Asymmetry of the perception of approaching or receding objects defined by moving cast shadows

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It has been proposed that objects which appear to be expanding, and represent approaching objects, are easier to detect than objects which appear to be contracting (Takeuchi, 1997; Shirai & Yamaguchi, 2004). To investigate this asymmetry in a visual search task we examined the detection of approaching and receding objects which were defined by moving cast shadows. The results showed that an "approaching" target among "receding" distractors was detected faster and more accurately than a "receding" target among "approaching" distractors (Experiment 1). In addition, this asymmetry did not occur if the luminance of the shadows was lighter than the background (Experiments 2 and 3). These findings suggest that the asymmetry of the perception of motion-in-depth could be caused by the depth information of cast shadows.

Key words: cast shadow, motion-in-depth, asymmetry, visual search

Several investigators have reported that the visual system has different sensitivities for expansion and contraction, which can represent approaching and receding objects. For example, Takeuchi (1997) demonstrated search asymmetry: the search for an expansion was faster than that for a contraction. In addition, Shirai & Yamaguchi (2004) showed that during a visual search an expanding circle with convex shading could be detected easier than one with concave shading. These findings suggest that the visual system may be specialized to detect approaching objects. The present study examined, in a visual search task, the detection of approaching and receding objects which were defined by the motion of cast shadows.

Method

Participants The graduate students who participated in Experiments 1, 2, and 3, had mean ages of 22.2 years (7 subjects), 22.2 years (5 subjects), and 26.5 years (2 subjects), respectively.

Stimuli and procedure Figure 1a shows an example of the stimulus used in Experiment 1. The stimuli consisted of static blue squares, each with the size 1.37 degrees × 1.37 degrees to 1.72 degrees × 1.72 degrees, partially superimposed with moving shadows, each with the size 1.37 degrees × 1.37 degrees to 1.72 degrees × 1.72 degrees). The background was a uniform gray surface having a size of 23.4 degrees × 23.4 degrees, and a luminance of 82.7 cd/m² in Experiments 1 and 2. The presentation of the stimulus display was fixed for 600 ms (60 ms/frame). The luminance of the shadows was changed to manipulate the depth information and dark gray shadows (luminance=8.7 cd/m²) were used in Experiment 1. The Michelson's contrast of the shadows for the background was 73.4%. Once the shadows move away from the squares, the squares apparently move towards the observer. When the shadows come close to the squares the squares apparently recede from the observer without any square changing its size. In Experiment 2 light gray shadows (luminance=114.7 cd/m²), which are less effective than dark shadows for creating motion-in-depth were used. The Michelson's contrast of the shadows for the background was 3.5%.
son’s contrast of the shadows in the background was 16.2%. In Experiment 3 the tone of the stimuli used in Experiment 1 was reversed so that the depth information was manipulated to have a Michelson’s contrast (86%) almost equal to that of Experiment 1. The size of the squares and their initial frame were randomly selected from 10 alternatives. The displays consisted of either 12, 24, or 36 items. The participants’ task was to search for a unique pattern of motion (the target), and to indicate the presence or absence of the target by pressing one of two keys. The Response Time (RT) of the each subject was measured. Each participant was tested with two conditions: a target square with a shadow moving away from it was embedded in squares with shadows moving toward them (the approaching condition), and a display with the reverse of the movements (the receding condition). Each experimental session contained 120 trials (conditions (2) × presence or absence of target (2) × display size (3) × 10 trials). For each condition there was also one practice session which was followed by two test sessions.

**Results and Discussion**

Figure 1b illustrates the mean RT for the trials with a target present in Experiment 1. Two-way repeated-measures analyses of variance (ANOVAs) were calculated using the data of each experiment with the correct RT, the condition (the approaching or receding condition), and the number of items, as main factors. In Experiment 1 significant main effects were revealed for the conditions (F(1, 6) = 11.64, p < .05) and the number of items (F(2, 12) = 5.51, p < .05). However, there were no significant main effects or interactions for Experiments 2 and 3. The results of Experiment 1 suggest that approaching objects which are defined by a moving cast shadow are detected faster than receding objects. The findings of Experiment 2 suggest that this asymmetry was not caused by the detection of light expanding shadows. Experiment 3 supported the results of Experiment 2 that can not be explained by the low Michelson’s contrast of the light gray shadows. Taken together, the present results indicate that depth cues of cast shadows cause the asymmetry of perception of motion-in-depth. This asymmetry appears to be consistent with the previous studies, which used expansion and contraction of the object itself. The human visual system may be more sensitive to the detection of approaching objects, regardless of depth cues.

**References**
