Supplementary Material

In this supplementary material section, we addressed two problems. First, we present results from a new behavior-pupillometry experiment to test whether there exists a left visual field bias in our paradigm when there is no spatial cuing. Second, we analyzed the eye movement data to test whether there are systematic differences in eye movement patterns between attend-left and attend-right trials.

Behavior-pupillometry Experiment

To test whether there is a left visual field bias in the absence of spatial cueing, we conducted a behavioral experiment along with pupillometry at the University of California, Davis using the same paradigm as the one in the manuscript. The experimental procedure was approved by the Institutional Review Board at the University of California Davis. N=10 subjects gave written informed consent and participated in the experiment.

At the beginning of each trial, an auditory cue instructed the participants to covertly direct their attention to either a spatial location (“left” or “right”) or a color (“red” or “green”) while fixating on the center of the screen. Following a random delay period between 3000 and 6000 ms, two colored rectangles (red or green) were presented for a duration of 200 ms, with one in each of the peripheral locations (indicated by two sets of dots in the upper left and upper right corners of the screen). On 10 % of the trials (invalid trials), only one rectangle was displayed, which was either not in the cued location for spatial trials or not having the cued color for color trials, and the participants were required to report the orientation of that rectangle. The invalidly cued trials were included to measure the behavioral benefits of attentional cuing (Posner 1980). An inter-trial interval was varied randomly from 8000 ms to 12800 ms following the target onset, before the start of the next trial. An SR Research EyeLink 1000 plus eye-tracker system (sampling rate 1000 Hz) was used to track eye movements and record pupillary data.

First, analyzing the behavioral data, we observed that the reaction time (RT) for validly cued trials (784 ± 153 ms) were shorter than invalidly cued trials (989 ± 223 ms; $p < 0.00003$), confirming that the participants followed the task instructions and used the cues to anticipate the target location or color. Second, analyzing the behavioral data from the attend-color trials (attend-red and attend-green), we found that the RT was significantly shorter for attended targets appearing in the left visual field than the right visual field, establishing a left visual field bias in our paradigm when there is no spatial attention cuing (Figure S1A). For spatial trials, no significant RT differences between attend-right and attend-left trials were found (Figure S1B), replicating our findings in the manuscript showing that the left visual field bias was reduced or eliminated with spatial cueing. Third, for the cue-evoked pupillometric analysis, data from nine participants were included (one participant was rejected due to equipment malfunction). Pupillary data was epoched 200 ms before the cue onset until 3000 ms after the cue-onset (-200 to 3000 ms). Pre-cue (-200 to 0 ms) data was used as a baseline to compute the percentage change of cue-related pupil dilation. The pupil dilation following attend-right cues was significantly larger than attend-left cues starting ~750 ms post-cue to the end of the time interval investigated ($p = 0.00002$, random permutation corrected); see Figure S1C.

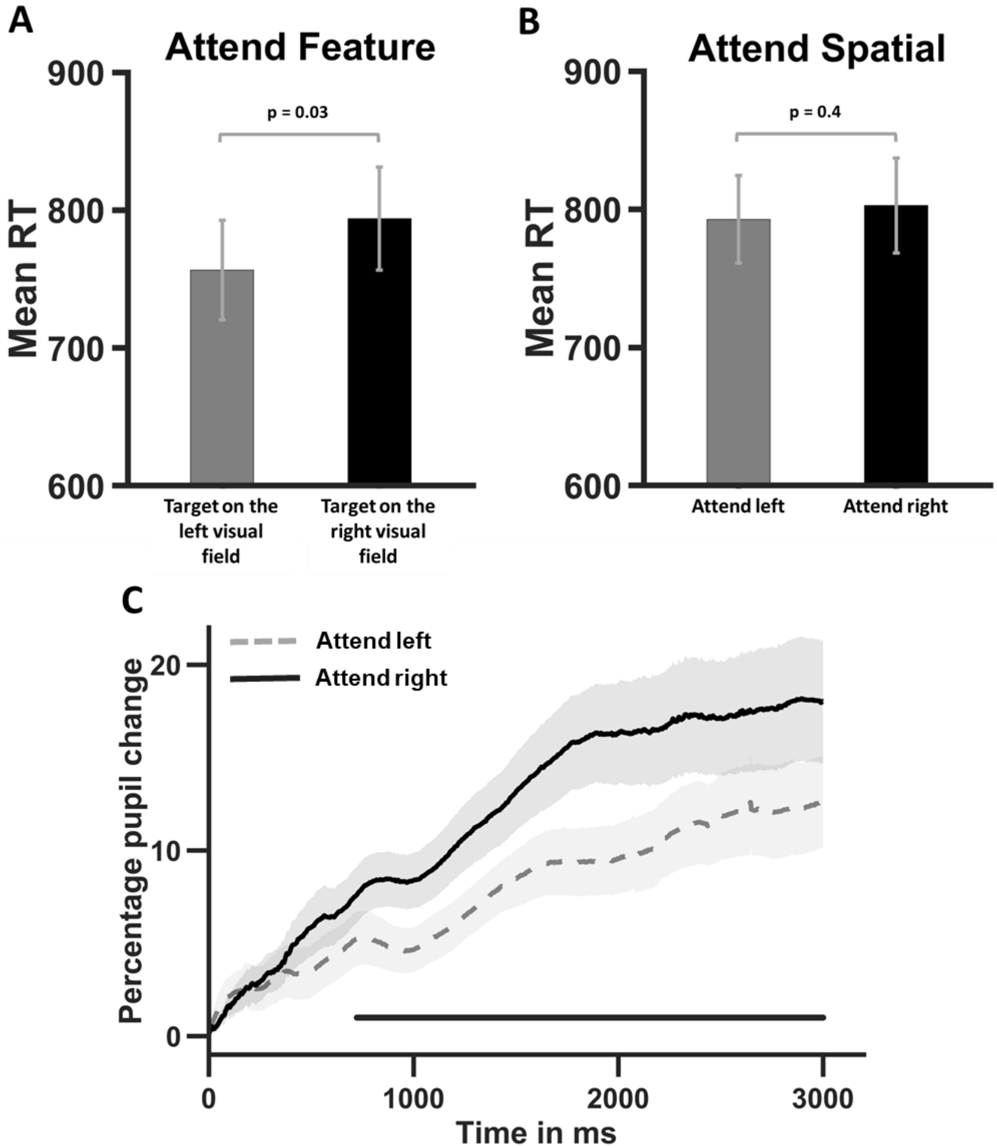

Figure S1. Behavioral and pupillometric data. A) Comparison of mean reaction time for attend-color trials between attended targets appearing in the left and in the right visual field. B) Comparison of mean reaction time between attend-left and attend-right trials. C) Cue-evoked pupil dilation between attend-left and attend-right trials. The horizontal line in black below the timecourse indicates statistically significant time period ($p<0.00002$; cluster corrected). The error-bars (A & B) and shaded regions around the time-course plots (C) denote SEM.

Decoding Eye-movement patterns during the Cue-to-target interval

To examine whether minor fixational eye movement (micro-saccade) patterns differentiated attend-left and attend-right trials, we analyzed the eye positions (x and y coordinates) during the cue-to-target interval. The temporally precise (1 kHz sampling rate) gaze patterns were averaged in 100 ms windows with a 50% overlap and linear support vector machines (SVM) with a 10-fold-cross validation approach was used to decode the attended cues (attend-right versus attend-left). The decoding accuracy time course was obtained by averaging the decoding accuracies across participants at each time point. We found that the decoding time course was at chance-level (50%) throughout the cue-to-target period, suggesting that there are no systematic differences in gaze patterns following attend-left and attend-right cues (Figure S2).

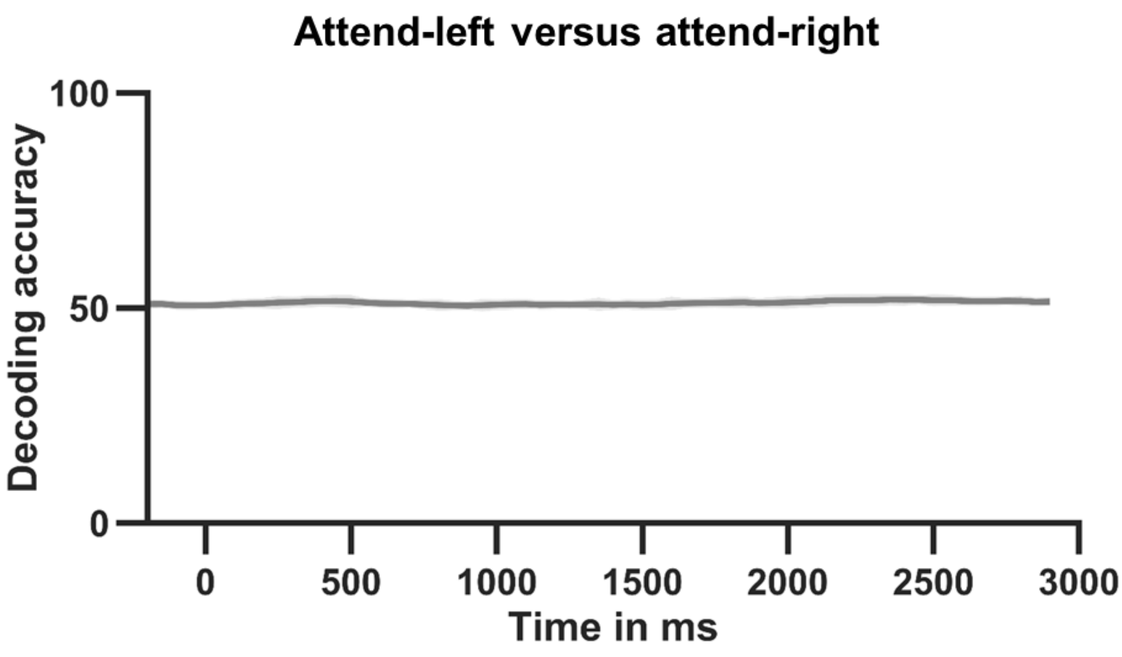

Figure S2. Decoding eye movement patterns. Timecourse of classifier (SVM) performance predicting attend-right and attend-left cues using X and Y gaze positions.