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Is masked priming modulated by memory load? A test of the automaticity of masked identity priming in lexical decision

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Abstract
One of the key assumptions of the masked priming lexical decision task (LDT) is that primes are processed without requiring attentional resources. Here, we tested this assumption by presenting a dual-task manipulation to increase memory load and measure the change in masked identity priming on the targets in the LDT. If masked priming does not require attentional resources, increased memory load should have no influence on the magnitude of the observed identity priming effects. We conducted two LDT experiments, using a within-subjects design, to investigate the effect of memory load (via a concurrent matching task Experiment 1 and a concurrent search task in Experiment 2) on masked identity priming. Results showed that the magnitude of masked identity priming on word targets was remarkably similar under high and low memory load. Thus, these experiments provide empirical evidence for the automaticity assumption of masked identity priming in the LDT.

Keywords Masked priming · Lexical decision · Automatic processes · Lexical access

One of the most useful techniques in word recognition research is the masked priming lexical decision task (LDT) introduced by Forster and Davis (1984). In each trial, participants are asked to make a word/nonword decision on an uppercase letter string. These target items are briefly preceded by a prime (around 30–50 ms) that is embedded between a forward mask and the target, so that subjects are not aware of the prime stimulus. Responses to the target *CHAIR* are faster when the masked prime is a related stimulus (e.g., an identity prime, *chair*) than when the prime is an unrelated stimulus (e.g., *mouse*), thus producing a priming effect.

It is commonly assumed that the processes of interest in the masked priming paradigm are automatic (see Forster, 1998; Grainger, 2008, for reviews). In this context, we consider that a process is automatic when it is unaffected by reduced attentional resources due to the demands of a concurrent task. For instance, when the target word is *CHAIR*, the masked identity prime *chair* would produce a head start for the processing of the target (i.e., a "savings" effect) relative to the masked unrelated prime *mouse,* even if participants are not devoting all of their attention to the task. This effect is reflected as a shift in the response-time distributions (see Gomez, Perea, & Ratcliff, 2013, for empirical and modeling evidence). Consistent with this view, masked priming effects can be obtained regardless of the proportion of related pairs (e.g., see Bodner & Stalinski, 2008; Grossi, 2006; Pecher, Zeelenberg, & Raaijmakers, 2002; Perea & Rosa, 2002).

However, there is some empirical evidence that suggests that masked priming effects may be modulated by spatial and temporal attention. With respect to spatial attention, Lachter, Forster, and Ruthruff (2004) found that masked identity priming in the LDT occurred when the prime was presented at an attended location (i.e., the same as the target location), but not when the prime was presented at an unattended location (i.e., one line above the target; see also Marzouki, Grainger, & Theeuwes, 2007, for converging evidence in an alphabetic decision task). Regarding temporal attention, Naccache, Blandin, and Dehaene (2002) varied the stimulus onset asynchrony (SOA) between prime and target (either variable or fixed) in a categorical task ("Is the number odd or even?"; e.g., prime: *3*; target: *7*). In the blocks in which the SOA was fixed, they found masked priming effect (i.e., predictable trial; e.g., primes and targets presented after 600 and 700 ms, respectively, after target onset). Critically, the priming effects vanished in the blocks in which the SOA was variable (i.e., the prime onset or the target onset could not be predicted) and

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concluded that this pattern was "inconsistent with the concept of a purely automatic spreading of activation during masked priming" (p. 416). To examine the generality of these findings, Fabre, Lemaire, and Grainger (2007) examined the role of temporal attention on masked priming for numbers (odd-parity task) and words (LDT). For numbers, they found a modulating effect of temporal attention on masked categorical priming in the odd-parity task, thus replicating Naccache et al.'s (2002) findings. But the key result was that temporal attention did not modulate the magnitude of masked identity priming in the LDT. To explain this dissociation, Fabre et al. (2007) indicated that "non-semantic lexical properties could be processed independently of temporal attention in contrast to semantic properties of stimuli" (p. 528). A similar dissociation was reported by Holcomb, Reder, Misra, and Grainger (2005) using event-related potentials: N400 effects were affected by prime awareness in masked semantic priming, but not in masked identity priming. Thus, at least for masked identity priming in the LDT, the key prerequisite is that participants attend the location of the prime/target (Lachter et al., 2004).

In the present study, we examined whether masked identity primes in the LDT are processed without attentional resources by inducing different degrees of memory load via a concurrent secondary task. If masked identity priming effects in the LDT do not require attentional processes, they should be invariant relative to this dual-task manipulation. Conversely, if masked priming effects in the LDT require some attentional resources, increased memory load might interfere with prime processing and reduce (or even eliminate) the identity priming effect. Rather surprisingly, there have been very few studies that have attempted to examine this issue in the LDT. To our knowledge, the one study that addresses this question is the experiment conducted by Bodner and Stalinski (2008). In their experiment, half of subjects ("high-load group") were asked to make a same–different decision on two random eight-digit strings, one presented immediately before each LDT trial and one presented immediately after (e.g., for a different trial: the reference could be *84762912* and the target could be *84562912*). Targets in the LDT were either primed with themselves (identity prime; e.g., *duck–DUCK*) or orthographically unrelated items (control prime; e.g. *wall–DUCK*). The other half of subjects ("no-load group") only received the LDT. Bodner and Stalinski (2008) observed comparable masked identity priming effects in the high-load and no-load groups (35 vs. 43 ms, respectively), and concluded that masked primes were processed without attentional resources in the LDT.

While the findings reported by Bodner and Stalinski (2008) are undoubtedly important, a potential shortcoming in their study is that the manipulation of memory load was between subjects. The nonsignificant 8-ms difference reported by Bodner and Stalinski (2008) could become significant with a more powerful within-subjects design. Indeed, in the lexical access literature, within-subjects manipulations are the preferred design: the variability between subjects in reaction times on the lexical decision task is rather large because RTs are not a pure measure of lexical entry, but of a number of other simultaneous processes involved with the task itself (see Ratcliff, Gomez, & McKoon, 2004). Furthermore, in the present experiments, rather than comparing a no-load condition with a load condition, we compared two conditions that induced different levels of memory load. This way, the LDT was always accompanied by a secondary task (i.e., the only difference between the high-load and low-load conditions was the degree of difficulty induced the secondary task).

We conducted two masked priming LDT experiments in which the target stimuli (e.g., *SAFARI*) were preceded by an identity prime (*safari*) or an unrelated word prime (*módulo* [Spanish for *module*]), thus allowing us to measure masked identity priming. We examined whether memory load modulates the size of masked priming effects in the LDT using a within-subjects manipulation. We chose masked identity priming because it produces larger and more consistent effect sizes than the other masked priming manipulations (e.g., form priming), and, hence, it may be more sensitive to interactions with memory load (see also Lachter et al., 2004, for a similar reasoning). To induce a differential memory load, the LDT was accompanied by a secondary task. In Experiment 1, the secondary task was a forced-choice perceptual identification task (e.g., see Gomez, Perea, & Ratcliff, 2008) in which the reference was a string of four consonants (an easy-to-remember string composed of four repeated consonants, like *MMMM,* or a difficult-to-remember string composed of four different consonants, like *LWRV*) that was presented for 1,000 ms immediately before each LDT and that participants were instructed to remember. This task has some desirable properties over old–new tasks (see Kroll, Yonelinas, Dobbins, & Frederick, 2002), and we chose it to discourage participants from basing their responses on biases toward "old" or "new" responses. After the LDT trial, they were given two strings (a target and a distractor) and were asked to pick the one that matched the reference (e.g., reference: *MMMM*; masked lexical decision: *#####–social–SOCIAL*; forced-choice memory task: *MMMM vs. DDDD*). In Experiment 2, we employed a probe-digit memory task (see Paap & Noel, 1991, for a similar secondary task), as it may require greater attentional resources than a forced-choice matching task. The secondary task involved strings of digits instead of letters (e.g., an easy-to-remember string composed of the same digit five times like *77777*, or a difficult-to-remember string composed of five different digits, like *35761*). Subjects were presented the string of digits immediately before each LDT trial, and after each trial they were asked to decide whether or not a given digit was present in the reference (e.g., reference: *77777*; masked lexical decision: *#####–social–SOCIAL*; target: *7*?).

The predictions are quite straightforward. If masked primes are processed without attentional resources in lexical decision, the size of masked identity priming should be similar under high and low memory load. Alternatively, if masked primes in lexical decision involve some attentional resources that may be hindered by memory load, the size of masked identity priming should be smaller under high rather than under low memory load.

Experiment 1

Method

Participants Subjects were 24 undergraduate students at the University of Valencia, who participated voluntarily in the experiment.

Materials Target words for the LDT included 160 Spanish words of six letters, all of them nouns, extracted from EsPal subtitle database (Duchon, Perea, Sebastián-Gallés, Martí, & Carreiras, 2013). The mean frequency per million was 81.1 (range: 1.1–1287.7) and the mean OLD20 was 1.75 (range: 1.2–2.2). We employed Wuggy (Keuleers & Brysbaert, 2010) to generate 160 orthographically legal pseudowords that matched with the target words in length and syllabic structure. The list of target stimuli is presented in the Appendix. Targets were presented in uppercase letters, and primes were presented in lowercase letters. Identity primes were the same as their respective targets. Control primes were orthographically unrelated and had been created by rearranging the order of identity primes.

For the secondary matching-to-a-stored-reference task, we employed four-letter consonant strings. Strings were divided in two groups: those that belonged to the "low memory load" condition (the same consonant repeated 4 times; i.e. *MMMM*) and those that belonged to the "high memory load" condition (four different consonants; i.e., *LWRV*) In the decision phase, participants were presented two four-letter consonant strings: One of the strings was identical to that presented in the study phase, and the other was a distractor. For low-memory-load trials, the distractor differed on repeated consonants across all four positions (e.g., *MMMM* vs. *DDDD*), whereas for high-memory-load trials, the distractor differed from the target on two letter positions (e.g., *LWRV* vs. *LSDV*). While these positions could be internal/external and adjacent/nonadjacent, in 60% of trials the difference between target and distractor was in the middle letters. This was done to increase the difficulty in the secondary task: Letter strings that differ in the internal letters are more confusable than those that differ in external letters (e.g., see Gomez et al., 2008). We created four lists to counterbalance each target stimulus across the four conditions (i.e., high memory load–identity prime; high memory load–unrelated prime; low memory load–identity prime; low memory load–unrelated prime). Six participants were randomly assigned to each list.

Procedure Participants were tested alone in a quiet room. Stimuli were presented on a Windows computer using DMDX (Forster & Forster, 2003) and on a CRT screen. Each trial consisted of three phases. Phase 1 consisted of a fixation point (+) for 400 ms, followed by the reference for the memory task presented for 1,000 ms. Phase 2 consisted of an LDT trial in which a forward mask (#####) was presented for 500 ms, the prime for 50 ms, and then the target for 2,000 ms (or until the participant responded). Subjects were instructed to decide whether the target item was a word (press *M*) or a nonword (press *Z*). Phase 3 consisted of a blank period of 500 ms followed by two strings of letters for 2,000 ms; one of the strings matched the reference from Phase 1 of the trial, and the other was a distractor; subjects had instructions to indicate with a key press the one that matched the reference (left—press *Z*; right—press *M*). The entire experiment lasted approximately 30 minutes with opportunities to take a break every 5–6 minutes.

Results and discussion

Secondary task (matching task) To analyze whether the cognitive manipulation produced the expected pattern in the matching task, we conducted *t* tests on the mean correct RTs (and error rates) on the target stimuli in the low-memory-load and the high-memory-load conditions. Before conducting the analyses on the latency data, we removed all responses less than 250 ms (less than 0.01% of the data). As expected, response times were longer are more error-prone under high memory load than in low memory load (RTs: 719 vs. 499 ms, respectively), $t(23) = 14.07$, $p < .001$; (percentage error: 7.8% vs. 5.4%, respectively), $t(23) = 2.91$, $p = .008$.

Lexical decision task Prior to the RT analyses, we removed all correct responses less than 250 ms (less than 0.1% of data) as well as error responses. The mean correct RT and percentage error per condition is presented in Table 1. As masked priming effects in lexical decision tend to be small and inconsistent for nonword targets (see Forster, 1998), we examined separately the data for word and nonword targets.

To test the two fixed effects on the RT word data (identity priming: identity, unrelated; memory load: low, high), we employed linear mixed-effects (LME) models in R (R Development Core Team, 2017) using the package lme4 (Bates, Mächler, Bolker, & Walker, 2015). We employed the model with the maximal random effect structure—that is, $LME\_RTwords = lmer(-1{,}000/RT \sim priming \times memload + (priming \times memload + 1|item) + (priming \times memload + 1|subject), data = memloadRTwords)$—note that latency data

Table 1 Mean response times (in ms) and percentage error rate (in parentheses) across conditions for words and pseudowords in Experiment 1

	Low memory load	High memory load
Word trials		
Identity	635 (3.8)	639 (3.5)
Control	682 (5.3)	680 (4.7)
Priming	47 (1.5)	41 (1.2)
Nonword trials		
Identity	759 (6.3)	760 (4.6)
Control	771 (5.8)	781 (6.6)
Priming	12 (−0.5)	21 (2.0)

Note. *Priming* refers to the difference between the control and identity conditions

were transformed (−1,000/RT) to maintain the normality assumption of LME models. The p values corresponding to each effect were obtained with the lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2017). The analyses on the accuracy data employed the glmer function in R. The analysis for the nonword targets was parallel to that of the word targets.

Word targets The analyses of the RTs showed that lexical decision times on the target words were, on average, 44 ms faster when preceded by an identity prime than when preceded by an unrelated prime, b = 0.1234, SE = 0.01448, t = 8.528, p < .001. In addition, there were no signs of an effect of memory load (the effect was less than 1 ms), t < 1. The identity priming effect was similar in magnitude under high and low memory load, as deduced by the lack of interaction between priming and memory load, t < 1.07, p > .29. The discussion of the features of the RT distribution is presented in conjunction with the results from Experiment 2 in the section RT Distribution.

The analyses of the accuracy data only showed that the identity priming effect approached significance, b = −0.3386, SE = 0.1903, z = −1.78, p = .075—the t values for the other effects were less than 0.64 (ps > .52).

Nonword targets The analyses of the latency data showed that lexical decision times on the nonword targets were, on average, 16 ms faster when preceded by an identity prime than when preceded by an unrelated prime, b = 0.0233, SE = 0.00833, t = 2.79, p = .006. Lexical decision times on nonwords were, on average, 5.5 ms slower under high than under low memory load, but the effect only approached significance, b = 0.0184, SE = 0.0095, t = 1.95, p = .06. The interaction between the two factors was not significant, t < 0.38, p > .70.

The analyses of the accuracy data failed to show significant effects of identity priming or memory load, both ts < 1.28, both ps > .20. The interaction between identity priming and memory load approached significance, z = 1.70, p = .090.

Results for word trials showed that the size of masked identity priming was similar under high and low memory load (around 41–47 ms), thus replicating the pattern reported by Bodner and Stalinski (2008), this time with a within-subjects design. Critically, the size of the masked identity priming is in line to that reported in the literature with 50-ms prime exposure duration primes (see Forster, 1998; Gomez et al., 2013). This may suggest that memory load does not affect the processing of masked primes.

However, there is a limitation in the present experiment: The memory load manipulation did not have an effect over the lexical decision times to words (i.e., the difference between the high-load and low-load condition for word trials was less than 1 ms) and the effect of memory load was only marginal to nonwords. Thus, one could easily argue that memory load did not differ much in the high-load relative to the low-load condition. Why did the manipulation of memory load fail to have a substantial effect on target performance? One potential reason is that the secondary task only involved discriminating the reference against a distractor rather than the identification of the whole letter string or the identification of one of its constituent letters. The 220-ms effect of memory load in the secondary matching task could have merely been because it is more difficult to discriminate the target from the distractor in the high-memory-load condition (i.e., two different letters; e.g., reference: *LWRV* and target: *LWRV* vs. *LSTV*) than in the low-memory-load condition (i.e., all four letters different; e.g., reference: *RRRR* and targets: *RRRR* vs. *MMMM*). Clearly, to examine whether masked identity priming is modulated by memory load in the LDT, it is necessary to run another experiment with a secondary task that effectively induces an overall effect of memory load.

In Experiment 2, we employed a memory-load manipulation that is known to have a detrimental effect on performance (see Paap & Noel, 1991): Participants had to identify whether a given element was in the reference string rather than discriminating the whole string against a distractor. The idea was that preparing for a single element decision task would require more memory resources than preparing for a string matching task in which the reference was presented with a distractor. Specifically, on each trial, we presented a string of five digits as a memory set (either the same digit [low memory load; e.g., *55555*] or different digits [high memory load; e.g., *84539*]), and after the LDT, participants had to indicate whether a digit was present in the sequence (e.g., *5*?). Thus, in Experiment 2, we tried to maximize the chances of finding an overall effect of memory load on performance. First, preparing for a single element decision task may require more memory resources than preparing for a string-matching task in which the reference was presented with a distractor. Second, the string was composed of five elements instead of four elements. Third, we used digit strings instead of consonant strings, as a number of studies point toward different processing pathways for the identification of digits and of numbers (e.g., see Baker et al., 2007), and, hence, it may increase the effects of memory load on performance (note that Bodner & Stalinski, 2008, also used strings of digits for the secondary task).

Experiment 2

Method

Participants A new sample of 24 undergraduate students at the University of Valencia participated voluntarily in the experiment.

Materials The target stimuli in the LDT were the same as in Experiment 1. For the secondary task, we employed five-digit strings. Strings were divided in two groups: those that belonged to the low-memory-load condition (the same digit repeated 5 times; e.g., *55555*) and those that belonged to high-memory-load condition (five different digits; e.g., *84539*). In the decision phase, participants were presented with a digit (randomly across positions) that could or could not have been presented in the reference string (e.g., *5*?). As permutations containing zero (e.g., *02568* or *93024*) may allow participants to reduce memory load by creating chunks of data, only digits from 1 to 9 were used to create the digit strings.

Procedure The procedure was parallel to Experiment 1, except for the differences in the secondary task. In Phase 1, participants were presented with a five-digit string (e.g., *84539*) for 1 second, and in Phase 3, participants were presented with a digit (e.g., *6*?) and were instructed to indicate whether the five-digit string contained the digit or not (no—press *Z*; yes—press *M*).

Results and discussion

Secondary task The analyses were the same as in Experiment 1. The correct mean RTs were longer and the error rates were higher under high than under low memory load (RTs: 770 vs. 568 ms, respectively), $t(23) = 18.54, p < .001$, (percentage error: 11.9 vs. 5.2%, respectively), $t(23) = 5.42, p < .001$.

Lexical decision task The statistical analyses were parallel to those in Experiment 1—less than 0.1% of response-time data were removed due to responses shorter than 250 ms. The mean RT and percentage error per condition is displayed in Table 2.

Word targets The analyses of the RTs showed that lexical decision times on the target words were, on average, 37 ms faster when preceded by an identity prime than when preceded by an unrelated prime, $b = 0.0862$, $SE = 0.0107$, $t = 8.02$, $p < .001$, Furthermore, lexical decision times on the target words were, on average, 25 ms slower under high memory load than under low memory load, $b = 0.0557$, $SE = 0.0176$, $t = 3.17$, $p = .004$. The interaction between the two factors did not approach significance, $t < 1$.

The analyses of the accuracy data only showed that a significant interaction between the two factors, $b = 0.8103$, $SE = 0.3796$, $z = 2.13$, $p = .033$: This reflected higher accuracy in the low-memory-load condition for those targets preceded by an identity priming than for those preceded by an unrelated prime, whereas the opposite trend occurred in the high-memory-load condition—note, however, that neither of the simple effects tests was significant (both $ps > .10$).

Table 2 Mean response times (in ms) and percentage error rate (in parentheses) across conditions for words and pseudowords in Experiment 2

	Low memory load	High memory load
Word trials		
Identity	690 (2.4)	712 (4.0)
Control	725 (3.6)	752 (2.8)
Priming	35 (1.2)	40 (−1.2)
Nonword trials		
Identity	807 (4.7)	847 (5.3)
Control	827 (5.8)	843 (5.7)
Priming	20 (1.1)	−4 (0.2)

Note. *Priming* refers to the difference between the control and identity conditions

Nonword targets The analyses of the latency data showed that lexical decision times on the nonword targets were, on average, 8 ms faster when preceded by an identity prime than when preceded by an unrelated prime, $b = 0.0211$, $SE = 0.0089$, $t = 2.36$, $p = .02$. In addition, lexical decision times were, on average, 28 ms slower under high memory load than under low memory load, $b = 0.0389$, $SE = 0.0139$, $t = 2.81$, $p = .01$. The interaction between the two factors approached significance, $b = 0.0301$, $SE = 0.0167$, $t = 1.81$, $p = .07$: This reflected that the identity priming effect occurred in the low-load condition (20 ms) rather than in the high-load condition (−4 ms). The analyses of the accuracy data did not show any significant effects, all $ts < 1.02$, $ps > .31$.

In Experiment 2, we obtained an effect of memory load on target performance: Response times to both words and nonwords were longer under high memory load than under low memory load (around 25–28 ms). Critically, the magnitude of the masked identity priming effect for word targets was similar under the two memory load scenarios (40 and 35 ms under high and low memory load, respectively). For nonword targets, the size of masked identity priming was greater under low than under high memory load (20 vs. −4 ms, respectively), but the interaction did not reach the criterion for significance—as masked identity priming effects for nonwords do not tend to be highly reliable across experiments (see Forster, 1998), we prefer to remain skeptical about this marginal effect.

RT distributions To analyze in further detail the masked identity priming effects for the latency data for words under high and low memory load in both experiments, we explored the distributional features of the RTs. To this end, we carried out separate analyses of variance (ANOVAs) for each experiment, using RTs as the dependent variable, and the quantiles .1, .2, .3, .4, .5, .7, .8, & .9, the memory load, and the type of prime as factors (9 × 2 × 2). Figures 1 and 2 show the quantiles averaged by participants (vincentiles in the left panel), as well as the residual quantiles (delta plots in the right panel). If masked identity priming reflects a "savings" effect from the identity primes that occurs without attentional resources, the effect should be similar in magnitude across quantiles—as reported by Gomez et al. (2013)—and critically, it should be so regardless of memory load. The ANOVA showed main effects of priming in both experiments: Experiment 1, $F(1, 23) = 69.07$, $MSE = 6227$, $p < .001$; Experiment 2, $F(1, 23) = 63.47$, $MSE = 4760.1$, $p < .001$. Memory load yielded significant effects only in Experiment 2: $F(1, 23) = 8.08$, $MSE = 20890.0$, $p = .009$, and $F < 0$ in Experiment 1. Most importantly, there were no signs of two-way or three-way interactions between quantile and priming/memory load (all *F*s < 1).

Converging evidence on whether masked identity priming effects are similar across quantiles regardless of memory load can be obtained from delta plots. Delta plots (De Jong, Liang, & Lauber, 1994) allow us to display the effect sizes across the quantiles of RT distributions. In other words, they are quantile–quantile residual plots; in this case, we show the difference between the identity prime and the control conditions (see right panel of Fig. 1). The residuals are reasonably consistent across all quantiles for both high-load and low-load conditions, which indicates a location shift for the RT distribution of about the same magnitude regardless of memory load. The *x*-axis in a delta plot is based on the overall speed for the conditions under examination, and as mentioned before, there is a main effect of memory load that is reflected in the location along the *x*-axis of the delta plots: The solid line (high load) is shifted to the right relative to dashed line (low load).

Finally, as a reviewer suggested, one might argue that as lexical access is relatively slow for unfamiliar, low-frequency words, these words may be most influenced by memory load in a masked priming procedure. To examine this question, we computed the magnitude of masked identity priming under high and low memory load for those words with a frequency of occurrence of 3 or less per million words (45 words). While this is a post hoc analysis that should be taken with caution, masked identity priming for these very low-frequency words was not affected by memory load: The priming effect was 31 vs. 26 ms, under high and low memory load, respectively.

General discussion

Word recognition researchers typically assume that masked primes in the LDT are processed without attentional resources. If so, increased memory load using a dual task should not affect the size of masked identity priming effects. We conducted two masked priming LDT experiments that manipulated memory load via a secondary task (a matching task in Experiment 1; a search task in Experiment 2). We did not find any signs of a modulation of the magnitude of masked identity priming effects for words as a function of memory load in any of the two experiments, thus extending the findings reported by Bodner and Stalinski (2008) to a within-subjects manipulation. The group RT analyses corroborated the linear mixed-effects analyses: The effect of masked identity priming reflected a "savings" effect across quantiles regardless of memory load, thus extending the findings reported by Gomez et al. (2013).

The present data, together with those of Bodner and Stalinski (2008), favor the view that, as long as the prime and target are within the focus of the participant's spatial attention, the effects of masked identity priming in the LDT are processed without attentional resources (see Lachter et al., 2004). Furthermore, the RT distribution analyses (see left panel of Fig. 1) are entirely consistent with the idea that the identity-priming condition enjoys a head start in processing across the entire distributions (see Gomez et al., 2013). Importantly, because the effect of memory load increased in the higher quantiles—as one would expect in a manipulation (namely, memory load) that may affect the decision processes (see Ratcliff, Gomez, & McKoon, 2004), the size of the masked identity priming effect was not affected by memory load.

The present study also has a methodological take-home message concerning the choice of a secondary task in dual-task experiments: Not all secondary tasks produce a differential effect of memory load. In Experiment 1, participants had to make a forced-choice matching task on two consonant strings, one presented immediately before each lexical decision trial and one presented immediately after accompanied by a distractor (e.g., low load: *RRRR* [all letters equal]; high load: *GJTM* [all letters different]; same–different task: *RRRR–DDDD* or *GJTM* vs. *GFDM*). However, overall response times to word targets in the LDT were virtually the same under high-load and low-load conditions. An explanation for this null effect is that preparing for a perceptual matching task in

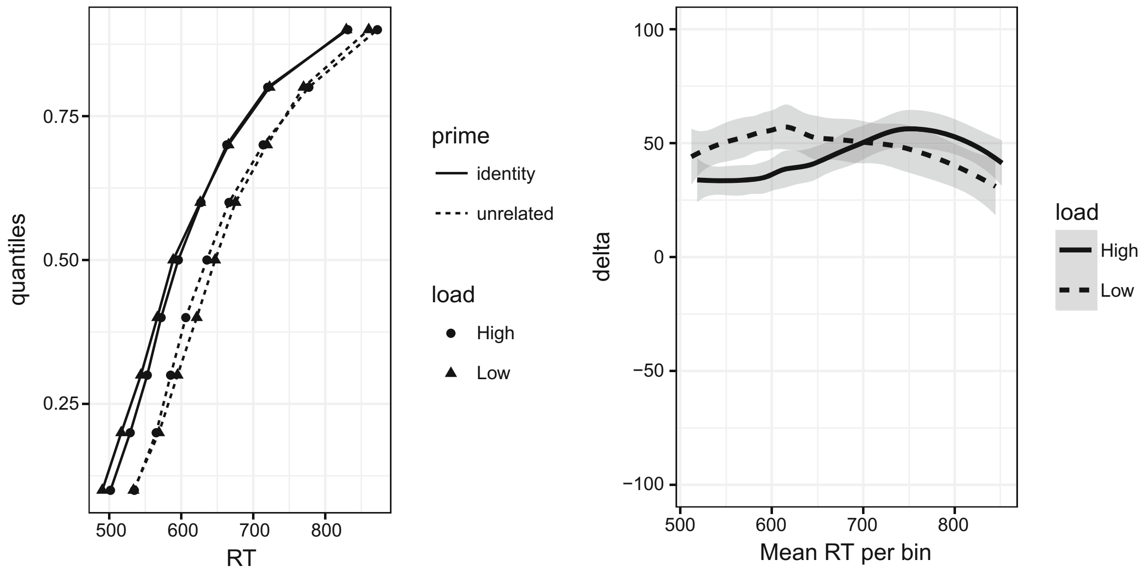

Fig. 1 Left panel displays group RT distributions across quantiles (.1, .2, .3, . . . , .9; also known as vincentiles) for the four conditions in Experiment 1. Right panel displays delta plots showing condition differences (deltas: effect of masked identity priming) as a function of quantile (.1, .2, .3, . . . , .9) and cognitive load (high vs. low). The code for this figure and for all the distributional analyses can be found at https://osf.io/jzdhf/

which the reference was presented along with a distractor does not require many attentional resources. Clearly, the ideal scenario when manipulating memory load is to use a secondary task that induces a sizable effect of memory load on target processing, such as a memory task that requires participants to decide whether a single element was present in the reference (e.g., a probe-digit memory task) or a memory task that requires reproducing the reference (see Heyman, Van Rensbergen, Storms, Hutchison, & De Deyne, 2015).

In sum, the present data favor the view that masked identity priming in the LDT does not require attentional resources processes (i.e., the magnitude of the priming effects is not modulated by memory load). This finding does not preclude that other types of prime–target relationships in masked priming experiments could be modulated by attentional factors (e.g., simple categorization tasks; see Fabre et al., 2007; Naccache et al., 2002). Further research should examine the interplay between memory load and various types of prime–target relationships (e.g., identity vs. semantic) in masked priming by measuring online measures of lexical access (i.e., event-related potentials).

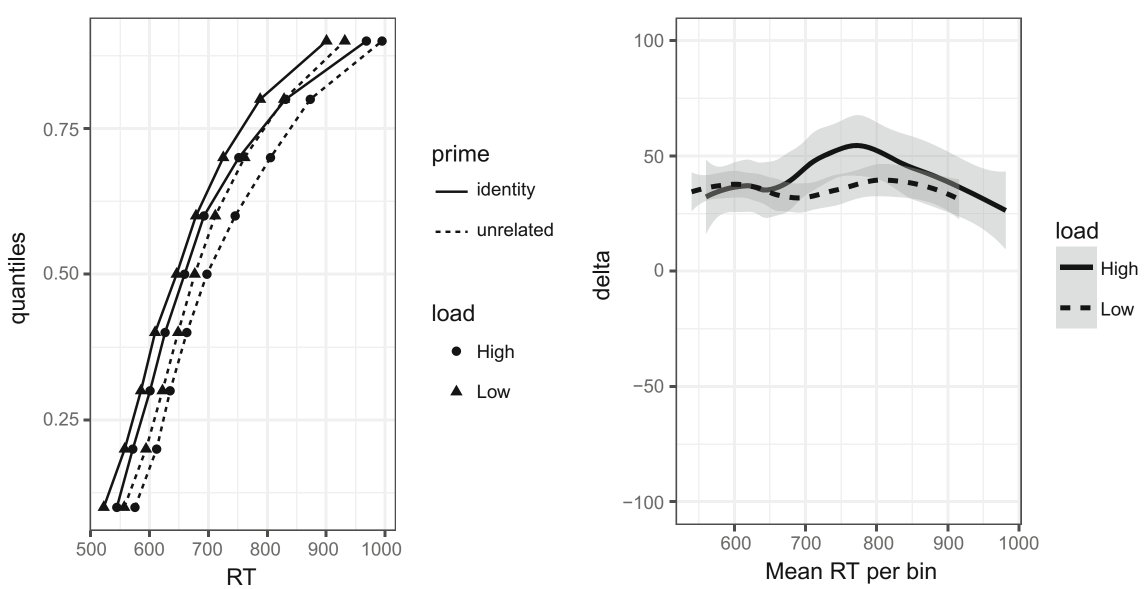

Fig. 2 Vincentiles (left panel) and delta plots for Experiment 2. The code for this figure and for all the distributional analyses can be found at https://osf.io/jzdhf/

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Appendix

List of words and orthographically legal nonwords used in the experiments

Words: RETINA; CENTRO; TORERO; RACIÓN; PRENSA; CUARTO; JOYERO; TIEMPO; SASTRE; MINERO; IMAGEN; CABEZA; CAMISA; ABUELO; OBRERO; PARQUE; RELATO; NOMBRE; CORRAL; PUENTE; COLEGA; PRUEBA; TIERRA; VIENTO; DIARIO; PRECIO; ESPEJO; CANELA; TRAMPA; BUITRE; PUERTA; VERANO; COCINA; BOCINA; SAFARI; FARAÓN; ANTOJO; MAÑANA; RECREO; DOCTOR; HAMBRE; TESORO; SANGRE; FUENTE; EQUIPO; MACETA; LADRÓN; FÁBULA; CIUDAD; FILTRO; ANIMAL; FLAUTA; JARRÓN; JABALÍ; HERIDA; CAMIÓN; SONIDO; AVISPA; ENVASE; BÚFALO; CUELLO; ATRASO; CORAZA; ANILLO; ÍNDICE; REFRÁN; PUPILA; CALCIO; ENIGMA; MÚSICA; SARTÉN; NERVIO; PÁGINA; ADORNO; LECTOR; FRANJA; PUEBLO; SEQUÍA; CRESTA; FÚTBOL; CORDÓN; CÓDIGO; NÚMERO; MOTIVO; ATASCO; MISIÓN; SUERTE; PASTEL; CUERPO; DESLIZ; OPCIÓN; MARIDO; CHARCO; ALMEJA; MÓDULO; CÁMARA; JIRAFA; PÁJARO; LIEBRE; REGALO; AHORRO; CUENTO; PILOTO; OFERTA; CHALET; ATLETA; GALOPE; CAMINO; CARTÓN; BANANA; JARDÍN; CÁRCEL; BOSQUE; FUERZA; LAGUNA; FATIGA; MÉDICO; DINERO; AZUFRE; PAREJA; MADERA; TEATRO; SEMANA; MANTEL; MARFIL; COYOTE; TIENDA; PARCHE; EMPLEO; MUEBLE; LITERA; NÓMINA; PINCEL; PIERNA; DESVÁN; HOMBRE; ESTUFA; ESPADA; FLUIDO; VUELTA; LLANTO; REPTIL; MINUTO; OLFATO; BRONCE; SÁBANA; PIEDRA; JARABE; SEÑORA; LLUVIA; SANDÍA; BROCHE; GRIETA; COMIDA; SALIVA; LASAÑA; FIESTA; ARRUGA; LENGUA; PEREZA

Nonwords: VIALIO; MICERA; APONSO; FIANTA; BULQUE; NACEZO; BRIRRE; ANCOPA; ZANACA; ENTEPO; MIORTA; AVERBA; FUCTOR; ZUESTE; BESDÍN; CHARIT; PÍNACA; MANDOL; GRERNA; JAUTRE; NENSIO; SIAMPO; LUERRO; ZACIBE; NUIBRE; PANIÓN; NÁVUSA; PLENTA; PLIETA; FECORA; MACEZA; FAUSTE; JENEÑA; BUENZO; FELBRO; SONCÁN; BRANZU; SICORO; OSPEZO; TUETRO; NICERO; SAURRA; ASAZAL; TIERTE; CESFRO; CRUEJA; DECRUA; VACINA; SONTÓN; GRINCE; ESCLEA; RÁVINA; SICIÓS; REGLÉN; BEAGRO; MESTEL; ZOCARO; ROMADO; GIENSA; GOYUSO; SILADO; CONIMA; MECINA; MÁVANA; ENZAPO; PERCEL; MÁFIRO; DINCÍA; SENFUA; TICERA; CHUVIO; SACIRA; ASFICA; JIUFAD; CACEPO; SARGÁN; FÚNFAR; NACAÓN; COFEPO; ENCICE; SÁRTIL; MACIDO; NOCERA; PENLLE; SAUDRE; SAVENA; FAGRÓN; MÓSANA; TONAMA; VATAZA; CÓCIRO; CALBIA; LLARTO; ACELLO; TRISPA; DERITO; POTAPO; MECEGA; ENCUTA; ACARNO; CICTER; ETOLMA; NEQUÍA; BRENIO; FRAUTU; ÍNCOSE; ISIMEN; ACIOZO; MERRAL; MANTIL; SICURO; VIENZA; JANCÍN; TANDRE; SÉVACO; HUMPLO; CEYUTE; TEÑURO; EQUEFO; DEVILO; ACOTRE; DESBEZ; CÓPAMO; MUBALA; CLUIBO; ALLUPO; RALAPA; GOLLÉN; GANQUE; PUSIÓN; SUASTO; GUMBRE; RESTRE; SAJIRU; FECINO; SACERO; CHENGO; AHOLLE; LICIFA; NÚCENA; PAÑINA; HASPLE; VIESTO; ALVEMA; NAROPE; PIEBLA; TÚCILO; HECADA; LUESTO; DECIRA; OBRICO; DUERTA; SUENDA; OPLIÓN; ZAVILÍ; NACURA; ZOCTIL; OPLINA; OVORDA; SÓCUZO

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