

An Optical Approach to Aid Cerebral Hemiplegics*

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Introduction. Communication is the process by which information is received, interpreted, and retained; however, communication often breaks down as a result of brain injury. It has been estimated (10) that there are 400,000 adults in the United States with some degree of communication loss from stroke, and each year another 20,000 people become similarly afflicted. The ability to transmit and/or receive information depends on visual and auditory comprehension and retention, reading comprehension, visual motor facility, and speech. These areas are so interrelated that a collapse in one often causes a breakdown in a closely connected ability (6).

One of the major factors contributing to a stroke patient's communication disorder is a visual field disturbance. A common problem incurred by stroke patients is that of homonymous hemianopsia. A schematic drawing of the central visual pathways (fig. 1) indicates that fibers from the temporal half of the retina of the right eye pass through the optic chiasm and, without crossing, pass to the lateral geniculate body of the right side. The nasal fibers from the left retina decussate in the optic chiasm and enter the optic track of the right cerebral hemisphere. There they join the uncrossed fibers from the temporal half of the right eye, and then pass to the lateral geniculate body. Thus, the termination of the nasal fibers is contralateral. As seen in figure 1, a large lesion of the occipital lobe on the right side blocks impulses from both eyes which results in left lateral homonymous hemianopsia; "half-blindness" because the geometric half of the visual field is involved; "homonymous" since the corresponding halves of each retina are blinded; "left lateral" be-

cause nothing to the left side is seen, and because the disturbance is named for the side of the visual field defect and not for the side of the "retinal blindness."

Background. For over a half century, various attempts have been made to aid the patient with homonymous hemianopsia. Duke-Elder (3) refers to the early work of Braunschweig (1920) and Strebel (1923) to enlarge the visual field by bending the light rays. In 1926, Weiner (9) reported the application of a prism as a mirror using the property of total internal reflection. In 1929, Young (11) successfully employed a reflecting prism to the spectacle correction of a 34-year-old female who had suffered permanent right homonymous hemianopsia with macular sparing during her eighth month of pregnancy. Young stated, ". . . it seems remarkable that this patient, who was at first almost helpless, now drives an automobile." The patient objected to the unsightliness of the prism. In 1949, Bell (1) used a small mirror appliance for patients with homonymous hemianopsia, but the number of successful cases was not reported. Burns and co-workers (2) reported a clinical evaluation of six patients with a similar defect; three were successful wearers of the mirror device. In 1955, Duszynski (4) recommended dichroic mirrors, also called "beam splitters" because they transmit certain spectral regions and reflect the remainder. However, the brightness difference between the direct field and the reflected image, together with the very conspicuous size—as large as a spectacle lens—were not appreciated by the wearers. No statistics on the results were quoted in his paper.

Three patients with long-term hemianopsia were fitted with a mirror device by Walsh and Smith (8) in 1966. Duszynski (4) showed what he described as, ". . . a conventional type of hemianopsia mirror"

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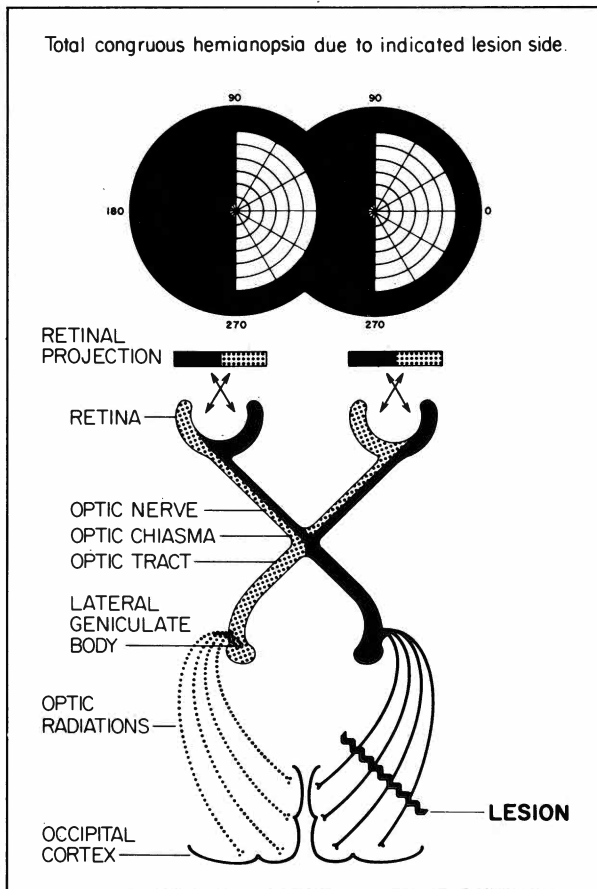


Fig. 1—Schematic drawing of the central visual pathways showing homonymous hemianopsia as a result of a lesion in the occipital cortex on the right side.

(manufactured by 'The House of Vision'). However, these items were made only rarely and by special order according to the same manufacturers (5). The mirrors were made of glass in the past and were a source of potential danger to a partially sighted individual.

Although some previous efforts have been made to develop an optical aid for hemianopic patients, no large scale attempt seems to have been undertaken, and only a few patients have received the benefits of such a device. Apparently, little has been done with specific reference to the large number of hemianopes in our medical centers, institutions, and nursing homes who are so disadvantaged by this portion of their illness that rehabilitative achievement is unusually difficult and unnecessarily prolonged.

Rationale. A patient with the type of lesion

shown schematically in figure 1 often suffers concurrent left hemiparesis, left hemianesthesia, and even agnosia for the left half of space, that is, inability to recognize or tendency to ignore the left side of space, including the left side of his own body. The portion of his body which he cannot feel or see may be cause for disruption of body-image and function.

Many patients are seen in the Medical College of Virginia Hospitals who have hemiplegia and hemianopsia. The development of patient awareness in the hemianopic field has been a most difficult problem. This condition seriously impedes the rehabilitation of the hemiplegic patient to such an extent that he must often remain in institutional care without ever developing enough facility to live in his own home, a foster home, or a home for the aged.

It should be understood that this is not an attempt to mediate sharp visual acuity in the retinal periphery, for acute visual perception is a function of the fovea centralis and drops off markedly a few degrees outside the macula in the normal eye. Visual perception and awareness of movement in the peripheral retina is of importance in the phylogenetic development of the vertebrate eye, and it is primarily this movement-seeing capacity which can be transferred to the functionally normal portion of the retina by this optical device.

Specific Aims.

1. To develop a series of plastic mirrors which can be mounted to a patient's spectacle frame as an aid to cerebral hemiplegics with homonymous hemianopsia.
2. To provide a clinical service for patients so afflicted within a broad geographical area. To our knowledge there is no such service available in the entire middle Atlantic region.
3. To adapt a particular device tailored to each patient, depending on his particular needs, thus expanding his binocular visual field as early as possible in the rehabilitative phase. While hemianopsia is a defect of the binocular field, incomplete or sector defects may also be treated by this device if the visual depression is a troublesome source of field restriction as, for example, a lower quadrant lateral hemianopsia on either side.
4. To provide the needed refractive correction made of plastic lenses so that the attached mirror device will not be a burden to the patient, but on the contrary, will be a real

source of added protection from hazard to the blind side and thus improve his perceptive faculty and spatial orientation.

Results and Discussion. Patients are available for this study at various levels of disability, not only from the MCV Hospitals, but from other institutions and from the private sector. In a pilot study, 12 patients with homonymous hemianopsia with central fixation sparing have benefited by one of our mirror prototypes. There has not been the opportunity for long-term follow-up to date, but the encouraging results may be exemplified by briefly discussing some of the observed clinical results.

Case 1: A middle-aged female patient with a left homonymous hemianopsia following a cerebral accident had lost all of her communicative ability and kept her head turned toward the right side about 25° with agnosia for the left side. A mirror was attached to a pair of plastic spectacles without her exact prescription lenses, since her refractive error could not be readily determined. Within a short span of a week or two the patient began to carry her head in the straight forward position and became aware of her surroundings on the blind side.

Case 2: A 67-year-old female stroke patient, blind in the right eye and with complete temporal field loss in the left eye, was treated with a mirror small enough so that it did not interfere either with central fixation or with the intact left nasal field. Due to the patient's post cataract left spectacle lens her visual field was further depressed. Yet, she adapted quickly to the mirror device, and for the first time since the cerebral vascular accident she could avoid obstacles to her left side.

Case 3: A young teen-age girl had a similar field loss, that is, light perception (without light projection) in the right eye, and complete temporal hemianopsia with macular sparing in the left eye, due to a severe head injury. The increased visual awareness was sufficient for her to obtain a driver's license from the State Division of Motor Vehicles.

Case 4: A 22-year-old male college student with left homonymous hemianopsia and binocular macular sparing adjusted quickly to the optical mirror, and he, also, was able to complete the requirements of the Division of Motor Vehicles for a Virginia driver's license.

Case 5: The subjective improvement in visual field expansion with the help of this appliance, which in turn aids in the total rehabilitative process, can be shown in this particular patient. An adult male was

brought to occupational therapy after having been fitted with one of the mirror devices, and for the first time he was able to sandpaper a whole section of a piece of 10" × 10" wood, that is, he could see both left and right sides of the working surface. Previously, he had always stopped at the center line and waited for one of the therapy personnel to come to his table and rotate the board 180°; he would then complete the remaining side. Figure 2 shows one of the mirror prototypes made larger than normal for photographic purpose.

An optical (mirror) device to project the mirror image of the blind field into the seeing half-field enables a patient to be aware of both sides of his environment and thus helps to expedite the usually long convalescent period. Hypalgesia and hypesthesia also slow the recovery process, but being able to see a paretic limb aids in the restoration of function. Information presented to the side of the "retinal blindness" through the mirror device has been helpful to all of the homonymous hemianopsia patients treated thus far. They soon learned to properly project the image to the correct side. Some investigators (7) have not had satisfactory results with such devices; however, this has not been our experience. Some patients have indicated that getting used to the device is similar to an automobile driver using the rear view mirror, that is, the person



Fig. 2—Image of a left eye through one of the mirror prototypes which aids the homonymous hemianopsia patient to be aware of his environment on the blind side.

adapts to the image projection. Thus, the patient enjoys fuller visual fields, which in turn improves his total functioning capabilities and reduces the possibility of accidents due to the lack of visual perception and recognition of motion in the area of the visual field loss.

The success of our pilot study has led to professional support from the Virginia Commission for the Visually Handicapped, the Virginia Department of Vocational Rehabilitation, the Department of Public Health of Richmond, Virginia, and the Veterans Administration Prosthetics and Sensory Services, as well as various departments of the School of Medicine at the Medical College of Virginia, Virginia Commonwealth University. A three-year expanded study is planned. Results will be disseminated in report form to the sponsoring and supportive agencies, referring physicians, and to the appropriate literature.

In summary, research has been directed to the design and development of an optical aid for patients suffering from hemiplegia caused by a cerebral hemorrhage, thrombosis, embolism, tumor, injury, and so forth, and to follow their visual rehabilitation up to a three-year convalescence. Hemianopsia frequently accompanies intracranial lesions, with a common type being homonymous hemianopsia, or blindness in the same half of the visual field of both eyes. A lesion on the right side of the brain causes a left homonymous hemianopsia so that the patient cannot see to the left of the mid-line without turning his head to the left side (fig. 1). An optical mirror permits the projection of the mirror image of the blind field into the seeing half-field to make the patient aware of both sides of his surroundings and thus helps to shorten the long recovery period (fig. 2). Hypalgesia and hypesthesia also delay convalescence, but awareness of the paretic side provides functional reinforcement. Then as the patient becomes rehabilitated, even if not completely and the homonymous hemianopsia remains, he will be able to carry on with his restricted field of vision, for example, see passing automobiles and other objects of danger which are projected onto his non-functioning side of the retina. A small plastic mirror attached

externally to the patient's spectacle frame causes only minimal interference in the remaining usable field of vision and expands the binocular visual field.

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