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Object Substitution Masking: When Does Mask Preview Work?

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When a target is enclosed by a 4-dot mask that persists after the target disappears, target identification is worse than it is when the mask terminates with the target. This masking effect is attributed to object substitution masking (OSM). Previewing the mask, however, attenuates OSM. This study investigated specific conditions under which mask preview was, or was not, effective in attenuating masking. In Experiment 1, the interstimulus interval (ISI) between previewed mask offset and target presentation was manipulated. The basic preview effect was replicated; neither ISI nor preview duration influenced target identification performance. In Experiment 2, mask configurations were manipulated. When the mask configuration at preview matched that at target presentation, the preview effect was replicated. New evidence of ineffective mask preview was found: When the two configurations did not match, performance declined. Yet, when the ISI between previewed mask offset and target presentation was removed such that the mask underwent apparent motion, preview was effective despite the configuration mismatch. An interpretation based on object representations provides an excellent account of these data.

Keywords: object substitution masking, preview effect, object-level representation

Visual backward masking refers to the reduction in the visibility of a target stimulus when a mask is presented within close spatial and temporal proximity of the target. Traditionally, masking paradigms have investigated low-level mechanisms (Breitmeyer, 1984). Recently, Di Lollo, Enns, and Rensink (2000; Enns & Di Lollo, 1997) reported a hitherto unrecognized form of visual backward masking, which they called object substitution masking (OSM). OSM appears to involve high-level attentional and object-recognition mechanisms. In a typical OSM task, the observer is presented with a brief visual display of geometric shapes. An object (the target) is enclosed by four dots (the mask) that correspond to the corners of an imaginary square. The observer is to report the shape of the target as accurately as possible. The dots appear simultaneously with the target. If the dots disappear with the target (simultaneous-offset condition), there is little impairment of target identification. However, if their offset is delayed relative to the target offset (delayed-offset condition), target identification is significantly impaired.

Di Lollo et al. (2000) emphasized the role of reentrant processes in explaining OSM. The reentrant-processing model assumes that the perception of visual objects depends on extended cycles of feedforward processes starting from the retina and extending to the higher level visual areas and feedback (or reentrant) processes that carry information from the higher levels to the lower levels (Lamme & Roelfsema, 2000). When the target and mask first appear, object information is initially processed at the feature level. At these early stages, only partial information about the target and mask gets routed to higher levels of the visual system, and object-recognition processes are initiated. However, this initial information does not allow a complete specification of the object's identity. Thus, the visual system needs to sample the input again to obtain more information. This process of sampling, construction, and resampling proceeds in cycles.

If the display remains unchanged, durable representations of the target and mask are established after several iterations. But if the target and mask are presented and then quickly removed before these durable representations are established, the visual system has to rely on their trace representations established in the initial processing stages, such as their iconic representations, to establish their object identities. These representations degrade rapidly over time, and the object identities will have to be recovered on the basis of this degraded information.

When the target and mask appear simultaneously, they compete against each other for identification processing. Consider the scenario in which the target is removed but the mask persists. Initial feedforward processing allows the visual system to establish a tentative (incomplete) representation of the stimulus. Feedback processes attempt to verify the accuracy of this representation by matching the continuing input against the tentative percept, which, presumably, consists of the target and dots. As the target terminates first while the mask persists, a mismatch occurs because the dots are still visible in visual short-term memory (VSTM) after the target has been removed. Thus, the visual system abandons the initial representation and establishes a new representation based solely on the dots. The visual system continues to sample information from the mask, and the resulting percept retains no information about the target. In a sense, the mask "object substitutes" the target. The durable representation that is eventually established is that of the mask and not the target. As a result, target information is unrepresented (or at least underrepresented). Under this

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view, OSM occurs only when the viewing condition does not permit a durable representation of the target to be established and some other visual information, such as the mask alone, persists in the display, thereby allowing its representation to be constructed more fully.

The Preview Effect

Yet OSM did not occur when the mask was previewed prior to the presentation of the target array (Tata & Giaschi, 2004). Even when the target terminates before the masks, the preview appears to inoculate against OSM. Thus, masking does not depend simply on whether the mask is physically sustained at the target location after the target terminates. Tata and Giaschi argued that the masking effect depends more crucially on "the temporal order in which the visual system attempts to deal with the objects in the visual display" (p. 266). When the mask is previewed, the visual system processes the mask and forms a representation of it in VSTM. At test, when the masks (re)appear with the target, the mask pattern has already been established. Consequently, visual processing continues apace, and the mask is unlikely to compete with the target for identification. As a result, the target is processed more effectively, and its durable representation is more likely to be established. Thus, previewing the mask appears to impair its ability to disrupt target perception. There have been several recent reports consistent with the view that previewing attenuates masking (e.g., Di Lollo et al., 2000; Neill, Hutchison, & Graves, 2002).

The reports suggest that so long as the mask is previewed, the masking effect is always attenuated. In addition, the duration of the preview did not affect its effectiveness (Neill et al., 2002; Tata & Giaschi, 2004). Even when the masks were briefly previewed (for 133 ms), the masking effect was reduced. Of particular interest is specifying the conditions under which previewing might be ineffective. These scenarios can shed light on the underlying visual cognitive processes that govern the capacity of an object to compete with other stimuli to be processed and identified.

Lleras and Moore (2003) argued that two different components contribute to the total interference in OSM: low-level backward masking and interference at higher, object-level representations. A critical differentiation between lower and higher level masking is whether the masking is location specific. If the underlying mechanisms are high-level ones, the exact location of the mask will not be crucial. Lleras and Moore tested the hypothesis that interference occurs at object-level representation. The task was to identify and report a black target among seven other gray distractors. In the critical condition, the four-dot masks terminated with the target and distractors. Following a variable interstimulus interval (ISI), the same masks were presented at positions slightly removed from their original positions.

When the ISI was short (17–34 ms), the masks appeared as though they had moved from their original locations to new locations. That is, an apparent motion effect obtained. If OSM relies on object-level representations, the fact that the locations of the masks had changed should not have diminished masking. On the other hand, if masking relies on low-level representations, this change in location should have diminished masking. The control condition consisted of a long (216–233 ms) ISI between the offset of the stimuli and the reappearance of the masks. Here, the masks would be perceived as terminating at their original locations, and a set of new masks would appear at the new locations (i.e., no apparent motion). This condition constituted a simultaneous-offset condition. If OSM depends on object-level representations, masking should not have occurred.

Lleras and Moore (2003) observed masking only in the short-ISI condition. They claimed that in this condition, the original object representation was maintained when the mask disappeared from the target location and then reappeared after a fleeting moment at the final mask location. This condition constituted a delayed-offset condition, and the net effect interfered with target identification. This interpretation indicates that at least some mechanisms underlying OSM must lie with object representations (i.e., the masking is not entirely "sensory").

Lleras and Moore (2003) demonstrated that object-level representations were implicated in OSM, but they did not foreclose the involvement of low-level representations. One way to investigate the latter is to manipulate the ISI between the offset of the previewed masks and the onset of the target array. When the ISI is long, one might expect the sensory representations of the previewed stimuli to deteriorate completely by the time the target array appears. If the attenuation of masking depends on the traces of the sensory representation, one ought to see a revival of the masking effect in the long-ISI condition. On the other hand, so long as nothing intervened during the blank period between the disappearance of the masks and their reappearance with the target and distractors, the object-level mask representations ought to survive the long ISI. Thus, one would not expect masking to be observed even when the ISI is long.

Experiment 1

We had three goals in Experiment 1. The first and second were to replicate the basic findings that previewing the masks attenuates OSM and that duration of mask preview does not influence its effectiveness to attenuate OSM (Neill et al., 2002; Tata & Giaschi, 2004). The third was to investigate the relative contribution of the lower and higher level representations to masking by varying ISI. The critical hypothesis was that, to the extent that the delay between previewed mask offset and final mask onset affects its representation in VSTM, ISI should modulate performance (e.g., if ISI is long, target identification should be poor).

Method

Participants. Twenty-seven undergraduates participated to fulfill course requirements. All had normal or corrected-to-normal vision.

Apparatus and setting. Each participant sat approximately 50 cm from the screen of a 19-in. (48-cm) color monitor controlled by a Macintosh G4 computer. Responses were gathered with a standard keyboard. Throughout the experiment, the monitor provided the only source of illumination.

Stimuli. The visual display was composed of a background light gray in color (luminance = 80 cd/m^2). All other stimuli presented were of a darker shade of gray (luminance = 40 cd/m^2). A fixation cross (subtending 0.6° × 0.6°of visual angle) was presented and was followed by four identical masks. Each mask was composed of four circular dots (each subtending 0.5° of visual angle in diameter) presented on the four corners of an imaginary square (subtending 3.4° of visual angle), enclosing either the target or a distractor. The target and distractors were Landolt C stimuli (each subtending 1.6° of visual angle in diameter) evenly distributed in a circular array (subtending 8° of visual angle in radius) that surrounded the fixation cross. Each of the four Landolt Cs had a small gap (subtending 0.2° of visual angle in width) that faced north, south, east, or west. On each trial, all four Landolt Cs were presented. One would be designated as the target, so that guess rate was 25%. The target was indicated by an arrow stimulus (subtending 1.6° of visual angle) that appeared simultaneously with the target and distractors. The arrow could point to any one of the four possible target locations. The target was presented equally often at all four locations on the target array.

Task. The task was to report the orientation of the target's gap. Participants used the keyboard's up-, down-, right-, and left-arrow keys to report gaps facing north, south, east, and west, respectively.

Design. A single-factor, within-subjects design was used. The independent variable (IV) was preview condition: (a) no preview, (b) long (1,000 ms) preview with no ISI, (c) long (980 ms) preview with short (20 ms) ISI, (d) short (100 ms) preview with long (900 ms) ISI, and (e) short (100 ms) preview with short (20 ms) ISI. ISI was defined to be the period between the offset of the previewed masks and the simultaneous onset of the Landolt C stimuli (i.e., the target and distractors) and masks. The dependent variable (DV) was response accuracy, measured in terms of proportion of correct responses. Each participant completed six experimental blocks of 20 trials each. The duration of each trial, defined as the period from the onset of the fixation cross to the final offset of the postmasks, was held constant at 1,620 ms across all five conditions to control for total trial duration. All five preview conditions occurred equally often, resulting in a total of 24 observations for each preview condition in the six blocks.

Procedure. Each participant engaged in a 25-min session. The participants were first shown an illustration of the standard visual display of the experiment. They then completed one 20-trial practice block followed by the experimental blocks. The trials were self paced, allowing the participants to rest between trials whenever they deemed it necessary.

The sequence of trial events is illustrated in Figure 1. Each trial began with the presentation of the fixation cross, which stayed on the display until the arrow replaced it. In the *no preview* condition, the target and distractors appeared simultaneously with the masks 1,000 ms after the fixation cross onset. In the *long preview, no ISI* condition, the masks appeared simultaneously with the fixation cross and stayed on the display throughout the trial; the target and distractors appeared 1,000 ms later following the masks. When the ISI was 0 ms, the target and distractors appeared as abrupt onsets.

In the *long preview, short ISI* condition, the masks appeared with the fixation cross and terminated after 980 ms; the same masks reappeared simultaneously with the target and distractors after an ISI of 20 ms. In the *short preview, long ISI* condition, the masks appeared with the fixation cross and terminated after 100 ms; 900 ms later, the same masks reappeared simultaneously with the target and distractors. In the *short preview, short ISI* condition, the masks appeared 880 ms after fixation cross onset and terminated after 100 ms; the same masks reappeared simultaneously with the target and distractors after an ISI of 20 ms. When the ISI was longer than 0 ms, the Landolt C stimuli and the masks appeared as abrupt onsets.

Across all five conditions, the arrow appeared simultaneously with the target and distractors. The target and distractors were shown for 20 ms, after which they terminated simultaneously with the arrow; the masks persisted for another 600 ms on the display.

Results

Data were collapsed across target locations. Figure 2 shows the proportion of correct responses as a function of preview condition. The proportion of correct responses in each condition was calculated for each participant and submitted to a one-way repeated-measures analysis of variance (ANOVA). There was a significant main effect of preview condition, $F(4, 104) = 5.04$, $MSE = 0.008$, $p < .005$, $\eta^2 = 0.16$.

To determine whether preview per se enhanced target identification performance, we compared the *no preview* condition with the *long preview, no ISI* condition: When the mask was previewed ($M = .66$, $SD = .16$), performance was significantly better than it was when the mask was not previewed ($M = .57$, $SD = .13$), $F(1, 26) = 14.95$, $MSE = 0.008$, $p < .005$, $\eta^2 = 0.37$. Previewing the mask enhanced performance. To determine whether duration of preview influenced performance, we compared the *long preview, short ISI* and *short preview, short ISI* conditions: Performance in the *long preview, short ISI* condition ($M = .65$, $SD = .15$) was not reliably different from that in the *short preview, short ISI* condition ($M = .64$, $SD = .17$), $F < 1$. Preview duration did not influence performance, replicating Neill et al.'s (2002) finding. To determine whether ISI modulated performance, we compared the *short preview, long ISI* and *short preview, short ISI* conditions: Performance in the *short preview, long ISI* condition ($M = .66$, $SD = .14$) did not differ reliably from that in the *short preview, short ISI* condition ($M = .64$, $SD = .17$), $F < 1$. ISI did not modulate performance.

Discussion

This experiment replicated the basic findings that previewing the masks attenuates masking and that the duration of preview does not influence target identification performance. More important, we found that ISI did not modulate performance. Masking was attenuated even at the longest (900 ms) ISI condition. It would appear then that the masking effect is not sensory in origin, as the sensory representation of the previewed masks would almost certainly have degraded completely after 900 ms.

Tata's and Giaschi's (2004, Experiment 2) goal was to show that when attention was deployed on the target array and not the mask, the effect of masking was reduced. They first presented the masks and then, in a subsequent frame, the same masks each enclosing an element of the target array. As the ISI between the masks and target frame was 0 ms, the target elements appeared as onsets. Objects that appear as onsets are prioritized and thus capture attention (e.g., Yantis & Johnson, 1990; Yantis & Jonides, 1984). Thus, one interpretation of these results is that when attention was prioritized on the Landolt C stimuli, the masks were rendered ineffective. We replicated the results of Tata and Giaschi. When the ISI was 0 ms, masking was attenuated compared with the control condition, in which there was no preview frame in the

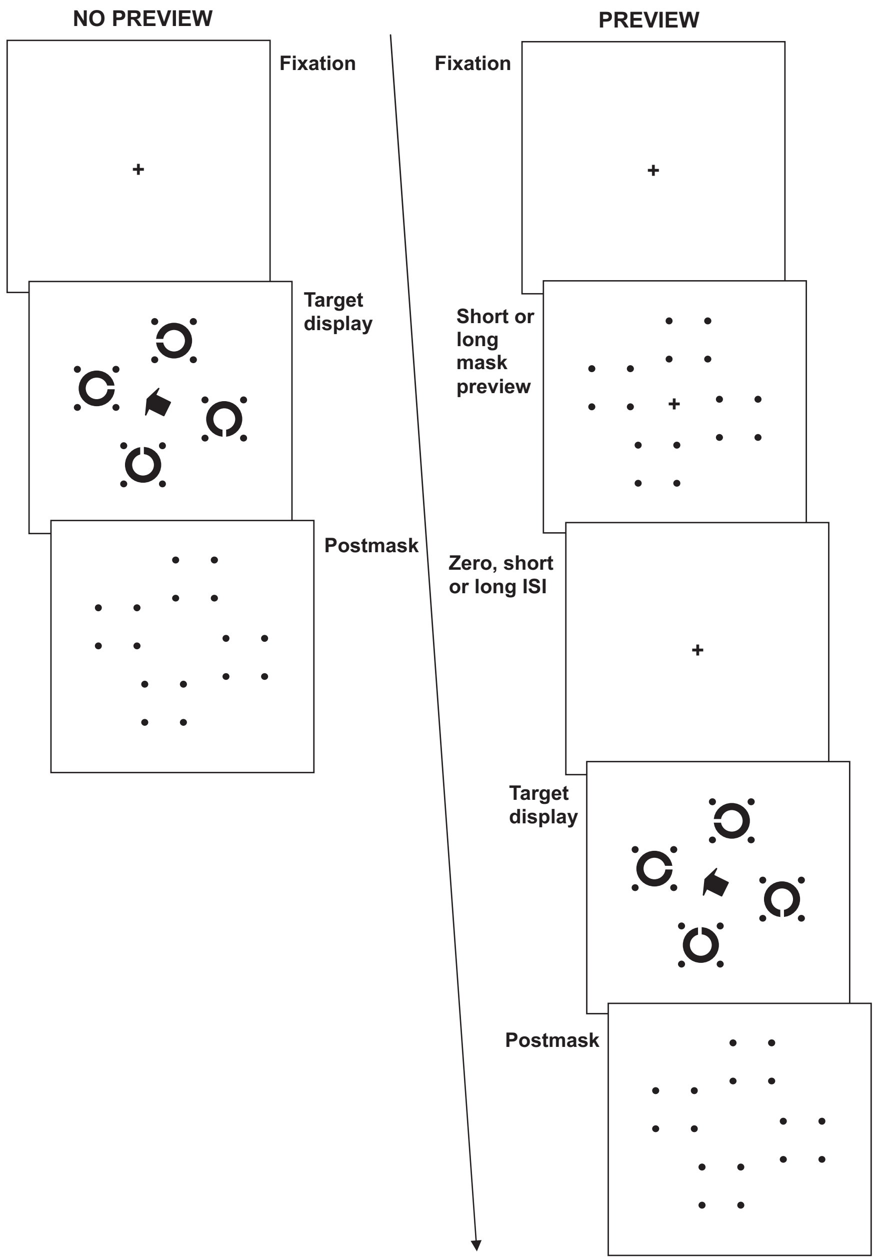

Figure 1. Schematic of the sequence in Experiment 1. ISI = interstimulus interval.

sequence. We also showed that the length of the preview did not modulate masking.

The question remains whether previewing the masks per se would attenuate masking. That is, if a representation of the mask was established, would this representation modulate OSM? To investigate a preview effect, we allowed both the masks and the elements of the target array to appear as onsets by inserting a blank frame between the preview frame and the target frame. The ISI was either 20 ms or 900 ms. As the masks and the elements of the target array all appeared as onsets, the latter would not be prioritized,[1] and no attention would be selectively deployed on them. If the locus of the preview effect was selective attention on the target array because it appeared as an onset, one should not expect an attenuation of masking. We observed similar improvement in target identification for the 20 ms and 900 ms conditions. Thus, for these conditions, the improved identification performance for the target array cannot be simply attributable to its prioritization due to the fact that the elements appeared as onsets.

In OSM, reentrant processing occurs because the earliest stages of visual processing fail to yield sufficient information for the

[1] Top-down control processing would have prioritized the Landolt C stimuli as they are the targets. Here, we are more interested in bottom-up control processes.

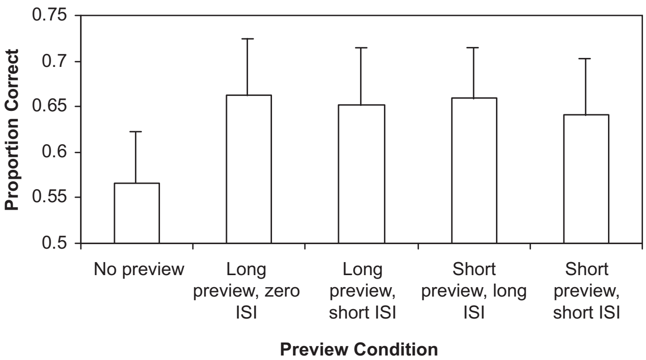

Figure 2. Proportion of correct responses as a function of preview condition in Experiment 1. ISI = interstimulus interval. Error bars indicate standard errors.

identities of the stimuli to be recovered. When the target stimuli disappear before the masks, the visual system, at the reentrant-processing stage, samples information provided by the masks that persist. But, if the representation of the mask has already been lodged in VSTM, as would be the case if it had been previewed, the mask would now compete less effectively with the target at the later reentrant-processing stages. In other words, previewing biases the competition at the feedforward stages of visual processing toward the Landolt C stimuli. As a result, OSM is attenuated.

This interpretation is consistent with the results of Lleras and Moore (2003), which implicated object-level representations as critical for OSM. It is also consistent with the results of Tata and Giaschi (2004, Experiment 3). They presented the search array on a grid background formed by intersecting vertical and horizontal lines. The rectangle masks that surrounded the search stimuli were positioned such that their outline was coincident with the background grid. Thus, the masks did not appear as separate objects. Now, even though the masks were previewed (as part of the background grid), OSM was still observed. It would appear that for the preview to work, object-level representations of the mask must first be lodged in VSTM. Once this obtains, the mask loses its potency in competing with the target for processing at the later visual processing stages.

Tata and Giaschi (2004, Experiment 3) suggest that in order for OSM to occur despite previewing, the mask at preview must be unrecognized by the visual system at test. Experiment 2 was designed to explore the conditions under which the same mask would fail to be recognized by the visual system at a later instance.

Experiment 2

In Experiment 2, the configuration of the four-dot mask was manipulated. In the critical (configuration change) conditions, each previewed mask (e.g., in a square configuration) underwent a 45° rotation so that the mask during target presentation was in a different (diamond) configuration. Note, however, that the mask was composed of the same four dots regardless of whether the mask was in a square or diamond configuration. The question we asked was whether previewing the mask in a configuration different from that which appeared in the target array would still inoculate the visual system against OSM.

Method

Participants. Twenty-three undergraduates participated to fulfill course requirements. All had normal or corrected-to-normal vision. None had participated in Experiment 1.

Apparatus, setting, task, and stimuli. The apparatus, setting, task, and stimuli were as in Experiment 1, with the following difference: Each mask was composed of four dots presented on the four corners of either an imaginary square or an imaginary diamond shape.

Design. A 4 × 2 within-subjects design was used. The IV of primary interest was preview condition: (a) no preview, (b) preview, with no change in mask configuration and an ISI of 900 ms, (c) preview, with a change in mask configuration and an ISI of 900 ms, and (d) preview, with a change in mask configuration and no ISI. ISI, as in Experiment 1, was defined as the temporal lag between previewed mask offset and target presentation. The second IV was mask configuration at preview: (a) diamond configuration or (b) square configuration. The DV was response accuracy, measured in terms of proportion of correct responses. Each participant completed four experimental blocks of 32 trials each. The duration of each trial was held constant at 1,820 ms across all eight conditions. All eight preview conditions occurred equally often, resulting in a total of 16 observations for each preview condition in the four blocks.

Procedure. The procedure was as in Experiment 1, with the following differences: Each participant completed one 16-trial practice block followed by the experimental blocks. The sequence of trial events is illustrated in Figure 3. In the *no preview* condition, the target and distractors appeared simultaneously with the masks (in either square or diamond configurations) 1,200 ms after the fixation cross onset. In the *preview, no configuration change, ISI* condition, the masks appeared simultaneously with the fixation cross and terminated after 300 ms; 900 ms later, the same masks (in the same configurations) reappeared simultaneously with the target and distractors. The sequence of the *preview, configuration change, ISI* condition was the same as that of the *preview, no configuration change, ISI* condition, except that the mask configuration during target presentation now differed from the previewed mask configuration. In the *preview, configuration change, no ISI* condition, the masks appeared 900 ms after fixation cross onset and persisted for 300 ms, after which the target and distractors appeared together with the altered mask configurations.

Results

Data were collapsed across target locations. Figure 4 shows the proportion of correct responses as a function of preview condition. The proportion of correct responses in each condition was calculated for each participant and submitted to a 4 × 2 repeated-measures ANOVA. There was a significant main effect of preview condition, $F(3, 66) = 3.36$, $MSE = 0.009$, $p < .05$, $\eta^2 = 0.12$. Neither the main effect of mask configuration at preview nor the interaction between preview condition and mask configuration at preview was significant, $F\text{s} < 1$.

To determine whether preview per se enhanced target identification performance, we compared the *no preview* condition with the *preview, no configuration change, ISI* condition: When the mask was previewed ($M = .60$, $SD = .14$), performance was

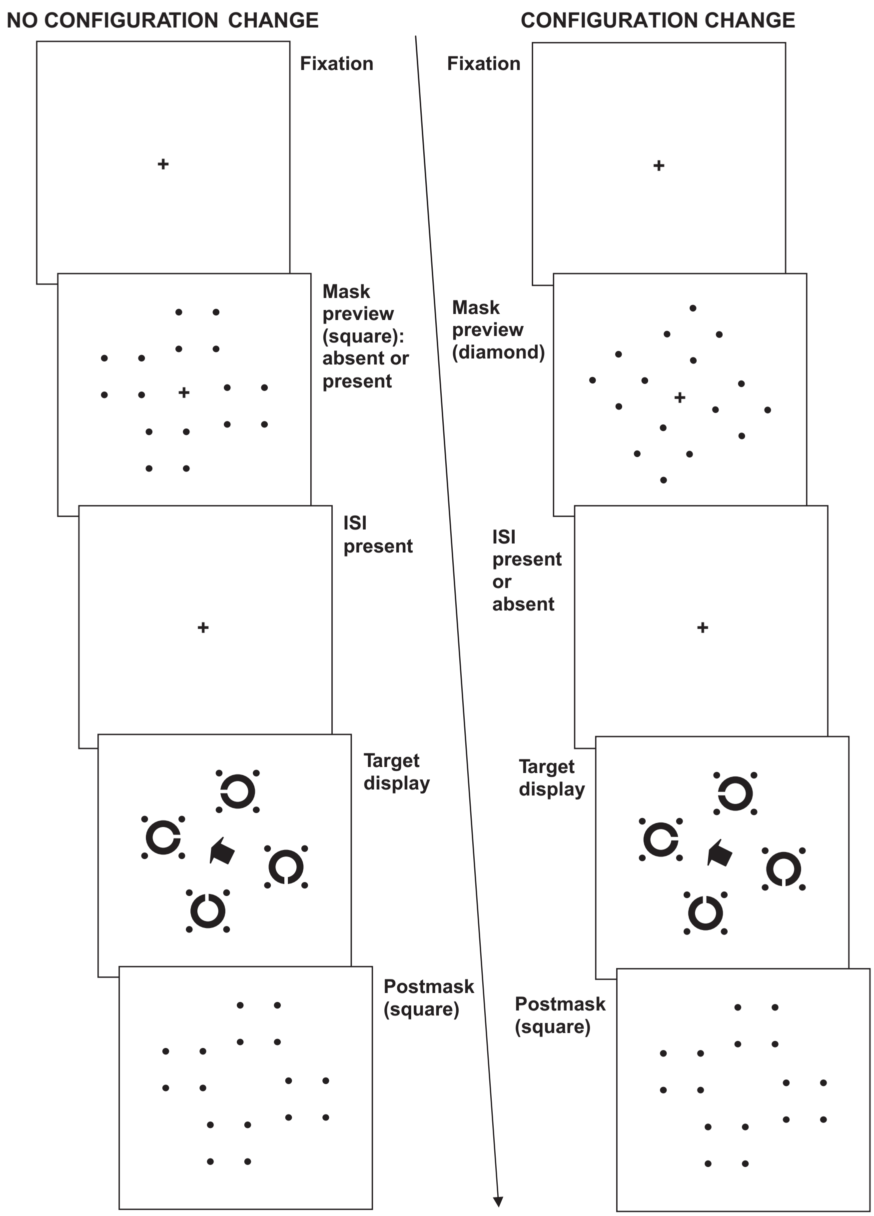

Figure 3. Schematic of the sequence in Experiment 2. ISI = interstimulus interval.

significantly better than it was when the mask was not previewed, (M = .52, SD = .15), $F(1, 22) = 5.90$, $MSE = 0.001$, $p < .05$, $\eta^2 = 0.28$. Previewing the mask enhanced performance. To determine the effects of configuration change on performance, we compared the *preview, no configuration change*, *ISI* and *preview, configuration change*, *ISI* conditions: Where there was configuration change (M = .53, SD = .12), performance was significantly worse than it was where there was no change (M = .60, SD = .14), $F(1, 22) = 7.78$, $MSE = 0.007$, $p < .05$, $\eta^2 = 0.29$. A change in mask configuration, with a delay of 900 ms between previewed mask offset and target presentation, impeded performance. To investigate the effects of the ISI variable on performance, we compared the *preview, configuration change, ISI* and *preview, configuration change, no ISI* conditions: Given a change in mask

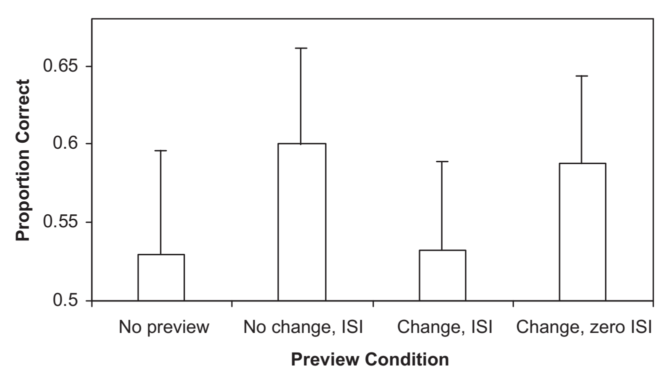

Figure 4. Proportion of correct responses as a function of preview condition in Experiment 2. ISI = interstimulus interval. Error bars indicate standard errors.

configuration, performance was significantly better when the ISI was absent ($M = .59$, $SD = .14$) than it was when the ISI was present ($M = .53$, $SD = .12$), $F(1, 2) = 4.64$, $MSE = 0.008$, $p < .05$, $\eta^2 = 0.26$. Apparent motion nullified the effects of configuration change.

Discussion

The basic preview effect in Experiment 1 was replicated. When the configuration presented at preview was identical to that presented at the target frame, masking was attenuated even though there was a 900 ms pause between the disappearance of the masks and their reappearance when the Landolt C stimuli were introduced. In contrast, previewing a mask that had a configuration that was different from the configuration at test did not attenuate masking, even though the masks were composed of the same four dots. But, when the ISI between previewed mask offset and target presentation was 0 ms, masking was attenuated even when the mask configuration at preview differed from that at test. Recall that Experiment 1 showed that the ISI variable did not affect the masking effect. Thus, the attenuation of masking cannot be due to the ISI variable.

Consider the *preview, configuration change, ISI* condition where, for example, a diamond configuration was previewed. Previewing led to its representation being lodged in VSTM. The mask then disappeared. When the mask (re)appeared with the target, it now assumed a square configuration. The representation of the mask at the target frame was therefore different from the representation in VSTM that was established at the preview stage. Although the square configuration, like the diamond configuration, was composed of the same four dots, the representation of the object (the four dots forming a shape) at preview differed from the object at test. For the visual system, there was, in a sense, no preview of the mask at the target frame. The consequence was that OSM was observed.

Yet, when ISI equaled 0 ms, there was an attenuation of masking even though the same mask had undergone the same kind of configuration change at test. Although the mask configuration at test differed from that at preview, the visual system would have flagged the mask in changed configuration as an object that it had already processed. Thus, the mask would likely be perceived by the visual system to have rotated from a diamond configuration (already lodged in VSTM) to a square configuration at the same location. Through this apparent motion, the square mask could be recognized by the visual system and therefore be less effective in competing with the target for reentrant processing. As a result, OSM was attenuated.

General Discussion

This study showed that previewing the mask pattern effectively attenuated masking and enhanced target identification performance in most situations. Neither preview duration nor ISI modulated performance (Experiment 1). In Experiment 2, the mask configuration differed from that at target presentation in some trials. The dots making up the mask were, however, identical. Thus, local sensory stimulation ought to have been more or less the same. When there was a delay of 900 ms between previewed mask offset and target presentation, previewing was found to be ineffective. Yet, when this delay was removed (i.e., ISI = 0 ms), preview attenuated masking. Taken together, these findings seem to suggest that whether mask preview is effective in attenuating OSM depends on how the masks are represented in VSTM and on whether these initial representations are associated with the masks that later (re)appear in the target frame. An interpretation based on object representations seems to provide an excellent account of these data.

When the mask is previewed, its representation will be quickly established and maintained in VSTM even after the mask disappears from view. So long as no new object intervenes during the blank period, which could obliterate the mask's representation, the specification of the mask's identity would have been complete when the mask reappears with the target. Thus, no further processing of the mask is necessary, and the reentrant processing can be devoted exclusively to the target. In Experiment 1, it was shown that masking was attenuated even at the longest (900 ms) ISI condition. Here, when the mask reappeared, it might indeed be categorized as a new token distinct from the token that had appeared previously (cf. Yantis & Gibson, 1994). But so long as its representation, established at preview, was still lodged in VSTM when the mask reappeared, the new token would be fully specified the moment it appeared. Thus, it would not compete with the target at the reentrant-processing phase, and OSM would be attenuated as a consequence.

The logic of reentrant processing is that these processes are intended to discover aspects of the stimulus that are underspecified in the initial processing stages. But if the representation of the stimulus has already been established and its aspects fully specified, reentrant processing of the new token should be unnecessary. As it does not compete with the target for further processing, there is greater likelihood that the target's representation will be established with greater fidelity. Thus, whether masking occurs depends on whether the mask type (rather than token) had been previously encoded.

In Experiment 2, the configuration of the previewed mask (e.g., diamond configuration) differed from that of the mask during target presentation (square configuration) in some trials. The diamond mask might be fully specified in VSTM after preview. But when the configuration during target presentation was different, initial processing yielded a representation that was different from what had been lodged in VSTM. The square configuration, like the diamond configuration, was composed of the same four dots, but the former was represented as a different object from the previewed object. Thus, when this square configuration was presented simultaneously with the target and persisted after the target disappeared, it now competed with the target for reentrant processing. As a result, OSM obtained as though there had been no previewing of the mask. Yet, when ISI equaled 0 ms, apparent motion allowed the visual system to encode the mask at preview and that at test to be the same object even though the two assumed different configurations. Thus, the mask at the target frame would be regarded by the visual system to have been fully processed, even though it had undergone a change in configuration. As a result, it did not disrupt the reentrant processing of the target.

Conclusion

We report new evidence of ineffective mask preview under the scenario in which the original object-level mask representation lodged in VSTM during the preview stage cannot be effectively associated with the mask that (re)appeared, after a temporal lag, during target presentation. This later mask became capable of competing with the target for reentrant processing and therefore inducing OSM. A new understanding of when exactly mask preview can inoculate against OSM is initiated.

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