Vision Research 50 (2010) 1131–1139

Contents lists available at ScienceDirect

Vision Research

journal homepage: www.elsevier.com/locate/visres

Temporonasal motion projected on the nasal retina underlies expansion–contraction asymmetry in vection

Takeharu Seno [a,*], Hiroyuki Ito [a], Shoji Sunaga [a], Shinji Nakamura [b]

[a] Faculty of Design, Kyushu University, 4-9-1 Shiobaru, Minami-ku, Fukuoka 815-8540, Japan

[b] Nihon Fukushi University, Faculty of Child Development, Division of Clinical Psychology, Okuda, Mihama-cho, Aichi 470-3295, Japan

ARTICLE INFO

Article history:
Received 21 August 2009
Received in revised form 19 March 2010

Keywords:
Vection
OKN
Optic flow

ABSTRACT

Contracting visual stimuli have been found to induce stronger vection than expanding stimuli. We sought to determine which component of motion underlies the advantage of contraction over expansion in inducing vection. Either the right or left hemi-visual field of an optic flow was presented to either the right or left eye. Our results revealed that without temporonasal motion projected on the nasal retina, vection was weak even with contracting stimuli. Conversely, vection was strong even with expanding stimuli if this type of motion was present. The advantage of contracting stimuli in inducing vection may be caused by anisotropy in processing motion on the nasal retina.

1. Introduction

A large number of studies in visual research have reported that contracting motion is more effective for inducing vection than expanding motion (e.g. Andersen, 1986; Bubka, Bonato, & Palmisano, 2008; Ito & Shibata, 2005; Reinhardt-Rutland, 1982). However, at present no sufficient explanation for this asymmetry has been proposed. The aim of the current study was to determine the critical component of motion in expanding and contracting flows that is critical in producing the asymmetry in vection induction strength. We hypothesized that this disparity is critically related to contracting visual stimuli typically involving a vection-enhancing motion component that is not shared by expanding stimuli. We tested the effects of motion direction in combination with retinal position on vection strength.

For clarity, we refer to the rightward and leftward motions for the right eye as 'nasotemporal' and 'temporonasal' motion (see Fig. 1). These terms are based on previous studies on optokinetic nystagmus (OKN; Collewijn, 1969; Distler, Vital-Durand, Korte, Korbmacher, & Hoffmann, 1999; Ter Braak, 1936; Van Hof-van Duin, 1978). Similarly, we term rightward (leftward) motion for the left eye 'temporonasal' (nasotemporal) motion.

In a previous study, Seno and Sato (2009) presented a vection-inducing stimulus only in the right (or left) half of the visual field using monocular viewing. Using this configuration, they manipulated the stimulated retinal areas (the nasal and temporal retinas) and motion directions (temporonasal and nasotemporal) independently. Their results revealed that temporonasal motion projected on the nasal retina was the most effective stimulus for inducing vection. They termed this component of motion the 'optimum motion', and proposed the involvement of subcortical neural activity in the underlying mechanism. Based on these earlier findings, we hypothesized that the increased vection strength induced by contracting compared with expanding visual stimuli is caused by the existence of an optimum motion for vection (temporonasal motion projected on the nasal retina), that is typically present in contracting but not expanding stimuli.

When viewing the center of the flow field in an expanding stimulus, leftward motion is present in the left visual field, with rightward motion in the right visual field. For the right eye, the motion in the left visual field corresponds to temporonasal motion projected on the temporal retina, and the motion in the right visual field corresponds to nasotemporal motion projected on the nasal retina (see Fig. 2 for details). For the left eye, the motion in the right visual field corresponds to temporonasal motion projected on the temporal retina, and the motion in the left visual field corresponds to nasotemporal motion projected on the nasal retina. Thus, for expanding visual stimuli, the optimum motion for inducing vection is not present. On the other hand, in contraction, a rightward motion is present in the left visual field, with a leftward motion in the right visual field. This means that for both the right and left eyes, there is temporonasal motion projected on the nasal retina and nasotemporal motion projected on the temporal retina (Fig. 2). Thus, optimum motion is typically present when viewing contracting stimuli.

In the current study we created contracting stimuli that did not contain optimum motion, and expanding stimuli that did contain optimum motion. According to our hypothesis, such a contracting stimulus would be expected to induce weaker vection (compared

* Corresponding author. Fax: +81 92 553 4496.
E-mail address: seno@design.kyushu-u.ac.jp (T. Seno).

0042-6989/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.visres.2010.03.020

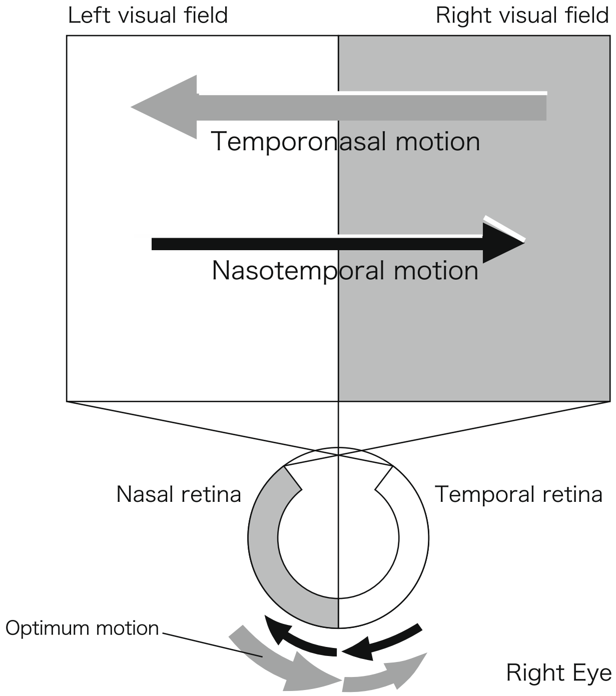

Fig. 1. Schematic illustration of the definition of motion directions, retinal positions and optimum motion for the right eye. The left visual field is projected on the temporal retina, and the right visual field on the nasal retina. The black curved arrows indicate the directions of retinal motion (not optimum motion). The gray, thick curved arrow is temporonasal motion projected on the nasal retina, that is, the optimum motion.

with a normal contracting stimulus), while an expanding stimulus including optimum motion would be expected to induce stronger vection (compared with a normal expanding stimulus, and to a contracting stimulus without optimum motion). We hypothesize that the critical factor determining the strength of vection induction is the existence or non-existence of the optimum motion, not the distinction between contraction and expansion.

To examine our hypothesis, we produced three types of vection stimuli simulating self-motion in directions along the line of sight (forward and backward motion), in 30° oriented directions from the line of sight (right-forward and left-backward motion), and in a 90° oriented direction (rightward motion). These optical flows enabled us to produce contraction that did not include optimum motion, expanding stimuli that included optimum motion, and horizontal translation stimuli that either did or did not include optimum motion, respectively. To manipulate the presence of optimum motion independently of optical flow type, we developed a new display method using dichoptic presentation of optical flows. In this method, for each participant either the right or left half of the optic flow is presented to either the right or left eye. If these stimuli are put together (right and left), they form a complete optic flow. The condition in which the right half of the optic flow was presented to the right eye, and the left half to the left eye, was referred to as the 'congruent' condition. When the right half was presented to the left eye, and the left half to the right eye, it was referred to as the 'incongruent' condition (see Fig. 3).

Under this configuration, when an expanding optic flow was the stimulus (Fig. 3), in the congruent conditions only nasotemporal motion projected on the nasal retina was present. In contrast, the incongruent condition only involved temporonasal motion projected on the temporal retina. When a contraction flow was employed, the optimum motion, that is, temporonasal motion projected on the nasal retina, was present in the congruent condition. However, in the incongruent condition, only nasotemporal motion projected on the temporal retina was present. Thus, for the contracting stimuli the optimum motion appeared only in the congruent condition. We refer to these first types of stimulus configuration as 'expansion/contraction displays'.

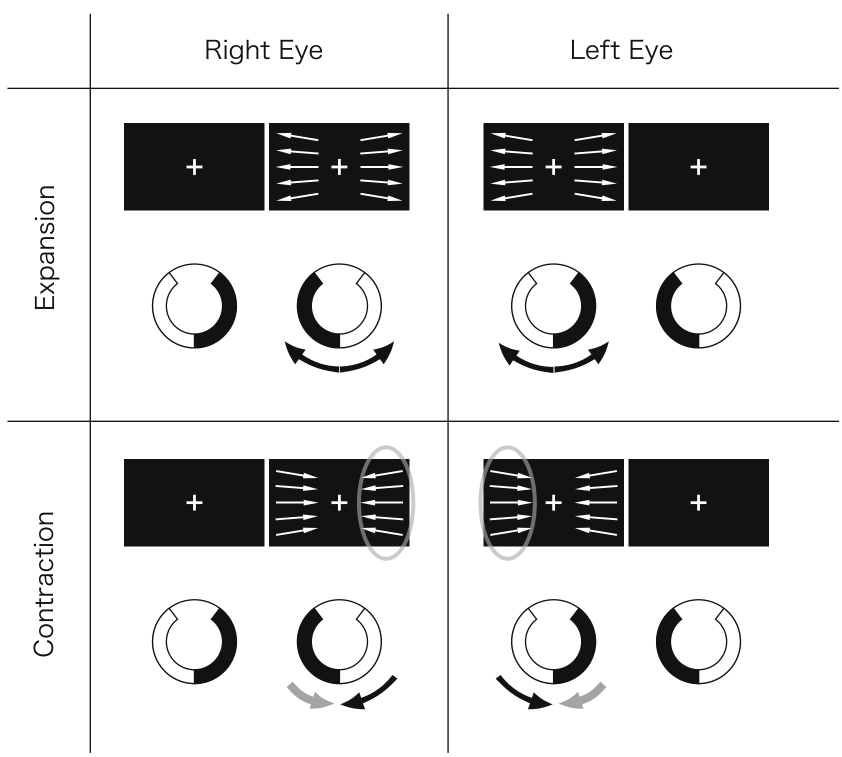

Fig. 2. Schematic illustration of the control conditions. The flows within the gray ellipses correspond to optimum motion. The black curved arrows under the eyeball indicate retinal motion that is not optimum, and the gray, thick curved arrows indicate optimum motion.