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Independence of space-based and feature-based attention in the determination of figure direction

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Introduction

Visual attention enhances our perception and even alters the perception of figures, as we often see in ambiguous figures. We investigated computationally the role of spatial attention in early vision for the perception of direction-of-figure (DOF). Spatial attention alters local contrast gain in early vision, thus apparent local contrast will be modulated. If the local contrast is the basis for the determination of border-ownership (BO) that tells which side of a contour owns the border [1,2], BO will be modulated based on the local contrast that is altered by the attention. If the effect of attention is significant, the activity of BO-selective cells will be facilitated/suppressed so that the DOF will be flipped.

Model

This model consists of three modules, V1, V2 and Posterior Parietal (PP) module, as illustrated in Figure 1. V1 and PP are linked mutually for the application of spatial attention to V1, and for the modification of spatial attention in PP. The V2 module determines DOF based on contrast gain that is extracted by the V1 module [2]. The PP represents spatial attention that will facilitate the contrast processes within the attended location in V1. Note that spatial attention does not directly affect the determination of DOF in the model. An artificial lesion of the connections between PP and V2 enables us to examine the exclusive role of attention applied to V1.

Simulation results

To examine whether the model based on contrast modulation changes BO depending on the location of attention, we carried out simulations of the model with ambiguous random-block stimuli with examples illustrated in Figure 2(A). The results were compared with that of the corresponding psychophysical experiment that utilized the same sets of stimuli. The model showed good agreement with human perception for modulation magnitude and its variance among stimuli. To investigate the sole effect of spatial attention in the presence of feature-based attention, we tried to separate the modulations of spatial attention and feature-based attention by introducing a familiar

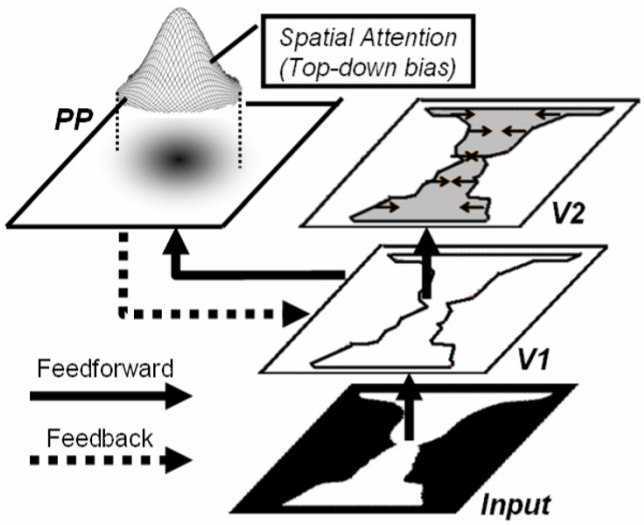

Figure 1
An illustration of the model architecture.

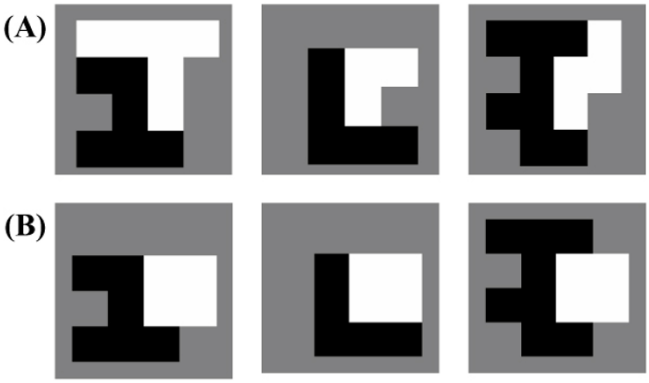

Figure 2
Examples of ambiguous random-block stimuli utilized for both simulation and psychophysics. (A) A combination of unfamiliar shapes. (B) A combination of familiar and unfamiliar shapes.

shape, such as a square as shown in Figure 2(B). When the stimulus included a familiar shape, human determination of BO shifted in the direction of the familiar shape, whereas our model did not exhibit such a shift. However, there was no significant difference in the modulation magnitude between the model and psychophysical data. This disagreement in BO shift, and agreement in modulation magnitude seems natural because the model does not include any mechanism for feature-based attention. These results suggest that the modulation of contrast gain in V1 underlies the modulation of BO direction based on spatial attention, and that spatial attention and feature-based attention operate nearly independently and probably additively.

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