Supplementary Information for

Temporal attention amplifies stimulus information in fronto-cingulate cortex at an intermediate processing stage

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Supplementary Text

Temporal attentional selection in two-target temporal cueing task

Perceptual sensitivity was impaired in the neutral condition (when the temporal precue was uninformative) compared to the valid condition for T1 (see Figure S1), confirming that observers could not fully process both stimuli and instead used attention to select the more relevant stimulus in the sequence. Such behavioral benefits are consistent with previous studies that used the two-target temporal cueing task (Denison et al., 2017, 2021; Fernández et al., 2019; Duyar et al., 2024), confirming that this task reliably elicits temporal attentional selection.

Replication of enhanced T1 orientation decoding with temporal attention

We confirmed the enhancement of temporal attention on orientation decoding for T1 using an identical analysis procedure in a separate dataset, in which the targets were superimposed on a 20-Hz flickering noise patch instead of a blank background (see Figure S2A). Although this experiment was not designed for decoding analysis due to the continuous presence of flickering noise, we again found an enhancement of orientation representation in attended vs. unattended trials at a similar time window around 250 ms (195-260 ms) after target onset (Figure S2B). Again, there was no effect of temporal attention on T2 decoding performance. The overlap of the time windows in which temporal attention enhanced orientation representations in the two experiments (235-260 ms after target onset) indicates that temporal attention reliably affects the orientation representation in an intermediate processing time window following the earliest visual evoked responses and peak decoding accuracy.

Brief early peak in decoding accuracy for T1

Although only the "critical window" around 250 ms passed the stringent cluster correction test across the full trial time series, we noted a brief early peak (at 90 ms after target onset, uncorrected $p = 0.019$) in decoding accuracy for T1 that appeared to be present when T1 was attended but absent when it was unattended (See Supplementary Figure S3A). Given a previous finding that temporal attention transiently affects evoked responses to steady-state visual stimulation (Denison et al., 2024), we used source reconstruction to investigate the cortical origin of this early peak modulation. The effects of temporal attention at 90 ms were strongest in occipital and parietal areas (Figure S3B), a strikingly different topography from the fronto-cingulate areas modulated during the later critical time window. This result suggests that any effect of temporal attention on early stimulus representations is localized to visual areas.

References

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Duyar, A., Ren, S., and Carrasco, M. (2024). When temporal attention interacts with expectation. *Scientific Reports*, 14(1):4624.

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Supplementary Figures

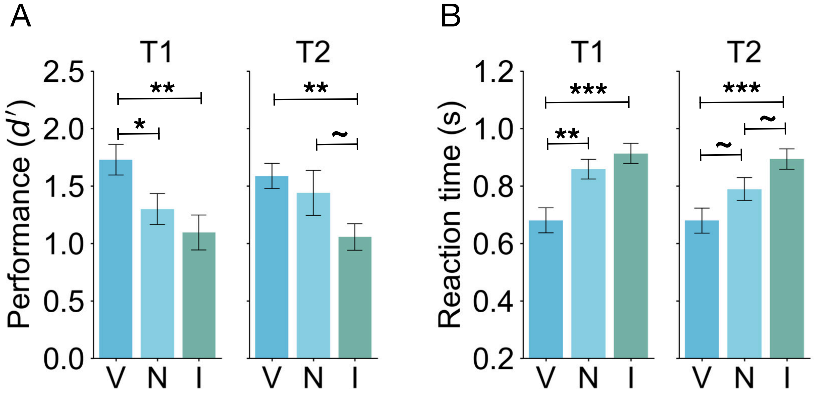

Figure S1. Behavioral results including the neutral condition. **(A)** Tilt discrimination (sensitivity) and **(B)** reaction time for each target (T1, T2) and validity condition. Error bars indicate ±1 SEM. ∼ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$; *** $p < 0.001$.

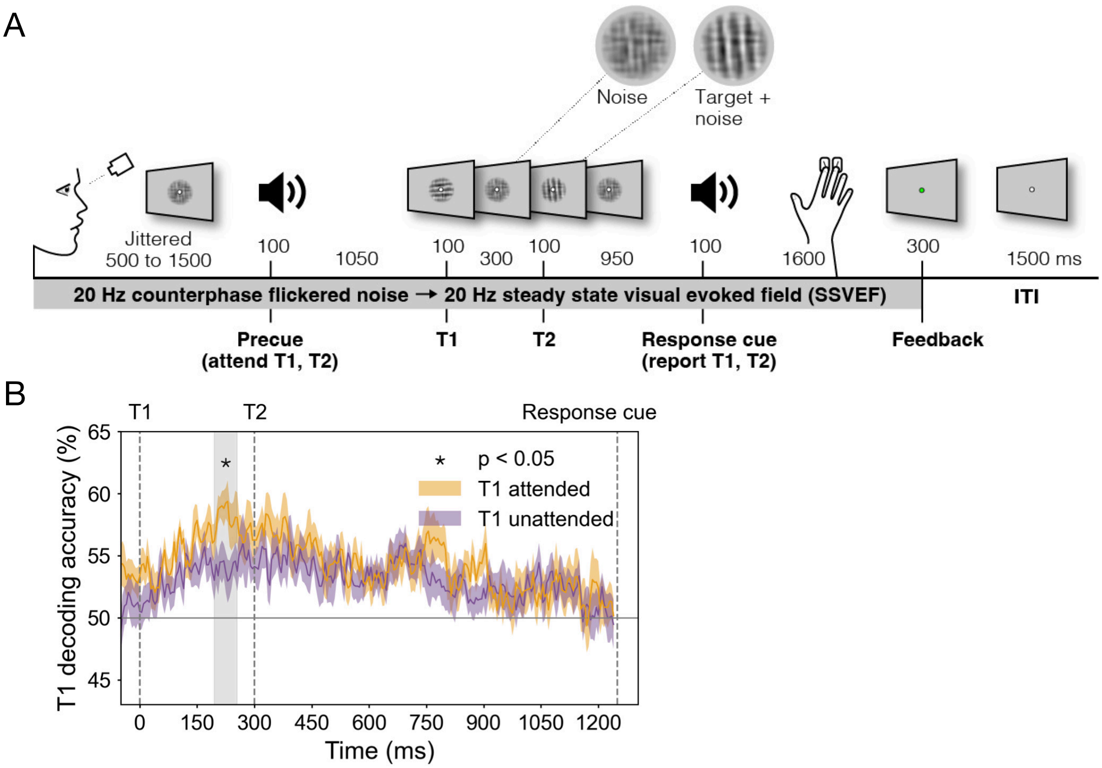

Figure S2. Decoding performance for a separate experiment with targets superimposed on flickering noise. **(A)** Two-target temporal cueing task. Trial timeline showing stimulus durations and SOAs. Targets were embedded in 20 Hz counterphase flickering noise. Precues and response cues were pure tones (high = cue T1, low = cue T2). **(B)** T1 orientation decoding performance for T1 attended and T1 unattended trials confirms enhancement of T1 representation in an intermediate time window.

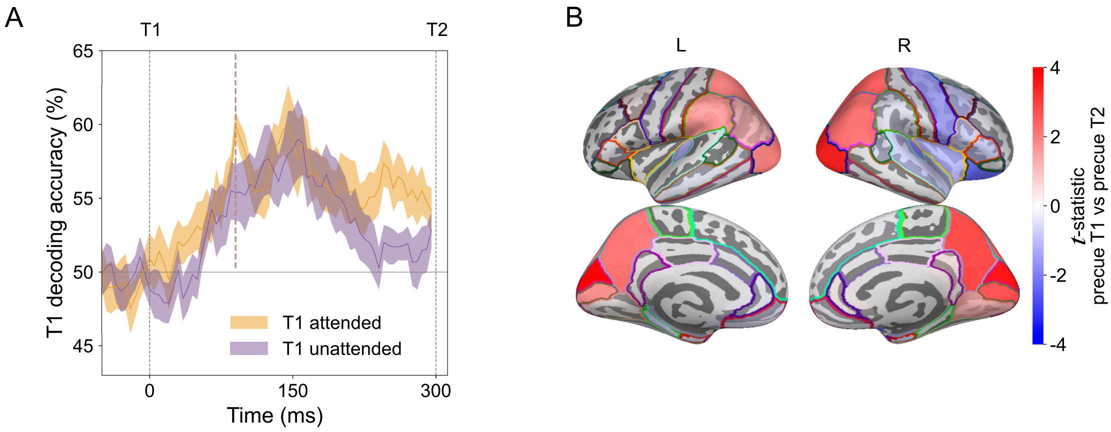

Figure S3. Topography of attentional enhancement of orientation representations during an early peak. **(A)** T1 decoding time series for attended and unattended trials highlighting early peak (thick dashed line, same data as in Figure 3C). **(B)** T1 decoding differences between attended and unattended conditions for left (L) and right (R) hemispheres at 90 ms after target onset for each of 68 DK ROIs.