Observer sensitivity to oriented stimuli altered after adaptation

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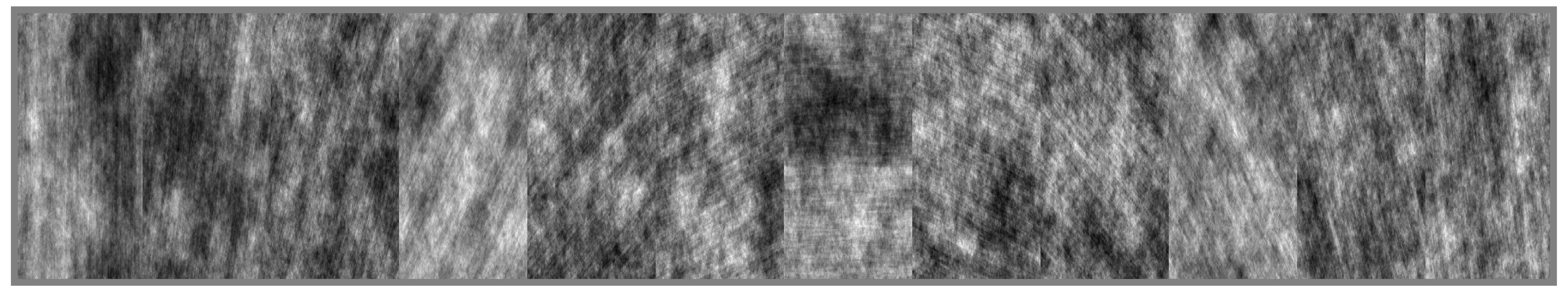
Introduction

Observer sensitivity to visual features is believed to be dependent on the distributions of said features in natural environments[5]. Sensitivity to orientation, for example, is higher for oblique orientations and lower for cardinally oriented content in natural environments, the inverse sensitivity to orientation measured with artificial stimuli[1,2,3]. There is an overrepresentation of cardinally oriented content in natural environments and it is believed that the reduced sensitivity to cardinals aids in generating an isotropic percept (even representation of all oriented content).



Here we explore how sensitivity to orientation may be associated with the distribution of orientation content in natural worlds by immersing observers in isotropic environments and measuring sensitivity to orientation before, during, and following adaptation.

Methods

Participants

A total of nine observers (N_{female} = 3) participated in this study. All had normal or corrected-to-normal visual acuity.

Apparatus

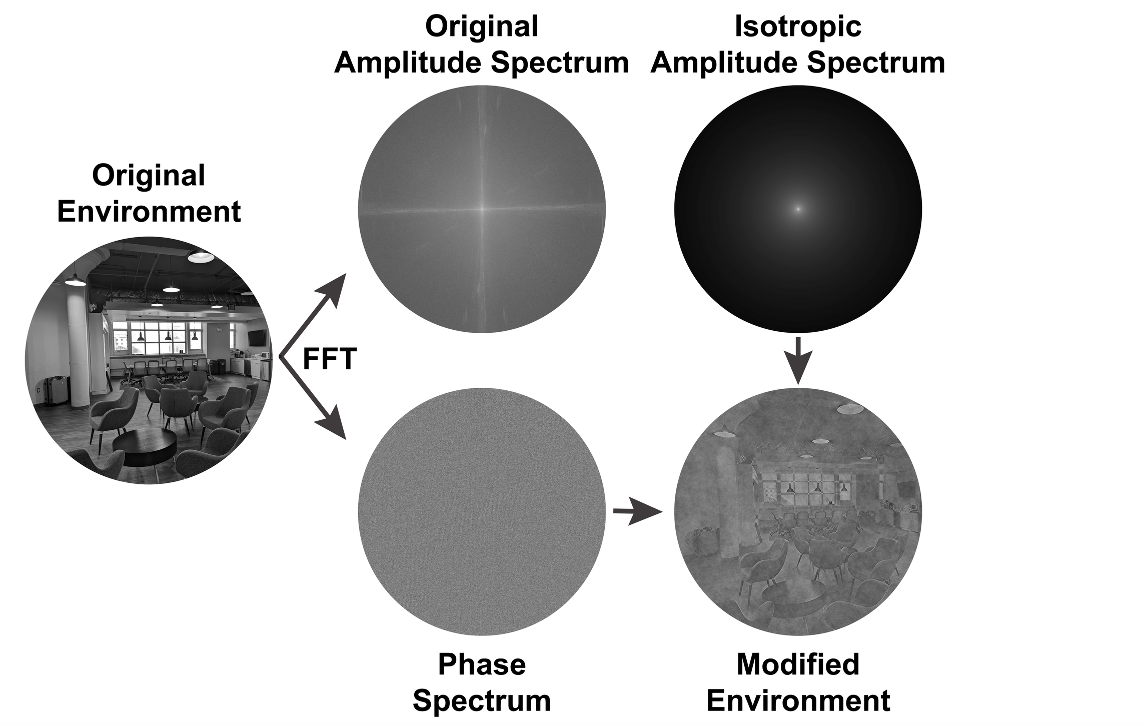
The experiment was conducted in an HTC Vive virtual reality headset, powered by a Dell Precision 7920 and a NVDIA GeForce GTX 1060 graphics card. The HTC Vive has a monocular resolution of 1080x1200 at a refresh rate of 90Hz.

The environment of observers was captured by a Chameleon3 USB camera, which capture images at a rate of XX and resolution of XX. Images collected by the camera were imported into MATLAB via the image acquisition toolbox for processing prior to being displayed to observers.

Environment Modification

At baseline, only the RMS contrast of images collected by the environment was adjusted to a value of 0.2.

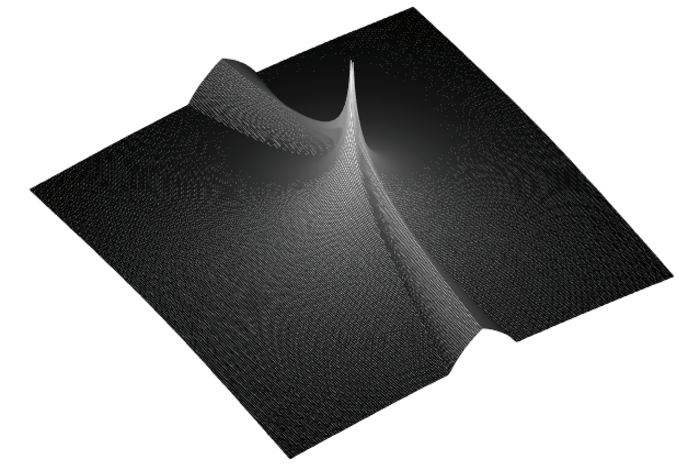
During adaptation, images collected by the camera were Fast Fourier transformed and their original amplitude spectrum was switched for an isotropic amplitude spectrum with an amplitude spectrum slope of 1/f. The original phase spectrum and new amplitude spectrum converted back to the spatial domain and contrast normalized (RMS = 0.2) prior to being shown to observers.



Stimulus Creation

Test stimuli were isotropic 1/f noise patches with an amplitude spectrum slope of 1.0 and random phase.

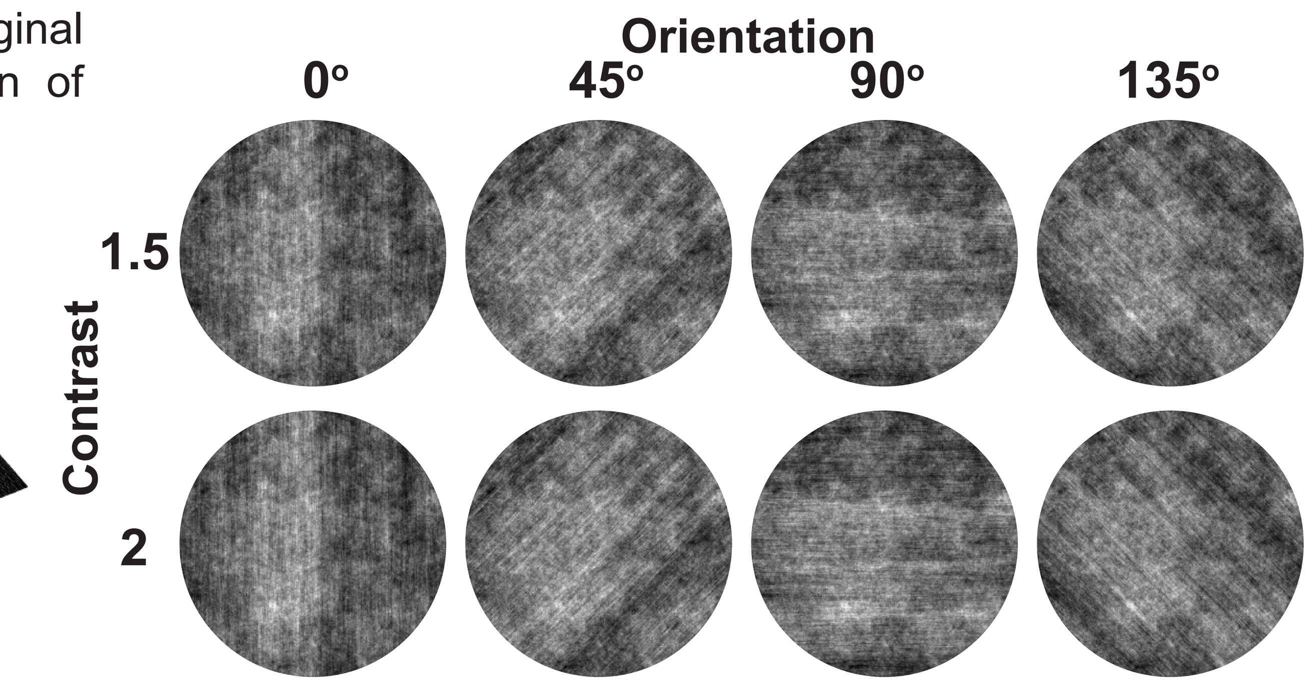
The 1/f noise patches were given an orientation component by multiplying their isotropic amplitude spectra with a bowtie with a 20° orientation bandwidth, effectively increasing the original amplitude at the orientation of the filter (±20°).



Procedures

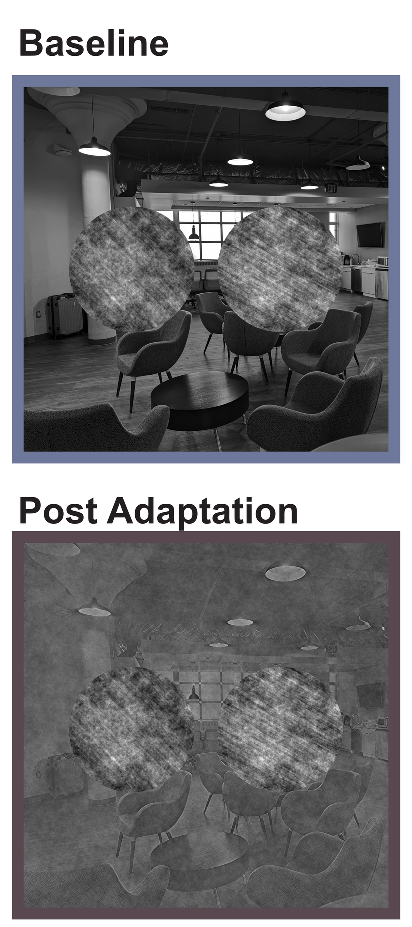
Sensitivity to orientation and contrast was measured with an matching task, whereby observers were asked to adjust the orientation and contrast of a test stimulus to match that of a reference stimulus.

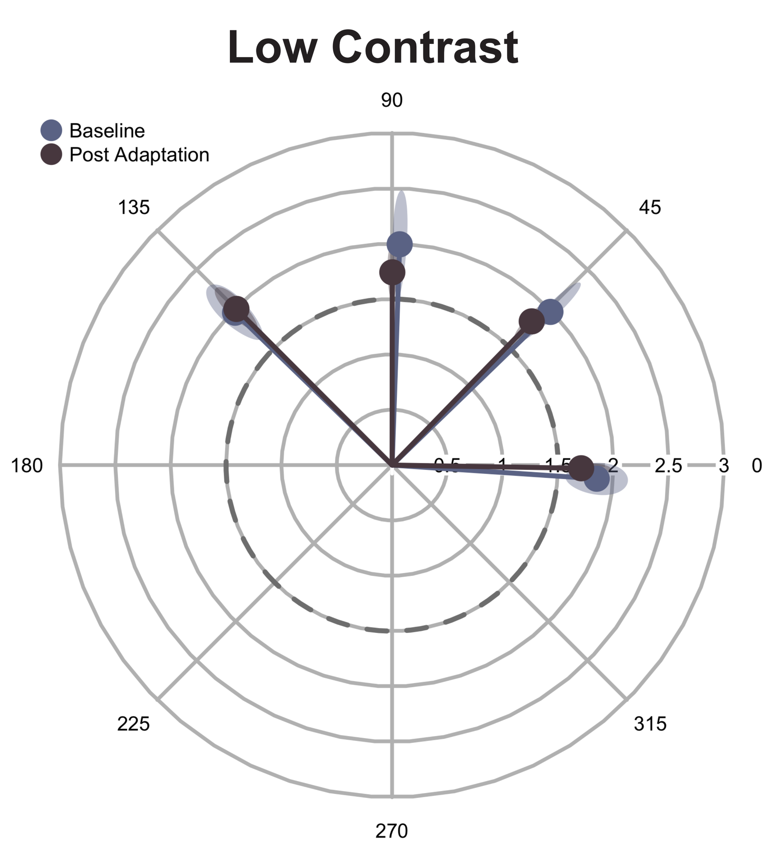
Observers completed the matching task at four reference orientations (0°,45°,90°,135°) and two contrast increments (1.5 and 2 times the original amplitude value) before, during and following a one hour adaptation period in the modified environment.

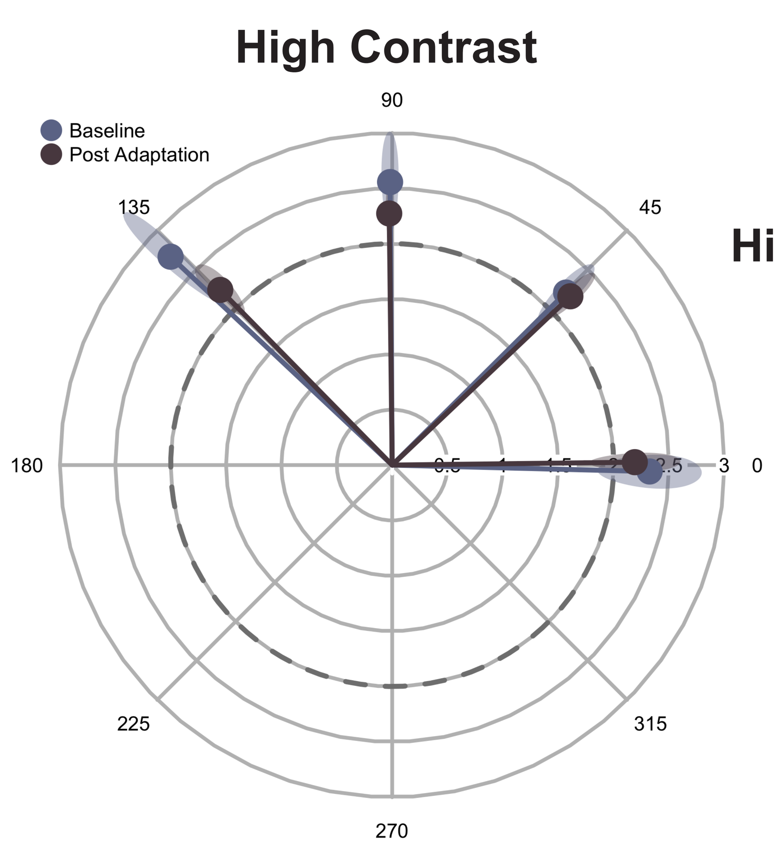


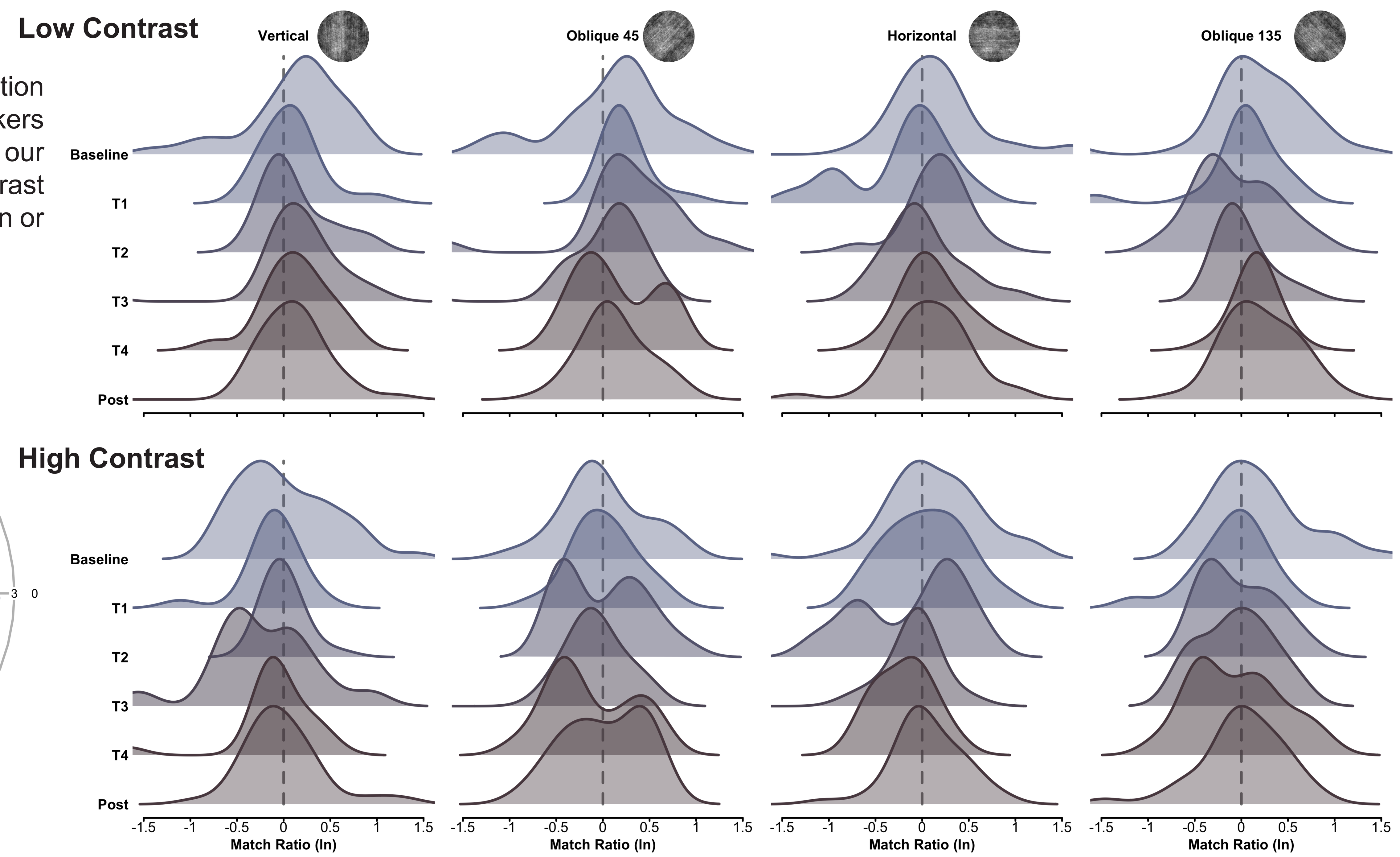
Results

We visualize contrast and orientation match values, both before and following the 60 minute adaptation period, on radial charts. The reference contrast value is indicated by the dashed line, while markers represent the average contrast and orientation match with standard error ellipses. We analyzed our contrast matching effects using a Repeated Measures ANOVA with reference orientation and contrast as factors. None of the possible interaction effects nor main effects of contrast, reference orientation or time were statistically significant.

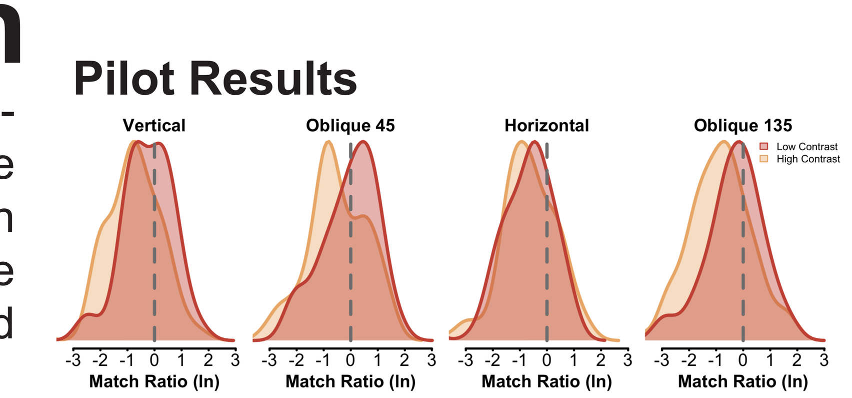








Conclusion



Observer sensitivity to features is associated with the distribution of said features in natural environments[5]. While previous research has found this adaptation procedure to alter sensitivity to natural scene features, we found little evidence of this with our orientation and contrast masking paradigm.

Measuring sensitivity to orientation in HMDs is unlikely to generate data of equal quality to that of more traditional displays. However, pilot work conducted with a larger sample size (N = 12) did demonstrate a reliable horizontal effect in our sample. Increasing the sample size may aid in measurement quality and better determine the magnitude of our effects.

A larger sample size, combined with analyses better suited to determine the temporal effects of our paradigm will aid in adequately determining the time course of adataption to the distribution of features in environments.

References

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