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ScienceDirect

Vision Research 47 (2007) 357–362

Vision Research

www.elsevier.com/locate/visres

Absence of flash-lag when judging global shape from local positions

Daniel Linares *, Joan López-Moliner

Grup Recerca Neurociència Cognitiva, Parc científic-Universitat de Barcelona, Spain

Received 14 June 2006; received in revised form 5 October 2006

Abstract

When a flash is presented aligned with a moving stimulus, the former is perceived to lag behind the latter (the flash-lag effect). We study whether this mislocalization occurs when a positional judgment is not required, but a veridical spatial relationship between moving and flashed stimuli is needed to perceive a global shape. To do this, we used Glass patterns that are formed by pairs of correlated dots. One dot of each pair was presented moving and, at a given moment, the other dot of each pair was flashed in order to build the Glass pattern. If a flash-lag effect occurs between each pair of dots, we expect the best perception of the global shape to occur when the flashed dots are presented before the moving dots arrive at the position that physically builds the Glass pattern. Contrary to this, we found that the best detection of Glass patterns occurred for the situation of physical alignment. This result is not consistent with a low-level contribution to the flash-lag effect.

Keywords: Flash-lag effect; Glass pattern

1. Introduction

In view of the biological relevance of detecting moving objects, neural mechanisms have been postulated so as to reduce (Whitney & Murakami, 1998; Whitney, Murakami, & Cavanagh, 2000) or correct (Nijhawan, 1994) the inevitable neural delays associated with their visual processing. The flash-lag effect, in which a briefly flashed object presented aligned with a moving one in the retina is perceived to lag behind it, has been suggested as the most convincing evidence for the existence of such mechanisms (Nijhawan, 1994; Whitney & Murakami, 1998; Whitney et al., 2000), although other alternative explanations have been proposed (rev. Krekelberg & Lappe, 2001; Nijhawan, 2002).

It is still an open question where in the visual pathway the mislocalization takes place, but some neurophysiological studies suggest a low-level contribution of these special mechanisms for the processing of moving stimuli that could occur as early as in the retina (Berry, Brivanlou, Jordan, & Meister, 1999) or LGN (Orban, Hoffmann, & Duysens, 1985).

If there is a contribution of early visual areas to the spatial mislocalization between moving and flashed stimuli, then this mislocalization can be expected to occur at a spatially local level and independently of the task. Here, we test this prediction by performing a form detection task in which a precise spatial local relationship between moving and flashed information is needed to perceive a global shape.

Specifically, we used a concentric Glass pattern (Glass, 1969). Concentric Glass patterns consist of a large number of pairs of dots. The first dot of each pair is positioned randomly within the stimulus area. The position of the second dot is determined by rotating the radial vector corresponding to the first dot by a fixed amount. The pattern creates the visual impression of a rotary visual structure (see Fig. 1). In our experiment one dot of each pair was flashed while the other was presented in motion (all the moving dots had the same direction). The best global form is

* Corresponding author. Present address: Hospital de Sant Joan de Deu, Edifici Docent, C/ Santa Rosa, 39-57, planta 4[a], 08950 Esplugues-Barcelona, Spain. Fax: +34 93 600 97 88.

E-mail address: linares@ub.edu (D. Linares).

0042-6989/$ - see front matter
doi:10.1016/j.visres.2006.10.013

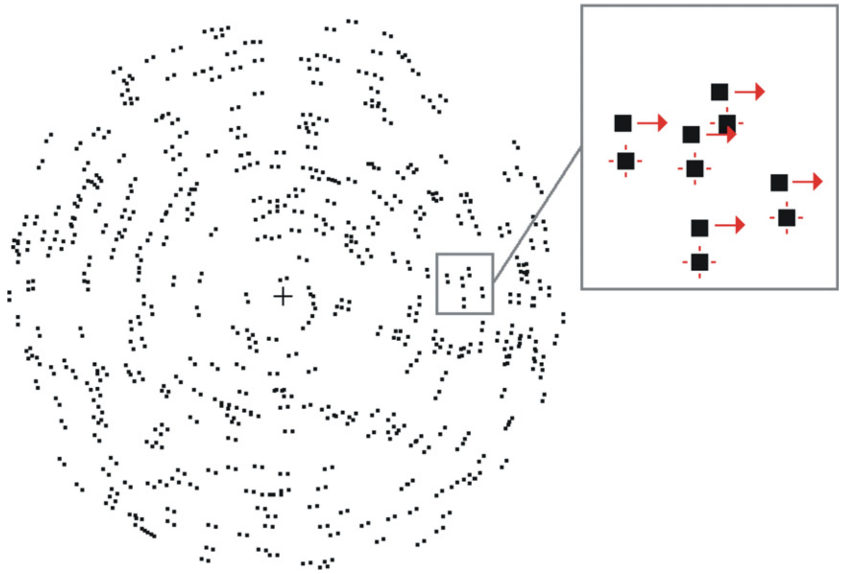

Fig. 1. Representation of the stimulus in the moving dots condition for a relative timing of zero. In the real experiment the contrast was reversed (white dots on black background).

physically obtained when the flashed dots of each pair are physically aligned (see inset of Fig. 1). However, if there is a flash-lag effect for each pair then the best global form should occur when the flashed dots are presented before the moving dots arrive at the position of physical alignment. As in the flash-lag, this would be so because a perceived (not physical) alignment would allow one to recover the global shape. By varying the timing at which the flashed dots were presented we explored when the best performance was achieved in a global form detection task.

2. Methods

Stimuli were displayed on a 19 in. CRT monitor (Philips Brilliance 109P4) at a refresh rate of 100 Hz and viewed binocularly from a distance of 50 cm in a dimly lit room. The dots (size: $0.16\ \text{deg} \times 0.16\ \text{deg}$) were shown within a circular aperture with a diameter of 23 deg of visual angle on a dark background. Three observers participated in the experiment, the first author (D.L.) and two observers who were naïve with respect to the purposes of the study (M.L., S.S.). Observers reported normal, or corrected to normal, visual acuity and color vision. Observers were instructed to maintain fixation on a cross presented at the center of the aperture. Observers were tested in two sessions for each of the conditions that will next be explained.

2.1. Moving dots condition

Each trial consisted of two successive intervals temporally separated by one second. The concentric Glass pattern was presented at random in either the first or the second interval. After each trial, the observer had to indicate which interval contained the concentric Glass pattern.

The interval that contained the concentric Glass pattern consisted of 400 dots (luminance 23 cd/m^2) moving at 6 deg/s. All the dots moved in the same direction. The direction was chosen at random from all possible directions in the plane and so was the initial location of each dot within the circular aperture. When a moving dot reached the limit of the invisible aperture, then it appeared on the opposite site of the aperture. After 500 ms, another 400 dots (flashed dots, luminance 93 cd/m^2) were displayed for 10 ms to build the concentric Glass pattern (see Fig. 1). The moving dots kept moving for 500 ms after the flashed dots were presented and then disappeared. So each interval lasted for one second and the concentric Glass pattern was available just for one frame (10 ms). The luminance was measured with steady presentation of the dots. The luminance of the flashed dots was greater in order to equate the perceived luminance.

The concentric Glass pattern was built by presenting a flashed dot at a distance of 0.32 deg from each moving dot (distance between the centers) in a direction perpendicular to the radial vector corresponding to the moving dot. The interval that did not contain the concentric Glass pattern was identical except that the direction between each moving dot and its associated flashed dot was chosen at random.

We have just described the situation of physical alignment: the flashed dots were displayed at the time relative to the position of the moving dots that allowed to built the concentric Glass pattern. We refer to this situation as the one corresponding to a relative timing of zero. But in each trial we varied this relative timing in a way that sometimes the flashed dots were presented before the moving dots arrive at the position of physical alignment (positive relative timings) and sometimes the flashed dots were presented after (negative relative timings). We used 10 relative timings ranged from −100 to 120 ms. Each relative timing was sampled 20 times within a single session according to the method of constant stimuli.

2.2. Static dots condition

This condition was identical to the moving dots condition, except for the fact that the dots that we previously referred to as moving dots here remained still for one second. The relative positions between the fixed dot and the corresponding flashed dot matched those that we used in the moving dots condition. As before the flashed dots were presented for 10 ms. This condition was used to examine how much the shift of half of the dots blurred the Glass pattern in absence of motion. For the sake of clarity, we keep using the term "relative timing" although here it has only a spatial meaning. We used the same 10 relative timings as before and were sampled 20 times.

2.3. One-dot position judgment condition

Each trial consisted of a single dot moving at a 6 deg/s in a random direction for one second. The initial position was chosen randomly within the area of the circular aperture. When a moving dot reached the limit of