

Binocular disparity in the surround biases V1 responses to ambiguous binocular stimuli within the classical receptive field

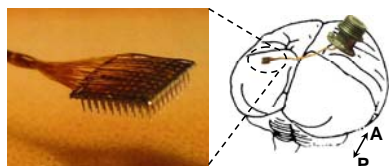
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INTRODUCTION

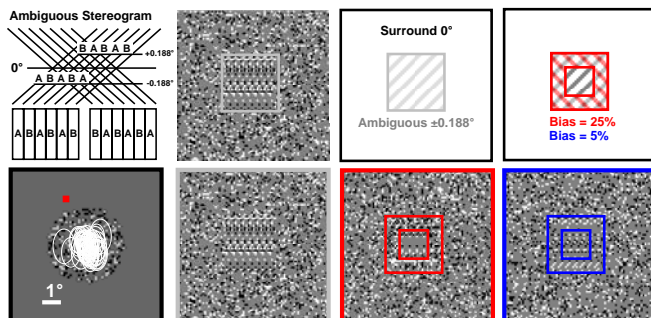
Several psychophysics studies have demonstrated that binocular disparity information is spatially propagated to regions with missing or ambiguous disparity features. In one particular study, Julesz and Chang (1976) presented a random dot stereogram with ambiguous binocular information. Features could be matched between the eyes so that a surface would be perceived as near or far. When a small amount (5%) of randomly placed dots were introduced with unambiguous binocular disparity, the percept of the ambiguous surface was biased towards the depth that was closest to the perceived depth of the random dots. We recorded from populations of visual cortical neurons while presenting nearly the same stimuli as that of Julesz and Chang. The one difference was that we presented the unambiguous "biasing" random dots only outside of the receptive fields (RFs) of the recorded neurons. The DRDS inside and in the immediate surround of the RFs were ambiguous and bistable: it could indicate a near or far surface. We analyzed the dynamics of the responses of a variety of neurons to this bistable stimulus when biased dots of different disparities were introduced into the RF surround.

NEUROPHYSIOLOGICAL METHODS



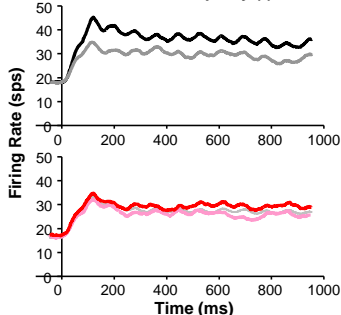
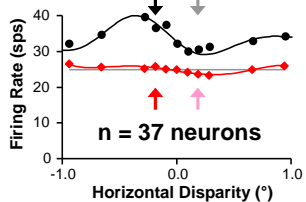
Recordings were made with a chronically implanted Utah Intracortical Electrode Array into V1 of an awake, behaving macaque performing a simple fixation task. Electrodes are 1-mm in length and arranged in a 10x10 grid with 0.4-mm spacing. Spikes were sorted offline with principal components analysis and manually set time-voltage thresholds.

VISUAL STIMULATION

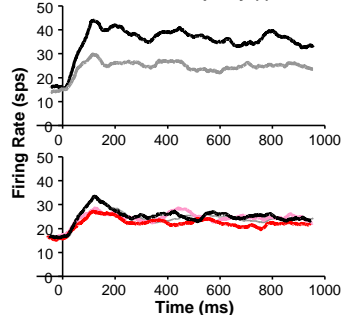
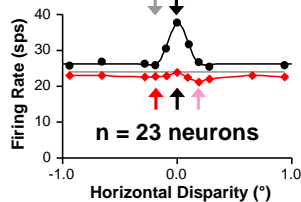


An ambiguous, bistable region of a dynamic random dot stereogram (DRDS) was generated by repeating a random dot pattern horizontally at a frequency equal to a fusible disparity to create the "wallpaper effect". This portion could be fused either at a near or far disparity. Unambiguous random dots at 11 disparities were added to the surrounding edge of the bistable region (5 and 25%) to bias the percept. Disparity tuning was measured with a standard DRDS in an aperture.

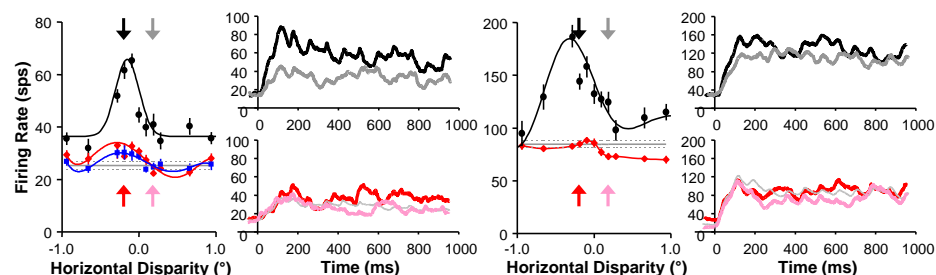
NEAR & FAR TUNED NEURONS



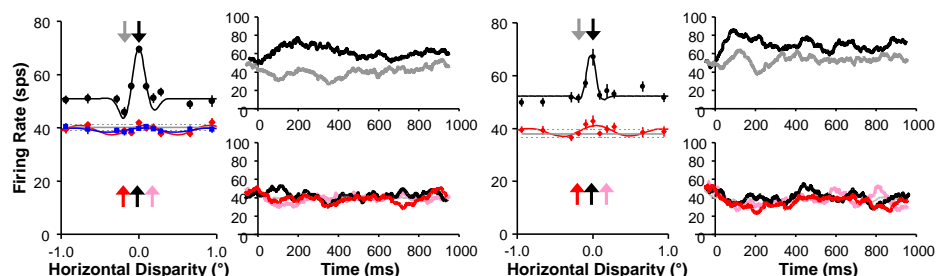
ZERO TUNED NEURONS



EXAMPLE RESPONSES OF NEAR & FAR DISPARITY TUNED NEURONS



EXAMPLE RESPONSES OF ZERO DISPARITY TUNED NEURONS



RESULTS

1. Near & far disparity tuned neurons responded preferentially to the bistable disparity closest to the disparity in the biasing surround (red versus pink).
2. The divergence between the preferred and non-preferred disparities of the bistable region was delayed compared to the diverging responses of the same disparities to unambiguous DRDS (black versus gray).
3. The suppression to bistable disparities was faster for neurons tuned to zero disparity (black vs. red/pink).

CONCLUSIONS

The slow development of tuning to the bistable stimulus for neurons tuned to near and far disparities is consistent with distant and delayed positive spike correlation observed among neurons with similar disparity tuning. The faster development of tuning of zero disparity tuned neurons is consistent with local suppressive interactions. Overall, this provides further evidence that cooperative and competitive interactions among V1 networks contribute to resolving local ambiguity of single neurons during stereo processing (Samonds et al. 2009).

REFERENCES

Julesz B, Chang J-J (1976) Interaction between pools of binocular disparity detectors tuned to different disparities. *Biol Cybern* 22: 107-119.
 Samonds JM, Potetz B, Lee TS (2009) Cooperative and competitive interactions facilitate stereo computations in macaque primary visual cortex. *J Neurosci* (under review)

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