The effect of the surface medium on search, identification, detection, and localization

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In the visual search paradigm using shading stimuli it is suggested that concavity is more dominant than convexity. However, in a figure and ground segregation task, the opposite is true. We proposed that a discrepancy in dominance could be based on whether or not subjects identified the properties of objects such as shape and orientation, and we confirmed this in four experiments. The results of the first and second experiments showed that searching for and identifying items composed of convex disks was more efficient than items composed of concave disks. The results of the third and fourth experiments showed that in detection and localization tasks, there were no significant differences in the dominance between convexity and concavity. These results suggest that convexity is dominant when subjects conduct a task requiring identification of the properties of objects, and that the visual system extracts appropriate information according to task demand.

Key words: shape from shading, search asymmetry, dominance

Introduction

The visual system must extract elementary features containing meaningful information about the structure of the environment. This function of the visual system has been investigated in many studies, especially in visual search paradigms. In a visual search task using shading stimuli, a target of a bottom-lit disk, perceived as 'concave', pops out among distracters of top-lit disks perceived as 'convex' but not vice versa (Kleffner & Ramachandran, 1992). It has been suggested that this asymmetry is evidence that the visual system registers concavity as a more important and salient feature than convexity.

However, the dominance of convexity has been also reported. Our previous study showed that in figure and ground segregation, the region composed of convex disks tends to be perceived as figure in comparison with the region composed of concave disks.

In this study, we explored the dominance in shading perception when subjects were required to identify properties of the objects.

Experiments

Method

Subjects Each of Experiments 1 and 2 were performed with 6 observers and 5 observers were involved in each of Experiments 3 and 4.

Apparatus All stimuli were presented on a 19-inch color monitor with a resolution of 75 Hz (Iiyama). An Apple computer (Power Macintosh G3 MT266) controlled the presentation of the stimuli and the response registration.

Stimuli Figure 1 shows the stimuli used in Experiment 1. The entire display subtended 12°×12° in visual angle. Each stimulus was composed of 15×15 shaded disks with a gray background whose luminance was 35 cd/m². Each disk subtended 0.8°. The luminance of the brightest region in a shaded disk was 73 cd/m², and the luminance of the darkest region was 10 cd/m². The search items (Experiment 1) and the target surface (Experiment 2, 3, and 4) were composed of top-lit disks when the background was composed of bottom-lit disks, and vice versa.

Procedure The following Experiments were conducted in a darkened room. To ensure the vertical
alignment of the head, a chin rest was utilized. In Experiment 1, subjects searched for a target composed of three shaded disks arranged vertically or obliquely among oblique or vertical distracters respectively. In Experiment 2, subjects identified the orientation (vertical or horizontal) of a surface composed of $4 \times 3$ shaded disks. In Experiment 3 the subjects tried to detect a surface composed of $3 \times 3$ shaded disks. In Experiment 4 the subjects reported whether a surface composed of $3 \times 3$ shaded disks was presented to the right or left of the visual field.

Results

Table 1 shows the results of Experiments 1, 2, 3, and 4. The data represent mean reaction times (ms) and Standard Error.

<table>
<thead>
<tr>
<th>Task (experiment number)</th>
<th>Disk types</th>
<th>convex</th>
<th>concave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search (experiment 1, N=6)</td>
<td>631</td>
<td>748</td>
<td>(±64.7)</td>
</tr>
<tr>
<td>Identification (experiment 2, N=6)</td>
<td>682</td>
<td>735</td>
<td>(±64.2)</td>
</tr>
<tr>
<td>Detection (experiment 3, N=5)</td>
<td>498</td>
<td>531</td>
<td>(±38.5)</td>
</tr>
<tr>
<td>Localization (experiment 4, N=4)</td>
<td>443</td>
<td>447</td>
<td>(±30.5)</td>
</tr>
</tbody>
</table>

Discussion

In this study we examined dominance in shading perception in search, identification, detection, and localization tasks. In the search and identification tasks (Experiments 1 and 2), convexity was dominant, on the other hand, this dominance was not observed in the detection and localization tasks.

The results in this study may imply that the way to extract a feature from a scene varies according to the problems we have to solve. In a normal search, where display is not mediated by the surface, we can locate the target without consciously identifying its shape or orientation. Therefore, the saliency is likely to be determined by a deviation from the standard. However, in identifying such object properties as shape or orientation, the saliency based on a deviation from the standard is useless. It is easy to identify the front shape of an object in comparison to the rear shape. Therefore, in identifying the properties of the object, convexity seems to be important.

References