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Report

pposite Modulation of High- and Low-Level Visual Aftereffects by Perceptual Grouping

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Summary

A fundamental task of visual perception is to group visual features—sometimes spatially separated and partially occluded—into coherent, unified representations of objects. Perceptual grouping can vastly simplify the description of a visual scene and is critical for our visual system to understand the three-dimensional visual world. Numerous neurophysiological and brain imaging studies have demonstrated that neural mechanisms of perceptual grouping are characterized by the enhancement of neural responses throughout the visual processing hierarchy, from lower visual areas processing grouped features to higher visual areas representing objects and shapes from grouping [1–3]. In a series of psychophysical adaptation experiments, we made the counterintuitive observation that perceptual grouping amplified the shape aftereffect but meanwhile, reduced the tilt aftereffect and the threshold elevation aftereffect (TEAE). Furthermore, the modulation of perceptual grouping on the TEAE showed a partial interocular transfer. This finding suggests a 2-fold effect of perceptual grouping—enhancing the high-level shape representation and attenuating the low-level

perceived normal diamond caused by adaption were taken as the magnitude of the TAE and the SAE respectively. If adaptation could generate a significant TAE and/or SAE, a vertical grating would be perceived to be left tilted and/or a normal diamond to be fat.

For three experimental conditions—adapting to the diamond stimulus, adapting to the nondiamond stimulus and baseline (without adaptation)—the perceived verticals (mean ± SEM) were 1.84° ± 0.76°, 3.31° ± 0.90°, and 0.29° ± 0.72°, respectively. TAEs were significant after adapting to both the nondiamond stimulus ($t = 4.90$, $p < 0.01$) and the diamond stimulus ($t = 3.31$, $p < 0.05$). The TAE from the nondiamond stimulus was significantly larger than that from the diamond stimulus ($t = 6.85$, $p < 0.01$) (Figure 2B). However, SAE measurements had a distinctive pattern. The aspect ratios of the perceived normal diamonds were 0.9937 ± 0.009, 0.9752 ± 0.01, and 0.9743 ± 0.01 for the three conditions. A significant SAE was found after adapting to the diamond stimulus ($t = 8.21$, $p < 0.01$), but not the nondiamond stimulus ($t = 0.49$, $p > 0.05$). The difference between the two adapting stimuli was significant ($t = 5.07$, $p < 0.01$) (Figure 2C). These results demonstrate that perceptual grouping could enhance the representation of the diamond shape but attenuate the representation of the bar orientation. The shape adaptation should take place in high-level visual areas because the SAE was evident even when the adapting and test stimuli were presented in the left and right visual fields, respectively. A possible area is the lateral occipital area (LO) because the LO in either hemisphere is responsive to shape images presented in both the left and right visual fields [16], although it still has a contralateral preference [17].

Effect of Perceptual Grouping on Threshold Elevation Aftereffect

It could be argued that, in experiment 1, the TAE reduction

Discussion

Our experiments provide clear evidence that perceptual grouping could magnify the high-level SAE but reduce the low-level TAE and TEAE. These results demonstrate that a functional role of perceptual grouping is enhancing the high-level shape representation and meanwhile weakening the representation of the constituent elements (i.e., bar orientations) of the shape. Moreover, the effect of perceptual grouping on the TEAE showed a partial interocular transfer—it was significantly reduced when the adapting and test stimuli are presented to different eyes compared to when presented to the same eye. This finding indicates that the grouping might have exerted influence on monocular neurons encoding the bar orientations.

In the past decade, many of single-unit and brain imaging studies showed that perceptual grouping increases neural activities not only in higher occipitotemporal areas selective

19. Festman, Y., and Ahissar, M. (2004). Attentional states and the degree of visual adaptation to gratings. Neural Netw. 17, 849–860.
20. Blake, R., Tadin, D., Sobel, K.V., Raissian, T.A., and Chong, S.C. (2006). Strength of early visual adaptation depends on visual awareness. Proc. Natl. Acad. Sci. USA 103, 4783–4788.
21. Bi, T., Cai, P., Zhou, T., and Fang, F. (2009). The effect of crowding on