Discussion

On the masking and disclosure of unconscious elaborate processing. A reply to Van Opstal, Reynvoet, and Verguts (2005)

Wilfried Kunde[a],*, Andrea Kiesel[b], Joachim Hoffmann[b]

[a]Department of Psychology, Martin-Luther-University Halle-Wittenberg, D 06099 Halle (Saale), Germany
[b]Department of Psychology, Julius-Maximilians-University of Wuerzburg, Germany

Abstract

We have recently argued that unconscious numerical stimuli might activate responses by a match with prespecified action trigger codes (action trigger account) rather than by semantic prime processing (elaborate processing account). [Van Opstal, F., Reynvoet, B., and Verguts, T. (2005). How to trigger elaborate processing? A comment on Kunde, Kiesel, and Hoffmann (2003). *Cognition*] replicate one piece of evidence for our inference—an inefficiency of primes not presented in target format (verbal or Arabic). But this was found only with letter masks and not with hash masks. The authors conclude that letter masks block unconscious prime processing, and that elaborate processing can account for unconscious priming effects if all its (sometimes subtle) side conditions are considered. We agree that the type of mask in general is an important factor in priming studies but we note that (i) the authors' mask-blocking hypothesis is not well supported by the data, (ii) clear evidence for semantic prime processing in their study is lacking and, (iii) differences in mask efficiency (rather than mask type) might account for the conflicting results. To corroborate this inference we replicate van Opstal et al.'s results with letter masks but reduced mask efficiency. Altogether their data do not challenge the action-trigger account nor do they strongly support the elaborate processing view.
© 2005 Elsevier B.V. All rights reserved.

Keywords: Masked priming; Number; Contextual influences

When required to categorize a numerical stimulus as smaller or larger than five responding is faster when the target is preceded by a masked prime that falls on the same side of the five as the target. According to the elaborate processing view this is so, because masked primes are unconsciously analyzed semantically up to the preparation of a task-defined motor response (e.g. Dehaene et al., 1998). Inspired by work by Ach (1910) and Neumann (1989) we have made an alternative suggestion. We reasoned that participants might categorize stimuli into appropriate action triggers depending on expectations and task instructions in advance of stimulus presentation (Kunde, Kiesel, & Hoffmann, 2003). Stimuli that match a trigger activate the corresponding action instantaneously without being processed up to a semantic level. For example, if participants expect the digit 2 to be presented in the experiment, any stimulus resembling the digit 2 will activate its assigned response to some extent without numerical processing or repeated practice. Several observations corroborated this proposal. Numerical primes do not activate responses when they fall outside the expected numerical target range, or when action triggers are recruited by non-numerical properties, or when primes occur in an unexpected format (Arabic instead of verbal or vice versa). Moreover, primes produced congruency effects independent of the numerical distance to the target, hence without a trace of a numerical evaluation.

Van Opstal, Reynvoet, & Verguts (2005) pick out one piece of evidence for the action trigger account (and against elaborate processing), namely the inefficiency of primes in a different format than the targets. Their Experiment 1 shows that primes in unexpected format can affect RTs when masked by hash symbols instead of letters. Experiment 2 shows that number masks reduce priming effects in general compared to letter masks. The results are attributed to a blocking of semantic prime processing by task-relevant mask symbols.

First of all, there is no reason to question the importance of the study's methodological conclusion "that even an apparent detail such as the composition of the mask, can lead to different results" (p. 14). In fact there is growing evidence showing that masks exert more effects than just rendering primes invisible (e.g. Verleger, et al., 2004). Also, the basic idea that the relevance of mask symbols interacts with ongoing prime processing is interesting. However, we question that van Opstal et al.'s explanation of mask-type effects is sufficiently covered by the reported data, and we suggest that mask efficiency rather than mask type might explain the apparent contradictions as well.

1. Important but ambiguous mask type effects (Van Opstal et al.'s Experiment 2)

We first want to comment on Van Opstal et al.'s Experiment 2, which varied trial by trial the format of primes, targets and masks (verbal or Arabic). Priming was generally lower with number masks than with letter masks, which is attributed to the higher "relevance of the symbols by which the mask is composed" (p. 2).

First of all, we find it hard to see why numbers were more relevant than letters in this experiment. After all, targets were presented in numerical and verbal format. So obviously, number masks and letter masks contained relevant objects to a similar extent.

Second, to us the relationship of these results to the 'active mask' hypothesis by Verleger et al. (2004) is much less straightforward than suggested. The active mask hypothesis deals with low-level perceptual mechanisms (rather than with semantic processing) to explain that masks which contain perceptual target features can occasionally produce inverted priming effects. To our reading this hypothesis does not claim (nor does the related object substitution hypothesis by Lleras & Enns, 2004) that task relevant mask symbols "may evoke more activation of task-relevant responses (which) interrupt prime-induced activation more strongly" (p. 10). In fact, Lleras and Enns (2004) seem to suggest the opposite when they infer that effects of mask type are based on "ordinary mechanisms of perceptual updating rather than on the inhibition of unconsciously activated responses" (p. 490).

Third, van Opstal et al.'s own 'mask-blocking' hypothesis appears not very consistent with their data. If target-resembling masks suppressed prime processing this should produce an interaction between targets and masks, namely a reduction of priming when target and mask share the same format. Yet, in Experiment 2 digit masks reduced priming independent of whether the target format was the same (Arabic) or different (verbal). As higher task-relevance of number masks can hardly be charged for this reduced priming effect (cf. our point 1), we conjecture that the reason for this result might be more peripheral, such as a higher density of digit masks (cf. the example on p. 11 '273837'vs. 'CTHCDT'). To support the task relevance hypothesis, differential effects of identical masks under varying task instructions would be needed.

Fourth, Experiment 2 misses any experimental variation necessary to evaluate the action-trigger account. That is, there was no between-participants variation of target format, or numerical target range, or instructions. Thus, to us Experiment 2 seems nondiagnostic regarding the action trigger account.

Fifth, Experiment 2 is nondiagnostic for elaborate processing as well. This is so because identical stimuli served as primes and targets, and hence any priming we see here might well be mediated by acquired S-R associations (Damian, 2001).

Taken together we found Experiment 2 not very telling regarding the elaborate processing versus action trigger debate and we find the hypothesis of the authors concerning the role of mask type not well supported by their data. We now turn to the more interesting (at least in our opinion) Experiment 1.

2. What discriminates hashes from letters ? (Van Opstal et al.'s Experiment 1)

Experiment 1a replicated one of our basic findings: Primes presented in a different format than the targets (verbal vs. Arabic) are inefficient, although conveying the same semantic information. We argued that this is so because action triggers are created in the format that participants expect to be relevant. Experiment 1b challenges this account: When masks were created of hash signs (#####) instead of letters (LFKCNO), priming did extend to a never used target format. This result suggests to the authors that masked primes were semantically processed.

We first want to comment on the authors' explanation of the dependency of (semantic) priming on mask type. It is suggested that "…with a less demanding mask elaborate

processing can explain priming" (p. 2). This account seems to come down to a resource concept: A semantic prime analysis occurs if the mask leaves sufficient resources, otherwise no semantic prime analysis (and hence, no priming) occurs. Such a resource limitation is an important qualification of earlier proposals suggesting that semantic processing is a kind of gratuitous default mode (e.g. Marcel, 1983). In a way this was a major motivation for our action-trigger account: If semantic processing is resource demanding subjects will look for ways to circumvent such resource burdens. Creating action triggers against which stimuli can be matched directly seems a conceivable way to do so.

Second, the evidence for the argument that masks interrupt prime processing to the extent they contain relevant (i.e. target-resembling) features seems not entirely compelling. As noted above, such a hypothesis might explain the removal of priming with letter masks and target WORDS, but it fails to account for the removal of priming with letter masks and target DIGITS. Thus, to our understanding, an interaction of mask format and target format is predicted, rather than a main effect of mask type.

Third, we hesitate to accept that the priming effects with hash masks were actually caused by semantic pathways. Here a notorious problem of the elaborate processing account shows up. How can we know that primes accessed semantic codes at the point in time they were presented? One potential indicator for numerical prime evaluation, the prime-target distance effect (i.e. faster responding with congruent primes the smaller the numerical distance to the target) was neither reported by van Opstal et al. nor did we find it for barely visible primes in our experiment (see below). This casts doubt on semantic prime processing for the experimental situations under consideration.

3. Mask efficiency (rather than mask type) can explain the data pattern

Given these inconsistencies we conjecture that another (admittedly more trivial) factor might explain the results as well. We assume that hashes are simply less efficient in masking primes than letters. Pattern masking is more efficient the more the masks resemble the primes (e.g. Breitmeyer, 1984). Target digits, target words, and mask letters all contain curves and straight lines (e.g. 1, 3, ONE, SIX, DEFGRL). By contrast hash-symbols consist of straight lines exclusively. This renders them less similar to words and digits, so that a reduced masking efficiency is to be expected. Moreover, all symbols were identical within hash masks, but different within letter masks (cf. ##### vs. LFKCNO). Conceivably, it is easier to detect primes against a homogenous than a heterogeneous background. There is some support for this assessment in van Opstal et al.'s data. Average prime discrimination performance was very low with letter masks (d'=0.003) whereas it was notably higher with hash masks (up to d'=0.269 for Arabic primes). Masking efficiency plays an important role for the action trigger account. Action triggers are determined by all stimuli that participants (correctly or incorrectly) believe to be response affording. This applies to targets but extends to instructions to consider certain stimuli or to occasionally perceived primes as well. Thus, to consider a stimulus format in creating a set of triggers it might suffice to perceive primes now and then in this particular format. Hence, a subtle increase in prime perceptibility might suffice to promote the creation of

action triggers in the suspected format, even if the targets appear exclusively in a different format.

4. An experiment: Letter masks with increased prime visibility

These considerations led us to conduct an experiment with our original letter masks but reduced masking efficiency (prime duration was increased to 72 ms). Other aspects were identical to our previous Experiment 4, with the exception that we tested only one group ($n = 16$, mean age 22.0) with digits as targets. Primes were presented in random order as digits or number words.

5. Results

RTs < 150 and > 1500 ms were excluded (0.2% of the data). Mean correct RTs and error rates are shown in Table 1. RTs were slower with incongruent than with congruent trials, $F(1, 15) = 88.8$, $p < .01$. The congruency effect was stronger with prime-target notation match than with nonmatch, $F(1, 15) = 23.6$, $p < .01$. Importantly, there was a congruency effect when prime and target had the same notation ($F(1, 15) = 70.5$, $p < .01$), as well as when they had different notations ($F(1, 15) = 8.2$, $p < .02$). The congruency effect was significant for primes from the target set ($F(1, 22) = 58.8$, $p < .01$), and primes outside the target set ($F(1, 22) = 68.0$, $p < .01$).

Prime awareness was assessed in the same way as in our previous study for the sake of comparability. Participants had to judge if a numerical prime (word or digit) or a neutral symbol (an ampersand) was presented between the masks. Our manipulation of prime visibility was successful. The average d' amounted to 0.66 which is considerably higher than in our original study ($d' = 0.22$). Mean d' for verbal primes was equal to 0.39 and not significantly higher than zero, $t(15) = 1.7$, $p = .11$. Yet, it is likely that with such a d' value the verbal primes were at least occasionally seen. Mean d' for Arabic primes was equal to 0.93, and above zero ($t(15) = 3.7$, $p < .01$), meaning that Arabic primes were identified above chance level. However, regression analyses with individual congruency effects and the d' measures as a predictor revealed significant (positive) intercepts for both, verbal primes ($t(15) = 2.4$, $p < .05$) and Arabic primes ($t(22) = 5.3$, $p < .01$) but non-significant

Table 1
Mean RTs and error rates, 72 ms letter mask

Prime type	Prime—target notation							
	Same				Different			
	Congruent		Incongruent		Congruent		Incongruent	
	RT	PE	RT	PE	RT	PE	RT	PE
From target set	416	4.32	461	7.36	419	3.83	429	3.78
Not from target set	425	2.90	461	7.43	422	3.21	431	4.23

slopes (both ps$>.25$). This indicates that there is unconscious priming for both types of primes (cf. Greenwald, Klinger, & Schuh, 1995).

It is worth noting here that van Opstal et al.'s (direct) prime awareness task indexed the same level of analysis as the (indirect) priming task (numerical evaluation in both cases). Our direct task (discriminating primes from a neutral symbol) indexed a lower level of stimulus analysis (form discrimination), which presumably renders it a more sensitive measure of prime awareness (cf. Kouider & Duproux, 2004; Naccache & Dehaene, 2001). When comparing these studies one should thus keep in mind that d' values with the present task will likely exceed those obtained with the task employed by van Opstal et al. Future experiments, using different awareness tasks might help to further scrutinize the role of prime awareness for cross-notation priming effects with fixed target notation.

Semantic processing of unconscious primes? To explore whether the priming effects were mediated by semantic codes we calculated the numerical prime-target distance effect for congruent primes. With Arabic primes the RTs (error rates) with a prime-target distance of 1, 2, or 3 amounted to 416 ms (2.1%), 433 ms (3.6%), 435 ms (5.5%). This effect reached significance in RTs, $F(2,14)=4.0$; $p=.03$. This is not too surprising since Arabic primes were more or less consciously perceptible and semantic processing of conscious stimuli is undisputed. More interesting are the results for the verbal primes which were detected around chance level. Here the RTs (error rates) with a prime-target distance of 1, 2, or 3 amounted to 424 ms (2.1%), 421 ms (4.4%), 417 ms (4.7%) (ps$>.15$ for the effect in RTs and error rates). Hence, there was no prime-target distance effect with barely discriminable primes and thus no trace of access to semantic codes (cf. Holender & Duscherer, 2003 for converging evidence).

6. Conclusion

Van Opstal et al.'s study poses an important note of cautiousness on the role of masks in priming studies. We believe, however, that the conclusion that hash masks allowed unconscious semantic processing, whereas letter masks did not, is not well covered by the reported data. Instead we suggest that the creation of action triggers in a format different from the targets was promoted by a subtle increase of prime visibility with hash masks instead of letter masks. This assessment was corroborated by showing that with the same masks as in our previous study, van Opstal et al.'s results can be replicated if prime visibility is moderately increased. Moreover our data revealed no hints for semantic processing of barely visible primes. Thus, we find ourselves left with the action trigger account as a viable explanation of unconscious priming. This is not meant to say that unconscious semantic processing was impossible at all (e.g. Reynvoet & Brysbaert, 2004). But as van Opstal et al. correctly point out, unconscious semantic processing is bound to particular side conditions which in our view renders it more exceptional than previously believed.

Acknowledgements

References

Ach, N. (1910). *Über die Willensakt und das Temperament*. Leipzig: Quelle and Meyer.

Breitmeyer, B. G. (1984). *Visual masking: an integrative approach*. New York: Oxford University Press.

Damian, M. F. (2001). Congruity effects evoked by subliminal presented primes: automaticity rather than semantic processing. *Journal of Experimental Psychology: Human Perception and Performance*, *27*, 154–165.

Dehaene, S., Naccache, L., Le Clec'h, G., Koechlin, E., Mueller, M., Dehaene-Lambertz, G., et al. (1998). Imaging unconscious semantic priming. *Nature*, *395*, 597–600.

Greenwald, A. G., Klinger, M. R., & Schuh, E. S. (1995). Activation by marginally perceptible ("subliminal") stimuli: Dissociation of unconscious from conscious cognition. *Journal of Experimental Psychology: General*, *124*, 22–42.

Holender, D., & Duscherer, K. (2003). 'Unconscious' semantic congruency effects depend on prime discriminability. *Abstracts of the Psychonomic Society*, *8*, 135.

Kouider, S., & Dupoux, E. (2004). Partial awareness creates the 'illusion' of subliminal semantic priming. *Psychological Science*, *15*, 75–81.

Kunde, W., Kiesel, A., & Hoffmann, J. (2003). Conscious control over the content of unconscious cognition. *Cognition*, *88*, 223–242.

Lleras, A., & Enns, J. T. (2004). Negative compatibility or object updating? A cautionary tale of mask-dependent priming. *Journal of Experimental Psychology: General*, *133*, 475–493.

Marcel, A. J. (1983). Conscious and unconscious perception: Experiments on visual masking and word recognition. *Cognitive Psychology*, *15*, 197–237.

Naccache, L., & Dehaene, S. (2001). Unconscious semantic priming extends to novel unseen stimuli. *Cognition*, *80*, 215–229.

Neumann, O. (1989). On the origins and status of the concept of automatic processing. *Zeitschrift für Psychologie*, *197*, 411–428.

Van Opstal, F., Reynvoet, B., & Verguts, T. (2005). How to trigger elaborate processing? A comment on Kunde, Kiesel, and Hoffmann (2003). *Cognition*

Reynvoet, B., & Brysbaert, M. (2004). Cross-notation number priming investigated at different stimulus asynchronies in parity and naming tasks. *Experimental Psychology*, *51*, 81–90.

Verleger, R., Jaskowski, P., Aydemir, A., van de Lubbe, R. H. J., & Groen, M. (2004). Qualitative differences between conscious and non-conscious processing? On inverse priming induced by masked arrows. *Journal of Experimental Psychology: General*, *133*, 494–515.