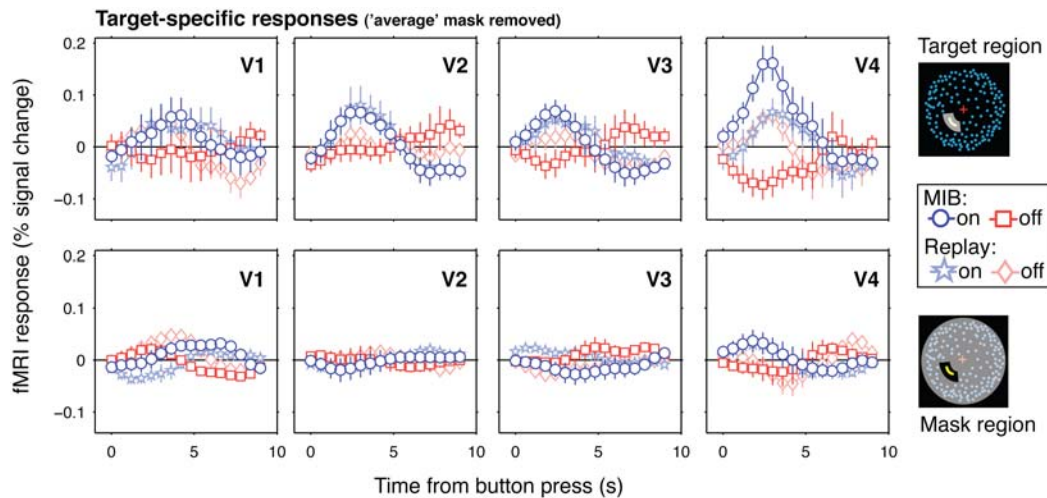


Supplementary Material

1. Target-specific responses in visual areas V1, V2, V3, and V4.

Supplementary Figure 1 shows the residual responses of target sub-regions (top panel) and mask sub-regions (bottom panel) of areas V1 through V4, after removal of the average mask sub-region time series, collapsed across all four areas. Thus, the residual responses of the target sub-regions in the top panel constitute an alternative estimate of the target-specific responses to the one presented in Figure 3 of the main paper, in which the mask sub-region's time series of each individual area was removed from the corresponding target sub-region's time series.

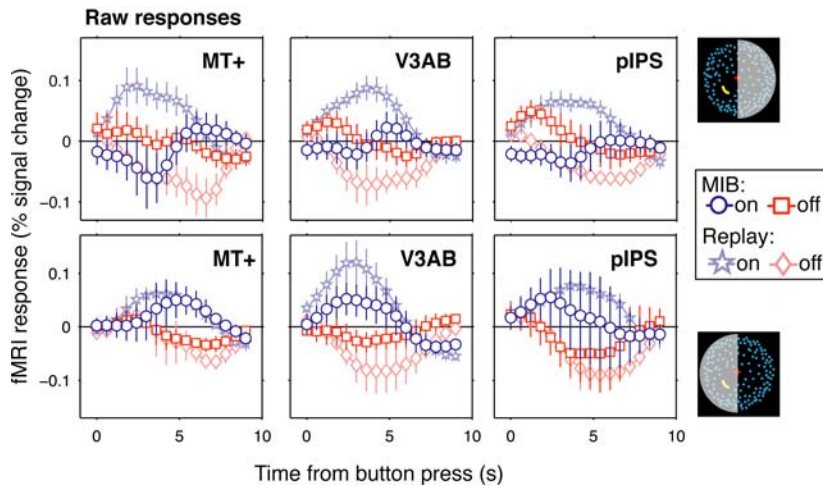


Supplementary Figure 1. Target-specific responses in visual areas V1 – V4 during MIB and replay. Residual disappearance ('off') and reappearance ('on') responses have been isolated for target (top panel) and mask (bottom panel) sub-regions (see icons, gray-shaded regions). Residuals were obtained by removing a 'global' time series, averaged across the mask sub-regions in all four areas. Event-related responses have been calculated from the residuals and averaged across subjects. Error bars indicate SEM across subjects ($n = 6$).

Both procedures of estimating target-specific responses yielded nearly identical results (compare top panel of Supplementary Figure 1 with Figure 3). Thus, the target-specific responses did not depend on the specific reference signal used as proxy for the 'global' response component to be removed from the signal measured in the target sub-regions. Furthermore, there was almost no residual response modulation in the mask sub-regions of any of the four visual areas (Supplementary Figure 1, bottom panel). This indicates that the responses of the mask sub-regions were in fact very similar to one another, i.e., global (see Results: A Global Response Component in Early Visual Cortex).

2. Raw responses in dorsal visual areas MT+, V3AB, and pIPS.

Supplementary Figure 2 shows the raw responses of dorsal visual areas MT+, V3AB, and pIPS for both hemispheres. Note that the initial response increases during target disappearance (red squares) are evident in the hemisphere ipsilateral (top panel), but not contralateral (bottom panel), to the target stimulus. Also note the strong dissociation between responses during MIB and replay in the hemisphere ipsilateral to the target (top panel).

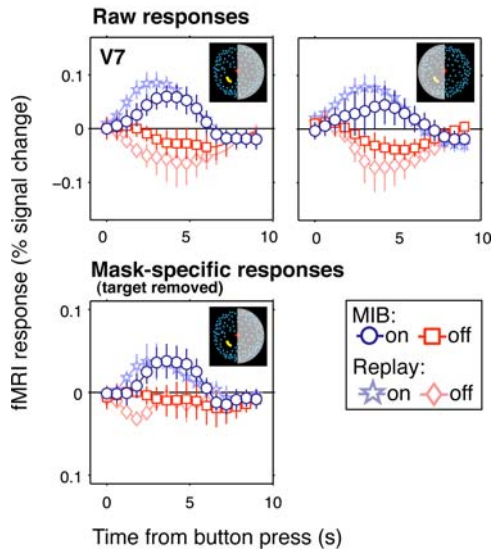


Supplementary Figure 2. MIB and replay responses in dorsal visual areas MT+, V3AB, and pIPS. Raw disappearance ('off') and reappearance ('on') responses are shown for two different sub-regions: Top panel, the mask sub-regions in the hemisphere ipsilateral to the target stimulus (i.e., contralateral to its cortical representation); bottom panel, the target + mask sub-regions in the hemisphere contralateral to the target stimulus (i.e., containing its cortical representation; see icons, gray shaded regions). Responses were averaged across subjects. Error bars indicate SEM across subjects ($n = 6$).

The robust replay response modulations in these dorsal areas ipsilateral to the disappearing and reappearing target stimulus might seem surprising. In fact, response amplitudes were strongly correlated across individual replay runs between ipsilateral and contralateral sub-regions of V3AB ($r = 0.89$, $p < 10^{-4}$) and pIPS ($r = 0.69$, $p < 10^{-4}$). Analogous response correlations between similar sub-regions of the two hemispheres have been observed in a spatial attention task (Sylvester et al., 2007). This response correlation might be stimulus-driven, reflecting neural populations with large response fields extending into the ipsilateral hemifield (Tootell et al., 1998), or it might be driven by the strong 'global' response component that was expressed in early visual cortex (see Results: A Global Response Component in Early Visual Cortex).

3. No opposite responses in dorsal visual area V7.

Supplementary Figure 3 shows disappearance and reappearance responses for MIB and replay in dorsal visual area V7. The raw responses are shown in the top panel. The mask-specific responses are shown in the bottom panel.

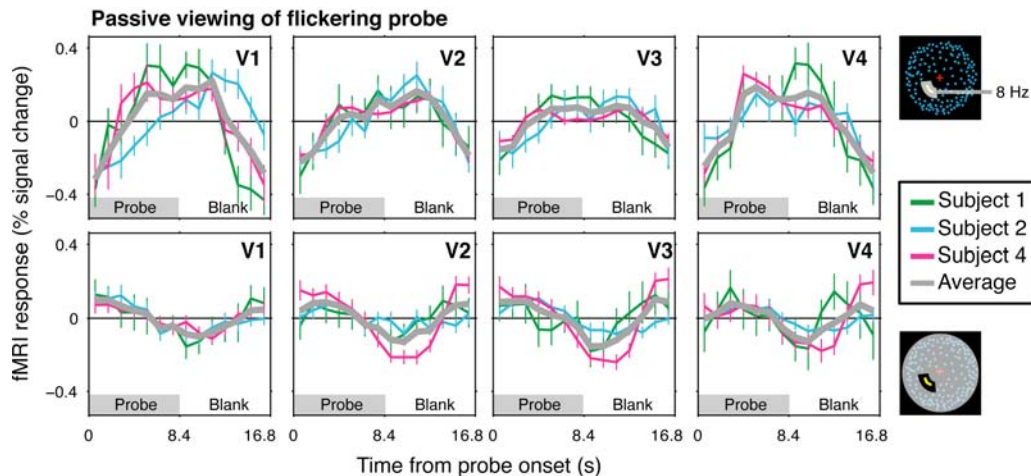


Supplementary Figure 3. MIB and replay responses in dorsal visual area V7. Raw disappearance ('off') and reappearance ('on') responses are shown in the top panel, for the mask sub-region (left) and the target + mask sub-region (right; see icons, gray-shaded regions). The mask-specific responses in the mask sub-region (see icon, gray-shaded region) are shown in the bottom panel. Mask-specific responses were isolated by removing the time series of the corresponding contralateral sub-region containing the target representation, before calculating event-related responses (see Materials and Methods: Isolation of Target- and Mask-specific Responses), and averaging across subjects. Error bars indicate SEM across subjects ($n = 6$).

Unlike the responses in the two adjacent areas V3AB and pIPS, the responses in V7 did not increase during target disappearance and did not decrease during target reappearance.

4. The ‘global’ component did not reflect cortical and/or hemodynamic point spread.

Given the separation of target and mask by only $\sim 1^\circ$ of visual angle and the cortical and hemodynamic point spread of $\sim 3 - 5$ mm in area V1 (Engel et al., 1997; Logothetis and Wandell, 2004), the fMRI responses elicited by both stimulus components must have overlapped. To test whether this overlap might, at least in part, account for the ‘global’ response modulation observed during the MIB and replay experiments, we measured fMRI responses to a single probe stimulus at the target location, flickering at ~ 8 Hz, in the presence of the mask. Three of the subjects passively viewed the periodic alternation between this flickering probe and blank (16.8 s per cycle). As in the MIB and replay experiments, the mask moved continuously throughout each run. Within each of the target and mask sub-regions in V1 through V4, we averaged the fMRI time series across gray matter voxels, extracted the responses evoked by individual stimulus cycles (14 time points) from the mean time series, and averaged these responses across cycles. The resulting mean response time courses are shown in Supplementary Figure 4.



Supplementary Figure 4. Retinotopic specificity in visual areas V1 – V4. Raw responses to a flickering (~ 8 Hz) probe stimulus at the location of the MIB target, and surrounded by the continuously moving mask are shown for two different retinotopic sub-regions: top panel, the sub-regions corresponding to the MIB target; bottom panel, the mask sub-regions (see icons, gray-shaded regions). The gray bar at the bottom of each plot indicates the interval, during which the flickering probe was presented. Error bars, within-subject SEM across stimulation cycles (subject 1: $n = 28$; subject 2: $n = 84$; subject 4: $n = 140$).

The presentation of the probe evoked response increases in the target sub-regions of all four visual areas (Supplementary Figure 4). In sharp contrast to the raw responses in MIB and replay experiments (Figure 8A and Supplementary Figure 5), these responses to the flickering probe were spatially-specific, accompanied by opposite-phase modulations of smaller amplitude in the mask sub-regions. The opposite-phase fMRI responses in the

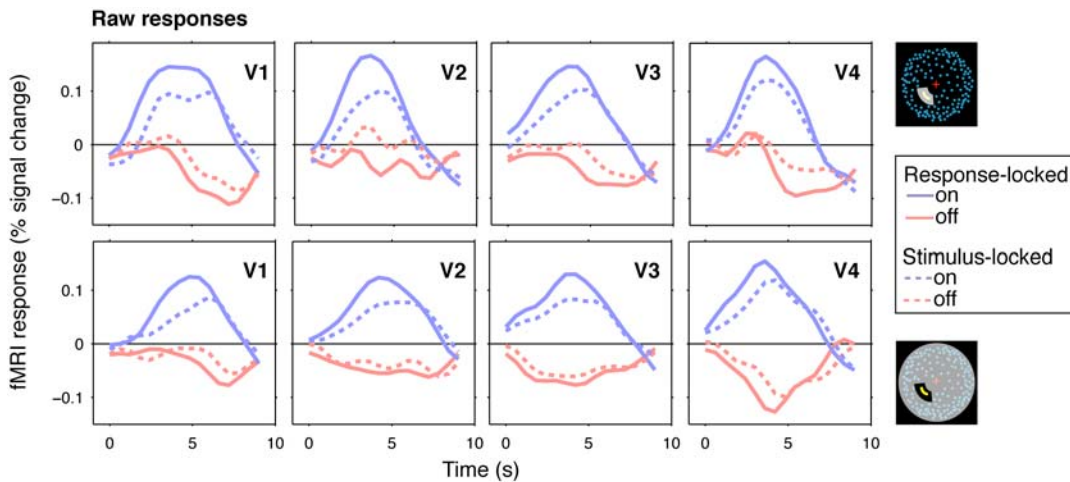
mask sub-regions might reflect indirect suppression of neural activity induced by the probe (Tootell et al., 1998; Shmuel et al., 2006), competition between the probe and mask representations (Bonneh et al., 2001; Graf et al., 2002; Keysers and Perrett, 2002), focal attention to the probe (Muller et al., 2005), or a combination of these factors.

The MIB and replay experiments differed from the control experiment (Supplementary Figure 4) in several respects: Subjects actively reported the visibility of the target during MIB and replay; the target appeared in an irregular (unpredictable) fashion; the target was static (less salient) than the flickering probe. It is likely that a combination of these factors was responsible for the 'global' response component measured during MIB and replay in early visual cortex.

Regardless, Supplementary Figure 4 demonstrates that visual stimulation at the target location could elicit distinctly different fMRI responses in the target and mask sub-regions. This establishes that the spatial separation between target and mask was in fact sufficient for isolating neural responses associated with the cortical representations of the two stimulus components with fMRI. Thus, cortical and/or hemodynamic point spread cannot account for the 'global' response measured in the mask sub-regions of V1 through V3 during MIB and replay.

5. The 'global' component was closely tied to perceptual report.

To further characterize the 'global' response component in early visual cortex, we calculated the replay responses time-locked to the stimulus changes ('on' and 'off'), as well as time-locked to the subsequent button press responses of the subjects. These two types of event-related responses are plotted superimposed in Supplementary Figure 5, for the target and mask sub-regions of visual areas V1 through V4. Responses in all sub-regions were consistently larger when time-locked to subjects' button presses than when time-locked to the corresponding stimulus changes.



Supplementary Figure 5. Response-locked 'global' component in visual areas V1 – V4 during replay. Raw replay responses are shown for two different retinotopic sub-regions: top panel, the target sub-regions; bottom panel, the mask sub-regions (see icons, gray-shaded regions). Responses are time-locked to the stimulus events (onsets/offsets, dashed curves) or to the button presses (solid curves). Responses were averaged across subjects.

Thus, the 'global' response component in early visual cortex was temporally more closely tied to subjects' behavioral reports of the stimulus changes during replay than to the stimulus changes themselves. This suggests that the 'global' component was non-sensory, i.e., not solely driven by the visual stimulus.

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