Supplementary material: Can the meaning of multiple words be integrated unconsciously?

Simon van Gaal\textsuperscript{1,2,3,4,*}, Lionel Naccache\textsuperscript{3,6,7}, Julia D. I. Meuwese\textsuperscript{4}, Anouk. M. van Loon\textsuperscript{4}, Alexa Leighton\textsuperscript{4}, Laurent Cohen\textsuperscript{3,6,7}, Stanislas Dehaene\textsuperscript{1,2,8,9}

\textsuperscript{1}Inserm, Cognitive Neuroimaging Unit, Gif-sur-Yvette, France
\textsuperscript{2}Commissariat à l’Energie Atomique, Neurospin Center, Gif-sur-Yvette, France
\textsuperscript{3}INSERM, ICM Research Center, UMRS 975, Paris, France
\textsuperscript{4}University of Amsterdam, Dept. of Psychology, the Netherlands
\textsuperscript{5}Donders Institute for Brain, Cognition and Behavior, the Netherlands
\textsuperscript{6}University Paris 6, Faculté de Médecine Pitié-Salpêtrière, Paris, France
\textsuperscript{7}AP-HP, Groupe hospitalier Pitié-Salpêtrière, Depts. of Neurophysiology & Neurology, Paris, France
\textsuperscript{8}Université Paris-Sud 11, Orsay, France
\textsuperscript{9}Collège de France, 75005 Paris, France

Methods

Exp. 3 - Temporal negation paradigm: modifier masked, adjective unmasked, noun is target

The overall set-up of this experiment was very similar to experiment 1 with some minor but crucial changes. This experiment consisted of only one session in which subjects performed the negation task without any negation training beforehand. The modifier was presented for 33 ms instead of 50 ms and always masked by forward and backward masks, each presented for 67 ms. The adjective was presented for 117 ms and followed by a briefly presented, and therefore ineffective, mask (17 ms). The target was presented immediately thereafter for 300 ms. Note that the overall duration of the trials was the same as in Exp. 1. Subjects performed four blocks of 160 trials and then a 4-choice discrimination task on modifier identity (two blocks of 40 trials). In the discrimination task, each target noun was followed after 500 ms by four choice options presented in capital letters (e.g., VERY HAPPY, NOT HAPPY, VERY SAD, NOT SAD) around fixation. This task set-up allowed us to calculate the percentage correct for the masked modifier, as well as for the unmasked adjective. So although the subject had 4 response options (i.e. “very bad”, “very good”, “not bad” and “not good” ), the response options “very bad” and “very
good” could be collapsed (both contain the word “very”). Therefore chance-level is 50% for the masked modifier. One subject did not perform the discrimination task because of time constraints.

**Exp. 4 - Temporal negation paradigm: modifier masked/unmasked, adjective is target**

To test the overall effectivity of the modifier to negate/strengthen the adjective, the target noun was omitted in experiment 4. Subjects responded to an unmasked adjective presented for 300 ms by indicating whether it was positive or negative. On half of the trials the modifier preceding the adjective (33 ms duration) was masked and on the other half it was not (mixed within blocks). Subjects performed six blocks of 80 trials after which they performed a 2-choice discrimination on the modifier (33 ms presentation). Each adjective was followed after 500 ms by two choice options presented left and right of fixation (VERY and NOT).

**Results**

**Exp. 3: Behavior**

When only the modifier was masked, while the adjective was visible, there was still no behavioral manifestation of a negation effect by the masked modifier (RT: $F_{1,16}=0.22$, $p=0.65$; ER: $F_{1,16}=0.07$, $p=0.80$; Fig S1A). Again, we observed only strong adjective priming effects onto the subsequent noun (RT: $F_{1,16}=41.9$, $p<0.001$; ER: $F_{1,16}=13.4$, $p=0.002$). The discrimination task administered at the end revealed that masked modifiers could not be discriminated above chance-level (50%), whereas unmasked modifiers could (masked: 51.4% correct, $t_{15}=0.81$, $p=0.42$; unmasked: 67.2% correct, $t_{15}=5.23$, $p<0.001$). The Bayes Factor for masked trials was 3.99 providing moderate evidence for the Null hypothesis.

**Exp. 4: Behavior**

In this experiment, we tested whether the absence of negation effects in behavior might have been caused by the overall task complexity or by the relatively long temporal distance between modifier onset and target onset (233 ms in Exp. 1). We reduced the complexity of the design by excluding the target nouns and instructed subjects to respond to an unmasked (visible) adjective (positive/negative judgment). Subjects typically respond faster to positive than to negative words [1], which was also the case here ($p<0.05$ for masked and unmasked conditions). However, again, this effect was not modulated by modifier identity on masked trials (RT: $F_{1,15}=0.29$, $p=0.597$; ER: $F_{1,15}=0.04$, $p=0.85$, Fig S1B), whereas this was the case on unmasked trials (RT: $F_{1,15}=20.0$, $p<0.001$; ER: $F_{1,15}=15.0$, $p=0.002$). Subjects could not discriminate masked modifiers above chance-level (53.1% correct, $t_{15}=1.14$, $p=0.26$), whereas they could for unmasked modifiers (88.6% correct, $t_{15}=10.33$, $p<0.001$). The Bayes Factor for masked trials was 2.91, reflecting moderate evidence for the Null hypothesis. Because participants did not perform any negation training before performing the latter task, this experiment also indicates that conscious negation effects do not require extensive negation training and can be observed from the start, without learning.
Figure S1. (A) RT and ER results for Exp. 3 in which only the modifier was masked. (B) RT and ER results for Exp. 4 in which the modifier was masked or unmasked and the adjective was the target (positive/negative judgment). A = adjective, N = noun, A+ = positive adjective, A- = negative adjective.

References