Bayesian inference accounts for the filling-in and suppression of visual perception of bars by context

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Visual input sensitivity and object recognition are largely influenced by contextual inputs. For instance, human sensitivity to detect a target bar is increased by the presence of colinear contextual bars which could group with the target into a smooth contour. The neurons in the primary visual cortex (V1) also increase their responses to a bar in the presence of colinear contextual bars. Using visual psychophysics and modeling methods, we investigate how contextual bars bias one to perceive or not to perceive the presence of a target bar, rather than on the input sensitivity. Unexpectedly, human observers are more likely to perceive a target when the context has a weaker rather than stronger contrast (Fig. 1B & C). When the context can perceptually group well with the would-be target, weak contrast contextual bars bias the observers to perceive a target relative to the condition without contexts, as if to fill in the target (Fig. 1A left). Meanwhile, high contrast contextual bars, regardless of whether they groups well with the target, bias the observers to perceive no target (Fig. 1A middle & right, and Fig. 1C). A Bayesian model of visual inference is shown to account for the data well, illustrating that the context influences the perception in two ways: (1) biasing observers’ prior belief that a target should be present according to visual grouping principles, and (2) biasing observers’ internal model of the likely input contrasts caused by a target bar. According to this model, our data suggest that the context does not influence the perceived contrast despite its influence on the bias to perceive the target’s presence, thereby suggesting that cortical areas beyond V1 are responsible for the visual inferences.

A: Detecting a weak vertical target bar in various contexts

Figure 1: A: even though the vertical target has the same low luminance contrast against background in all three contexts, one is most likely to see a vertical target bar in the left (fill-in), and least likely in the right (suppression), example. B & C: human observer’s probability of seeing the vertical target bar (vs. target contrast) is higher in weak context (B) than in strong context (C).

Acknowledgments

We thank Gatsby Charitable Foundation and BBSRC for funding, and J.A. Solomon, M.J. Morgan, and P. Dayan for comments.