Task-Relevance of Features Modulates Object Substitution Masking

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Introduction

Object Substitution Masking (OSM) & Recovery

- OSM refers to a phenomenon in which the identification of a target object is inhibited when surrounded by sparse dots that remain visible after the target disappears (Enns & Di Lollo, 1997).
- It has been observed using simple, feature-based targets and masks (i.e. Landolt-Cs and dots) (Goodhew et al., 2011), as well as more meaningful ones (Savino & Kahan, 2023).
- Previous research has also reported a recovery phenomenon, in which target identification improves as dot-offset delay increases (Goodhew et al., 2011; Savino & Kahan, 2023).

Reentrant Processing Theory

- Visual perception is not a simple bottom-up process. Rather it is the result of dynamic interactions between sensory information and higher level interpretation.
- Reentrant processing theory posits that the iterative nature of visual perception - "checking" representations in higher level brain regions against those in lower level regions - leads to the updating of target representations as sensory information changes. When a target disappears, the initial representation of the target and mask is updated to include only the mask (Enns & Di Lollo, 2000). This effect is exacerbated when the target and mask are perceived as a singular object.

Task-Relevancy

- Savino & Kahan (2023) showed that the overlap of task-relevant features affected both masking and recovery when participants were asked to identify the target's object-identity. It was unclear whether this finding would persist when the task-relevant dimension was basic features (i.e. the target's orientation).
- The present study replicated Savino & Kahan's (2023), but asked participants to identify a target's orientation, rather than it's object-identity.

Present Hypotheses

- In an target-orientation identification task, overlap in the orientation of target and mask features will (1) increase masking and (2) affect patterns of recovery.

Method

Participants

- 20 undergraduate students from Bard College
- Convenience and snowball sampling

Design: Within-Subjects

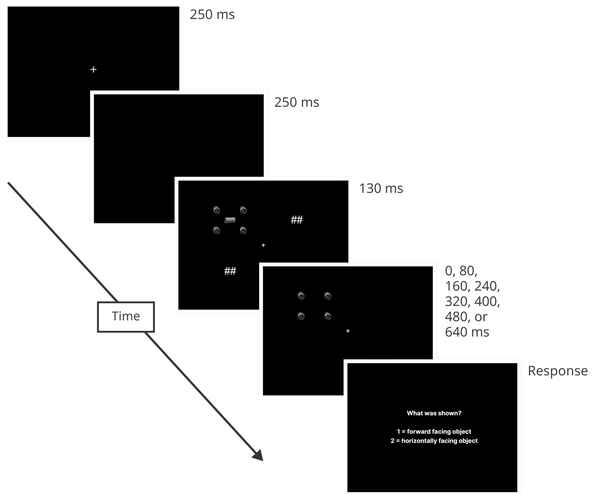
- 2 (orientation: congruent vs incongruent) x 2 (object: congruent vs incongruent) x 8 (mask offset: 0, 80, 160, 240, 320, 400, 480, 640 ms)

Procedure

- All participants filled out demographics and informed consent forms prior to completing the experiment.
- Each trial began with a blank black screen, followed by a white fixation point (+), followed by another blank screen (Figure 1).
- The target and mask then appeared together in one of four locations (upper left, upper right, lower left, lower right), with distractors (##) in the three remaining locations. The target then disappeared.
- After the mask disappeared, participants identified the target's orientation by pressing "1" (forward-facing) or "2" (horizontal) on the keyboard.
- Participants completed 8 practice trials and 504 experimental trials (four blocks of 126), for a total of 512 randomized trials.
- Participants took self-paced rest breaks between blocks.
- Participants received a $5 gift card as compensation.

Method (continued)

Figure 1
Graphic Depiction of the Sequence of Events



Note. Adapted from Savino and Kahan (2023). Copyright 2022 by American Psychological Association.

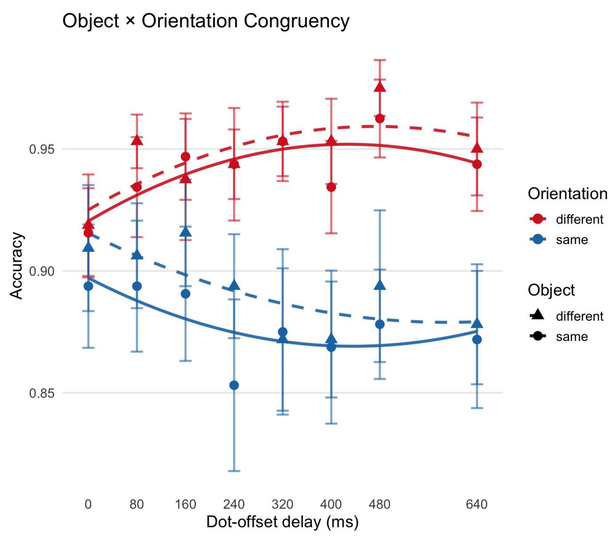
Method (continued)

Figure 2
Experimental Stimuli

Note. Images adapted from "The Amsterdam Library of Object Images" by J. M. Geusebroek, G. J. Burghouts, and A. W. Smeulders, 2005, International Journal of Computer Vision 61(1), pp. 103–112 (https://doi.org/10.1023/B:VISI.0000042993.50813.60). Copyright 2005 by Springer.

Results

Figure 3
Mean Accuracy Rates Along and Best Fitting Quadratic Curves as a Function of Target-Mask Orientation Congruency and Object Congruency as a Function of Dot-Offset Delay



Note. Target and mask were displayed together for 130 ms. Error bars represent ± 1 standard error of the mean.

Results (continued)

Accuracy

- A significant main effect of orientation congruency indicated that overlap of task-relevant features affected masking $F(1, 19) = 8.91$, $p = .008$, $\eta^2G = .080$. Participants were more accurate when target-mask pairings had incongruent orientations than when they had congruent orientations.
- There were no other significant main effects or interactions.

Slope Analysis (0 ms & 640 ms)

- Main effect of orientation congruency (0 ms): $F(1, 19) = 9.47368$, $p = .006$, $\eta p^2 = .111$. When there was no delay between the target and mask (0 ms), participants performed significantly better when the orientations did not match than when they did.
- No significant effects at 640 ms.

Slope Analysis T-Tests (0 ms & 640 ms)

- Significantly positive slope for different-orientation same-object (0 ms): $t(19) = 2.43$, $p = .025$, $d = 0.543$. When the target and mask depicted the same object in different orientations at a 0 ms delay, participants' accuracy showed a trend toward improvement.
- No other slopes significantly different from zero at 0 ms.
- No slopes significantly different from zero at 640 ms.

Discussion

Hypothesis 1: Supported

- The overlap of task-relevant features (orientation) affected masking: participants experienced more masking in the same-orientation conditions than in the different-orientation conditions. This is consistent with Savino and Kahan's (2023) finding that task goals affect early visual processing.

Hypothesis 2: Not Supported

- The effect of delay did not differ significantly between orientation conditions. Whereas there was partial support for immediate recovery (+ slope at 0 ms) in the different-orientation same-object condition, there was no further support for immediate or extended recovery (- slope at 0 ms *and* + slope at 640 ms).
- Unlike Savino and Kahan (2023), we found little evidence that (1) accuracy improved as mask offset increased for incongruent-orientation target-mask pairings or that (2) accuracy initially declined and later improved in congruent-orientation pairings.

Conclusions

- These results suggest that task-relevancy impacts reentrant processes in OSM, highlighting the importance of cognitive control to visual perception. The overlap of task-relevant features seems to inhibit participants' ability to distinguish between a target and mask, leading them to perceive the pair as a single object and thereby experience greater masking via updating.

Future Research

- Future studies should clarify whether recovery can occur in same-orientation conditions under different contexts.
- The Bard Attention and Performance lab is currently exploring whether the salience of object-level information (due to extended processing time) may have inhibited the recovery of orientation information. The lab also plans to study how OSM paradigms involving meaningful stimuli (e.g., language) may differ based on sample characteristics (bilingual vs native).

References

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