


**Reduction of Body Sway by Stimuli Imaged within a Cortical Scotoma: A Case Study**

Jane E. Raymond* and Herschel W. Leibowitz

The reduction of body sway by visual stimulation was equally effective for stimuli imaged within a cortical scotoma or in the mirror image position in the normal visual field. The results are consistent with the concept of distinct visual orientation and discrimination modes of processing visual information, which suggests that spatial orientation functions do not necessarily involve awareness. Invest Ophthalmol Vis Sci 26:1021–1024, 1985

Using ablation techniques, Schneider demonstrated that visual discrimination and visually-guided spatial orientation can be selectively dissociated in the hamster. His finding that removal of either the visual cortex or the superior colliculus disrupted discrimination or orientation functions, respectively, suggested the existence of two reasonably separate and parallel visual systems. For humans, Held has proposed the term “two modes of processing” to differentiate object recognition, ie, “focal” vision, from spatial orientation, ie, “ambient” vision. Subsequent research has suggested that the focal mode, which addresses the question of “what,” is cortically based and well-represented in consciousness. Alternatively, the ambient mode, which concerns the question of “where,” is thought to be mediated reflexively with little or no conscious concomitant.

Evidence for the dissociation of discrimination and orientation functions in humans has been found in the study of cortically blind individuals. Observations of visual functions in patients with unilateral cortical lesions has shown that while pattern vision is probably absent in the scotomatous field, some residual visual functions (eg, flicker perception, motion perception, or the appearance of eye movements toward unseen objects in the blind hemifield) may remain. Although earlier views of cortically blind patients conservatively held that any reported residual vision resulted from surviving cortical tissue, more recent evidence suggests that some visual functions persist and may be mediated by subcortical pathways. Perenin and Jean-nerod examined the capacity of hemianopic patients to point to a briefly flashed light presented in their blind field. By comparing patients with pre- and postgeniculate lesions, they were able to demonstrate that elimination of cortical inputs only (ie, postgeniculate lesions) did not impair pointing, whereas removal of both cortical and subcortical pathways did. Similarly, accurate pointing to unseen objects by cortically blind patients was also reported by Bridgeman and Staggs. In a study involving patients with unilateral surgical removal of one hemisphere, it was reported that patients were able to make saccades towards objects placed in their hemianopic field, although the accuracy of such eye movements is quite poor.

In the studies described above, the cortically blind observer is asked to make a conscious judgement regarding the position of unseen objects in space. Since residual visual functions in cortically blind individuals are most likely to be ambient and, therefore, primarily reflexive, their existence may be more
Fig. 1. Kinetic visual fields measured with a Goldman perimeter. The area inside the dashed line indicates the seeing portions of the visual field.

Easily demonstrated by employing visual tasks that do not require voluntary behaviors. Such a function is the attenuation of low frequency body sway in the presence of visual stimuli. Control of body sway is a convenient, objective, and easily quantifiable visually-controlled response which is under reflexive control. In the present note, the existence of ambient visual function in cortically blind areas of the visual field was demonstrated by observing reductions in body sway by stimuli imaged within a scotomatous area.

Materials and Methods. A left-handed, 19-year-old male college student volunteered to be the subject of the present experiment after having signed an informed consent form regarding the details of the experimental procedure. At the age of 15, he experienced the sudden onset of a severe right hemiplegia with associated aphasia, headache, and right homonymous hemianopia. CT scan at that time revealed evidence of infarction in the deep left temporal lobe. Cerebral angiography showed only one abnormality consisting of a narrowing of the left carotid artery over a 1.0-1.5 cm segment. Other aspects of the neurologic examination were unremarkable. The diagnosis was complicated migraine with associated infarct and renovascular hypertension. Two years later, the patient had no speech disturbances, only mild spasticity on the right, mild impairment of fine motor control in the upper and lower right extremities, mild right hyperflexia, and a right Babinski sign. His gait was almost normal. He continued to have a right superior quadrantopia with normal pupillary reflexes, normal eye movements, and no papilledema.

At the time of the experiment (ie, 4 yr after the infarct), kinetic visual fields were measured using a Goldman perimeter. Visual fields are shown in Figure 1. Visual acuity was also assessed and found to be 20/20 in both eyes.

Posural stability was measured with a force platform (Kistler, Model 926 A) and an online PDP (DEC, 11/34) computer. The data acquisition program calculated the center pressure under the foot at a rate of 50 Hz for a 10-sec period. These data were used to calculate the vectorial sum of displacement (ie, change in location of the center of pressure) in the anterior-posterior and medial-lateral directions to arrive at an estimate of the total excursion during the 10-sec interval.

The force platform was enclosed in a light tight booth. Visual stimuli used in the experiment were placed inside the booth at a distance of 50.8 cm from the subject’s eye. Fixation was provided by a red light emitting diode (LED), while the stabilizing stimuli were generated using a masked electroluminescent panel.

Postural control was measured under six different stimulus conditions. In four of these conditions, a green disk of light was presented 20.6 deg from the fovea along the oblique meridian of either the upper left (seeing) or the upper right (scotomatous) visual field. Along with a fixation light, this stabilizing stimulus was viewed binocularly in the otherwise dark booth. The green disk was either large (4.3 deg in diameter) and dim (6.8 cd/m²) or small (2.2 deg in diameter) and bright (26.0 cd/m²). The total luminous flux from either stimulus was the same. A fifth condition to measure baseline body sway in the absence of the stabilizing stimuli was conducted in the dark with only the red fixation light present. A sixth condition was conducted in which the subject closed his eyes while standing in a brightly lit room. This latter condition was included to estimate the
effect of contourless diffuse light. Six trials were presented for each of the four conditions with a stabilizing stimulus. Postural control in the dark condition was assessed on 12 trials. Three trials of standing in the brightly lit room with eyes closed were conducted. All conditions were presented in a counter-balanced fashion to control for the effects of fatigue.

On a given trial, the subject positioned his left foot on the center of the 62 cm by 41 cm force platform and stood comfortably on both feet until the trial was initiated. He was instructed to fixate the LED and, following a ready signal, to maintain balance on the left foot only for a 30-sec period. The 10-sec body sway sampling interval was initiated silently at a random interval (between 5 and 15 sec) after the onset of the trial. When required, the stabilizing stimulus was silently switched on at the time of the ready signal. Between trials, the subject rested for at least 30 sec in a brightly lit room to prevent dark adaptation. Although no objective measure of fixation was obtained, the patient was periodically informed of the importance of maintaining fixation on the LED. He was highly cooperative throughout the experiment and voluntarily terminated several trials in which fixation was lost. At the end of each trial, the subject was asked to report whether a disk had been present. He could not reliably detect the presence of either the large or small disk when it was imaged within the scotomatous field.

Prior to beginning the experiment, detectability of the stabilizing disk was more formally assessed by conducting a series of simple detection trials. On a given trial, the disk was presented either in the upper left or upper right quadrants of the visual field (20.6 deg from the forehead along the oblique meridians). All trials were conducted in the dark with only the fixation LED visible at the onset of the trial. The patient fixated the LED and signalled that he was ready. On half the trials, the disk was then silently illuminated and the patient responded whether or not he could detect its presence. Although the patient claimed he could not see anything in his scotomatous field, he was encouraged to guess. He was told that the disk would be present on 50% of the trials and that by guessing he could improve his score. When the disk was presented to his scotomatous field, the percentage of correct responses was not significantly different from chance. When the disk was imaged in his seeing field, 100% detection was obtained. As before, no objective measure of fixation was obtained.

Results. The mean total excursion of the center of pressure obtained in the six conditions of testing are presented in Figure 2. Standard deviations were 0.1 cm or less for all conditions. It will be noted that visual stimuli reduced total body sway excursion by approximately 50% relative to that measured in the dark and in the contourless light condition. Moreover, the magnitude of this reduction was independent of whether the stimulus was imaged within the scotoma or in the corresponding mirror image position in the seeing field. There were no differences due to stimulus size or luminance.

Discussion. Consistent with previous findings, the results demonstrate that the presence of visual stimuli reduces body sway. Moreover, the stabilizing effect of visual stimuli was observed to be as strong when stimuli were presented within a cortical scotoma as when presented in the mirror image position in a seeing portion of the visual field. This effect suggests that in the patient observed, visual pathways mediating postural control remained intact while those mediating perception did not. These results are consistent with previous studies which suggest that the contribution of vision to spatial orientation does not necessarily involve awareness.

Since fixation was not objectively measured, the possibility remains that the subject adjusted his eye position so that the stabilizing stimuli were positioned on the seeing portions of the visual field. The subject, however, appeared to be aware of the need to maintain a steady eye position on the fixation target and voluntarily terminated trials in which he failed to do this. This behavior suggests that "cheating" does not account for the present observations. A second problem is that the image of the disk may have formed a diffuse streak on the retina which may have extended beyond the scotomatous region. This light scatter could then have been used to stabilize body posture.

While it is difficult to rule out this possibility, the patient was unable to detect the presence of the disk when imaged in the scotoma, which suggests that any diffuse light landing on the seeing portions of the retina was of subthreshold intensity. It seems unlikely that mechanisms mediating detection would be less
sensitive than those involved in the visual control of body sway.

Since interpretation of results from blindsight experiments, such as this, is difficult in view of the possible artifacts described above, and since this is a single subject study, caution must be exercised in drawing conclusions from this report. However, the results suggest important implications for the evaluation of visual function following brain damage. Because the majority of visual testing procedures are designed to evaluate focal vision and are insensitive to ambient functions, they do not reflect the potential contribution of vision to spatial orientation capacities.

Key words: body sway, cortical scotoma, blindsight, visual–vestibular interaction, visual orientation

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From the Department of Psychology, Moore Building, Pennsylvania State University, University Park, Pennsylvania. *Present address: Department of Psychology, University of Calgary, Calgary, Alberta, Canada T2N 1N4. Sponsored by a PDF to J. E. Raymond from the Medical Research Council of Canada and by grant EY-03276 from the National Eye Institute. Submitted for publication: September 6, 1983. Reprint requests: J. E. Raymond, PhD, Department of Psychology, University of Calgary, Calgary, Alberta, Canada T2N 1N4.

The Relationship between Tonic Accommodation and Ciliary Muscle Innervation

Bernard Gilmartin and Robert E. Hogan

Previous studies have used Badal laser optometry to demonstrate significant variance in the distribution of tonic (or "dark-focus") resting positions of accommodation (TA) for groups of observers. This study investigates whether individual differences in TA are due to individual differences in autonomic tone of the ciliary muscle by comparing separately the effects of a muscarinic receptor antagonist (Tropicamide 0.5%) and a beta receptor agonist (Isoprenaline 3%) on the distribution of TA. Ten subjects were used for each study with mean ages of 23.2 and 23.0 yr, respectively. The distribution of TA within each subject group was equivalent. Darkroom measurements of TA and pupil diameter were determined with a Badal laser optometer and infrared photography. Distance correction and amplitude of accommodation were determined by standard optometric techniques. Isoprenaline produced a significant hyperopic shift in TA of 0.47 D over 22 min but this was not accompanied by a significant change in standard deviation of the TA distribution. This finding was in accord with the authors' previously reported investigation using the beta receptor antagonist Timolol Maleate. Tropicamide also produced a significant hyperopic shift in TA of 1.24 D over 24 min, and this was accompanied by a significant change in standard deviation of the distribution from 0.87 to 0.17. The results indicate that the parasympathetic system plays a significant role in determining the TA position and that the variations in TA between individuals is a consequence of parasympathetic rather than sympathetic ciliary muscle tone. Invest Ophthalmol Vis Sci 26:1024–1028, 1985

It is well established that accommodation adopts an intermediate resting position when the quality of visual stimulation is degraded,1 and the term tonic accommodation (TA) is appropriate when describing

References