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Poster presentation

Can reduced contour detection performance in the periphery be explained by larger integration fields?

Nadja Schinkel-Bielefeld*[1], Udo A Ernst[2], Klaus R Pawelzik[2], Simon D Neitzel[3], Sunita Mandon[3], Andreas A Kreiter[3] and Ruth Rosenholtz[1]

Address: [1]Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA, [2]Institute for Theoretical Neurophysics, University of Bremen, 28334 Bremen, Germany and [3]Institute for Brain Research, University of Bremen, 28334 Bremen, Germany

Email: Nadja Schinkel-Bielefeld* - schinkel@mit.edu

* Corresponding author

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Human contour integration performance decreases [1,2] with eccentricity, though less so for contours with good gestalt properties [3]. However, the cause is still not well understood. On the one hand, there is reduced visual acuity in the periphery due to cortical magnification. The same area of the visual field is mapped to a larger area of cortical surface close to the fovea than in the periphery. On the other hand, there is visual crowding. Elements that are clearly recognizable when shown in isolation are harder to recognize when surrounded by similar objects. The critical spacing for crowding has shown to be approximately half the eccentricity [4]. So crowding could be caused by larger integration fields in the periphery that span at least half the eccentricity.

We simulate contour integration by a Bayesian model and evaluate model predictions by comparison to human psychophysical experiments. The key components of this model are the afferent input due to the visual stimulus and the lateral connections between neurons representing edge elements of different preferred orientation. Lateral connection structures can be described by a so-called association field (AF), a conditional link probability density that gives for each pair of edge elements the probability that these are grouped together.

Contour detection experiments showed that human errors are not made randomly but are highly correlated among different subjects, indicating that humans tend to find the same illusory contours in the stimulus. Hence we require the model to reproduce not only human performance but also the specific errors made by humans.

In this model we explored different symmetries and geometries of AFs. Of all tested AF choices, an AF extracted from natural image statistics describes human contour integration best. This confirms the hypothesis that the visual system is shaped by experience and weights of the horizontal connections between orientation selective cells are adapted to natural image statistics.

Furthermore, we modulated the afferent input in order to mimic cortical magnification. We also varied the range of the horizontal connections according to Bouma's law [4] to simulate crowding. Our results indicate that human performance and correlations among humans can be reached by the model by modifying the afferent input. In contrast, varying the range of the AF according to Bouma's law in this framework reproduces human performance for different eccentricities, but cannot account for the correlated responses observed among humans.

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