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Critical role of top-down processes and the push-pull mechanism in semantic single negative priming

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ABSTRACT

The present study investigated the roles of bottom-up mask-triggered inhibition and top-down inhibition in semantic categorization using the single negative priming (NP) paradigm. The masking (bottom-up) and ignore instructions (top-down, i.e., instructing participants to ignore the primes) were manipulated in Experiments 1–3 and Experiment 4, respectively. No priming was observed when only the masking was manipulated (Experiments 2 and 3), but NP was observed when a possible top-down ignore strategy (Experiment 1) or an ignore instruction (Experiment 4) was added. The results indicate that bottom-up mask-triggered inhibition cannot elicit semantic single NP by itself. However, top-down inhibition from an ignore instruction or ignore strategy is critical for triggering reliable semantic single NP. The findings suggest that semantic single NP originates from a push-pull mechanism by facilitating responses to unrelated trials and inhibiting responses to related trials. The experimental evidence also suggests that unconscious processes can be modulated by top-down control.

1. Introduction

Negative priming (NP) refers to the case in which responding to a current (probe) target is disrupted (e.g., slowed) if it has been ignored in a preceding (prime) trial (Tipper, 1985). In the typical NP task, target stimuli are accompanied by distracting stimuli in both prime and probe trials, and subjects are required to respond to a target while ignoring a distractor. It is widely accepted that selective attention plays a key role in triggering NP. Specifically, an inhibitory mechanism of attention that results from actively selecting against the distractors in the prime trials elicits NP (e.g., Tipper, 1985; Tipper & Cranston, 1985). In contrast, some studies have found reliable NP even when no selective attention appears to be necessary during the presentation of the priming stimulus (i.e., a single prime; Milliken, Joordens, Merikle, & Seiffert, 1998; Wood & Milliken, 1998). Thus, an increasing number of studies have begun investigating the mechanisms underlying single NP (Daza, Ortells, & Noguera, 2007; Machado, Guiney, & Struthers, 2013; Machado, Wyatt, Devine, & Knight, 2007; Noguera, Ortells, Abad, Carmona, & Daza, 2007; Ortells, Fox, Noguera, & Abad, 2003; Ortells, Noguera, Álvarez, Carmona, & Houghton, 2016). The classic single NP paradigm typically involves the following procedure. First, a single prime is briefly presented at the center of a screen (50 ms or less). Second, a pattern mask is presented at the prime

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location. Finally, a target with or without distractors is presented. Participants are asked to ignore the prime and respond to the target as quickly and accurately as possible.

Semantic single NP usually occurs when participants perform a relatively demanding forced-choice task, such as lexical decision (Noguera et al., 2007; Ortells et al., 2016; Wentura & Frings, 2005) or semantic categorization (instead of naming; Daza et al., 2007; Ortells, Daza, & Fox, 2003; Ortells, Fox, et al., 2003; Wang, Zhao, Liu, Wei, & Di, 2014) on the probe target. Moreover, we found that semantic single NP can be observed only when several boundary conditions are established by reviewing previous studies on this specific domain. Specifically, the possibility of observing semantic single NP has critically depended on the following: (a) a relatively weak prime (a weakly or subliminally activated prime), meaning a single prime word is presented briefly (for 50 ms or less) and followed by a masking pattern (Kiefer & Martens, 2010; Martens, Ansorge, & Kiefer, 2011; Martens & Kiefer, 2009; Neill & Kahan, 1999; Ortells, Fox, et al., 2003; Wentura & Frings, 2005); (b) an appropriate prime-target stimulus onset asynchrony (SOA) (Daza et al., 2007; Wang et al., 2014); and (c) an ignore instruction that asks participants to actively ignore the prime stimulus (Noguera et al., 2007; Ortells, Fox, et al., 2003).

Semantic single NP can be explained in terms of an inhibitory mechanism (top-down) resulting from actively ignoring a prime (e.g., Daza et al., 2007; Noguera et al., 2007; Ortells, Fox, et al., 2003; Wang et al., 2014). This top-down inhibition would cause slow responses to targets belonging to the same semantic category as the primes, thus reducing (or reversing) positive priming (i.e., PP, which indicates that reactions to the targets are faster when preceded by related primes and delayed when preceded by unrelated primes). Several studies have found that PP resulted when an instruction required participants to attend to and remember the prime instead of ignoring it (Abad, Noguera, & Ortells, 2003; Noguera et al., 2007; Ortells, Fox, et al., 2003; Ortells & Tudela, 1996). The inhibitory model assumes that inhibition requires time to develop. A relatively long prime-target SOA can ensure the development of an inhibitory mechanism (e.g., Daza et al., 2007; Neill & Westberry, 1987; Ortells, Abad, Noguera, & Lupiáñez, 2001; Wang et al., 2014; Yee, 1991). Furthermore, Wang et al. (2014; see also Daza et al., 2007) demonstrated that either a relatively long prime-mask or mask-target inter-stimulus interval (ISI) facilitated the development of an inhibitory mechanism, resulting in NP. If, however, both the prime-mask and mask-target ISI were eliminated with a persistent mask, then PP was observed. These results can be attributed to the fact that continuous perceptual input from the mask interferes with the buildup of an inhibitory mechanism (Houghton, Tipper, Weaver, & Shore, 1996). Only if the to-be-ignored prime has a relatively weak representation, i.e., the prime is presented for a briefer period (50 ms or less) and post-masked, will the inhibition resulting from the ignore instruction be sufficiently strong to reverse the PP to NP (see Ortells, Fox, et al., 2003). Therefore, reliable semantic single NP will be observed only when all three boundary conditions identified above are satisfied.

However, semantic single NP may not be solely attributable to the top-down inhibitory mechanism resulting from actively ignoring a prime. The inhibitory mechanism caused by presenting mask stimuli after the prime (i.e., mask-triggered inhibition) may also play an important role in semantic single NP, as the (a) and (b) boundary conditions also satisfy the conditions required to elicit mask-triggered inhibition. The mask-triggered inhibition hypothesis was proposed by Jaśkowski and colleagues (Jaśkowski, 2007, 2008, 2009; Jaśkowski, Białuńska, Tomanek, & Verleger, 2008; Jaśkowski & Przekoracka-Krawczyk, 2005; Jaśkowski & Slósarek, 2007; Jaśkowski & Verleger, 2007; Verleger, Jaśkowski, Aydemi, Van der Lubbe, & Groen, 2004), and it can fully explain the negative compatibility effect.[2] This hypothesis assumes that the sudden onset of a mask after the prime interrupts the response preparation to the initial prime activation. This sudden onset works as an emergency brake and triggers an automatic inhibition of the ongoing action (see Jaśkowski, 2007; Jaśkowski et al., 2008). Therefore, the mask-triggered inhibition is perceived as a type of bottom-up control. Numerous studies (e.g., Jaśkowski, 2007; Jaśkowski & Slósarek, 2007; Jaśkowski & Verleger, 2007; Lingnau & Vorberg, 2005; Sumner & Brandwood, 2008) have demonstrated that this inhibitory mechanism cannot develop if the prime-target SOA is brief, indicating that the inhibitory mechanism requires time to form. For example, Lingnau and Vorberg (2005) demonstrated that inhibition is stronger when the mask-target interval is longer. Furthermore, the representation of the prime must be relatively weak: the prime is presented for a briefer period, and the post-mask is necessary; otherwise, priming will not reverse to negative (see Jaśkowski et al., 2008).

Studies that investigated the role of ignore instructions in semantic single NP manipulated attentional instructions ("attend to and remember" and "ignore") and found NP in the "ignore" trials but not in the "attend" trials (Noguera et al., 2007; Ortells, Fox, et al., 2003). These findings do not prove, however, that semantic single NP is caused by the ignore instruction because mask-triggered inhibition cannot reverse priming when the primes obtain more attentional resources (Jaśkowski, 2007, 2008; Jaśkowski et al., 2008). That is, both top-down inhibition from ignore instructions and bottom-up inhibition from masking may influence the priming effect in the "ignore" trials, whereas neither type of inhibition modulates this effect in the "attend" trials. Therefore, studies have not definitively identified which of the two types of inhibitory mechanisms causes semantic single NP.

Accordingly, this study investigated the roles of bottom-up and top-down inhibitory mechanisms in triggering semantic single NP. The masking (representing bottom-up mask-triggered inhibition) was manipulated without using either "attend to and remember" or "ignore" instructions in Experiments 1–3, whereas the ignore instruction (representing top-down inhibition) was manipulated in Experiment 4.

[2] The negative compatibility effect is similar to single NP except that arrows typically serve as primes and targets. Moreover, Bennett, Lleras, Oriet, and Enns (2007) found a reliable negative effect when they employed emotional face stimuli. Emotional face and semantic word stimuli are typically regarded as having similar processing mechanisms (see Wierzbicka, 1995).