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The effects of simulated refractive asymmetries on eye dominance

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In an experimental test of the relationship between eye dominance and monocular acuity, 20 observers (10 consistent right-eyed and 10 consistent left-eyed) were exposed to a systematic degradation of the vision in the dominant eye while they performed eye dominance tests. This was accomplished by placing plus lenses of various strengths in front of the dominant eye. It was found that natural eye dominance behaviors are highly resistant to change and do so only in the presence of very large refractive asymmetries.

In 1593, Porta noticed that there are some situations when both eyes are open, yet only the input from one is utilized. He suggested a demonstration to prove this. He held a staff in front of himself, keeping both eyes open. He then aligned its tip with a mark on a distant wall. He alternately closed each eye and found that the point of the staff remained in perfect alignment with one eye's view; however, it seemed clearly off target when viewed with the other eye alone. This demonstration indicates that the point of the staff and the distant target are aligned in only one eye's view, while the misaligned view of the other eye is ignored or suppressed. However, the observer is not aware that he is sighting with only one eye, but rather believes that both eyes are being used simultaneously.

The consistent use of one eye in binocular alignment situations is called "sighting dominance." It is the type of eye dominance most commonly referred to, and it is a well-documented phenomenon. For observers with normal acuity, 65% habitually use their right eye in sighting tasks, 32% consistently use the left eye, and the remaining 3% are ambiocular (Porac & Cohen, 1976). These proportions are relatively constant over a wide range of age groups (Coren, 1974; Groden, 1969; Jasper & Raney, 1937; Miles, 1929; Updegraff, 1932) and are independent of cultural factors (Dawson, 1972; Hughes, 1953).

Although the existence of sighting dominance is well known, the mechanisms which underlie such preferential use of one eye remain unclear. It seems reasonable to assume that structural differences between the two eyes, such as refractive or motoric superiority of one member, could provide a basis for such preferential sighting behavior. Thus, it is commonly suggested that the eye with better acuity becomes the sighting dominant eye. Using this straightforward common sense approach to visual functions, Duke-Elder (1949) suggested that when monocular acuity is approximately equal, sighting preferences are weakened or disappear entirely. Unfortunately, the data bearing upon the relationship between sighting dominance and visual acuity is not as clear-cut as such statements might suggest. For instance, a series of studies used observers who had been prescreened to guarantee equal monocular acuity. They found that consistent sighting behaviors, replicating the usual population percentages, are still found (Coren & Kaplan, 1973; Porac & Coren, 1975a, b). Other studies have used correlational techniques in an attempt to relate sighting dominance to visual acuity. They have produced mixed results. Van Biervlet (1901), Woo (1928), and Woo and Pearson (1927) have reported that the eye with better acuity is the eye chosen to sight with, while Coons and Mathias (1928), Coren and Kaplan (1973), Cuff (1931), Gahagan (1933), Geldard and Crockett (1930), Gronwall and Sampson (1971), and Snyder and Snyder (1928) have failed to find similar relationships. These inconsistencies may result from differences in individual samples of observers or in testing conditions. For example, Crovitz (1961) has shown that visual acuity and sighting dominance are more likely to be related in left-eyed sighters than in right-eyed sighters. On the other hand, Porac, Whitford, and Coren (in press) have suggested that sighting dominance is related to near-point as opposed to far-point tests of visual acuity.

Given the inconsistencies in this body of data, it is surprising to note that no one has attempted a direct experimental test of the relationship between acuity and sighting dominance. It is possible to systematically de-

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grade the monocular acuity of the sighting dominant eye while leaving the nondominant eye refractively normal. Under such conditions one could observe when, and if, any change in sighting preference occurs. The present study is an attempt to explore the relationship between visual acuity and sighting dominance using such a direct experimental manipulation.

METHOD

Subjects

Twenty observers were paid for their participation in this experiment. They were prescreened, and all conformed to the following criteria.

Visual acuity. All observers had 20/20 Snellen acuity in both eyes, as tested at both near and far convergence positions via the Keystone Visual Skills Battery.

Sighting dominance. Two tests of sighting dominance were administered. The first was the Point Test. The experimenter stood approximately 1.8 m in front of the subject and asked him/her to extend a hand and to point at the experimenter's nose, while keeping both eyes open. The eye used to perform the alignment was noted. It should be clear that this test is a variant of the demonstration used by Porta (1593) and has been used by Coren and Kaplan (1973), Crovitz and Zener (1962), Palmer (1947), and Porac and Coren (1975a). Four administrations were given. The hand used to point with was alternated to control for any bias due to manual dominance.

The second test was the Miles ABC Test. Here the subject covered the face with the side end of a truncated cardboard cone which was open at both ends. The cone was squeezed between the two hands in order to see through the far aperture. With both eyes open, the observer viewed a target approximately 1.8 m in front of him/her. The eye used to sight with was noted. This test was also administered four times.

All right-eyed responses were scored as +1 and all left-eyed responses as −1. The final sighting score was the algebraic sum of the right and left responses. This scoring procedure provides a graded index of the direction and strength of sighting dominance. However, since this study required consistent, strongly dominant observers, 10 individuals were selected with strong right-eyed dominance (+8) and 10 with strong left-eyed dominance (−8).

Procedure

Each screened participant was fitted with a spectacle frame designed to hold a series of American Optical Company test lenses. The lenses measured from 0- to 10-plus prism diopters in graded steps of +1 diopter. Each test lens could be inserted into the spectacle frame in front of the sighting dominant eye. The 11 lenses were used in a different random order for each participant. The procedure for each test trial involved insertion of the lens, after which the subject was allowed to freely inspect the room and the surroundings for 60 sec. Both eyes were kept open. This inspection period allowed the observer to become familiar with the test lens. At the end of the inspection period the subject was tested on six repetitions of the Point Test. The scoring procedure was similar to that used in the prescreening phase of the experiment. Following testing, the lens was removed from the spectacle frame and the subject rested for 60 sec, during which he viewed the surroundings binocularly. This procedure was repeated until each observer had been tested on all 11 lenses.

RESULTS AND DISCUSSION

The results of this experiment are shown in Figure 1, where each data point represents the algebraic sum of

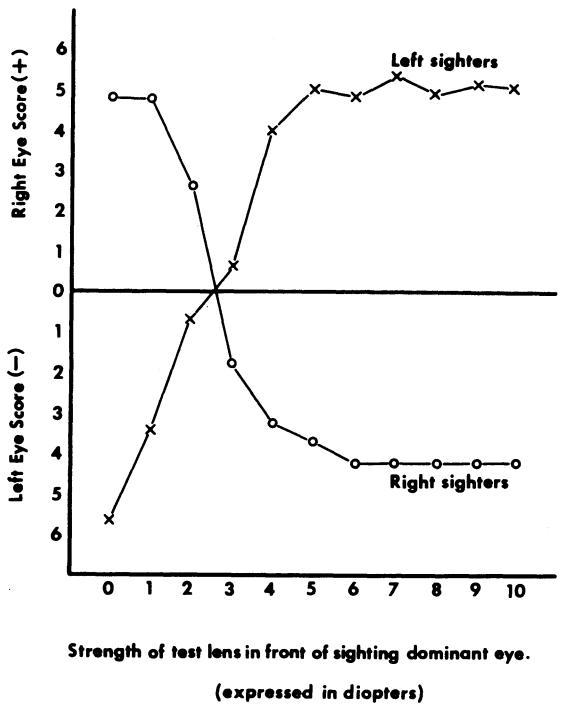

Figure 1. Changes in sighting dominance scores for right- and left-eyed subjects as a function of the strength of the test lens in front of the sighting dominant eye. (Sighting dominance scores are the algebraic sum of the right- and the left-eye responses.)

right and left sighting responses as the sighting eye is exposed to test lenses of varying strength. In effect, the sighting eye is becoming more myopic relative to the nonsighting eye. Perfectly consistent dominance would be scored as +6 or −6 on this graph.

As one can see from the figure, by severely degrading vision in the sighting dominant eye, one can alter the eye used to sight with. However, the shift to the more visually acute eye does not occur until the vision in the sighting eye has been degraded by a lens between 2 and 3 diopters in strength. In terms of Snellen ratios for far-point testing, this represents a refractive asymmetry of 20/20 in the more acute eye and approximately 20/200 in the sighting dominant eye. However, the complete take-over by the nonsighting eye does not occur even with this degree of stimulus degradation. In fact, the asymptotic performance is not reached until the vision in the sighting eye has been blurred with the test lens of 6 diopters. This represents a massive refractive asymmetry between the two eyes and is analogous to a state of visual pathology, such as that found where one eye's view is clinically suppressed. It is interesting to note that the present data indicate that both right- and left-eyed sighters act similarly.

These findings indicate that strong natural sighting preferences are altered only when large refractive asymmetries exist between the two eyes. Not all visually normal observers are completely consistent sighters such as those selected for this study. For example,

Porac and Coren (1975a), using a graded measure such as that used here, have shown that only 47% of right-eyed individuals and 26% of left-eyed individuals use their sighting dominant eye for *all* sighting coordinations. As seen in Figure 1, the shift in sighting preference as a function of reduced visual acuity in the normally dominant eye seems to be a gradual one. Hence, it may be the case that slight inconsistencies in sighting behaviors may be the result of small refractive differences between the two eyes. Looked at in this way, we may offer potential clarification for the discrepancies which exist in the literature concerning the relationship between sighting dominance and visual acuity. If samples of observers are prescreened to narrow the range of refractive asymmetries, the likelihood that a relationship will occur is greatly reduced. It is likely that the sighting eye will be the more acute eye, if the contralateral eye is very weak. However, when only minor imbalances in acuity exist, the sighting behaviors may be mixed, at times favoring the more acute and at times the less acute eye. Such gradation in dominance will only manifest itself when sighting dominance is measured as a graded scale, with scores from repeated measurements. Unfortunately, as Porac and Coren (1976) have pointed out, most investigators tend to use dichotomous classifications (right vs left) based upon a few observations. This greatly reduces the likelihood that the relationship will emerge in their data. Furthermore, the restriction of the sample to a narrow range of normal observers, homogeneous in acuity across the two eyes, would further reduce the likelihood that the relationship would appear in most survey samples.

The data from this study make it clear that there is a relationship between sighting dominance and visual acuity. However, the relationship depends upon massive differences in refraction between the two eyes. Perhaps the most remarkable aspect of sighting dominance is the preference for the input to the habitual sighting eye despite the fact that it may not be the best information available. This may well indicate that sighting dominance reflects a form of sensory or sensory-motor laterality which is independent from, or only partially dependent upon, the refractive quality of the visual input.

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