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Neural representations of visual salience in primary visual cortex

Jit Hon Bong*[1], Shih-Cheng Yen[1], Rodrigo F Salazar[2] and Charles M Gray[2]

Address: [1]Department of Electrical & Computer Engineering, National University of Singapore, Singapore 117576, Singapore and [2]Center for Computational Biology, Montana State University, Bozeman, Montana 59717, USA

Email: Jit Hon Bong* - g0700204@nus.edu.sg

* Corresponding author

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Introduction

A number of previous studies have implicated the period and the level of sustained firing (30–40 ms after response onset) as a neural representation of visual salience [1,2]. We investigated this hypothesis by recording from the primary visual cortex of macaque monkeys while they performed a contour detection task.

Methods

The visual stimuli consisted of an array of randomly drifting Gabor patches, with a subset aligned to form a coherently drifting closed contour. This contour was designed to optimally stimulate the non-overlapping receptive fields of two or more neurons under study. Two additional salience conditions were tested by adding orientation jitter to the Gabor patches that were not stimulating the receptive fields of the recorded cells. Contours also appeared with equal probability at an alternative "control" location that was equidistant from the fixation point. The stimuli appeared 500 ms after initial fixation and the animals were free to saccade to the target as soon as they were detected. The animals received a juice reward if they performed this task correctly within 300 ms of the stimulus onset. Only correct trials were considered in this analysis. Currently, we have analyzed the responses of 110 well-isolated neurons in one animal.

Results

We computed the modulation indexes [1] from 30 ms after response onset to the saccade onset for each trial and the distributions for each salience condition were not significantly different from zero (sign-test, $p > 0.05$) and were not significantly different from each other (Kruskal-Wallis non-parametric ANOVA test, $p > 0.05$). We then identified cells in which the mean firing rate in the aforementioned window was significantly different from the control condition in at least one salience condition (KW, $p < 0.05$, $n = 14$). The modulation indexes of this group were significantly greater than zero (sign-test, $p < 0.01$) with median values of (0.2398, 0.0899, -0.0968) corresponding to the high, middle, and low salience conditions. Significant differences were also found across salience conditions (KW, $p < 0.05$). We also computed the correlation coefficients between the modulation indexes of this group and their corresponding behavioral performance. The correlation coefficients were significantly different from zero (sign-test, $p < 0.01$) with a median value of 0.8761.

Discussion

Our results indicate that in a behavioral paradigm in which animals were free to perform a detection task as quickly as they desired, only a subset (12.7%) of well-isolated neurons modulate their firing rate during the period of sustained activity in a fashion that was consistent with visual salience. We are currently investigating alternative neural representations including joint firing and latencies.

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