Spatial organization by common-fate motion affects brightness computation on articulated surrounds

Masataka SAWAYAMA* and Eiji KIMURA

Chiba University

By adding small patches of different luminances to a uniform field surrounding a target, the effect of the surrounding luminance on target brightness can be enhanced (articulation effect). The present study investigated whether the articulation effect is governed only by retinal proximity or also affected by spatial organization by common-fate motion. The target in the present study was a moving patch located at the center of an articulated surround. It was moved with small patches and/or the uniform background within the surround with the same speed, direction, and timing. The target was easily grouped with the patches and/or the background depending upon what simultaneously moved, although retinal proximity was kept almost constant. The results indicated clear influences of spatial organization as well as retinal proximity on the articulation effect. These findings suggest that the brightness computation on the articulated field could depend upon both the spatial luminance distribution in the retinal image, and spatial structure where retinal elements were spatially organized by common-fate motion.

Key words: brightness computation, articulation, spatial organization

When a uniform field surrounds a target, its brightness depends upon the luminance of the surrounding field. Moreover, the effect of the surrounding luminance can be enhanced by articulating the surround (i.e., adding small patches of different luminances to the uniform field), even if the spatially-averaged luminance is kept constant (Gilchrist et al., 1999). This articulation effect suggests that the brightness computation on articulated surrounds is different from that on uniform surrounds.

To investigate the visual mechanisms underlying the articulation effect, the present study asked whether the effect is governed only by retinal proximity or also affected by spatial organization. Thus, we manipulated the spatial organization by common-fate motion, while keeping the retinal proximity almost constant.

Methods

Observers. Four observers (including the first author) with normal or corrected to normal visual acuity participated in the experiment.

* Masataka SAWAYAMA is now at Graduate School of Advanced Integration Science, Chiba University 1-33, Yayoi-cho, Inage-ku, Chiba-shi, Chiba, 2638522. He is also Research Fellow of the Japan Society for the Promotion of Science.

Stimuli. Two types of the surrounds were used: uniform and articulated. Each surround was a light or dark square field of 7° × 7°. Under the uniform condition, a spatially uniform surround was used (Figure 1d, e). Under the articulated condition, 1° × 1° patches of different luminances were added to the uniform background while preserving the spatially-averaged luminance of the surround (Figure 1a–c). The target was a moving patch, with a size of 1° × 1°.

Figure 1. An illustration of the stimulus conditions on the dark surround. Under the articulated condition, the target movement was synchronized with: only the patches (a); both the patches and the background (b), or; only the background (c). Under the uniform condition the target movement was synchronized with the background (d), or the target was moved and the background was stationary (e).

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located at the center of the surround. It was moved alternatively, up and down, and right and left with a speed of 2.25 degrees/s.

By manipulating the types of common-fate motion, the regions with which the target was grouped were changed. Under the articulated condition, three types of motion stimuli were produced by moving the patches and/or the background within the surround, together with the target, at the same speed and timing, and in the same direction. In the first condition only the patches were moved (Figure 1a). In the second condition, both the patches and the background were moved (Figure 1b). In the third condition, only the background was moved (Figure 1c). The target was easily grouped with the patches in the first two conditions. In contrast, it was easily segregated from the patches in the third condition, although retinal proximity was kept almost constant. Under the uniform condition, two types of motion stimuli were used. In one condition, the surround was moved in synchronization with the target (Figure 1d). In the second condition, the surround was stationary (Figure 1e).

The luminance of the small patches ranged from 0.83 to 1.36 log cd/m² in the light articulated surround and from 0.05 to 0.58 log cd/m² in the dark articulated surround. In both the uniform and articulated conditions, the spatially-averaged luminance of the light and dark surrounds was 1.16 and 0.38 log cd/m², respectively. The luminance of the target was 0.80 log cd/m². A matching stimulus was a moving patch with a size of 1°×1° placed on a checkerboard surround with a size of 7°×7° and composed of 1.16 and 0.38 log cd/m² checks.

Procedure. The observers matched the brightness of the target by adjusting the luminance of the matching stimulus.

Results and Discussion

Figure 2 plots the PSEs for different stimulus conditions (Points of Subjective Equality), which were averaged across different observers. The difference between the PSEs on the dark surround (solid symbols in Figure 2) and those on the light surround (open symbols in Figure 2) indicates the effect of the surrounding luminance on target brightness. The differences under the articulated condition (Figures 2A–C) were larger than those under the uniform condition (Figures 2D, E; p < .05). Thus, the articulation effect was confirmed in the present study.

The results indicated clear influences of spatial organization on the articulation effect. The effect was stronger when the target was grouped with the patches (Figure 2A, B) than when it was not (Figure 2C; p < .05), although retinal proximity was kept almost constant under these conditions. In addition, the effect of retinal proximity could also be found. Even when the target was segregated from the patches (Figure 2C), a significant articulation effect was still found (p < .05), although it was reduced in magnitude.

Overall, these findings suggest that brightness perception on the articulated surrounds is affected by both retinal proximity and spatial organization. It seems that the brightness on the articulated surround is computed depending upon both the spatial luminance distribution in the retinal image, and the spatial structure where retinal elements were already spatially organized by a common-fate motion.

References