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Supplementary Data

Distinct Contributions of the Magnocellular and Parvocellular Visual Streams to Perceptual Selection

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Effective contrast experiments

In Experiment 1, we observed an increase in SIA rivalry with increasing flicker frequency for high spatial frequency IOS rivalry gratings. While this effect of flicker frequency on perception of high spatial frequency stimuli is not incompatible with the M/P framework, it is also not predicted by this framework. We hypothesized that decreases in effective contrast with increasing flicker frequency could explain this effect, since reducing physical stimulus contrast has been shown to increase the predominance of SIA rivalry in IOS rivalry (Lee and Blake, 1999). Therefore, in Supplementary Experiment 1 (SE1), we tested whether non-flickering gratings that were matched in effective contrast to gratings with different flicker frequencies would yield IOS rivalry percepts similar to those observed with flickering gratings that had the same effective contrast. In Supplementary Experiment 2 (SE2), we tested whether equating effective contrast for gratings with different flicker frequencies would eliminate the effect of flicker frequency on the IOS rivalry index. Two subjects participated in these experiments; both had also participated in Experiment 1 (Subject 1 was an author). Both experiments consisted of a contrast matching session and an IOS rivalry session.

Methods

Contrast matching. Two pairs of gratings with the same properties as those used in Experiment 1 were arranged vertically on a screen, one pair on top of the other, and viewed through a mirror stereoscope. The display setup was identical to that described in the Methods section in the main text. The gratings had a spatial frequency of 7 cpd and were oriented with +/- 45˚ tilt from vertical. Because the two gratings comprising each pair were identical, they were binocularly fused when viewed through the stereoscope, yielding a percept of two tilted gratings, one on top of the other.

The top grating pair was the "standard" and always had a physical contrast of 25%, corresponding to the contrast of the gratings in Experiment 1. The bottom grating pair was the "adjusted" stimulus – that is, subjects adjusted the physical contrast of this stimulus to match the perceived contrast of the fixed standard. In SE1 contrast matching runs, the standard flickered and the adjusted stimulus did not flicker. In SE2 runs, the adjusted stimulus flickered, while the standard did not flicker. Flicker frequencies of 0 (no flicker), 6, 9 15, 22.5, or 30 Hz were tested, and flicker was on/off with a 50% duty cycle. Each run contained four trials: in two of these, the adjusted stimulus initially had 100% contrast, while in the other two, the adjusted stimulus initially had 4% contrast. The "matched contrast value" for each run was taken to be the mean of the values from the four trials. Thus, SE1 contrast matching produced estimates of the effective contrast of a 25% physical contrast grating flickering at different frequencies, while SE2 contrast matching produced estimates of the physical contrast of a grating flickering at different frequencies required to have an effective contrast equal to a non-flickering 25% contrast grating.

IOS rivalry. IOS rivalry stimuli were presented for periods of 60 s while subjects held down keys to report fast-switch, slow-switch (tilted left), or slow-switch (tilted right) percepts. Stimuli and procedures were identical to those used in Experiment 1, except for the following: 1) All stimuli had a spatial frequency of 7 cpd. 2) In SE1, gratings did not flicker but were presented at six different contrasts in different trials. Each flicker frequency was presented at a different contrast that was derived for each subject from the contrast matching portion of SE1. In SE2, IOS rivalry gratings flickered on and off with a 50% duty cycle at frequencies of 0, 6, 9, 15, 22.5, and 30 Hz in different trials. Gratings with each of these flicker frequencies were set to the corresponding matched contrast values measured in the contrast matching portion of SE2. Three trials in each condition were presented in SE1 and six trials in each condition were presented in SE2, with three trials per condition in each of two blocks. All conditions were randomly intermixed within a block.

Results

Contrast matching. Both subjects showed the expected pattern of results in both SE1 and SE2 contrast matching sessions: a decrease in effective contrast as flicker frequency increased. In SE1, in which the standard was flickering, matched contrast values for the adjusted stimulus decreased with increasing flicker frequency (Figure S4A, top), while in SE2, in which the adjusted stimulus was flickering, matched contrast values for that stimulus increased with increasing flicker frequency (Figure S4A, bottom).

IOS rivalry. In the IOS rivalry portion of SE1, both subjects showed increases in SIA rivalry as the contrast of the gratings was reduced, even though none of the gratings were flickering (Figure S4B, middle). This increase was similar to the effect of flicker frequency for high spatial frequency gratings in Experiment 1 (Figure S4B, top). In SE2, when effective contrast was equated for stimuli with different flicker frequencies, the flicker frequency effect seen in Experiment 1 was not apparent for either subject (Figure S4B, bottom). Together, these experiments suggest that the increase in SIA rivalry for high spatial frequency IOS rivalry gratings in Experiment 1 may be accounted for by changes in effective contrast and not by changes in flicker frequency per se.

Supplementary Figures

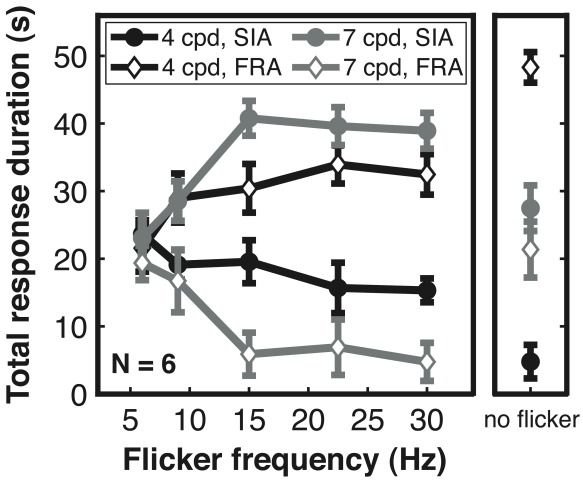

Figure S1. Mean total duration of SIA and FRA rivalry responses from Experiment 1. Each trial duration was 60 s. For high spatial frequency gratings (7 cpd, gray), SIA rivalry (filled circles) increased while FRA rivalry (empty diamonds) decreased with increasing flicker frequency. The opposite pattern held for low spatial frequency gratings (4 cpd, black). Error bars show *SEM* across subjects.

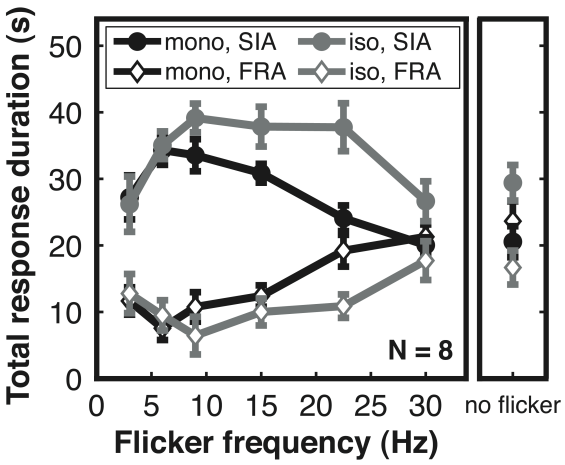

Figure S2. Mean total duration of SIA and FRA rivalry responses from Experiment 2. Each trial duration was 60 s. Isoluminant stimuli (gray) generally resulted in increased SIA rivalry (filled circles) and reduced FRA rivalry (empty diamonds) compared to monochrome stimuli (black). Error bars show *SEM* across subjects.

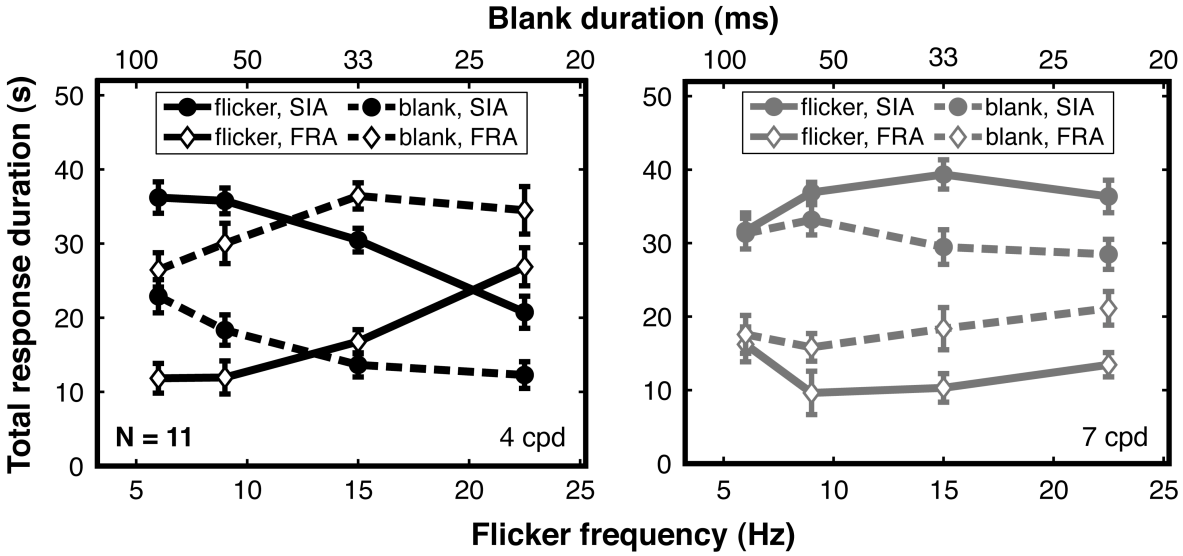

Figure S3. Mean total duration of SIA and FRA rivalry responses from Experiment 3. Each trial duration was 60 s. Overall, less SIA rivalry (filled circles) and more FRA rivalry (empty diamonds) was observed for blank-only trials (dashed lines) compared to flicker trials (solid lines). However, the effects of flicker frequency were similar for blank-only and flicker trials. This was the case for both the low spatial frequency (4 cpd, left, black lines) and high spatial frequency (7 cpd, right, gray lines) conditions. Error bars show *SEM* across subjects.

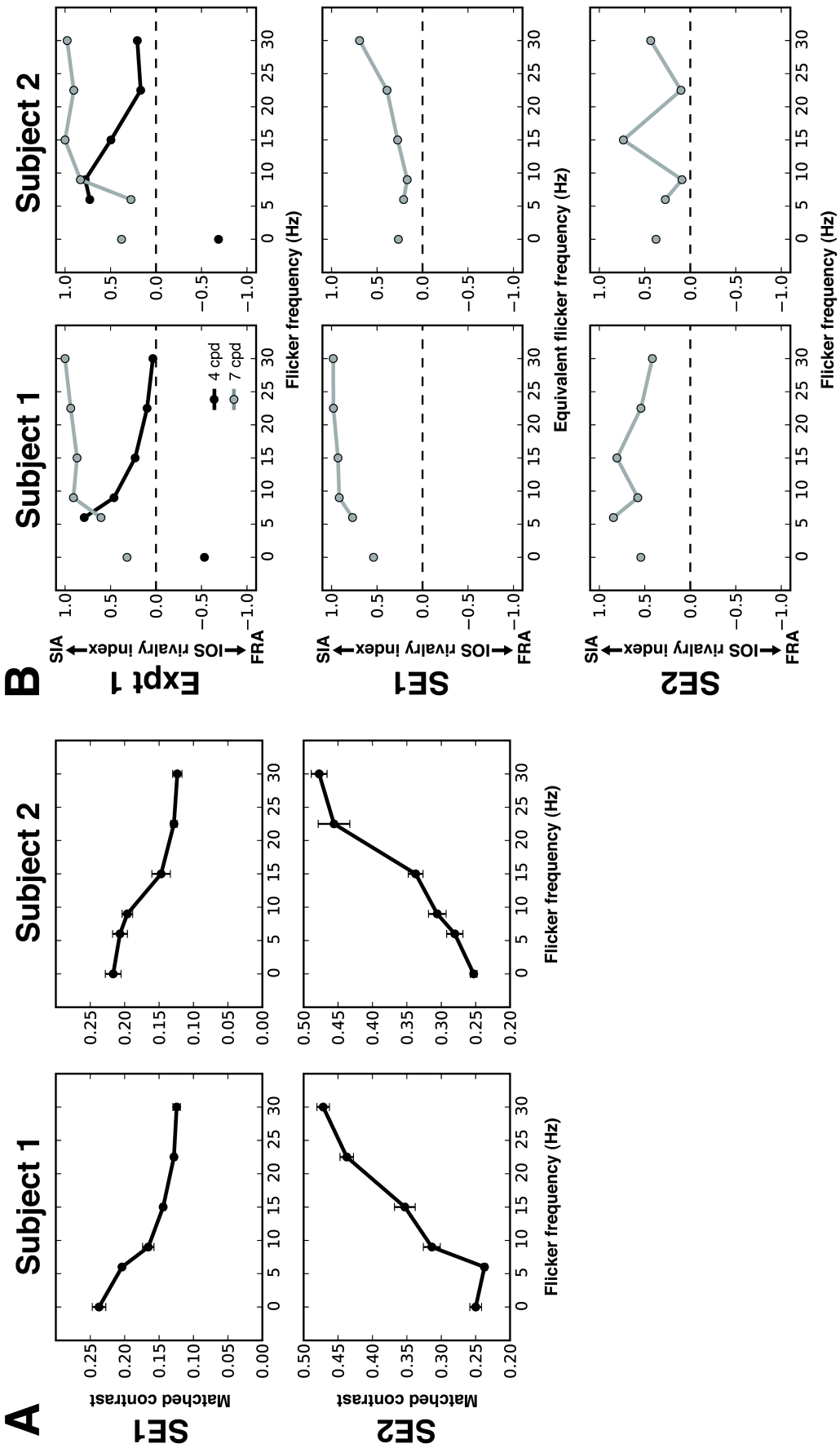
A
Subject 1
Subject 2
SE1
SE2
Matched contrast
Flicker frequency (Hz)
B
Expt 1
SE1
SE2
SIA
FRA
IOS rivalry index
4 cpd
7 cpd
Flicker frequency (Hz)
Equivalent flicker frequency (Hz)

Figure S4. *(previous page)* IOS rivalry effective contrast experiments. (A) Contrast matching results. In SE1 (top), two subjects adjusted the contrast of a non-flickering grating to perceptually match it to a 25% contrast standard grating that flickered on and off at one of six flicker frequencies. In SE2 (bottom), the same subjects adjusted the contrast of a flickering grating (same flicker frequencies) to match the contrast of a non-flickering standard with 25% contrast. Error bars are *SEM* of the four contrast matching trials in each condition. In all cases, increasing flicker frequency reduced effective contrast. (B) Results of IOS rivalry experiments with matched contrast. *Top:* Individual subject data from Experiment 1 for Subjects 1 and 2. These subjects are representative of the group that participated in Experiment 1. *Middle:* In SE1, subjects viewed non-flickering IOS rivalry stimuli with contrast that was matched to a 25% contrast stimulus flickering at different frequencies ("Equivalent flicker frequency"). Both subjects reported more SIA rivalry for lower contrast (higher equivalent flicker frequency) gratings. *Bottom:* In SE2, subjects viewed flickering IOS rivalry stimuli for which effective contrast was equated across flicker frequencies. There was no apparent change in the IOS rivalry index as a function of flicker frequency.

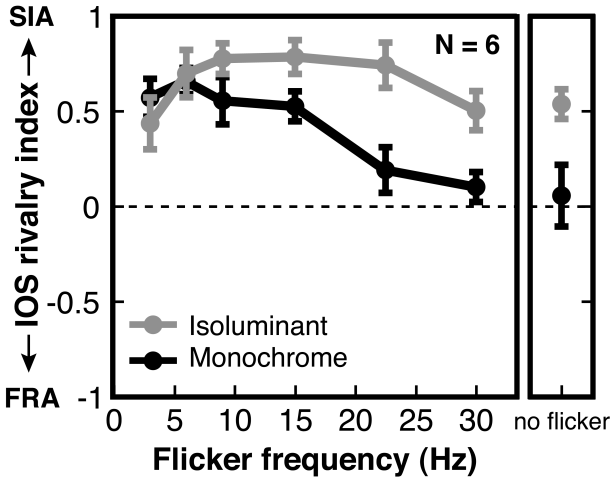

Figure S5. Results of Experiment 2: Significant interaction between flicker frequency and isoluminance condition for the subset of subjects that showed a main effect of isoluminance. Data are plotted for the six subjects who individually reported significantly more SIA or less FRA rivalry for the isoluminant compared to the monochrome stimuli at one or more flicker frequencies. As flicker frequency increased, SIA rivalry decreased for monochrome stimuli, but there was no significant effect of flicker frequency on the IOS rivalry index for isoluminant stimuli.