

Classification images reveal observer templates underlying the direct tilt illusion

Ian van der Linde^{1,4}, Abtine Tavassoli^{1,2}, Alan C Bovik^{1,2}, Lawrence K Cormack^{1,3}

¹Center for Perceptual Systems ; ²Dept. of Electrical and Computer Engineering ; ³Dept. of Psychology, The University of Texas at Austin
⁴Dept. of Computing, Anglia Ruskin University, UK {i.v.d.linde@anglia.ac.uk}



Discussion

An underlying assumption of the methodology used, reinforced by the data collected in this and earlier experiments, is that observers will often fixate, en route to the target, a number of tiles that they believe to resemble that target. Additionally we assume that, when an incorrect selection is made, oftentimes the tile erroneously selected was mistaken for the target. In this experiment these assumptions are validated, with target-like structures within both the spatial (not shown) and spectral representations appearing in all categories of fixated tile.

For both observers, a repulsive tilt was observed relative to the orientation of the background inducer, where relatively low tilt was seen in the distracter-absent control condition. We find that the tilt illusion was effective in the periphery ($\overline{f_{FA}}$), exemplified by our non-foveal categories, and less so when the tile was subjected to foveal scrutiny (f_{FA} shows foveated tiles were falsely accepted, and f_{CR} foveated tiles that were correctly rejected, upon foveation, in favour of continuing the search).

Conclusions

Earlier studies measured a direct tilt illusion effect of 1-7deg rotation either foveally or at small eccentricities with 2AFC/yes-no psychophysics; our study reveals that this phenomenon is more prominent in a naturalistic visual search scenario (foveal groups 1-5 deg rotation, non-foveal groups 10-20 deg rotation). Two interpretations are:

- flood-fill inducer disrupts observer's perceived vertical (note: the stimulus grid appears to the observer as an illusory parallelogram).
- inducer attenuates the saliency of inducer-like orientations and amplifies the saliency of orientations rotated anticlockwise from vertical.

Our results show that peripherally viewed tiles are misperceived prior to foveal scrutiny; we do not ascribe this to decreased spatial acuity alone since, under such a scenario, one would expect no further orientation bias above that observed for foveal viewing, merely an increase in orientation uncertainty. Our finding greater tilt for extra-foveal tiles is compatible with the observations of Wenderoth & Johnstone (1988), that an increase in the direct tilt illusion can be gained by favouring stimulation of the transient, magnocellular system. Our study has important implications for understanding orientation perception in wide-FOV active vision.

Citations

A. Tavassoli, I. van der Linde, A.C. Bovik, L.K. Cormack (In Press) "An efficient technique for revealing visual search strategies with classification images", *Perception & Psychophysics*.
 D. M. Eagleman (2001) "Visual illusions and neurobiology", *Nature Reviews Neuroscience*, 2 (12): 920-926.
 P. Wenderoth & S. Johnstone (1988) "The different mechanisms of the direct and indirect tilt illusions", *Vision Research* 28(2): 301-312.

Introduction

Illusions are a powerful tool to probe the neural architecture of vision (Eagleman, 2001). The tilt illusion (a phenomenon of simultaneous orientation contrast) demonstrates how the sensation of orientation is misperceived in the presence of an inducer (Fig. 1). A fast classification image (CI) technique (Tavassoli et al., *in press*) was used to assess the impact of the direct tilt illusion during a visual search task.

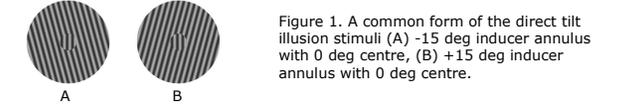


Figure 1. A common form of the direct tilt illusion stimuli (A) -15 deg inducer annulus with 0 deg centre, (B) +15 deg inducer annulus with 0 deg centre.

Method

A single search target (an 8cpd sine-wave grating oriented at 0 deg) was embedded in a grid of circularly masked 1/f noise tiles of 1 deg visual angle each. In an eye-tracker, observers searched the grid, spanning 7x7 deg visual angle, to find the target in a series of 5s time-limited trials. Two "flood-fill" background inducer orientations (-15 deg and +15 deg, i.e. maximally effective (Wenderoth & Johnstone, 1988), vertically offset 8cpd sine-wave gratings) and a distracter-absent control condition were run, using two normal/corrected human observers (IVDL and AT) at 700 trials per condition. Stimuli are shown in Fig. 2. A QUEST procedure enabled us to establish individual 68% correct SNR thresholds prior to data collection to promote sufficient exploratory eye movements.

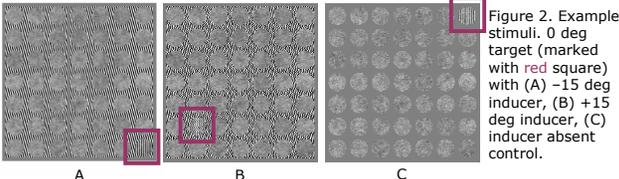


Figure 2. Example stimuli. 0 deg target (marked with red square) with (A) -15 deg inducer, (B) +15 deg inducer, (C) inducer absent control.

CI/averaging of noise tiles categories was performed off-line using the taxonomy defined in Tavassoli, et al (*in press*), except that each tile category was additionally subjected to a FFT in order to probe orientation bias via the amplitude spectrum.

Results

Spectral results for signal absent (SA) data, constructed by averaging **fixated** tiles that **did not** contain the target, are shown for the two observers (Fig. 3A). SA results contain the most compelling data since they are not affected by the additive influence of the target in the tile as displayed, and result purely from random perturbations of noise that resemble the target sufficiently well to cause the observer to make an erroneous visit, and potential erroneous acceptance of the tile as the search target.

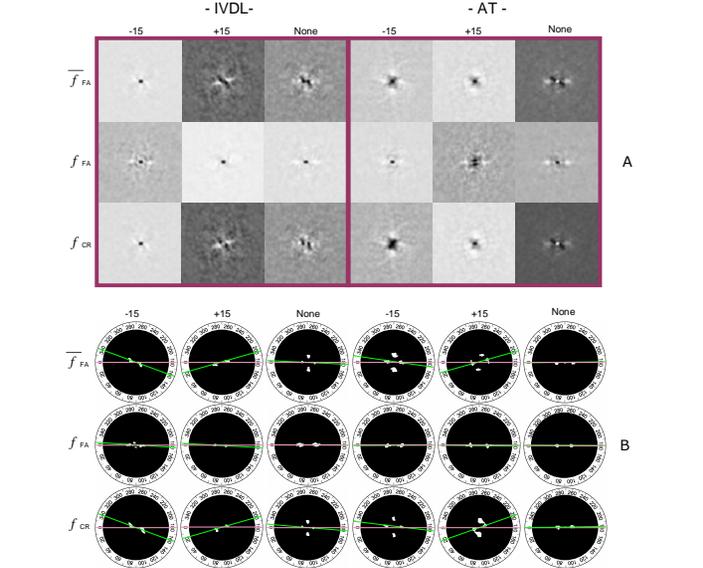


Figure 3. Signal absent results (excluding $\overline{f_{CR}}$) for each of the two observers under three experimental conditions. (A) FFTs normalised with respect to each other, i.e. contrast stretching within a distracter condition/observer group encompassing all categories. (B) Annotated Maxima. Note: Bezel provided for relative guidance only.

In Fig. 3B local maxima were identified via the MATLAB extended-maxima transform using 8-connected neighbourhoods. Illustrative lines of angle were drawn by joining opposing maxima through the centre (green line). True vertical (appearing as horizontal in the Fourier domain) is annotated (pink line).