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Note

Line bisection in unilateral homonymous visual field defects

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ABSTRACT

The contralesional line bisection error in unilateral homonymous hemianopia is a frequent but neglected clinical phenomenon. Our knowledge about this bisection error is based on small samples of hemianopic patients. Moreover, horizontal line bisection has never been investigated in other unilateral visual field defects. The present study is the first to examine line bisection in a large, representative sample of patients with unilateral homonymous visual field defects. We investigated horizontal line bisection in 129 patients with left- or right-sided homonymous hemianopia (60.5%), upper and lower quadranopia (24.8%), and paracentral scotoma (14.7%), and determined the magnitude and direction of line bisection error. The contralesional horizontal line bisection error was present not only in patients with hemianopia but also in those with upper or lower quadranopia or paracentral scotoma. Neither the type nor the severity of the visual field defect was found to determine the bisection error. Only the side of the field defect seemed to determine the horizontal direction of the bisection error (left-/rightward). The contralesional bisection error is not a specifically ''hemianopic'' phenomenon. It is frequently associated with any unilateral homonymous visual field defect, i.e., hemianopia, upper/lower quadranopia, paracentral scotoma. Moreover, our results further support the recent finding that the contralesional bisection error is not a direct consequence of the visual field defect. Yet, they also suggest that, although the visual field defect does not seem to be the primary cause of the contralesional bisection error, it may nevertheless contribute to it.

1. Introduction

Unilateral homonymous visual field defects are one of the most frequent functional sequelae of acquired brain injury (Suchoff et al., 2008). They are caused by unilateral injury to the postchiasmatic visual pathway, which is frequently accompanied by extrastriate lesions, and lead to the loss of vision in corresponding parts of both monocular hemifields contralateral to the side of brain injury. Hemianopia is the most common field defect (loss of both monocular hemifields), followed by quadranopia (vision loss in the upper or lower quadrant), and paracentral scotoma (small island-like parafoveal field defect) (Zihl, 2000; Zhang et al., 2006).

It is well-known that these patients show severe impairments of reading (Schuett et al., 2008) and visual exploration (Zihl, 2000). It is not well-known, however, that patients with unilateral homonymous hemianopia also frequently suffer from a persistent spatial distortion that is characterized by

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a reliable contralesional deviation in manual bisection of horizontal lines towards the side of their affected hemifield (Barton and Black, 1998; Barton et al., 1998; Zihl, 2000; Hausmann et al., 2003; Doricchi et al., 2005). This error is significantly larger than that of normal observers, who typically bisect horizontal lines with a slight leftward error (i.e., pseudoneglect) (Jewell and McCourt, 2000).

The contralesional bisection error may indicate an underlying visual–spatial disorder that affects the horizontal egocentric visual midline and causes a systematic, contralesional shift of the visual midline or subjective straight-ahead direction in visual–spatial judgments as well as spatial orientation problems (Ferber and Karnath, 1999; Kerkhoff, 1999; Zihl, 2000; Zihl et al., 2009). Since such a visual–spatial disorder is unexpected in a pure visual–perceptual deficit such as hemianopia, it is not surprising that unfortunately, and despite a much longer history, the contralesional line bisection error is also less well-known than the ipsilesional bisection error associated with visual–spatial neglect (Kerkhoff and Bucher, 2008).

Only few studies have dealt with line bisection in visual field loss since the first reports on the hemianopic contralesional line bisection error (Axenfeld, 1894; Liepmann and Kalmus, 1900; Best, 1910a, 1910b). Further, most of our knowledge is based on relatively small samples of patients with unilateral homonymous hemianopia (Barton and Black, 1998; Barton et al., 1998; Zihl, 2000; Hausmann et al., 2003; Doricchi et al., 2005). Although a recent study examined the contralesional bisection error and determined its origin in a large sample of hemianopic patients (Zihl et al., 2009), line bisection has never been investigated in other homonymous visual field defects [with the exception of a single report that studied line bisection in six patients with altitudinal visual field defects (Kerkhoff, 1993)]. Thus, it is still unknown whether the contralesional bisection error is a specifically ''hemianopic'' phenomenon, or whether it is also present in other types of unilateral visual field defects.

We therefore investigated line bisection in a large, representative sample of 129 patients with left- or right-sided unilateral homonymous hemianopia, upper or lower quadranopia, or paracentral scotoma, and determined the magnitude and direction of line bisection error for each subgroup. We also wished to examine the effects of the severity and side of the visual field defect on line bisection performance in order to test whether the contralesional bisection error is a consequence of the visual field defect itself. If the bisection error is a direct consequence of hemianopia, the error should be found in all patients with visual field loss and its magnitude should be negatively correlated with the severity of the visual defect, i.e., the smaller the visual field sparing, the larger the bisection error.

2. Methods

2.1. Subjects

Ethical approval for this study was in accordance with the ethical standards of the Max-Planck-Institute of Psychiatry Munich, and written consent was obtained from all participants. 129 patients with homonymous unilateral visual field defects (visual field sparing $\leq 10^{\circ}$) participated in this study. None of the patients had received any treatment for their visual field defect. Only right-handed patients [laterality quotient of >+80 in the Edinburgh Handedness Inventory (Oldfield, 1971)] were included to eliminate the effects of handedness, which is a significant factor affecting line bisection performance (Jewell and McCourt, 2000), and all patients had adequate motor performance of the right hand. Patients with reduced visual acuity (<.90 for near and far binocular vision), impaired spatial contrast sensitivity as assessed with the Vistech contrast sensitivity test, disturbances of the anterior visual pathways or the oculomotor system (according to ophthalmologic examination), visual neglect, alexia, impaired verbal comprehension, or paresis of the upper extremities were excluded. For excluding patients with any signs of visual neglect, we administered tests similar to those described in the Behavioural Inattention Test (Halligan et al., 1991) (letter and star cancellation, figure and shape copying, and drawing from memory); none of our patients omitted targets in the contralesional hemifield, and copying and drawing from memory were entirely normal. All participants had at least 5 years of education. Demographic and clinical details of the patients are presented in Table 1. Homonymous hemianopia was the most frequent type of visual field loss (60.5%), followed by quadranopia (24.8%), and paracentral scotoma (14.7%). 53.5% of patients showed a left-sided visual field defect, 46.5% a right-sided field defect. Mean visual field sparing was 3.4° (range: 1–10°). Occipital stroke was the most common etiology of brain injury (109 patients, 84.5%); 11 patients (8.5%) suffered from closed head trauma, and 9 patients (7%) underwent surgical removal of an occipital tumor. Time since brain injury was on average 26.1 weeks, and varied between 2 weeks and 8 years.

2.2. Visual field testing

Monocular and binocular visual fields were assessed using kinetic perimetry with a Tübingen perimeter. Target diameter was 69 min of arc of visual angle, its luminance was 102 cd/m^2; background luminance was 3.2 cd/m^2. The target was moved with a speed of ~2°/sec from the periphery towards the perimeter's centre. Patients were instructed to fixate a small red spot of light (diameter: 30 min of arc) in the centre of the sphere and to press a response button as soon as they detected the target. Fixation accuracy was monitored through a telescope. The visual field border was determined along 16 meridians. Visual field sparing was defined as the extent of visual field in degrees (°) between the fovea and the visual field border along the left or right horizontal axes in cases with hemianopia or paracentral scotoma, or along the main meridians in the right upper (45°), left upper (135°), left lower (225°), or right lower (315°) meridians in cases with upper and lower quadranopia, respectively. Visual field sparing indicates the severity of the visual field defect, i.e., the smaller the field sparing the more severe is the visual field defect.

2.3. Assessment of line bisection

We assessed line bisection performance using the conventional paper-and-pencil bisection task, which is typically used with hemianopic patients and has been found to be a valid test for assessing line bisection performance in visual field defects