

Supplementary Methods

1. Ethics statement

Observers wore their normal optical correction if required. A written informed consent was obtained from each of them before the start of the test. This study complied with the Declaration of Helsinki and was approved by the Institutional Review Boards of McGill University. The methods were carried out in accordance with the approved guidelines.

2. Apparatus

All stimuli were generated using a PC running Matlab (MathWorks, Natick, MA) and a ViSaGe video-graphics card (Cambridge Research Systems, Kent, UK) to achieve a 14-bit of contrast resolution. A Sony Trinitron (GDM 500DIS) monitor (Sony Corporation, Tokyo, Japan), with a frame rate of 120 Hz and a spatial resolution of 1024×768 was used to present stimuli. The screen was gamma corrected using the VSG calibration routine with the OptiCal photometer (Cambridge Research Systems). The spectral emission functions of the red, green, and blue phosphors of the monitor were measured using a Spectra Scan PR-645 spectrophotometer (Photo Research Inc., Chatsworth, CA). The standard CIE-1931 chromaticity coordinates of the red, green, and blue phosphors were $(x = 0.610, y = 0.333)$, $(x = 0.302, y = 0.591)$, and $(x = 0.153, y = 0.084)$, respectively. The background was achromatic with a mean luminance of 51 cd/m^2 at the screen centre. All experiments were conducted in a dimly lit room. During the measurements, observers viewed the stimuli via a large custom-built 8-mirror stereoscope with a viewing distance of 178 cm,

although for Expt. 2 only a small stereoscope was used with a viewing distance of 58 cm. In Expts. 3 - 6, movies were played with an Apple iPod 3 and displayed with a Vuzix Wrap 920 Video Eyewear (Vuzix Corporation, Rochester, New York, USA). The display size was of 31° diagonal and the resolution of each screen was 640 × 480 pixels.

3. Stimuli and colour contrast

The edges of the stimulus were blurred by a truncated half-Gaussian envelope ($\sigma=0.26^\circ$), with a central plateau region (1.58 cycles). Their contrasts were supra-threshold and were set based on individual subjects' contrast detection threshold. In the monocular detection threshold measurement, the stimulus presented to the tested eye in each trial was an oriented Gabor stimulus (either 45° or 135° ; spatial frequency = 1.0 cycle/deg, σ of Gaussian envelope = 1.9°). Gabors were presented in a contrast modulated temporal profile with a ramped onset/offset (25 ms each onset and offset) and a plateau (66.4 ms). Contrast is set randomly from six predetermined contrast levels. The unmeasured eye viewed a mean luminance background.

Similar to a previous study[1], stimuli were represented in a three-dimensional cone-contrast space[2, 3] in which each axis is defined by the incremental stimulus intensity for each cone type to a given stimulus normalized by the respective intensity of the fixed adapting white background. Cone excitations for the L-, M-, and S-cones were calculated using the cone fundamentals of Smith and Pokorny (1975)[4]. A linear transform was calculated to specify the required red, green or blue phosphor contrasts of the monitor for given cone

contrasts. Postreceptoral luminance and red-green cone-opponent mechanisms were isolated by using achromatic stimuli (equal L, M and S cone contrasts) and isoluminant red-green stimuli with L and M cone contrasts proportionally weighted for the isoluminant point ($L: -\alpha M$, where α is a numerical constant representing the L:M cone balance at isoluminance determined for each subject individually). Stimulus contrast was defined as the vector length in cone contrast units.

In preliminary trials, observers' isoluminant point (i.e., α) of each eye was measured using a minimum motion task[5] in which the perceived minimum motion of a Gabor stimulus (spatial frequency = 1.0 cycle/deg matching that used for the binocular combination task, temporal frequency = 2 Hz) was estimated using a method of adjustment. Since the isoluminant points were not significantly different between eyes for any of our observers, we averaged the data for the two eyes (10 repetitions/eye) of each observer.

4. Movies processing in different experiments

Movies were encoded with OpenShot Video Editor (OpenShot Studios, LLC) in 640 pixels × 480 pixels resolution, 4:3 ratio, 30 frames per second, mp4 format with mpeg4 video codec at 5.00 Mb/s. The images for the two eyes were encoded in a side-by-side format, so the image resolution was 320 × 480 in each eye and the image was horizontally stretched to fit the screen. The grey-scale filtering operation was processed using the 'Greyscale' filter from the MLT framework (Melttech, LLC) and the mean luminance condition was achieved by calculating the average luminance over the full course of the movie. All isoluminant chromatic stimuli were Gaussian low-pass filtered with

a cut-off of 5 cycles/deg to ensure there was minimal artefactual achromatic contamination due to optical aberrations[6]. The colour filtering operations were performed with custom programs in Matlab. Different forms of monocular deprivation were provided by dichoptic movie formatting. Expts. 3 and 4 investigated the effects of selective achromatic deprivation. A selective monocular deprivation of achromatic contrast was obtained by formatting a movie with everything except the achromatic content of one eye's image removed (i.e., a mean luminance in one eye and only achromatic content in the other eye; Expt. 3). In this case, there was no chromatic information. In Expt. 4, the chromatic information was retained in both eyes (i.e., isoluminant), chromatic content in one eye and both chromatic and achromatic content in the other eye). Expts. 5 and 6 investigated the effects of selective chromatic deprivation. In Expt. 5, a selective monocular deprivation of chromatic contrast was obtained by formatting a movie with a mean luminance in one eye and isoluminant chromatic content in the other eye. In Expt. 6, the achromatic information was retained in both eyes, with achromatic content in one eye and both chromatic and achromatic content in the other eye.

5. Detailed procedures for measuring the monocular contrast threshold

In Exp. 2, we measured one psychometric function before the patching stage and three psychometric functions that were started at 0, 30, and 60 minutes after removal of the patch. In the measure, observers' accuracies in identifying grating orientation at six contrast levels, with each level containing

80 trials, were measured. The contrast levels were chosen based on preliminary measurements of an individuals' contrast threshold. In each trial, an oriented Gabor pattern (either 45° or 135°) at a contrast randomly selected from the prearranged six contrast levels, was presented for 116 ms; while the unmeasured eye viewed a mean luminance background. Observers were asked to respond to the orientation of the grating by a key press. The next trial came automatically 400 ms after the key press. Audio feedback was provided.

We fitted these psychometric functions using Quick functions with parametric maximum likelihood estimation[7]. The two parameters of the Quick function, alpha and beta, represent the threshold corresponding to 81.6% accuracy and the slope of the psychometric function at that point, respectively. The mean and variances of these two parameters were determined by a 500 bootstrapping simulation[8]. A two-independent-samples Z-test was conducted based on the bootstrap results to statistically estimate difference between red-green isoluminant chromatic and achromatic threshold measures.

6. Detailed procedures for measuring the sensory eye dominance

The procedure for measuring perceived phase was similar to that reported in previous studies[9], in which observers were asked to adjust the vertical position of a 1-pixel reference line to indicate the perceived phase of the binocularly perceived horizontal grating, defined by the location of the centre of the dark (or green) bar of the grating. For each subject, the interocular contrast ratio was set so that there was equal contribution from each eye to the binocularly fused image (binocularly perceived contrast close to zero) in

the pre-deprivation measure. This is referred to as the balance point[9-12]. To make a valid comparison between the results for isoluminant chromatic and luminance gratings, the base contrast was set in the unpatched eye to be the same multiples of an individual's contrast detection threshold for isoluminant chromatic and achromatic gratings. Due to the limitation of the colour gamut of the monitor, this ratio was set close to the maximal chromatic contrast of the monitor.

7. Data analyses.

Data were analysed using repeated measures within-subject analysis of variance (ANOVA). Mauchly's test was applied to verify the assumption of sphericity. Two-tailed one-sample t-test was used to compare one data point with 0; two tailed paired-samples t-test was used to compare the area difference between conditions for each experiment.

References:

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