Central and peripheral difference in perceptual bias in ambiguous perception using dichoptic stimuli — implications for the analysis-by-synthesis process in visual recognition

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Abstract: Eye movements bring attended visual inputs to the center of vision for further processing. Thus, central and peripheral vision should have different functional roles. Here, we use observations of visual perception under dichoptic stimuli to infer that there is a difference in the top-down feedback from higher brain centers to primary visual cortex. Visual stimuli to the two eyes were designed such that the sum and difference of the binocular input from the two eyes have the form of two different gratings. These gratings differed in their motion direction, tilt direction (Fig. 1A), or color, and duly evoked ambiguous percepts for the corresponding feature. Observers were more likely to perceive the feature in the binocular summation rather than the difference channel (Fig. 1B). However, this perceptual bias towards the binocular summation signal was weaker or absent in peripheral vision, even when central and peripheral vision showed no difference in contrast sensitivity to the binocular summation signal relative to that to the binocular difference signal. We propose that this bias can arise from top-down feedback as part of an analysis-by-synthesis computation. The feedback is of the input predicted using prior information by the upper level perceptual hypothesis about the visual scene; the hypothesis is verified by comparing the feedback with the actual visual input. We illustrate this process using a conceptual circuit model. In this framework, a bias towards binocular summation can arise from the prior knowledge that inputs are usually correlated between the two eyes. Accordingly, a weaker bias in the periphery implies that the top-down feedback is weaker there. Testable experimental predictions are presented and discussed.

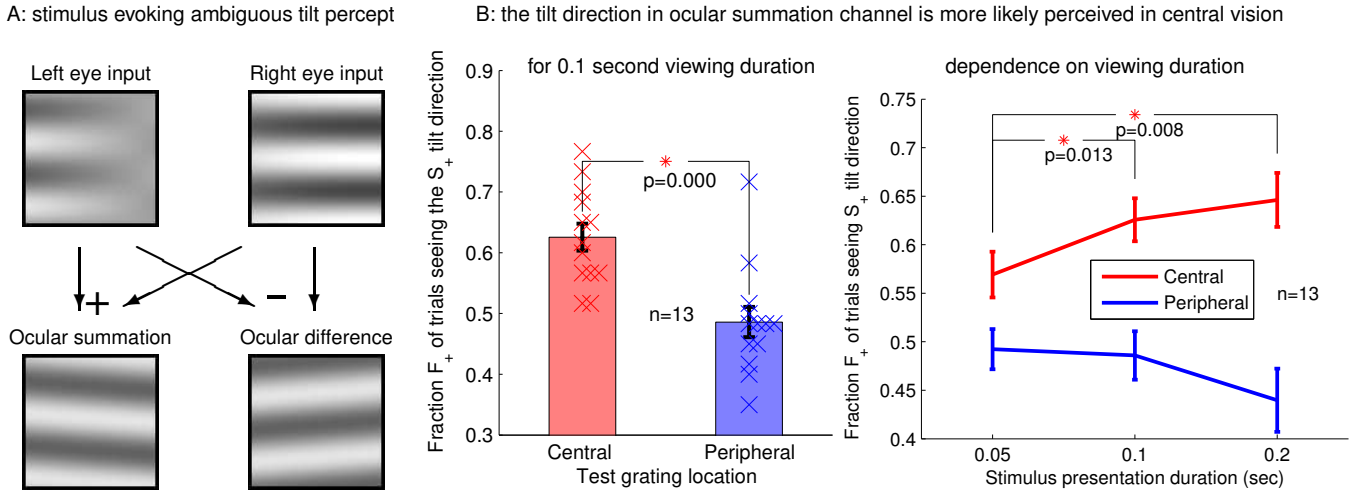

Figure 1: The dichoptic stimulus in (A) is made by two underlying gratings, which are tilted in opposite directions from horizontal and are made from adding and subtracting, respectively, visual inputs to the two eyes. When observers were asked to report by forced choice whether they see the grating tilted clockwise or anticlockwise from horziontal, they were more likely to report the percept arising from the signal in the ocular summation channel, especially when the stimulus was viewed in central rather than peripheral vision, (see the left plot in B, individual 'x's are from individual observers, the data bars are the averages across observers). In central but not in peripheral vision, this bias towards the ocular summation channel increases with viewing duration (the right plot in B). The peripheral location in (B) is 10^o in lower visual field. Stimuli in peripheral were spatially scaled to roughly compensate for visual acuity changes.

Keywords: Central vision, peripheral vision, dichoptic stimuli, visual decoding, top-down feedback, primary visual cortex (V1), analysis-by-synthesis.