CORTEX 44 (2008) 200–205

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Historical paper

Line bisection as an early method to assess homonymous hemianopia

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ARTICLE INFO

Article history:
Received 27 February 2006
Reviewed 22 April 2006
Revised 19 July 2006
Accepted 25 July 2006
Action editor Georg Goldenberg
Published online 17 November 2007

Keywords:
Line bisection
Hemianopia
Assessment
Spatial neglect

ABSTRACT

Horizontal line bisection task is a common clinical task well known to most neuropsychologists. Typically, patients with visuospatial neglect show a reliable ipsilesional deviation in the bisection of long lines. Less well known in the English literature is the typical line bisection error observed in hemianopic patients who show the opposite deviation. In fact, this contralesional deviation in bisection was well known in the old German scientific literature. In 1894, more than 110 years ago, the German physician Dr. D. Axenfeld published a short case report about line bisection as a ''simple method to diagnose hemianopia''. His paper is one (if not the first) historical report, describing the ''typical hemianopic line bisection error''. At the time of its publication, it was a very popular paper in the German scientific community frequently cited by subsequent researchers. Between 1900 and 1920, Axenfeld's observation motivated several further studies using bisection by well-known researchers such as Best, Liepmann, Wilbrand, Poppelreuter and Fuchs. Surprisingly, most of today's clinical and cognitive studies use experimental modifications of line bisection in neglect patients and healthy subjects, often without realizing that this task was originally devised for the assessment of hemianopic patients. Consequently, the hemianopic line bisection error was ''neglected'' for many decades until its recent ''rediscovery''. The present paper has three aims. First, Axenfeld's classical report is translated. Second, interpretations arising from early bisection studies (around 1900–1930) in hemianopic patients are summarized and framed within contemporary science. Finally, we attempt to explain why this formerly well-known clinical phenomenon was forgotten later for nearly a century.

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doi:10.1016/j.cortex.2006.07.002

1. Axenfeld's report

1.1. *A simple method to diagnose hemianopia (Axenfeld, 1894)*

It is well known that we are subject to an illusion when we compare two distances, one in the upper and the other in the lower part of the visual field, in the way that we overjudge the upper distance. When we try to bisect a vertical straight line by visual estimate we make the upper part too short; in experiments by Delboeuf (1886) cited in Axenfeld (1894) the average difference was 1/16. Even smaller differences are perceived in the outer and inner half of the visual field; they are only obtained with monocular viewing; you typically make the outer (temporal) half, hence the right for the right eye, the left for the left eye, too short.

According to experiments by Kundt this error is 1/40 at the most. These phenomena explain themselves by the muscle forces at the eyeball. The profile of the lower (muscle) surpasses that of the upper eye muscle considerably despite their same length, and the same holds true for the inner as contrasted to the outer eye muscle (I cite Wundt, Physiologische Psychologie II, 1, 122). Accordingly one may assume, that in order to produce an eye ball excursion of the same size the upper eye muscle requires a somewhat greater innervation energy than the lower, and the outer a greater than the inner.

I had the opportunity to study an individual, who had sustained a large brain injury in the region of the upper left occipital gyrus subsequent to a trauma. There was rightsided lateral homonymous hemianopia with dyschromatopsia for yellow and blue. After a transient period with agitation, hemiparesis and aphasia there remained no serious movement handicap in any part of the body. Attentive observation revealed that the patient performed combined (binocular) eye movements to the left side more vigorously than to the right side, such that a slight paresis of the right external rectus (eye muscle) and left internal rectus (eye muscle) could be assumed. There was no ptosis, nor nystagmus. From the literature available to me I see that hemiopia is rarely accompanied by eye muscle disorders, or perhaps slighter degrees of impairments are disregarded. From a theoretical viewpoint these are always to be expected. Actually, in order to explain the fact that the eye always directs itself with the macula (yellow spot) towards the light source we have to assume, that at a central position the inner quadrant of the retina is coupled with the musculus rectus externus and the outer quadrant with the internus rectus, the upper with the inferior rectus etc., so that light perception and movement impulse arise simultaneously and are simultaneously reduced.

When confronted with a narrow paper stripe of 6 cm length and the instruction to bisect it monocularly, the patient committed (1) errors substantially larger than those found by Kundt, on average .06 (the patient was a farmer who could neither read nor write); (2) he made, as the normal subject, the outer half too small, only when keeping the right eye open; however with the left eye he on the contrary made the inner half too short; the error was .1; and (3) he committed the same error to a larger extent with both eyes open during bisection of the paper stripe, the error was .15. The vertical paper stripe was halved normally, in the way that the upper half was made too small. The explanation of this phenomenon emerges from that proposed by Wundt for the normal eye, except that it is not the greater or weaker profile of the muscle, but the greater or weaker power of it that has to be taken into account.

Hence, if a subject commits during monocular bisection of a horizontal line with each eye always the same error, in the way that he makes the same half too short, and when he commits the same error to even a larger extent with both eyes open, it is a question of homonymous lateral hemianopia on the same side as the shorter half of the bisected line. The method suggested here may be useful in cases, where we have no immediate access to a perimeter, in the private practice, for non-specialists, and to unmask malingerers.

2. Early studies on line bisection

When investigating the eyes of a patient with right hemianopia, Hugo Liepmann, assistant at the psychiatric hospital of Dalldorf (today ''Karl Bonhoffer Heilstätten, Berlin Lichtenau/Germany) observed by chance that his patient, while bisecting vertical lines normally, erred constantly when asked to bisect a horizontal line, in the way overestimating the right segment of the line. E. Kalmus, assistant at the psychiatric hospital in Lübeck/Germany replicated Liepmann's observation in one of his hemianopic patients. Consulting the available literature of that time, Liepmann and Kalmus (1900) found the short case report by Axenfeld, translated above, but no further investigations concerning their observations. Like Axenfeld, Liepmann and Kalmus were aware of the clinical implications of their observation for the assessment of hemianopia (because line bisection does not require fixation and could complete the perimetric diagnosis). Moreover, they stated, that this observation has ''mainly theoretical relevance as being a fact to which must be referred to in a theory about the coming off of our spatial understanding'' (Liepmann and Kalmus, 1900, p. 838). In administering the line bisection task to patients with left and right hemianopia, the authors proved, ''whether the phenomenon [...] would have a right to generality and whether the way and the condition of its occurrence would permit the attempt of an explanation'' (Liepmann and Kalmus, 1900, p. 838). Deviations to the respective scotomatous field occurred in 81% of the 600 bisection trials in all patients. The magnitude of the deviation was 3–20% of the whole line length (see Fig. 1).

In varying the length of the presented lines they found the largest error in lines of 4–10 cm length, while the error was absent when bisecting short lines (0.5–2 cm). When head movements were made, there was no proportional increase relative to the lengths of lines, and the error disappeared with very long lines (40–50 cm). The authors also found an analogous deterioration when patients had to judge the centre of a circle (a task many decades later used with neglect patients, cf. Halligan and Marshall, 1991a).

A great deal of research has been conducted in patients with hemineglect and in healthy subjects in order to establish the mechanisms underlying the spatial nature of normal and distorted performance in line bisection. Liepmann and