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Supplemental Information

Monovision and the Misperception of Motion

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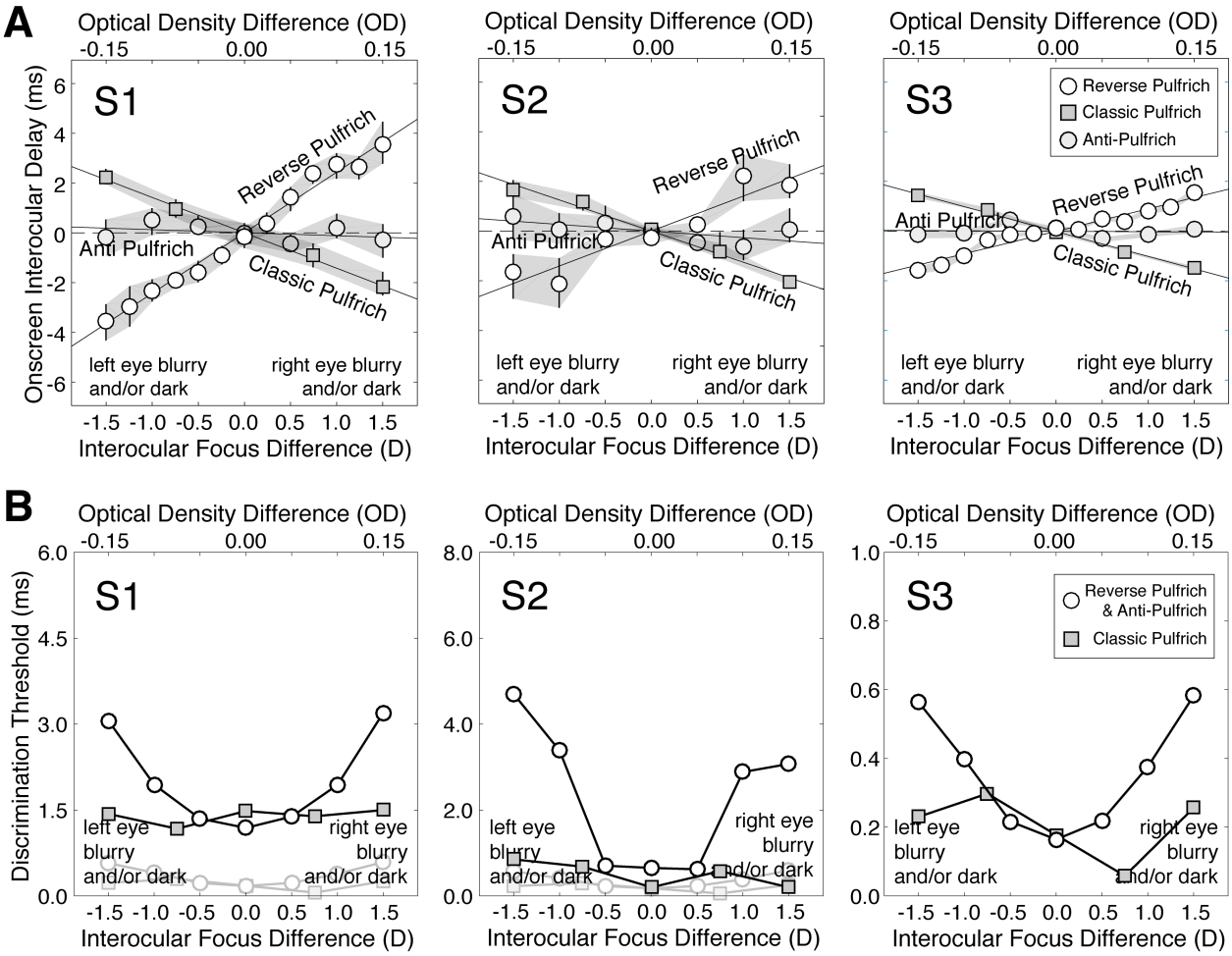

Figure S1. Reverse, classic, and anti-Pulfrich conditions: Interocular delays and discrimination thresholds. Related to Figure 2. **A** Reverse, classic, and anti-Pulfrich effects. Interocular differences in focus error cause the reverse Pulfrich effect; the blurrier image is processed more quickly. Interocular differences in retinal illuminance cause the classic Pulfrich effect; the darker image is processed more slowly. In the anti-Pulfrich condition, the blurry image is darkened to eliminate interocular delay (see Methods). **B** Discrimination thresholds. Thresholds for each observer ($d' = 1.0$) in the reverse Pulfrich conditions (interocular focus differences) and the anti-Pulfrich conditions (interocular focus differences plus retinal illuminance differences) were similar and were thus averaged together (white circles). In each human observer, discrimination thresholds increased systematically with differences in interocular blur, consistent with the classic literature on how blur differences deteriorate stereoacuity[S1]. These threshold functions thus provide evidence that the desired optical conditions were achieved. To reduce clutter, bootstrapped 95% confidence intervals are not plotted. In all cases but one, the confidence interval is smaller than the data point. Discrimination threshold in the classic Pulfrich conditions (i.e. interocular retinal illuminance differences only) are also shown (gray squares). Differences in retinal illuminance up to $\pm$0.15OD had no systematic effect on thresholds. (Note: the y-axis has a different scale for each observer to emphasize the similarities in the threshold patterns. To give a sense of scale, the classic Pulfrich data from observer S3, the most sensitive observer, is re-plotted in the subplots for observers S1 and S2; faint circles and squares.)

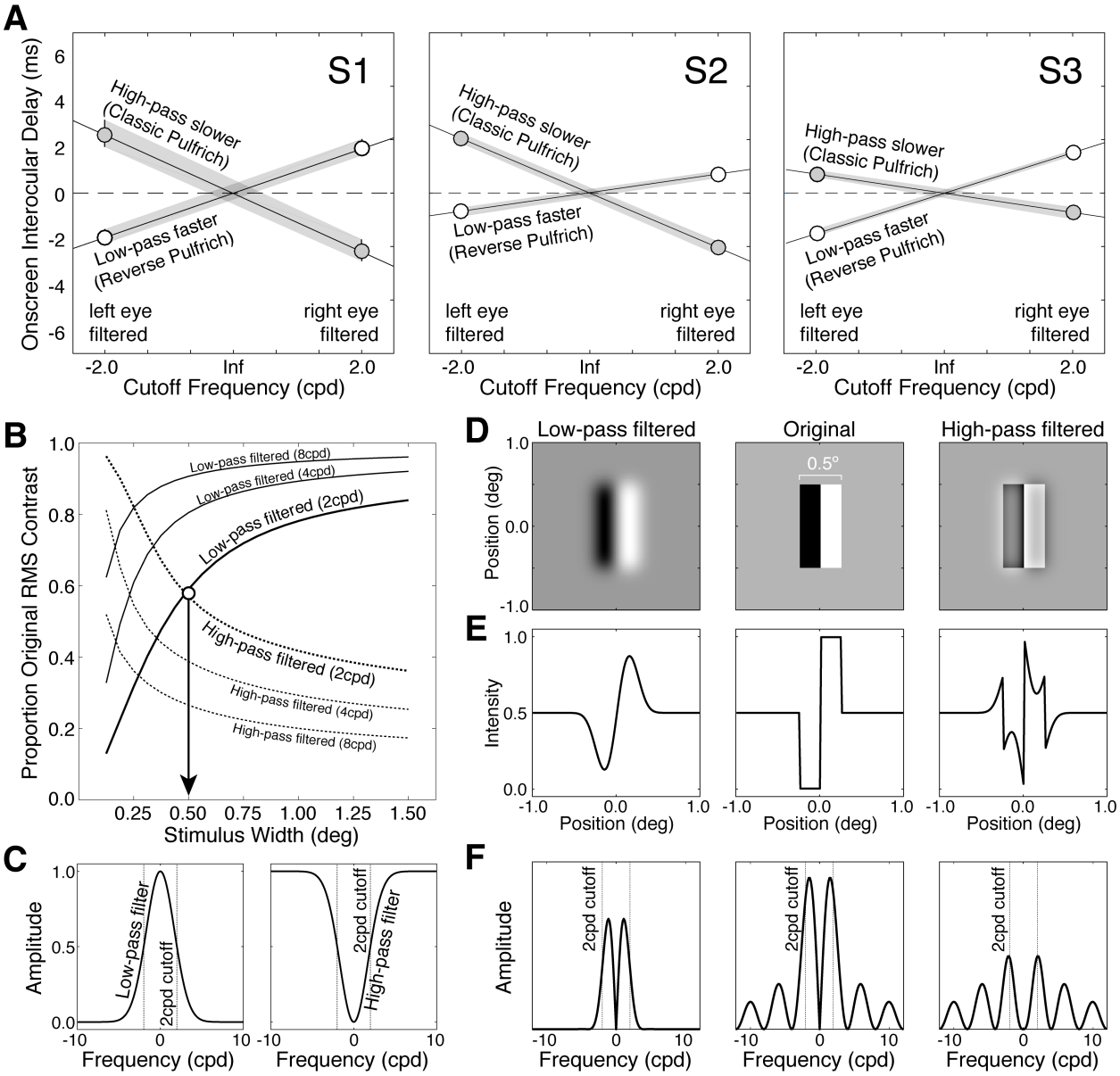

Figure S2. Spatial frequency filtered stimuli: Interocular delays and stimulus construction. Related to Figure 3. A Interocular delays with high- and low-pass filtered stimuli for each human observer. The onscreen image for one eye was filtered and the image for the other eye was left unperturbed. High-pass filtered images were processed slower than the unperturbed images, similar to how reduced retinal illuminances induces the classic Pulfrich effect. Low-pass filtered images were processed faster than unperturbed images, similar to how optical blur induces the reverse Pulfrich effect. **B** Proportion of original stimulus contrast after low-pass filtering vs. high-pass filtering (solid vs. dashed curves, respectively) as a function of total black-white (or white-black) bar width. The white circle and arrow indicate the stimulus width (0.5º) that equates the root-mean-squared (RMS) contrast of the stimulus after low- and high-pass filtering. Because low-pass and high-pass filtered images had identical luminance and contrast, the differential effects in A cannot be attributed to luminance or contrast. **C** Low-pass and high-pass filters with a 2cpd cutoff frequency. **D** Low-pass filtered stimulus, original stimulus, and high-pass filtered stimulus with matched luminance and contrast. **E** Horizontal intensity profiles of the stimuli in D. **F** Amplitude spectra of the horizontal intensity profiles in E. Note how, for each stimulus type, the peak of the lowest frequency lobe shifts relative to the cutoff frequency of the filters.

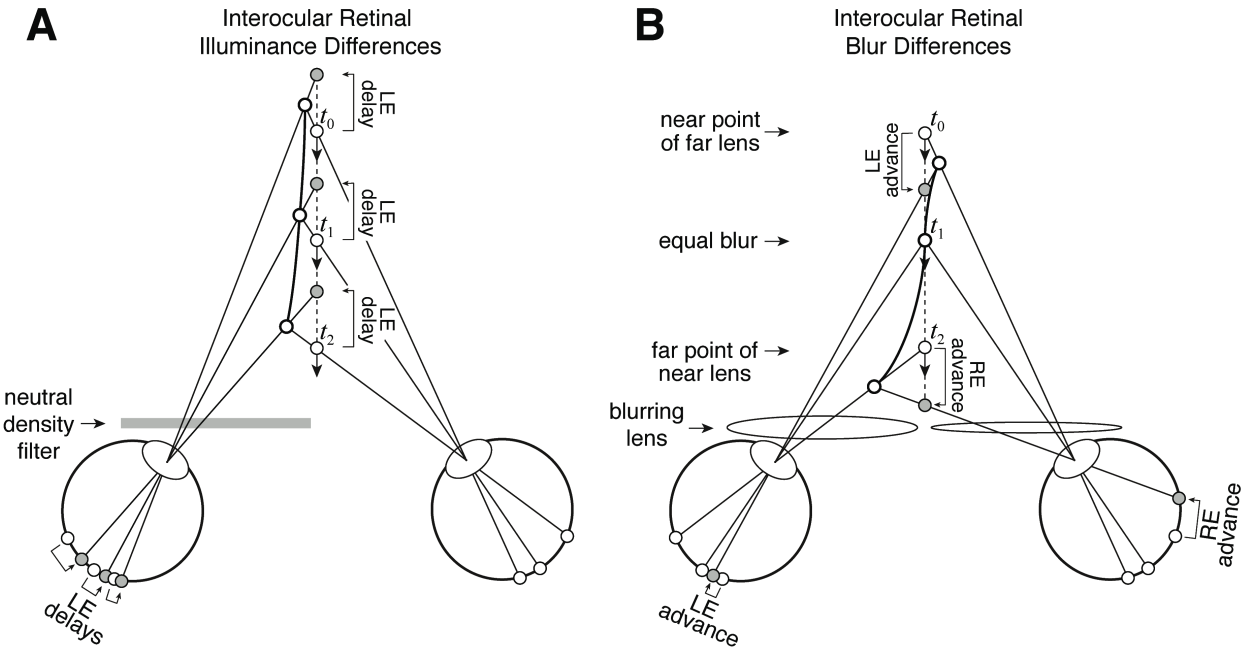

Figure S3. Misperception of motion towards the observer. Related to Figure 4. A Predicted perceived motion trajectory (bold curve), given target motion directly towards the observer (dashed line), with an interocular retinal illuminance difference. Here, a neutral density filter in front of the left eye causes its image to be processed more slowly, regardless of target distance. Stereo-geometry predicts that the target will appear to travel along a curved trajectory that bends towards the darkened eye (bold curve) rather than in a straight line[S2]. **B** Predicted perceived motion trajectory, given target motion directly towards the observer, with an interocular blur difference. The left eye is corrected for near and the right eye is corrected for far. The eye that is processed more quickly now changes systematically as a function of target distance. When the target is far, the left eye image will be blurry and be processed more quickly. When the target arrives at an intermediate distance where both eyes will form equally blurry images, the processing will be the same in both eyes and the target will appear to move directly towards the observer. When the target is near, the right eye image will be blurry and processed more quickly. The resulting illusory motion will trace an S-curve trajectory as the target traverses the distances between the near point of the far lens and the far point of the near lens. Even more striking effects occur for targets moving towards and to the side of the observer, along oblique motion trajectories. A full description of these effects, however, is beyond the scope of the current paper. (Note: the diagrams are not to scale.)

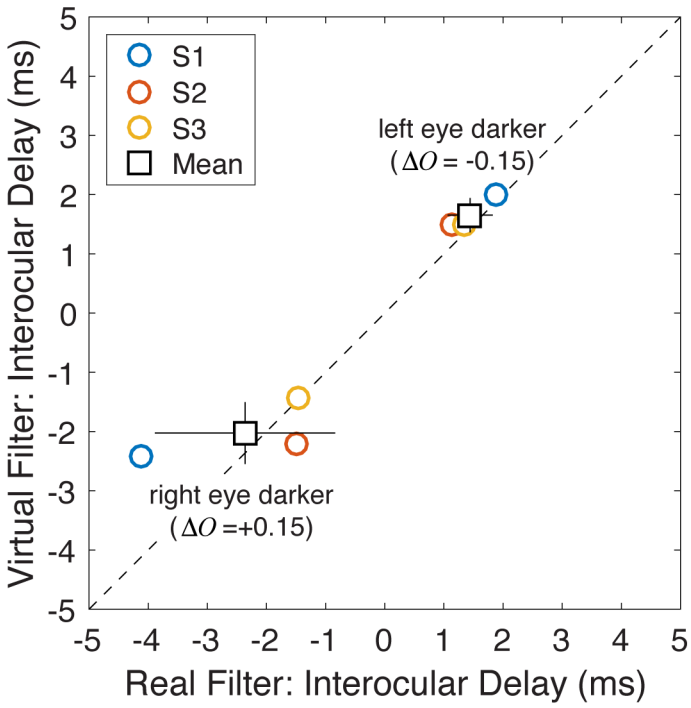

Figure S4. Real and virtual neutral density filters: Interocular delays. Related to STAR Methods-Neutral Density Filters. Real and virtual neutral density filters with the same optical densities (i.e. 0.15OD; 71% transmittance) caused similar delays for all human observers (colored circles) and the mean human observer (black square). Interocular differences in optical density, ΔO, are negative when the left eye retinal illuminance is reduced and positive when the right eye retinal illuminance is reduced. Error bars indicate standard deviations. The results suggest that the software implementation of the virtual neutral density filters was accurate.

Supplemental References

S1. Westheimer G, McKee SP. Stereoscopic acuity with defocused and spatially filtered retinal images. J Opt Soc Am A 1980;70:772–8.

S2. Spiegler JB. Apparent path of a pulfrich target as a function of the slope of its plane of notion. Am J Optom Physiol Opt 1986;63:209–16.