RESEARCH REPORT

"The Mask Who Wasn't There": Visual Masking Effect With the Perceptual Absence of the Mask

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Does a visual mask need to be perceptually present to disrupt processing? In the present research, we proposed to explore the link between perceptual and memory mechanisms by demonstrating that a typical sensory phenomenon (visual masking) can be replicated at a memory level. Experiment 1 highlighted an interference effect of a visual mask on the categorization of auditory targets and confirmed the multimodal nature of knowledge. In Experiment 2, we proposed to reactivate this mask in a categorization task on visual targets. Results showed that the sensory mask has disrupted (slower reaction times) the processing of the targets whether the mask was perceptually present or reactivated in memory. These results support a sensory-based conception of memory processing and suggest that the difference between perceptual processes and memory processes is characterized by the presence (perception) or the absence (memory) of the sensory properties involved in the activity.

Keywords: embodied cognition, memory, perception, cross-modal masking, interference effect

In everyday life, each of us performs the constant perceptual processing of the environment and collects and integrates numerous items of sensory information (Calvert & Thesen, 2004). Alongside these perceptual activities, knowledge related to our environment is continually "recovered" from memory. However, the question of the link between perceptual activities and memory activities is still far from being resolved. Embodied cognition theory proposes that conceptual knowledge is closely linked to the situation and is grounded in sensory and motor systems (Barsalou, 1999, 2008). Given that perceptual processes and conceptual knowledge in memory are partially based on the same sensory–motor system (e.g., Slotnick, 2004), perceptual processing should be influenced not only by components currently present in the environment but also by components reactivated in memory. In

other words, this leads to the thought-provoking idea that it might be possible to obtain a sensory effect (e.g., visual masking) even when a stimulus that is perceptually absent is reactivated in memory. In the experiments reported here, we explore this idea by showing, for the first time, that masking effects can be found (a) when a memory component is masked (Experiment 1) and (b) when a stimulus is masked by a memory component (Experiment 2).

In embodied cognition theory, the activation of a component in one modality induces the reactivation of related components in other modalities (for a review, see Versace, Labeye, Badard, & Rose, 2009). When the sensory–motor components of a memory trace are reactivated by the current situation, this activation is thought to propagate to other components that are not perceptually present and to lead to cross-modal activations (for a review, see Martin & Chao, 2001). An increasing number of behavioral studies have demonstrated the influence of the reactivation of memory components on perceptual processes (e.g., Goldstone, 1995; Kaschak et al., 2005; Meteyard, Bahrami, & Vigliocco, 2007; Riou, Lesourd, Brunel, & Versace, 2011) and have shown that sensory–motor components are also activated during language processes (e.g., Stanfield & Zwaan, 2001; Zwaan, Stanfield, & Yaxley, 2002) as well as typical cross-modal priming effect (Vallet, Brunel, & Versace, 2010). Given that knowledge emerges from the activation of neuronal systems that are typically associated with perceptuomotor mechanisms (Jääskeläinen, Ahveninen, Belliveau, Raij, & Sams, 2007; Weinberger, 2004), studies have shown that the reactivation of one modality can have an influence on another modality (Rey, Riou, Cherdieu, & Versace, 2014) and

that conceptual processes involve perceptual components that belong to different modalities (Pecher, Zeelenberg, & Barsalou, 2003).

The influence of present components or reactivated components on perceptual or conceptual processes has been explored in the literature. However, as far as we know, no study has as yet examined the possibility of replicating a typical sensory effect with reactivated components. The present study used a sensory phenomenon: visual masking. In the literature, perceptual masking has been extensively studied and has been widely used to explore the dynamics of visual information processing. By inducing a spatiotemporal conflict, a mask presented before (forward masking) or after (backward masking) a target reduces its visibility (Enns & Di Lollo, 2000). Based on recent evidence, we propose the thought-provoking hypothesis that it might be possible to induce this conflict not only by means of a perceptually present mask but also by means of a mask reactivated in memory. The goal of the present study was to show that a typical sensory phenomenon, namely, visual masking, (a) can be observed in the processing of a target component that is only reactivated in memory (Experiment 1) and (b) can be observed without the presence of a perceptual mask (Experiment 2).

First, if memory consists of sensory components that are linked to single traces, a visual mask should directly disrupt the simultaneous processing of targets that are sensible to the mask whatever their modality of presentation. We reasoned that the simultaneous presentation of a visual mask and auditory targets that correspond to the masked visual stimuli should slow down the processing of these auditory targets. Second, our aim was to go further by exploring the following question: can a visual masking effect be replicated in the absence of the mask? To address this question, we investigated whether a reactivated mask can influence the processing of targets in the same way as a perceptually present mask. To our knowledge, no previous study has explored the possibility of replicating a basic sensory effect, such as the masking effect, with memory mechanisms. Indeed, if conceptual processes and perceptual processes are based on the same sensory-motor system, then the sensory mask should be associated within a memory trace. This sensory mask should have a similar influence irrespective of whether it is perceptually present or reactivated in memory. Two experiments were conducted to test these hypotheses in which we showed, in Experiment 1, that a present visual mask can disrupt the processing of auditory targets (the mask disrupts the processing of the reactivated visual memory component) and, in Experiment 2, that a reactivated mask can disrupt the processing of visual targets (the reactivated visual mask acts in the same way as a perceptually present mask).

Pretest of the Mask

In visual masking, the reduction of the target's visibility depends on various factors (e.g., luminance, shape, color, contours, contrast, and stimulus-onset asynchrony [SOA]), these factors leading to more or less effective masking effect (Breitmeyer & Ögmen, 2006). Among these factors, the target's visibility is greatly influenced by spatial overlap between the mask and the targets (Macknik, Martinez-Conde, & Haglund, 2000; Schiller, 1966). The goal of this pretest was therefore to distinguish between target stimuli for which the mask induced a high or a low reduction of visibility.

Method

Materials. A visual mask was created with Photoshop CS4 (Adobe Systems, San Jose, CA) by stacking and deforming 40 photographs (the targets corresponding to 20 animals and 20 artifacts presented as gray-scale decontextualized pictures; see Appendix) to disrupt their processing. As a control, we used a control mask (a gray square; see Figure 1). The mask, the control mask, and the photographs had the same format (200×200 pixels with a resolution of 72×72 dots per inch).

Procedure, and participants. Sixteen participants ($M_{age} = 22.34$, $SD = 2.53$) took part in the pretest. Using a backward masking paradigm, the target picture (presented for 100 ms) was immediately followed by the mask or the control mask (presented for 100 ms). Participants had to judge as quickly and accurately as possible whether the target represented an animal or an artifact (each target was presented once with the mask and once with the control mask).

Results

Latencies of less than 150 ms and more than 1,500 ms were removed (less than 5% of the data). For all analyses, a p value of .05 was used as statistical significance. The analysis of variance (ANOVA) on correct-response rate did not reveal a significant main effect of mask condition, $F(1, 23) < 1$; there was no difference between the mask ($M = 94.06$, $SD = 3.75$) and the control mask conditions ($M = 94.53$, $SD = 3.56$). The analyses of the latencies revealed a significant mask-type main effect, the targets were categorized more slowly when they were presented with the mask ($M = 548$ ms, $SE = 17$ ms) rather than the control mask ($M = 527$ ms, $SE = 15$ ms), $F(1, 15) = 21.57$, $p < .001$, $\eta_p^2 = .59$.

Embodied cognition theories suggest that both perceptual and conceptual processes rely on the same sensorimotor systems and that conceptual processes simulations utilize perceptual mechanisms. Consequently, showing that the same distribution of reaction times (RTs) across specific objects occurred across the pilot study, and our two experiments would suggest that a common process underlies both perceptual and conceptual processes. To explore this possibility, we created two groups of targets as a function of their reduction of visibility. For each target, we computed the difference between the RTs in the mask condition and the RTs in the control mask condition. According to their position
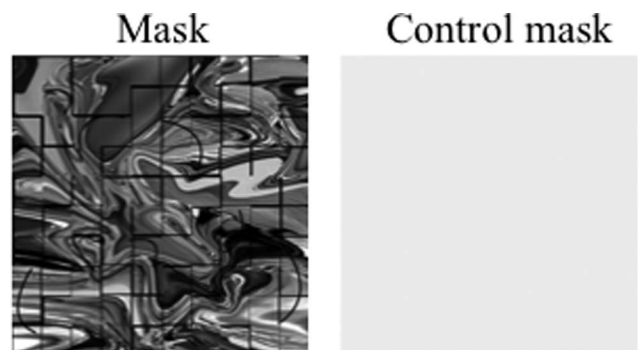

Figure 1. The mask and the control mask used in the experiments of the present study.

relative to the median, we selected the 20 targets with a higher reduction of visibility due to the mask (*high-sensitivity targets*: 10 animals and 10 artifacts) and the 20 targets with a lower reduction of visibility (*low-sensitivity targets*: 10 animals and 10 artifacts). The high-sensitivity targets were categorized less rapidly in the mask condition ($M = 567$ ms, $SE = 18$ ms) than in the control mask condition ($M = 521$ ms, $SE = 16$ ms), $F(1, 15) = 31.38, p < .001$. In contrast, there was no difference for the low-sensitivity targets presented after the mask ($M = 531$ ms, $SE = 17$ ms) or the control mask ($M = 536$ ms, $SE = 16$ ms), $F(1, 15) < 1$.

As the visual mask induces a reduction of the visibility of the targets, the sensitivity of the targets should be dependent on the overlap between the visual characteristics of the mask and the targets. This overlap should be more important for the high-sensitivity targets than the low-sensitivity targets. An additional experiment was conducted on 10 additional participants (seven women; $M_{age} = 26.43$ years, $SD = 3.54$) for whom the mask was superimposed on each target. The experimenter progressively decreased the opacity of the mask (1% per 500 ms) until participants could correctly identify the target (answer were given orally). For each target, the mean percentage of mask opacity that corresponded to the identification of the picture for each participant was calculated. If the participants gave an incorrect answer, the experimenter told him or her that his or her answer was wrong and started again to decrease the opacity of the mask. Results showed that the reduction of the mask opacity required for the participant to identify the pictures was higher for high-sensitivity ($M = 67.55\%$, $SD = 5.51\%$) than for the low-sensitivity targets ($M = 79.92\%$, $SD = 3.05\%$), $F(1, 9) = 3,152.71, p < .001, \eta_p^2 = .99$. In other words, the overlap of the visual characteristics of the mask and the targets was greater for the targets with a high sensitivity than the targets with a low sensitivity.

Experiment 1

If memory traces are composed of numerous multisensory properties closely interrelated, the disruption of the processing of some properties (e.g., visual properties) within a single trace should slow down the processing of the associated properties within this trace (e.g., auditory properties). In Experiment 1, we aimed to replicate the visual masking effect using auditory targets that refer to the categories in the pretest. Assuming that the pictures we used were representative of these categories, a visual mask that disrupted the visual component of these categories (see the pretest) should slow down the categorization of auditory targets belonging to these categories.

In the visual masking, the reduction of the target's visibility is partially due to the visual persistence of the mask (Francis, Grossberg, & Mingolla, 1994). To reproduce the overlap between the mask and the targets in the pretest, we presented the mask (or control mask) and the auditory targets simultaneously (SOA of 0 ms) in this experiment.

Method

Participants. Sixteen undergraduates with normal or corrected-to-normal vision and audition volunteered to take part in the experiment ($M_{age} = 24.31$ years, $SD = 6.48$). None of them had taken part in the pretest.

Materials. We used the same mask and control mask as we used in the pretest. The photographs were replaced by sounds: 40 sounds, with duration of 1,000 ms, were selected (20 sounds of animals and 20 sounds of artifacts) corresponding to the 40 previous photographs (e.g., the sound of "meow" corresponding to the cat picture).

Procedure. The visual mask or the visual control mask was presented simultaneously with the sound of an animal or an artifact for 1,000 ms. Each target was presented twice, once with the mask and once with the control mask in a pseudo-random order. Participants had to judge as quickly and accurately as possible whether the auditory target represented an animal or an artifact (Figure 2). They indicated their choice by pressing the appropriate keys—*a* or *p*—on the AZERTY keyboard (the response keys were counterbalanced across participants). Participants were told to keep their eyes open because it would be important for the experiment. At the end of the experiment, we asked them whether they had kept their eyes open and told them it was important to create the association.

Results and Discussion

Latencies of less than 150 ms and more than 1,500 ms were removed; then latencies that differed by more than 2.5 standard deviations from the individual means in each condition were discarded (less than 5% of the data). Separate ANOVAs were performed on the percentages of correct responses and latencies with mask type (mask or control mask) and target sensitivity (low or high sensitivity) as within-subject variables. As for the percentages of correct responses, the mask-type main effect, $F(1, 15) = 2.40, p = .14$, and the target-sensitivity interaction were nonsignificant, $F(1, 15) < 1$, while the sensitivity-main effect was only marginally significant, $F(1, 15) = 4.37, p = .054, \eta_p^2 = .22$ (correct-response rate for high-sensitivity targets with the mask: $M = 93.13, SD = 5.44$, and with the control mask: $M = 91.25, SD = 5.92$; correct-response rate for low-sensitivity targets with the mask: $M = 91.56, SD = 6.51$, and with the control mask: $M = 87.81, SD = 7.06$).

The analyses on latencies indicated a main effect of the mask, $F(1, 15) = 9.20, p < .01, \eta_p^2 = .38$, and a significant interaction between the mask type and the target sensitivity, $F(1, 15) = 15.32, p < .005, \eta_p^2 = .51$ (Figure 3). Responses were significantly slower for the high-sensitivity targets when they were presented with the mask ($M = 786$ ms, $SE = 39$ ms) rather than with the control mask
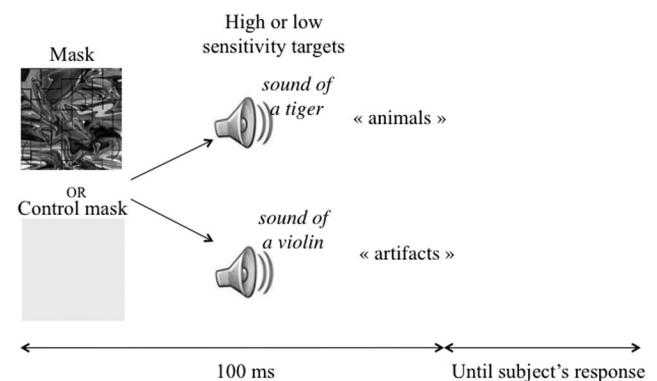

Figure 2. Illustration of the experimental protocol of Experiment 1. ms = milliseconds.
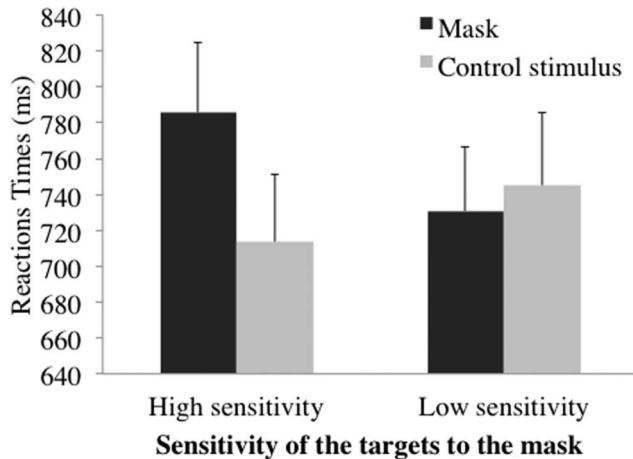
Figure 3. Mean reaction times as function of the target sensitivity for each mask type for Experiment 1. Error bars represent standard errors. ms = milliseconds.

($M = 714$ ms, $SE = 36$ ms), $F(1, 15) = 34.93$, $p < .005$. As in the pretest, no significant effect was observed for the low-sensitivity targets when they were presented with the mask ($M = 731$ ms, $SE = 38$ ms) or with the control mask ($M = 745$ ms, $SE = 41$ ms), $F(1, 15) < 1$.

The results showed that a visual mask could disrupt the processing of auditory targets that corresponded to the pictures having a high sensitivity to the mask. We can assume that the presentation of the auditory targets reactivated the other components of the trace such as the visual components that are related to the visual mask.

To be able to generalize our results not only to other participants but also to other stimuli, we performed a mixed-effects model (Baayen, Davidson, & Bates, 2008; Judd, Westfall, & Kenny, 2012). This type of model allowed us not only to use both participants and stimuli as random variables but also to keep sensitivity as a continuous variable. This analysis also revealed a significant type of mask by sensitivity interaction, $F(1, 14.96) = 18.5$, $p < .001$.

In Experiment 1, we found that the mask could disrupt an absent component of the target. In Experiment 2, we proposed to disrupt the processing of targets with the reactivation of the mask (i.e., with a mask not perceptually present but reactivated). To do this, we replaced the mask and the control mask by a sound (high-pitched or low-pitched) with which they were previously associated in a learning phase.

Experiment 2

Method

Participants. Twenty-four undergraduates with normal or corrected-to-normal vision and audition participated to the experiment ($M_{age} = 21.95$ years, $SD = 4.20$). None of them had taken part in the previous experiments.

Materials. The same stimuli as in the pretest were used. Two auditory stimuli were added, a high-pitched sound of 550 Hz and a low-pitched sound of 250 Hz.

Procedure. The experiment consisted of two phases:

Learning phase. The mask or the control mask was presented in the center of the screen for 100 ms. For half of the participants, the mask was systematically and simultaneously presented with the high-pitched sound and the control mask was presented with the low-pitched sound (the opposite arrangement was used for the other half of the participants). Participants had to judge whether the sound corresponded to a high-pitched or a low-pitched sound and were instructed to look at the screen during all the phase. The mask and the control mask were presented 30 times in a random order to create a nonexplicit picture–sound association (Figure 4a).

Test phase. The high-pitched or the low-pitched sound (previously associated with the mask or the control mask) was presented simultaneously with the targets for 100 ms (Figure 4b). Again, participants had to judge as quickly and accurately as possible whether the target represented an animal or an artifact.

Results and Discussion

The same cutoff as in the pretest and in Experiment 1 was used (which eliminated less than 5% of the data).

Learning phase. The analyses did not reveal a significant difference between the sounds associated with the mask and the control mask for the correct-response rate (participants performed the task accurately with a correct-response rate of 93%), $F(1, 23) < 1$, and the latencies, $F(1, 23) < 1$.

Test phase. The ANOVA performed on the correct responses rate did not reveal significant effect, $F(1, 23) < 1$ (correct-response rate for high-sensitivity targets with the mask: $M = 95.21$, $SD = 4.03$, and with the control mask: $M = 94.79$, $SD = 4.77$; correct-response rate for low-sensitivity targets with the mask: $M = 95.63$, $SD = 4.50$, and with the control mask: $M = 94.38$, $SD = 3.99$). The analyses on latencies indicated a main effect of the mask type, $F(1, 23) = 15.79$, $p < .01$, $\eta_p^2 = .41$, and a significant interaction between mask type and target sensitivity, $F(1, 23) = 13.53$, $p < .005$, $\eta_p^2 = .37$ (Figure 5). For the
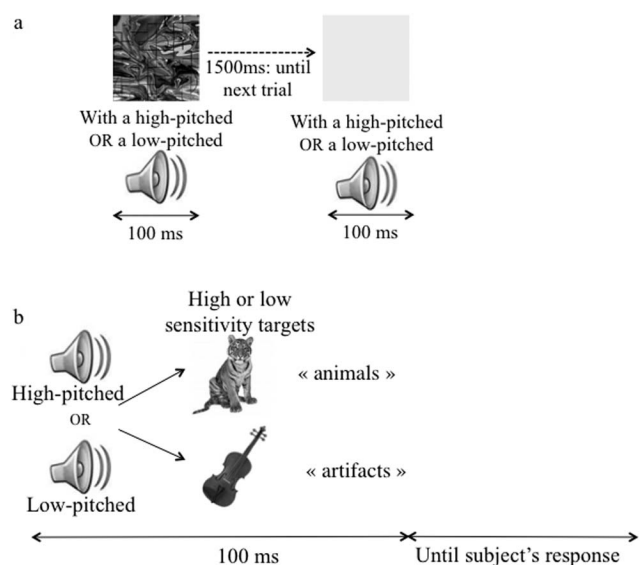

Figure 4. Illustration of (a) the learning phase and (b) the test phase of Experiment 2. ms = milliseconds.
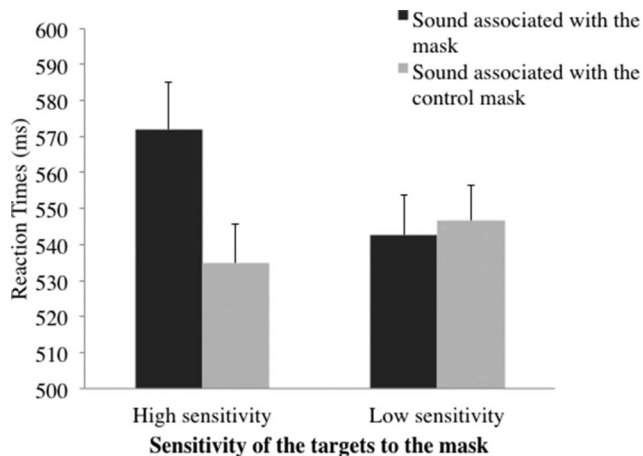
Figure 5. Mean reaction times as function of the target sensitivity for each mask type for Experiment 2. Error bars represent standard errors. ms = milliseconds.

high-sensitivity targets, responses were significantly slower when they were presented with the sound previously associated with the mask ($M = 572$ ms, $SE = 13$ ms) rather than the sound previously associated with the control mask ($M = 535$ ms, $SE = 11$ ms), $F(1, 23) = 19.21$, $p < .001$. In contrast, no significant effect was observed for the low-sensitivity targets when they were presented with the mask ($M = 543$ ms, $SE = 11$ ms) or the control mask ($M = 547$ ms, $SE = 10$ ms), $F(1, 31) < 1$. Again, as it was the case in Experiment 1, the analysis based on mixed-effects model also revealed a significant type of target sensitivity interaction, $F(1, 21.20) = 23.3$, $p < .001$.

General Discussion

As perceptual processes, the retrieval in memory of visual and auditory information involves the activation of sensory areas (Wheeler, Peterson, & Buckner, 2000). Behavioral studies have shown the propagation of activation to visual properties (e.g., Kaschak et al., 2005) and auditory properties (e.g., Brunel, Labeye, Lesourd, & Versace, 2009). Based on the hypothesis that the multimodal properties that composed a single memory trace are closely related, Experiment 1 explored whether the processing of auditory targets could be disrupted by the presentation of a visual mask. In this experiment, participants took longer to categorize high-sensitivity targets when presented with the mask than when presented with the control mask. This finding highlights an interference effect of a visual mask on auditory target and confirms the sensorimotor nature of memory traces.

Based on this first result, we assumed that if conceptual processes and perceptual processes share common sensorimotor systems, then a component implied in perceptual processes or memory processes should play a similar role. This assumption was explored in a cross-modal priming paradigm in which the visual mask was reactivated by an associated sound in the learning phase. The results showed that a reactivated mask (perceptually absent) could disrupt the processing of visual targets as a perceptual mask does. If a sensory effect can be replicated with reactivated components, then this is consistent with the idea that memory traces are

composed of sensorial components that play a similar role when they are reactivated or perceptually present in the current situation (see Versace et al., 2014). By demonstrating that a typical sensory phenomenon (the visual masking) can be replicated at a memory level, the present study supports the idea of a similarity between perceptual processes and conceptual processes implicated in the visual sensory masking.

The masking effect obtained in these experiments cannot be explained by an attentional effect. Indeed, if the visual mask was more visually complex than the control mask, a higher level of attention on the mask compared with the control mask would influence the processing on the targets. But if that was the case, the perceptually present mask and the reactivated mask should have had the same disrupting effect on all the targets. Indeed, the low-sensitivity targets were not sensitive to the perceptually present or reactivated mask in either experiment.

The same distribution of RTs across targets was observed in all the experiments whether the mask was present or only reactivated in memory as well as the visual components of the targets, which could be present (Experiment 2) or reactivated (Experiment 1). This result is consistent with the claim of embodied cognition theories that common mechanisms underlie both perceptual processes and conceptual processes. Together with various recent studies in the literature revealing an overlapping between perceptual processes and conceptual processes (e.g., Rey, Riou, & Versace, in press; Vermeulen, Chang, Corneille, Pleyers, & Mermillod, 2013; Vermeulen, Corneille, & Niedenthal, 2008), the present demonstration shows a sensory masking effect with the involvement of reactivated components in memory. Recently, Xie, Wang, Sun, and Chang (2013) showed dissociation between color and shape in the overlap between conceptual and perceptual processing (e.g., color conceptual processing was not affected by the perceptual shape of pictures). We could use the present paradigm to further investigate this dissociation across visual properties, namely, color and shape. For instance, we could use a first-reactivated mask that shares color similarities with one group of pictures and a second-reactivated mask that shares shape similarities with another group of pictures. With the first mask, the processing of pictures with color similarities should be disrupted but not the processing of pictures with shape similarities (and conversely).

In conclusion, a masking effect is possible with the reactivation of a sensory mask. It becomes difficult to dissociate perceptual mechanisms from conceptual mechanisms other than on the basis of the presence (perceptual processing) or absence (memory processing) of the characteristics of the objects to which the processing is applied.

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(*Appendix follows*)

Appendix

Complete List of Target Pictures or Sounds

Category	High reduction of visibility (high-sensitivity targets)	Low reduction of visibility (low-sensitivity targets)
Animals	Bird	Bear
	Frog	Cat
	Goat	Chimpanzee
	Goose	Cow
	Hen	Dog
	Owl	Dolphin
	Parrot	Donkey
	Puma	Horse
	Sheep	Tiger
	Wolf	Vulture
Objects	Accordion	Alarm clock
	Dishwasher	Banjo
	Electric Mower	Bell
	Maracas	Chainsaw
	Phone	Electric mixer
	Razor	Hairdryer
	Tam-tam	Microwave
	Trumpet	Motorcycle
	Violin	Piano
	Whistle	Vacuum