increased PP, irrespective of the prime exposure time, the presence vs. absence of prime masking, and the kind of probe display (conflict vs. non-conflict). Conversely, an "ignore" instruction produced reliable NP when the single prime was briefly presented for 50 ms (or less) and pattern masked. When the ignored prime was displayed for 100 ms (or more) and unmasked, PP was rather found, independently of the absence vs. absence of probe distractors, a result pattern that resembles that reported by Neill & Kahan (1999).

A potential explanation of the dependence of single NP on prime duration is that the latter factor could affect the level of awareness of a prime's identity. The absence of conscious awareness of the prime's identity has been viewed by some authors as one of the markers of traditional NP effects (e.g. Tipper, 2001; see also Frings and Wentura,

2005). For example, Tipper (1985) observed that NP effects were usually found for those participants that reported to be unaware of the prime distractor's identity. Likewise, most participants in experiments by Milliken et al. (1998) were unable to report the identity of the ignored single prime (see also Frings and Wentura, 2005, Experiment 2). A similar argument was used by Neill and Kahan (1999) to explain the opposite priming pattern (i.e., negative vs. positive) that was observed in their Experiments 1a and 1b, in which the prime word was always displayed for 33 ms and pattern masked.

Yet, it is important to highlight that participants' self-reports of prime awareness did not interact significantly with priming effects in either of experiments by Neill and Kahan (1999). In a similar vein, Ortells, Fox, Noguera & Abad (2003; see also Noguera et al., 2007) reported no reliable correlation between repetition priming effects for each participant and either their prime awareness' self-reports (i.e., a subjective measure) or their individual d' scores in a visibility test of masked words presented for short or longer durations (i.e., an objective index of awareness). It appears then that the status of a briefly presented (and pattern masked) single prime relative to conscious awareness is somewhat ambiguous. In fact, prime awareness *at the time of processing the prime trial* is not generally assessed in NP studies. Rather, at the end of the experimental session participants are asked to estimate approximately how often they were aware of the identity of the ignored prime stimulus. It could be the case that even if a stimulus was consciously perceived at the moment of its presentation in the prime display[1], participants reported to be unaware of its identity as a result of actively ignoring and/or selecting-against that stimulus in the prime trial.

In order to provide further evidence in support of a possible dependence of single NP on prime awareness, we used an experimental procedure which has shown consistent dissociations between consciously and unconsciously perceived stimuli, such that they can lead to qualitatively different (e.g., positive vs. negative priming) behavioural consequences (e.g., Daza, Ortells & Fox, 2002; Debner & Jacoby, 1994; Draine & Greenwald, 1998; Merikle & Joordens, 1997; Ortells, Daza & Fox, 2003; Ortells, Vellido, Daza & Noguera, 2006). Rather than manipulating the prime duration, the likelihood that a prime word was perceived with or without awareness was controlled by varying the *stimulus quality*, such that the prime word was always presented for 33 ms and followed by a mask

[1] Note on this respect that in traditional NP studies the prime display is not visually degraded (i.e., briefly displayed and/or pattern masked), such that participants could readily be aware of stimuli' identity.

appearing either immediately (i.e., a prime-mask stimulus onset asynchrony –SOA- of 33 ms), or after a time delay following the prime word offset. Whereas presenting the prime word under immediate masking aimed to prevent its conscious identification, with a delayed mask the prime word could be clearly visible and easily identifiable[2].

A second goal of the present study was to test whether single NP can generalize to semantic associates of the prime words. Given that prior research on single NP has always been conducted with identity NP tasks, in which the prime stimulus itself is repeated as the probe target, it remains unclear whether such an effect operates either at a relatively low feature (perceptual) level, or at a more abstract (categorical) level of representation. Negative priming has usually been considered a relevant finding not only in promoting dual conceptions of selective attention (i.e., excitatory mechanisms would be complemented by inhibitory processes), but also in suggesting that an ignored stimulus may undergo a deep level of processing, as invoked for example by late-selection attention models. Consequently, it would be critically important to demonstrate that NP does not depend on physical identity between prime and target, and it can also generalize to semantic associates of the prime stimulus (cf. Neill & Mathis, 1998).

But research examining *semantic* NP for related words[3] has often produced contradictory and unstable results (see Fox, 1995, for a review), with some researchers even arguing, given own null findings, that *semantic* NP simply does not exist (e.g., MacLeod, Chiappe, & Fox, 2002; see also Chiappe & MacLeod, 1995). In fact, reviewing the most recent attempts to find semantic NP reveals that it is found if several boundary conditions are given, some of them being rather untypical for *identity* NP research. For example, identity NP studies usually employ very small material sets (e.g., eight different words), whereas in semantic NP research large material sets are used such that often each stimulus occurred only once during an

[2] A number of previous studies (e.g., Cheesman & Merikle, 1985; 1986; Daza et al., 2002; Merikle, Joordens, & Stolz, 1995; Ortells et al., 2003; Ortells et al., 2006) have consistently found that whereas under delayed masking participants are aware of the prime word's identity, a prime-mask SOA of 33 ms (immediate masking) is clearly *below* most participants' threshold for *subjective* awareness.

[3] Semantic NP has been readily observed when the stimuli are pictures (e.g., Allport, Tipper & Chmiel, 1985; Tipper 1985; Tipper & Driver, 1988). For example, by using overimposed pictures of objects, Tipper (1985) found reliable NP effects not only from identical pictures, but also from categorically pictures (e.g., cat – dog). But given that pictures within the same category can have greater structural similarity than do objects in different categories (e.g., Rosch, Mervis, Gray, Johnson & Boyes-Braem, 1976), it remains possible that NP effects for related pictures can operate at a physical feature level rather than at an abstract categorical level of representation.

experiment (e.g. Abad et al., 2003; Ortells et al., 2001; Yee, 1991). Also, identity NP is usually only observed if the probe target is accompanied by a distractor as well (but see Frings & Wentura, 2005; Ortells, Fox, Noguera & Abad, 2003). However, semantic NP has been found without probe distractors (e.g. Abad et al., 2003; Ortells et al., 2001; Ortells & Tudela, 1996; Yee, 1991).

Finally, identity NP has usually been observed across a wide variety of stimulus materials and task demands (see Fox, 1995, for a review), such as letter-identification, or word (or colour) naming. But this is not the case regarding semantic NP. Virtually all prior studies reporting reliable semantic NP from words required participants to make a (perhaps more demanding) binary judgment task such as lexical decision on probe trials (e.g., Abad et al., 2003; Fox, 1994; 1996; Ortells at al., 2001; Richards, 1999). The observed dependence of semantic NP on task demands could be consistent with the idea that the inhibition mechanism of selective attention is flexible, adjusting to the behavioural demands of the task (e.g., Houghton & Tipper, 1994; Tipper, Weaver & Houghton, 1994). From that viewpoint, what gets inhibition is determined by the nature of the task, such that only those stimulus properties that directly compete with the target in terms of the goals to be achieved will be inhibited. It could be argued that a binary judgment task, such as lexical decision, would encourage much more semantic processing than it does a naming task, and hence semantic NP would be easier to obtain with the former that with the latter kind of task (Richards, 1999; see also MacLeod et al., 2002 for a similar argument)[4].

Yet, a non-inhibitory account for semantic NP with lexical decisions would also be possible. It has been suggested that semantic priming effects in lexical decision tasks can reflect the involvement of post-lexical backward strategies (e.g., Neely, 1991; see also May, Kane, & Hasher, 1995), such as *retrospective semantic-matching* (e.g., Neely, Keefe, & Ross, 1989), which might bias participants' responses to the probe target by speeding judgements of the related words and/or hampering judgements of the unrelated words (see Neely, 1991 for a review on that issue). Accordingly, we consider important to elucidate whether semantic NP from words can also be observed with other tasks engaging semantic processing, such semantic categorization or word identification, in which backward checking strategies (i.e., retrospective semantic matching) would not be thought to operate. This was the second aim of the present research.

[4] Note in fact that semantic PP with a naming task has also proved difficult to obtain, at least in languages with a shallow orthography, such as Spanish language (e.g., Cañas, Bajo, Burton, Burton, Corsbur & Padilla, 1994).

EXPERIMENT 1

The experimental procedure used in this and the next experiment was as follows: Participants were required to make a forced-choice task consisting of either a binary animate/inanimate judgment, or a four-choice word identification task, on a single target word that was centrally presented on the probe display. The probe target was preceded (600 ms before) by a prime word that was associatively and categorically related (e.g. TIGER – lion) to the target on half of the trials (related trials), whereas on the other half (unrelated trials) it belonged to a different semantic category to that of the target (e.g., TIGER – pencil). The prime word was always centrally displayed for 33 ms in an otherwise empty field, and followed either immediately or after a delay of 434 ms (depending on the experimental condition) by a pattern mask consisting of a random series of consonants. Independently of the masking condition (immediate vs. delayed) type, participants were encouraged to willingly ignore the prime word as it would act as a distractor that could interfere with their responses to the upcoming word target. To the extent that single NP critically depends on a lack of prime awareness at the time of processing the prime trial, we then expect a reliable interaction between masking type and prime-probe relatedness. That is, a reliable NP effect should be observed under immediate masking (i.e., degraded prime stimuli) but not under delayed masking (i.e., undegraded primes).

On the other hand, if semantic NP from words is not *task bound*, in the sense that it does not necessarily reflect the involvement of post-lexical checking strategies, then such an effect should be observed with probe tasks others than lexical decision, as was the case in the present Experiment.

METHOD

Participants. Forty-six (23 participants for each group) undergraduate students at the University of Almería participated in a single experimental session for course credit. All had normal or corrected-to-normal vision and were between the ages of 19 and 35 years.

Apparatus and Stimuli. Stimuli were displayed on a VGA color monitor controlled by E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) implemented on an IBM/ PC compatible computer. Responses were collected on a computer keyboard; response accuracy and latency to the nearest millisecond were measured by the E-Prime software. All stimuli were displayed in gray characters (with each character subtending about .29 degrees horizontally and .49 degrees vertically)

against a black background and they were centered both horizontally and vertically at a viewing distance of approximately 60 cm. Four concrete and familiar words in the Spanish language, 2 "animals" (CAT, DOG) and 2 "objects" (PENCIL, PAPER) were used as both prime and target stimuli throughout the experiment, with the only difference being that they were displayed in uppercase characters when appeared as a prime, and in lowercase characters when appeared as a target stimulus. A random string of seven grey letters (MDGTKSN) subtending about 2.46 degrees horizontally and .49 degrees vertically, was used as the pattern-mask. Participants were required to make a forced-choice task consisting of either a binary animate/inanimate judgment on a single target word (by pressing either the "M" or the "C" key on the computer keyboard), or a four-choice word identification task (selecting it among four different keys -"M", "N", "X" or "C"-), with the type of task varying across different trial blocks. Mapping of responses and correct key were counterbalanced across participants.

Design and Procedure. Participants were tested individually in a sound-damped, dimly lit room. General task instructions were relayed verbally. The timing of the specific stimulus events on each trial for the immediate masking group was as follows: (1) A fixation display (*) was presented for 500 ms; (2) an uppercase prime word presented for 33 ms; (3) a pattern mask (i.e., MDGTKSN), which was immediately presented following the prime display offset for 567 ms; (4) a lowercase target word (presented until response) that participants were required to either categorize (animate vs. inanimate) or identify (depending on the trial block). The sequence of events on each trial for the delayed masking group was the same as that under the immediate masking condition, with the only difference being that the presentation of the 33-ms prime word was now followed by a blank screen for 434 ms, and was then followed by the pattern mask for 133 ms. Whereas the prime-mask stimulus onset asynchrony (SOA) was of either 33 ms or 567 ms for immediate and delayed masking conditions, respectively, the prime-target SOA was always of 600 ms.

For each masking condition, the 50% of trials were related trials, on which the target was always a highly associated word of the same semantic category as that of the prime (e.g. CAT – dog). The remaining 50% were unrelated trials on which the target belonged to a different semantic category as that of the prime (e.g. CAT – pencil). Following the participants' response a new trial began.

The participants in each group took part in a single session (lasting about 24 minutes) consisting of two blocks of 112 trials (16 practice trials followed by 96 experimental trials), one block for each task (i.e., semantic categorization and word identification), with the order of blocks being counterbalanced across participants.

Participants were told that the main goal of the experiment was to investigate how effectively they could ignore irrelevant information to improve their performance. They were instructed to exclusively attend to the target stimulus while ignoring the prime word, treating it as a distractor. At the end of the experimental session, participants were asked to estimate approximately how often they were aware of the identity of the prime words.

RESULTS

Mean reaction times (RTs) and error rates were entered into two 2 x 2 x 2 analyses of variance (ANOVAs), with masking condition (immediate vs. delayed mask) as between-participants factor and prime-target relationship (related vs. unrelated) and task type (semantic categorization vs. word identification) as within-participants factors.

No reliable effects were found in the analysis of error rates. In the analysis of RTs, there was a significant crossover interaction between masking condition and prime-target relationship (F (1, 44) = 20.30, MSe = 764.2, $p < .0001$). Such an interaction showed an opposite priming pattern as a function of masking condition, with such a priming pattern remaining fairly the same across both semantic categorization and word identification tasks (see Table 1).

Table 1. Mean reaction times (in milliseconds) and error proportion (in parentheses) as a function of masking condition (immediate vs. delayed) and prime-target relationship (unrelated vs. related) for Experiment 1.

	Masking Condition	
Prime-Target Relationship	Immediate	Delayed
Related	628 (.04)	685 (.03)
Unrelated	642 (.04)	662 (.03)

For the immediate masking condition, a positive semantic priming effect of + 14 ms was found (F (1,22) = 7.73; MSe = 562.67, $p < .0109$), such that RTs on related trials were reliably *faster* than RTs on unrelated trials (see Table 1). By contrast, with the delayed mask a negative priming effect (i.e., faster RTs on unrelated relative to related trials) of – 23 ms was found (F (1,22) = 12.57; MSe = 965.73, $p < .0018$). The main effect of task type was also significant (F (1,44) = 83.89; MSe = 6541.99, $p < .0001$), so that RTs were reliably slower with the four-choice word identification task (709 ms) than with the semantic categorization binary task (600 msec). However, this factor did not interact with any other variable.

DISCUSSION

There were two relevant findings in the present experiment. First, we found that a single ignored word can give rise under several conditions (i.e., delayed masking) to reliable *semantic* NP, thus showing that single NP does not depend on physical identity between prime and target, as it can also generalize to semantic associates of a prime word. Whereas in virtually all prior demonstrations of semantic NP with words a lexical decision task was used (e.g., Abad et al., 2003; Fox, 1994; Fuentes & Tudela, 1992; Noguera et al., 2007; Ortells & Tudela, 1996; Ortells et al., 2001; Yee, 1991), in the present study participants made different kinds of forced-choice tasks others than lexical decision on probe trials. It appears then that semantic NP is not *task-bound*, as such an effect can also be observed under conditions where backward post-lexical strategies (e.g., semantic matching) would not be thought to operate.

The present results are also in line with prior research showing reliable semantic NP when the probe display contains a single target stimulus in an otherwise empty field (e.g., Abad et al., 2003; Fox, 1994; Noguera et al., 2007; Ortells & Tudela, 1996; Ortells et al., 2001; Richards, 1999; Yee, 1991). That finding is not necessarily inconsistent with the view assuming a dependence of negative priming effects on the selection requirements of the probe task (e.g., Lowe, 1979; Milliken et al., 1998; Moore, 1994; Tipper & Cranston, 1985). Thus, the use of a forced-choice task such as semantic categorization on probe trials could be enough demanding to induce an active selection state on probe trials (thus producing negative priming under several conditions), so that the difficulty of the probe task emulates the distraction effect of competition on the probe display.

A second main finding in the experiment was that masking manipulations resulted effective to modulate semantic priming effects from single ignored words, as revealed by a reliable interaction between masking

type and prime-probe relatedness. Yet, we observed an opposite priming pattern to that predicted by an *unawareness* prime hypothesis. Thus, only when the presentation of the pattern mask was delayed relative to the prime offset, such that participants could be able to consciously perceive the prime word (see Footnote 1), an instruction to willingly ignore that stimulus resulted in reliable NP. But when the prime word was immediately masked thus preventing or making difficult its conscious identification, the NP effects disappeared and reversed to an opposite, though also reliable PP.

The demonstration of a "crossover" interaction between priming effects and masking type replicates the results of a number of previous studies, which have demonstrated that unattended stimuli of which participants are not aware can lead to qualitatively different consequences (e.g., positive vs. negative priming effects) than when they are aware of those same stimuli (e.g., Daza et al., 2002; Debner & Jacoby, 1994; Draine & Greenwald, 1998; Merikle & Joordens, 1997; Ortells, Daza & Fox, 2003; Ortells, Vellido, Daza & Noguera, 2006). Particularly, obtaining reliable facilitation effects from immediately masked words with tasks demanding a semantic level of representation, is clearly consistent with behavioural and neuroscientific evidence (e.g., Copland, de Zubicaray, McMahon, Wilson, Eastburn, & Cheney, 2003; Deacon, Hewit, Yang & Nagata, 2000; Kiefer, 2002; Ortells, Daza & Fox, 2003) suggesting that semantic activation can occur without conscious identification of word stimuli, at least when they are presented below what Cheesman and Merikle (1986) refer to as a "subjective threshold".

Note however, that the positive instead of negative priming that was observed under immediate masking, is somewhat at odds with other studies obtaining single NP when the prime word is briefly presented and pattern masked. (e.g., Frings & Wentura, 2005; Experiment 2; Healy & Burt, 2003; Experiment 1; Milliken et al., 1998; Experiment 2; Neill & Kahan, 1999; Experiment 1a; Ortells, Fox, Noguera & Abad, 2003; Experiments 1-4). Whereas the reasons for these discrepancies are unclear, it is important to highlight that in all these studies a *repetition* instead of semantic priming paradigm was used. As suggested by some authors (e.g., Deacon et al., 2000), it still remains the possibility that prime masking would produce different results when repetition (i.e., identity priming) is manipulated as opposed to associative or categorical (semantic) priming. Note in fact that unlike identity NP, *semantic* NP has usually been shown with unmasked prime stimuli (e.g., Fox, 1994; Fuentes & Tudela, 1992; Ortells et al., 2001; Ortells & Tudela, 1996; Richards, 1999; Yee, 1991). In either case, given the novelty of our findings in showing (a) reliable semantic NP from *single* words under task conditions others than binary tasks (e.g., lexical decision),

and (b) a dependence of semantic NP on prime awareness, we considered worthy to replicate these results.

EXPERIMENT 2

The present study was procedurally similar to that of Experiment 1 with two main differences: First, only the four-choice word identification task was used. Second, the masking type was manipulated in a within-participants (random) design. In prior studies examining qualitative differences between perception with and without awareness, the immediate and delayed masking conditions usually varied across either different participants (e.g., Daza et al., 2002; Debner & Jacoby, 1994; Merikle & Joordens, 1997), or different trial blocks (e.g., Ortells, Daza & Fox, 2003). Under these conditions, it remains possible that the observed results (i.e., priming by masking type interaction) could reflect some strategic differences other than masking manipulations per se. There is some evidence that semantic priming under immediate masking can be modulated by the context manipulation, a finding that challenges the automaticity hypothesis (e.g., Smith, Besner & Miyoshi, 1994; see also Schlaghecken & Eimer, 2004). For example, Smith et al. (1994) found that priming effects produced by consciously perceived words remained fairly the same irrespective of whether the masking conditions were manipulated either blocked (i.e., a between-participant design) or mixed (i.e., a within-participant –random- design). In clear contrast, semantic priming from immediately masked words reached significance only in the blocked condition, but never in the mixed-presentation condition, in which both masking conditions varied randomly from trial to trial. According to Smith et al. (1994) whether priming effects under immediate masking would mainly reflect an automatic semantic activation (e.g., it is initiated without intention or awareness), then those effects should be not influenced by the concurrent presentation of consciously perceived words (i.e., the mixed condition), as was really the case. Accordingly, we consider worthy to replicate the differential priming pattern (i.e., positive vs. negative) as a function of masking type that was observed in Experiment 1, when the immediate and delayed masking trials were randomly intermixed within the experimental session. This was the main aim of the present experiment.

METHOD

Participants. Twenty-four undergraduate students at the University of Almería participated in a single experimental session for course credit. All had normal or corrected-to-normal vision and were between the ages of 19 and 35 years.

Stimuli and Procedure. These were similar to those of Experiment 1, except that in the present experiment (a) only the four-choice word identification task was used, and (b) the presence of either an immediate or a delayed mask was manipulated in a within-participant design, such that the two masking conditions varied randomly within a block.

Each participant took part in a single session consisting of one block of 32 practice trials followed by one block of 128 experimental trials. Half of both practice and experimental trials were "immediate masking trials" and the other half "delayed masking trials", with both masking conditions varying randomly from trial to trial. On the 50% of trials the prime-target pairs were highly associated words belonging to the same semantic category (related trials), whereas on the remaining 50% (unrelated trials) the prime and target words belonged to different semantic categories. As in Experiment 1, at the end of the experimental session participants were asked if they were aware (at anytime) of the prime word's identity on both immediate and delayed masking trials.

RESULTS

Mean RTs and error rates were entered into two 2 x 2 ANOVAs, with masking condition (immediate vs. delayed) and prime–target relationship (related vs. unrelated) as within-participants factors.

Table 2. Mean reaction times (in milliseconds) and error proportion (in parentheses) as a function of masking condition (immediate vs. delayed) and prime-target relationship (unrelated vs. related) for Experiment 2.

	Masking Condition	
Prime-Target Relationship	Immediate	Delayed
Related	730 (.03)	756 (.03)
Unrelated	760 (.04)	733 (.05)

No reliable effects were found in the analysis of error rates. In the analysis of RTs, there was a significant crossover interaction between masking condition and prime-target relationship (F (1, 23) = 9.48, MSe = 1798.26, $p < .0053$), which showed the same differential priming pattern as a function of masking condition as that observed in Experiment 1 (see Table 2). Namely, positive semantic priming (+ 30 ms) for the immediate masking trials (F (1,23) = 4.45; MSe = 2433.11, $p < .0460$), and negative semantic priming (- 23 ms) for the delayed masking trials (F (1, 23) = 4.62; MSe = 1404.91, $p < .0423$).

DISCUSSION

The present results replicate those from Experiment 1 in demonstrating that even if participants are explicitly instructed for ignoring a briefly presented single word, no negative priming effect is found when that stimulus is immediately masked to prevent its conscious identification.

Whereas such a result appears to be in clear contrast with several prior reports of single NP from briefly presented and masked words, obtaining reliable positive priming under immediate masking trials provides compelling evidence of semantic processing in the absence of perceptual awareness (see also Daza et al., 2002; Merikle & Joordens, 1997; Ortells, Daza & Fox, 2003; Ortells, Vellido, Daza & Noguera, 2006). Also, obtaining facilitatory priming from immediately masked words despite the concurrent presentation of consciously-perceived words (i.e., delayed masking trials), as was the case in the present Experiment, provides further and strongest evidence for unconscious (automatic) perception, since those priming effects would be not affected by context manipulations.

GENERAL DISCUSSION

There is now broad evidence that the Negative Priming (NP) effect can be demonstrated even when no selection is apparently required during presentation of a single prime stimulus (i.e., there is no target to which participants responded during prime presentation). Whereas single NP was originally reported only for "conflict" probe trials, in which the target was presented along with a competing distractor (e.g. Milliken et al, 1998), further empirical work on single NP has revealed that manipulations affecting the processing of the prime stimulus would be more determinant to single NP than the presence vs. absence of probe distractors. Thus, the likelihood to observe single NP would critically depend on (a) instructing participants to actively ignore the prime stimulus (e.g., Noguera, et al., 2007; Ortells et al., 2003; see also Ortells, Fox, Noguera & Abad, 2006), and (b) presenting the prime for a relatively short (e.g., 50 ms or less) time

exposure (e.g., Neill & Kahan, 1999; Neill, Kahan & VerWys, 1996; Ortells, Fox, Noguera & Abad, 2003).

The results of the present research replicate and extend these latter findings in showing that manipulations affecting prime awareness would also be critical to single NP. In both Experiments 1 and 2 we consistently found that a briefly presented (33 ms) and post-masked single prime word that participants were instructed to willingly ignore, produced facilitatory priming when it was immediately followed by the mask, thus preventing its conscious identification. But a NP effect was rather found when the prime word offset was followed by a blank screen prior the mask onset, thus rendering the prime clearly visible and identifiable (see Footnote 1). This latter result would be not necessarily undermine the notion that negative priming effects reflect an absence of conscious awareness of the prime's identity, as argued by some authors (e.g., Tipper, 2001). It could be the case that as a *consequence* of actively ignoring a single prime word, participants were unaware of that stimulus even when it was not visually degraded (i.e., delayed masking), such that participants were able to consciously identify the prime word at the time of its presentation in the prime display. In fact, participants in both Experiments 1 and 2, self-reported as unaware of the ignored word's identity on most of trials, irrespective of the masking condition.

As noted in the introduction, single NP was considered by some authors (e.g., Milliken et al., 1998) as a problematic finding for selective inhibition theories. Yet, the ignored priming effects in our experiments could be explained in terms of attentional inhibitory mechanisms, if an assumption is made that selective inhibition acting on pre-activated representations of a prime word can operate not only under ''spatial'' coordinates (i.e., *where* to attend vs. ignore), but also under a ''temporal'' dimension (i.e., *when* to attend vs. ignore; see also Tipper for a similar line of argument). In fact, the different priming pattern (i.e., positive vs. negative) that was observed as a function of masking type (immediate vs. delayed), would be consistent with the inhibitory model developed by Houghton and Tipper (1994). They describe a neural network model in which an internal template is created against which perceptual inputs are compared. The template contains stimulus features that specify which object is the target for action (see also Duncan & Humphreys, 1992, for similar template matching selection mechanisms). For example, if participants are told to name the red object in each stimulus array, the template would be red (Tipper & Cranston, 1985). Other potential templates include shape, size, or any other feature, such as location in a temporal sequence (e.g., Milliken et al., 1998), that distinguishes target from distractor. Any inputs matching this template receive excitatory

feedback, while those of the distractor which mismatch the template receive inhibitory feedback, with both excitatory and inhibitory feedback being viewed as independent selection mechanisms. A main property of the Houghton and Tipper model is that inhibition (or suppression) that feeds back to the distractor input is *reactive*, such that the level of inhibition is determined by the relative perceptual and/or response salience of the distractor. Distractors that are more salient and intrude into the control of action would receive larger inhibitory feedback than less salient distractors. Note that the notion of reactive inhibition would be able to accommodate the pattern of results reported here. It seems plausible that an ignored single word that is not immediately post-masked (i.e., delayed masking) could be a perceptually more salient and competing distractor, as compared to a brief prime word that is immediately followed by the mask. This could explain the emergence of NP in the former (delayed) but not in the latter (immediate) masking condition in our experiments.

A second main finding in the present research is that single NP can generalize to semantic associates of the prime words. Whereas the status of semantic NP for related words is still considered by several authors as remaining elusive (e.g. MacLeod et al., 2002, see also Chiappe & MacLeod, 1995), our results replicate and extend some recent findings (e.g. Abad et al., 2003; Ortells et al., 2001; Richards, 1999) in showing that *semantic* NP from *singly presented* words can also be a robust effect, even when other tasks different to the lexical decision are used, such as semantic categorization or a four-choice word identification task. Obtaining semantic NP with these latter tasks clearly demonstrates that such an effect would not be due to backward post-lexical strategies, as it could be the case when a lexical decision is used on probe trials (e.g., Noguera et al., 2007; Ortells et al., 2001).

As previously noted, the dilution of semantic NP (and its reversal into PP) under the immediate masking condition clearly contrasts with results from several prior studies, which have reported *negative* rather than positive priming from briefly presented and immediately masked single words (e.g., Frings & Wentura, 2005; Experiment 2; Neill & Kahan, 1999, Experiment 1a; Ortells, Fox, Noguera & Abad, 2003, Experiments 1-4, Milliken et al., 1998, Experiment 2). But note that in all of these experiments an *identity* instead of *semantic* NP paradigm was used. As suggested by some authors (e.g. Deacon et al., 2000), it remains possible that prime masking produces a different result pattern when identity priming is manipulated as opposed to semantic (i.e., associative or categorical) priming. In fact, identity NP has widely proved its consistency and generality regardless whether or not the prime stimuli are presented under pattern masking. But this is not the case regarding semantic NP. Thus, whereas studies reporting no semantic NP

evidence have usually presented postmasks following the prime words (e.g., Chiappe & Macleod, 1995; Tipper & Baylis, 1987; Tipper & Driver, 1988), in virtually all prior reports of semantic NP the prime stimuli are unmasked (e.g., Fox, 1994; Fuentes & Tudela, 1992; Ortells et al., 2001; Ortells & Tudela, 1996; Richards, 1999; Yee, 1991). Further research addressing possible differences between identity and semantic NP as a function of prime masking is clearly needed.

In either case, two main contributions are conveyed in the present research. First, to our knowledge, this is the first study to show reliable *semantic* NP from *singly presented* words by using probe tasks such as semantic categorization or word identification, in which it is assumed that post-lexical checking strategies are not at work. Second, ignoring a single, briefly exposed (33 ms) and masked prime could be necessary but *not sufficient* prerequisites to obtain NP in our task. The present experiments consistently demonstrated that single NP was only observed when the onset of the pattern mask following the prime stimulus was delayed, such that participants could have been aware of the prime's identity. But positive instead of negative priming was found when the prime stimulus was immediately followed by the mask, thus preventing the conscious identification of the former. Overall, such an opposite priming pattern as a function of masking type (immediate vs. delayed), appears to be consistent with results from an increasingly number of studies, which demonstrate that perceiving a stimulus with or without phenomenological awareness can lead to qualitatively different behavioral consequences, which reflect the contribution of strategy-based (controlled) and automatic components, respectively (e.g., Daza et al., 2002; Debner & Jacoby, 1994; Draine & Greenwald, 1998; Merikle & Joordens, 1997; Ortells, Daza & Fox, 2003; Ortells, Vellido, Daza & Noguera, 2006; Reingold & Merikle, 1988).

It is now well established that information consciously perceived enables individuals to act intentionally and to produce effects in the world, such that they are able to explicitly follow instructions or to use predictive strategies based on stimulus redundancy (e.g., predicting the color or the semantic category of a forthcoming target). In contrast, information perceived without awareness leads to more automatic reactions that cannot be controlled by individuals (e.g. Daza et al., 2002; Merikle & Joordens, 1997; Ortells, Daza & Fox, 2003; Ortells, Vellido, Daza & Noguera, 2006). To the extent that selective inhibition has been considered as a controlled process (e.g. Conway & Engle, 1994; Engle, Conway, Tuholski & Shisler, 1995; Nakagawa, 1991), it makes sense that an instruction to actively ignore a single prime word could only be effective (thus resulting in reliable NP) when that stimulus is not visually degraded (i.e., followed by a delayed mask), such that participant could readily be aware of its identity.

RESUMEN

Priming semántico negativo producido por palabras enmascaradas en ausencia de distractores. El presente estudio investiga si la obtención de priming semántico negativo ante una única palabra ignorada depende del nivel de conciencia de dicha palabra. En cada ensayo aparecía brevemente una palabra previa seguida inmediatamente o tras un intervalo de demora, por una máscara de patrón. A continuación aparecía una palabra objetivo ante la que los participantes debían realizar una tarea de categorización semántica o una tarea de identificación de elección forzada. Se instruyó a los sujetos a que atendieran la palabra objetivo e ignoraran la palabra previa, considerándola como un distractor. Las palabras previa y objetivo pertenecían a la misma categoría semántica en la mitad de los ensayos, y a distintas categorías en los ensayos restantes. Los resultados mostraron un patrón diferencial de efectos de priming semántico en función del tipo de enmascaramiento: Priming negativo con la máscara demorada, y facilitación con la máscara inmediata. Estos resultados demuestran que el tipo de enmascaramiento, que supuestamente afecta a la percepción consciente vs. no consciente de la palabra previa, constituiría una variable crítica para obtener priming semántico negativo ante una única palabra. También son consistentes con la idea de que la percepción con y sin conciencia produce consecuencias comportamentales cualitativamente diferentes, que reflejan la contribución de procesos controlados y automáticos, respectivamente.

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