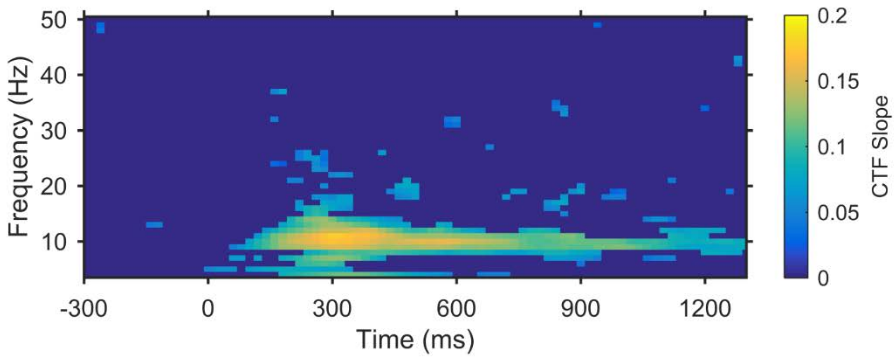

Figure S1. Spatially selective oscillatory activity is specific to the alpha band (8–12 Hz); related to Figure 2. CTF selectivity (measured as CTF slope) as a function of time and frequency (4–50 Hz, in 1-Hz bands) Points at which CTF selectivity was not reliable above chance, as determined by permutation testing, are set to zero (dark blue). To reduce computation time, we down-sampled power values from 250 Hz to 50 Hz (i.e., one sample every 20 ms). Note that we down-sampled power values after filtering and applying the Hilbert transform so that down-sampling did not affect how power values were obtained.

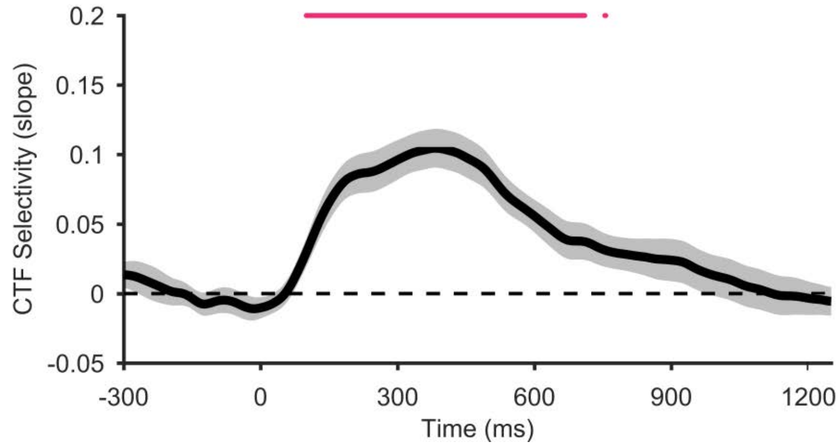

Figure S2. Spatial representations of the distractor position resemble the spatial representation of the target position; related to Figure 3. In our standard IEM procedure, we obtained target-related CTFs by training and testing on the target position (see STAR Methods). Similarly, we obtained distractor-related CTFs by training and testing on the distractor position. This analysis leaves open the possibility that the pattern of alpha-band activity that represents target and distractor positions is different. To test this possibility, we ran an analysis in which we trained the IEM on the target position and tested on the distractor position using the data from Experiment 2a (see STAR Methods). The plot shows the selectivity of resulting distractor-related CTF across time (measured as CTF slope) We observed a reliable distractor-related CTF when when training the IEM on the target postion. This result demonstrates that the alpha-band representation of the distractor position resembles that of the target position. The magenta marker at the top of the plot shows the period of reliable spatial selectivity. The shaded error bar reflects ±1 bootstrapped SEM across subjects.

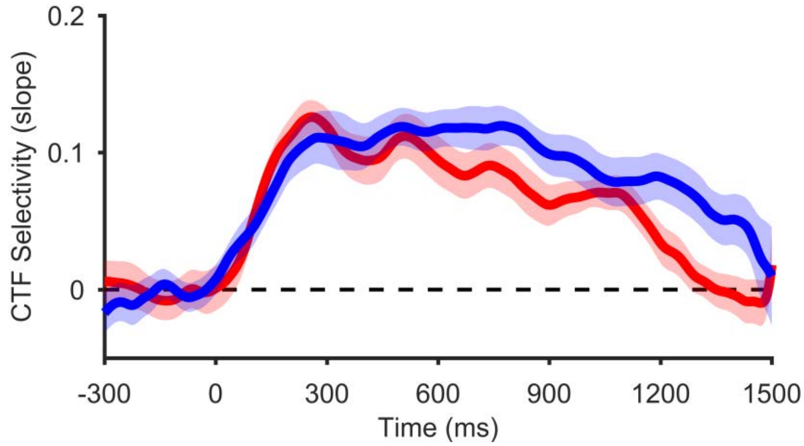

Figure S3. Control analysis in Experiment 3; related to Figure 4. In Experiment 3, our task required subjects to attend and encode both items in order to determine which item was the to-be-remembered target (the circle with the higher digit). It is possible that on trials in which the higher digit was 7 (the highest digit in the set of possible digits) subjects did not need to attend the distractor item because a 7 was always the higher digit in the display. Thus, we re-ran our analysis, excluding trials in which the target was 7. The plot shows the CTF selectivity of alpha-band CTFs when we excluded trials in which the larger digit was 7. Again, we found that alpha-band CTF selectivity was higher for the target than for the distractor throughout the delay period (150–1500 ms, $p < 0.001$, bootstrap resampling test). Shaded error bar reflects ±1 bootstrapped SEM across subjects.

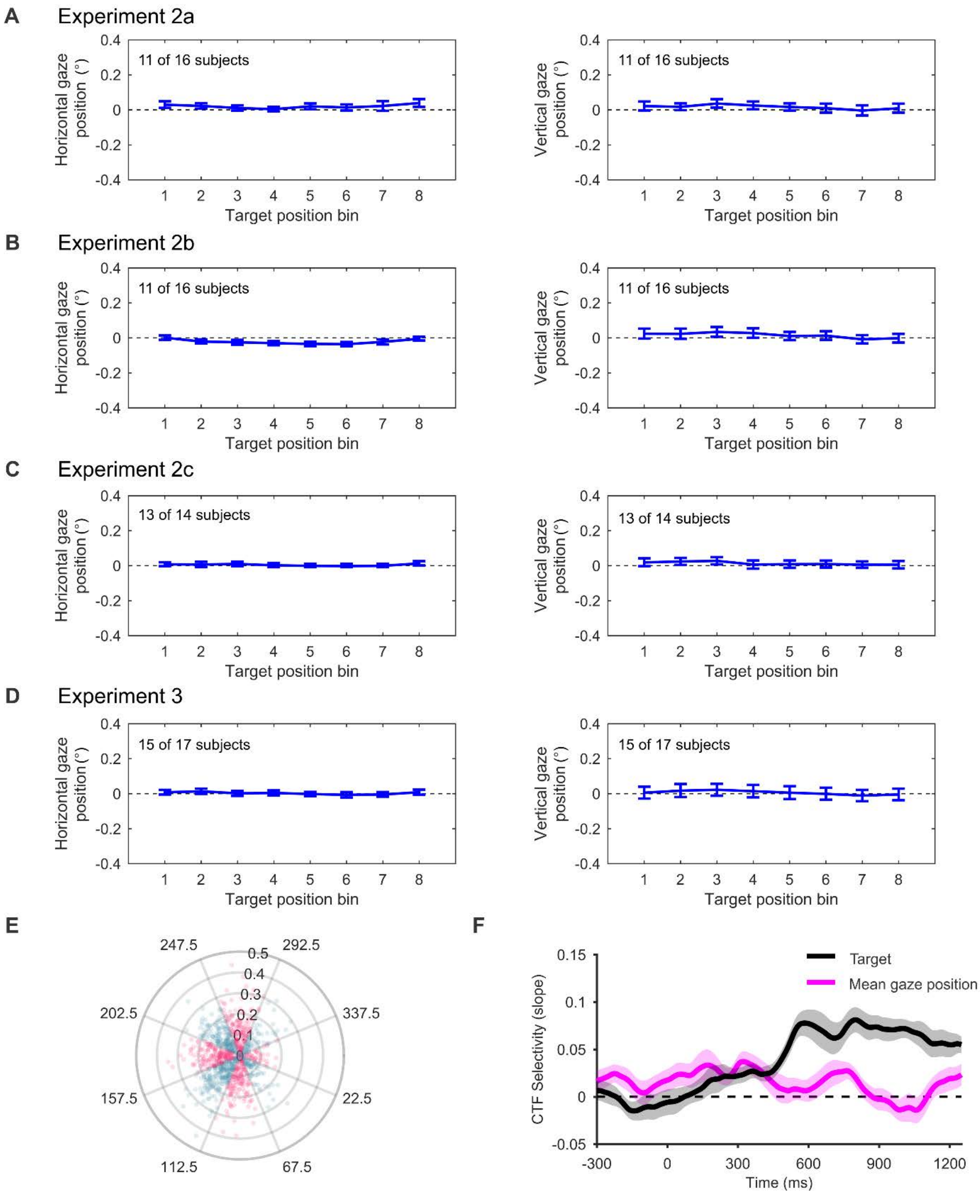

Figure S4. Eye movement controls; related to figures 3-4. (A-D) Mean horizontal (left) and vertical (right) gaze position (following the onset of the sample array) as a function of the position bin that the target appeared in. Gaze position was drift corrected to maximize sensitivity to any small changes in gaze position from the pre-stimulus period (see STAR Methods). We observed remarkable little variation in mean gaze position as a function of the position of the target position (less than 0.05° of visual angle), showing that we achieved an extremely high standard of fixation compliance. Each panel indicates the number of subjects that had usable eye tracking data out of the total sample in each experiment. Error bars represent ±1 SEM across subjects. (E) Mean gaze position for each trial sorted in eight gaze position bins for a sample subject. The radial axis is in degrees of visual angle. (F) Alpha-band CTFs reconstructed on the basis of the target position bin (black line) and gaze position bin (pink line) in Experiment 2c. We observed a clear target-related CTF but did not observe clear evidence for a gaze-position-related CTF. This analysis shows that alpha-band activity tracks the location of the target position rather than small variations in gaze position. Shaded error bars represent ±1 bootstrapped SEM across subjects.

	SD	P_g	P_s
Exp. 1 (360° color space)	13.5° ± 1.0	0.8% ± 0.3	N/A
Exp. 2a (360° color space)	16.5° ± 0.6	0.5% ± 0.2	0.3% ± 0.1
Exp. 2b (180° orientation space)	12.2° ± 0.6	2.6% ± 0.6	0.3% ± 0.1
Exp. 2c (180° orientation space)	10.1° ± 0.7	0.8% ± 0.3	N/A
Exp. 3 (360° color space)	15.0° ± 0.7	0.6% ± 0.1	1.2% ± 0.2

Table S1. Summary of parameter estimates (mean ± SEM) for mixture models fitted to response error distributions for each experiment; related to figure 2-4. We calculated response error as the angular difference between the reported stimulus value (i.e., color or orientation) and the presented stimulus value. We fitted each subject's response error distribution with a mixture model (see STAR Methods). *SD* is the standard deviation of the von Mises distribution (circular normal distribution), which estimates the variability in target-related responses. Note that the *SD* values cannot be directly compared between the color experiments and the orientation experiments because the color values spanned 360° and the orientation values spanned 180°. P_g estimates the rate of guessing (i.e., random responses). P_s estimates the rate misreporting the distractor value instead of the target value. Note that we only estimated swapping in our experiments that included a single distractor (experiments 2a, 2b, and 3).