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The Dominant Eye

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The dominant eye has often been defined as the eye whose input is favored in behavioral coordinations in which only one eye can be used, the eye preferred when monocular views are discrepant, or the eye manifesting physiological or refractive superiority. Although its functional significance has not yet been ascertained, patterns of ocular dominance have been shown to be related to a large number of perceptual, performance, and clinical phenomena. The nature of these relationships has remained obscure due to the variety of alternative tests for and theoretical definitions of eye dominance.

The members of a bilateral pair of structures in the body seldom exhibit perfect equality. Often, one member of the pair tends to be preferred over the other in behavioral coordinations, or it seems to manifest physiological superiority. Thus, it is defined as *dominant*. If one consistently writes or throws a ball with the right hand, one is said to have a dominant right hand. Likewise, if one always kicks a ball with the left foot, this would be one's dominant foot.

Handedness and footedness are manifestations of sidedness or lateral dominance that have been described for centuries. They are so common that words derived from hand usage have been incorporated into the language. For example, the word *adroit* is derived from the French word referring to the right or agile side, while *gawky* refers to the left side. However, one does not encounter references to any form of lateral dominance other than that of the limbs until 1593 when Porta discussed the existence of a dominant eye in his book *De Refractione.*

Porta noticed that even when both eyes are open, the input from only one may be used. He suggested a demonstration that may easily be repeated: First, one holds a pencil directly in front of oneself. Then, keeping both eyes open, one aligns its tip with a point on a distant wall. If one alternately winks each eye, the pencil will remain in good alignment with the target for one eye's view; however, for the other eye's view, it will seem to be shifted out of alignment. This implies that the pencil and the distant point have been aligned only in one eye's view, and the misaligned view of the other eye has been ignored or suppressed. It is intriguing to note that during the performance of this simple task, one is not aware that this alignment depends upon only a single eye's view. Rather one believes that both eyes are simultaneously being used.

In coordinations such as these, the observer *unconsciously* selects one monocular input even though conditions allow for full binocular viewing. The unconscious aspect of the behavior probably accounts for the fact that references to eye dominance do not appear in the literature again until 270 years after Porta's original report. The phenomenon is briefly mentioned by Humphrey (1861) and Donders (1864). Then there are only scattered reports of a dominant eye until the mid-1920s when interest in the problem resulted in a flurry of research. At the present time, over 235 papers have been published that incorporate measures of ocular dominance (Coren & Porac, 1975).

Ocular dominance does not have a long research history, but this brevity is not indicative of its perceptual importance. The following is a situation that commonly occurs

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when one points at a distant target with one's finger. In this simple situation, one cannot effectively use both eyes. Convergence on one's fingertip will result in stimulation of noncorresponding retinal points by the distant target, and it will appear double. Convergence on the target will result in double images of the fingertip. Thus, a significant behavioral and perceptual problem emerges. One must either point to two phenomenal targets with one finger or point to one phenomenal target with two apparent fingers. Yet, in one's normal coordinations no difficulty arises. One is not normally aware of any diplopia, and only conscious direction of attention will make one cognizant of its existence. The problem of visual interference has been solved by dependence upon the input from only one eye in the performance of this alignment task and simultaneous suppression of the view from the contralateral eye in order to eliminate diplopic interference. In situations such as this, it is behaviorally adaptive for one eye to give way to the other. Adoption of a strategy of monocular viewing, despite the fact that both eyes are open, simplifies problems of coordination and localization between near and far distances. The eye whose input is used in these situations is usually defined as the dominant eye.

The action of the dominant eye in assuming priority of input when binocular stimulation no longer provides stable, nonconflicting information has a behavioral function that is quite clear. Unfortunately, the last 60 years of research on the phenomenon have not been distinguished by such clarity. The area has been marked with definitional as well as theoretical disagreement. Investigators have not reached a consensus as to what measures or behaviors distinguish the dominant eye from its contralateral partner. Since the usefulness of any concept of eye dominance depends in great measure upon the ability to define which eye is dominant, it seems appropriate to begin our discussion with a definition of eye dominance before proceeding to a consideration of its behavioral implications.

Definition of the Dominant Eye

As in other areas of psychological research, definitions of eye dominance are often derived from the tests that are used to measure the phenomenon. Since there seem to be as many tests for eye dominance as there are researchers who are interested in the problem, this approach has often increased confusion rather than clarified the nature of the dominant eye. Walls (1951) cataloged approximately 25 different eye dominance measures, and many more could be added to his list. As a starting point, the measures that have been most commonly used to ascertain and define eye dominance are presented.

1. *Sighting tests:* To a psychologist, the most interesting and relevant tests for ocular dominance are behavioral. A frequently used criterion for determining the dominant eye is to ascertain which eye is habitually favored in monocular sighting tasks, such as looking through a telescope. Since only one can be be used, a monocular selection is forced. The eye that is preferred in these situations is called the sighting dominant eye. A variety of sighting measures have been devised. Crider (1944), Coren and Kaplan (1973) and Harris (1957) have described some of the most frequently encountered variants of such tests. Scheidemann and Robinette (1932) and Suchman (1968) have provided forms of this test that can be used with preverbal children and infants.

2. *Unconscious sighting tests:* Conscious sighting measures can be contaminated by the fact that one knows that only one eye will be used in the given coordination. Hence, one may deliberate upon selecting which eye will be used, or one may have been trained to use a particular eye when choice is available. Such training is often associated with learning to use a microscope.

Most importantly, eyedness measures in these situations can be affected by hand dominance unless care is taken to avoid such contamination. Thus, in sighting down a rifle, the pressure to have the dominant hand on the trigger might be stronger than the pressure to have the dominant eye aligned with the sights. Several tests have been designed to avoid these difficulties. The situation is manipulated so that one believes that one is operating with full binocular vision, and manual dominance is not allowed to interact with the measure. Porta's (1593) previously mentioned near–far alignment demonstration is an example of an unconscious sighting task. However, the most popular test of this sort (because it also controls for handedness) was devised by Miles (1929, 1930). In this test, one covers one's face with the wide end of a truncated cardboard cone that is held with both hands. One then peers at a distant target that is seen through the smaller end of the cone. One's subjective experience in this task is that the alignment is being performed by placing the cone midway between the two eyes. One is not aware that this cannot be the case and that the target may only be seen when the aperture is aligned with one hand or the other. The eye selected is the dominant one.

Although the Miles's (1930) test seems to be the most widely used unconscious sighting test for both adults and children (Updegraff, 1932), other unconscious sighting measures have been described (Asher, 1961; Coren & Kaplan, 1973; Crider, 1944; Cuff, 1930; Palmer, 1947). Coren (1974) has described an unconscious sighting measure that is usable with preverbal infants, and Crovitz and Zener (1962) have devised a group test for eye dominance based upon near–far alignment. An interesting variant of an unconscious sighting test has been described by Crider and Gronwall and Sampson (1971). In this test, one holds a small card in front of oneself and reads it. In most instances, one preferentially aligns the card with one eye or the other. This appears to be another example of unconscious sighting, but it may also be somewhat contaminated by handedness.

3. *Binocular rivalry tests:* Binocular rivalry occurs when the monocular views presented to the two eyes are discrepant and cannot be stereoscopically fused. In this situation the two views alternate in consciousness. Since asymmetries in the rivalry situation may indicate differences in the saliency of the sensory input, tests of binocular rivalry have been used in defining the dominant eye (Cohen, 1952; Toch, 1960; Washburn, Faison, & Scott, 1934). Usually, the dominant eye is defined as the one that maintains its view in consciousness for a longer period of time.

4. *Acuity tests:* Investigators interested in clinical problems of vision have frequently defined the dominant eye as the physiologically or refractively superior eye. The most common definition is based upon measurements of visual acuity. For example, Duke-Elder (1952) defined the dominant eye as one that manifests better resolution acuity on standard acuity tests (e.g., Snellen letters, Landolt C's, etc.).

5. *Motoric efficiency tests:* Another form of superiority that one eye may manifest concerns asymmetries in motoric efficiency. For example, Crider (1935), Dolman (1920), and Ogle (1964) defined the dominant eye as the one that shows no deviation or phoria during binocular fixation. As a variant of this view, other investigators have studied fixation behavior under conditions of strained convergence where the binocularly fixated target is held very close to the face. The eye that continues to maintain fixation under these conditions is said to be the dominant one (Coren, 1974; Mills, 1925, 1928). Schoen and Scofield (1935) measured the motoric efficiency of the dominant eye by determining which eye maintained fusional control while convergence was taxed with a displacing prism positioned in front of one eye. An interesting, although probably unreliable, approach to possible motoric imbalances has been described by Danielson (1930) and Kovac and Horkovic (1970). They contended that winking can be an indicator of the dominant eye. The dominant eye is defined as either the eye that is more difficult to wink or the eye that cannot be winked without some lowering of the contralateral eyelid.

The preceding five classes of eye dominance tests are most frequently encountered in the literature. These have received the most empirical and theoretical attention. However, there are additional viewpoints that are less prominent.

6. *Clarity tests:* Pascal (1926) suggested that the dominant eye provides an image that is perceptually clearer and more intense. He defined the dominant eye as the one that gives the impression of having a more deeply

saturated color when a filter is alternately placed before each eye. Kovac and Horkovic (1970) and Kovac and Ley (1969) related image-clarity differences to differences in the size of the pupillary aperture. The dominant eye, according to their definition, has a larger pupil; thus, it receives more light and produces a clearer image.

7. *Perceptual efficiency tests:* A number of investigators have used dichoptic presentations of discrepant images presented at brief exposures to explore and define ocular dominance (Kephart & Revesman, 1953; Ondercin, Perry, & Childers, 1973; Perry & Childers, 1972). In these studies where the input to the two eyes is different (i.e., different digits or letters), the dominant eye is the one whose view predominates.

8. *Measurements of innervation density:* There is an interesting variant on the theme of physiological asymmetries that was suggested by Vinar (cited in Kovac & Horkovic, 1970). By means of ophthalmological techniques, he examined the density relationship between the receptors and the surrounding tissue in each eye. He defined the dominant eye as the one displaying a greater receptor density. This method has also been used by Kovac and Horkovic.

Because many forms of dominance testing have been used, the present list is only partial and globally organizes a number of different criteria. However, it should be sufficient to convince the reader that eye dominance has been defined in terms of a large and diverse battery of visual skills. To the extent that each test embodies a definition of ocular dominance, we are forced to conclude that a large number of alternative definitions exist for the dominant eye. Perhaps some additional clarity can be provided by looking at the interrelationships among these measures.

Patterns of Ocular Dominance

A multitude of theoretical orientations are implied by the plethora of criteria used to define the dominant eye. Thus, it is not surprising to find only low intercorrelations between the various measures (Coren & Kaplan, 1973; Crider, 1944; Gronwall & Sampson, 1971; Jasper & Raney, 1937; Washburn et al., 1934). This lack of consistency has led Flax (1966) to suggest that the concept of eye dominance may not be useful at all.

If all measures of ocular dominance were highly intercorrelated, this would lead to the conclusion that eye dominance consists of a single mechanism. This was the earliest view of the phenomenon (Parsons, 1924; Porta, 1593), and it has continued until the present day (Gronwall & Sampson, 1971; Harris, 1957). However, many investigators have contended that eye dominance consists of several factors that may, in fact, be independent of each other. Thus, a number of different typologies of ocular dominance have been developed over the years (Berner & Berner, 1953; Cohen, 1952; Coren & Kaplan, 1973; Jasper & Raney, 1937; Lederer, 1961; Walls, 1951). Unfortunately, the problem of eye dominance does not seem to be simplified by the fact that its various manifestations are seen as independent phenomena. The typologists continue to disagree about the relevant forms of dominance that exist and about the number of different mechanisms represented in ocular dominance. The different forms of eye dominance that have been postulated range from two (Berner & Berner, 1953; Cohen, 1952; Walls, 1951) to as many as five (Lederer, 1961). However, most of these investigators have predominantly relied upon the existing literature in order to establish their classification schemes.

In a recent study, Coren and Kaplan (1973) addressed themselves to this issue via an empirical study. They administered a representative battery of 13 common tests for eye dominance to a sample of subjects. In order to achieve maximal discriminability, they chose not to use the traditional dichotomous scoring procedures (right vs. left) but rather scored the results in a graded fashion that permitted the assessment of strength as well as direction of dominance. A factor analysis was performed on the data, and three orthogonal factors emerged: *sighting, sensory,* and *acuity dominance.* The names applied to the factors attempt to reflect the clusters of tests that characterize each one.

As this is the only systematic attempt to devise a classificatory scheme for eye dominance, which is based completely on nondichotomous scoring procedures, we shall use their classifications in an attempt to discover general trends and patterns of interrelationships among eye dominance mechanisms.

1. *Sighting dominance:* This is the form of eye dominance most analogous to handedness or footedness, and it is generally measured by performance on various conscious and unconscious sighting tasks. It reflects a behavioral selection or preference for one eye's input in two types of situations. Either both eyes cannot be simultaneously used, or their views are discrepant and unfusible. Besides being the most commonly measured form of ocular dominance, it also seems to be the most reliably obtained. For example, the sighting dominance factor in the Coren and Kaplan (1973) study accounted for 67% of the common variance among all of the measures used.

Over the years a number of studies have explored sighting dominance using large samples, and population norms are reasonably consistent over these reports. Table 1 summarizes the results of this work. As can be seen from this table, approximately 65% of all observers sight with the right eye, 32% sight with the left eye, and the remaining 3% show no consistent preference. This means that given repeated sighting opportunities or various sighting tasks, 97% of all observers will consistently use the same eye. Sighting dominance is a consistent and pervasive phenomenon. As Table 1 illustrates, the behavior seems to be relatively independent of chronological age or cultural differences. In fact, it has even been shown that animals, particularly monkeys, display behaviors characteristic of a sighting dominant eye (Cole, 1957; Hall & Mayer, 1966; Kounin, 1938; Kruper, Boyle, & Patton, 1966; Kruper, Patton, & Koskoff, 1971; Smith, 1970). However, there appears to be no evidence for sighting dominance in animals other than primates. Thus Crinella, Robinson, and Fish (1972) have reported that cats display a paw preference but not an eye preference. This suggests that sighting dominance may be important to animals with binocular fields that overlap a great deal, such as is found in the primates.

TABLE 1

STUDIES ON SIGHTING DOMINANCE SHOWING POPULATION PERCENTAGES OBTAINED

Study	Location of study	Subjects	% sighting dominance Right	Left	Mixed
Miles (1929)	U. S.	Children	67	30	4
		Adults	66	30	4
Jasper & Raney (1937)	U. S.	Children	63	27	—
Crider (1944)	U. S.	Adults	62	31	7
Zoetrout (1947)	U. S.	Adults	77	23	—
Nagamata (1951)	Japan	Adults	66	34	—
Hughes (1953)	Great Britain	Adults	82	18	—
Spong (1962)	Australia	Children	65	35	—
Groden (1969)	U. S.	Children	53	25	22
Dawson (1972)	Africa	Adults	67	33	—
	Australia	Adults	60	40	—
Coren & Kaplan (1973)	U. S.	Adults	62	28	10
Coren (1974)	U. S.	Infants	62	38	—
		Children	65	35	—
		Adults	65	35	—

Sighting dominance may be predictive of some pathological visual conditions. Coren and Duckman (1975) have shown that a certain type of long-term functional monocular suppression, known as amblyopia ex anopsia, or "lazy eye," is most apt to develop in the nonsighting eye. Similarly, Hugonnier and Clayette-Hugonnier (1969) indicated that one who displays strong sighting dominance is more likely to develop motoric malfunctions in the nonsighting eye.

Recently, some individual differences in sighting dominance have come to light. First, right-eyed sighters appear to be more consistent in their sighting preference than left-eyed sighters (Friedlander, 1971; Porac & Coren, 1975a). Second, although there appear to be no sex differences associated with the proportions of right- and left-eyed sighters, Porac and Coren (1975a) have shown that males display more consistent sighting behaviors than do females. In fact, the entire distribution of right-eyed scores in their male sample showed a shift toward the extreme right in comparison with the females. They have suggested that these sex differences may be due to environmental pressures. For example, differential participation in sports activities involving eye–hand coordination may favor consistent laterality.

2. *Sensory dominance:* Sensory dominance is best seen in binocular rivalry situations where two discrepant monocular images alternate in the conscious percept. If one eye's view is present for longer periods of time, this is taken as evidence for the sensory dominance of that eye's input. Unlike sighting dominance, sensory dominance has received relatively little attention, and population norms are not well-established. By taking the results of a number of studies that employed a binocular rivalry test for dominance, it is possible to estimate the relative distribution of right- and left-sensory-dominant observers. Based upon the data of Cohen (1952), Coren and Kaplan (1973), Porac (1974), and Washburn et al., (1934), 48% of the combined samples showed preference for the right eye, 32% favored the left eye, and 19% were ambi-ocular. Thus, sensory dominance seems to favor the right eye, as does sighting dominance. However, the manifest dextrality is considerably weaker than in sighting dominance. In addition, there is a report of a developmental increase in the strength of sensory dominance, which is not apparent in the literature on sighting dominance (Humphiss, 1969).

Sensory dominance represents a condition in which there is a sustained discrepancy in the input to the two eyes. These inputs are nonfusible and alternate in consciousness. Such stimulus conditions are seldom found in normal viewing but seem confined to pathological conditions such as strabismus or anisometropia. It may be the case that this mechanism does not express itself until the normal binocular coordinations are in a state of malfunction, and thus it may not be important for visually normal observers.

3. *Acuity dominance:* Acuity dominance refers to the eye that performs with more accuracy on measures of visual acuity. In clinical situations, this is the criterion that is most often used to determine ocular dominance. Massive acuity differences between the two eyes may influence the dominance relationship (Friedlander, 1971). However, Duke-Elder's (1952) statement that the absence of monocular acuity asymmetries weakens any manifest eye dominance does not appear to be true (Crovitz, 1961). This has been directly verified in studies where subjects have been prescreened to guarantee that no imbalances in acuities existed. Consistent sighting and rivalry dominance performances, in percentages consonant with the usual population norms, have still been observed (Coren & Kaplan, 1973; Porac & Coren, 1975a).

The exact behavioral implications of acuity dominance are somewhat unclear. Various attempts have been made to correlate acuity dominance to sighting dominance. Porac and Coren (1975b), Van Biervlet (1901), Woo (1928), and Woo and Pearson (1927) have reported that the eye with better visual acuity tends to be the eye chosen to sight with. However, a large number of other investigations have failed to confirm this relationship (Coons & Mathias, 1928; Coren & Kaplan, 1973; Cuff, 1931; Gahagan, 1933; Geldard & Crockett, 1930; Gronwall & Sampson, 1971; Snyder & Snyder, 1928). Crovitz (1961) found that left-eyed sighters are more apt to have better visual acuity in their sighting eye than are right-eyed sighters.

The only measures of ocular dominance that seem to be associated with acuity dominance are those related to situations in which dichoptic or nondichoptic information is tachistoscopically presented (Coren & Kaplan, 1973; Hayashi & Bryden, 1967; Kephart & Revesman, 1953; Perry & Childers, 1972). The eye whose input is most frequently reported is the eye with the better acuity. However, even this relationship does not appear to hold as exposure time is lengthened to values approximating 250 msec (Porac, 1974). Hence, a normal observer, who does not have massive acuity imbalances between the two eyes, is not particularly dependent upon an acuity-dominant eye. This factor may play a role in cases where ocular pathology or large refractive asymmetries exist.

When we carefully consider the three forms of ocular dominance, it is clear that sighting dominance is the most frequently measured and best understood. In addition, the dominance patterns manifested in sighting behavior are the only ones that appear to be part of normal visual coordinations. When this fact is combined with Coren and Kaplan's (1973) demonstration that the sighting dominance factor accounts for the greatest portion of the variance in their study, we are tempted to agree with Crider (1944), who felt that sighting dominance is the only significant form of eye dominance. In this review, as we consider the interaction between the dominant eye and various behavioral phenomena, the term *dominant eye* refers to the sighting dominant eye.

Eye Dominance and Generalized Laterality

Ocular Dominance and Cerebral Dominance

The earliest view of eye dominance regarded it as one aspect of a generalized laterality dimension in which the typical human being is right-handed, right-footed, and right-eyed (Porta, 1593). The modern restatement of this view attempts to establish relationships between eye dominance and a dominant cerebral hemisphere using the dominant hand as an index of cerebral dominance (Belmont & Birch, 1963; Berman, 1973; Delacato, 1959; Friedlander, 1971; Harris, 1957; Orton, 1937; Parsons, 1924).

There is little neurological and physiological data to support the presence of any relationship between ocular and cerebral dominance. It is true that innervations to the arms and legs are basically under the control of the contralateral cerebral hemisphere. The left hemisphere controls the right arm and leg, while the right hemisphere controls the left limbs. Thus, it may be appropriate to say that if one is right-handed, one's left cerebral hemisphere would be dominant. Such a simple relationship does not appear in the visual system, since there is a semi-decussation of the optic fibers at the optic chiasm. Hence, neural messages from the right hemi-retinae of both eyes travel to the right cerebral hemisphere, while those from the left hemi-retinae go to the left cerebral hemisphere. In other words, stimulation of any one eye reaches both cerebral hemispheres. Evidence from various types of brain lesions demonstrate how the fields of view in each eye are related to the bilateral nature of the optic projections. If one side of the brain is destroyed, one loses control of the contralateral hand and foot. However, one does not become blind in one eye; rather, one exhibits hemianopsia or blindness for half of the field of view in each eye. The neurological picture is further complicated by evidence suggesting that the foveal region of each retina is bilaterally represented. Thus, in cases of hemianopsia, one may find that foveal vision remains unimpaired even in the presence of hemi-retinal blindness (Halstead, Walker, & Bucy, 1940; Penfield & Rasmussen, 1950; Sanford & Bair, 1939). Since eye dominance is an exhibited preference for the input to one eye, the neurological facts mitigate against a simple relationship to a dominant cerebral hemisphere. It cannot be said that one who is right-eyed demonstrates the dominance of the left cerebral hemisphere, or any hemisphere for that matter.

These neurological facts notwithstanding, the notion of a generalized dimension of laterality has often been examined by attempting to establish the correlation between handedness and eyedness. The experimental results on this issue are rather mixed. There are some studies that seem to find that eyedness and handedness are in fact correlated (Coons & Mathias, 1928; Eyre & Schmeckle, 1933; Friedlander, 1971; Humphrey, 1861; Miles, 1930; Parsons, 1924; Selzer, 1933; Updegraff, 1932; Van Biervlet, 1901). Other reports indicate that there is no relationship between the dominant eye and the dominant hand (Coren & Kaplan, 1973; Cuff, 1931; Geldard & Crockett, 1930; Groden, 1969; Gronwall & Sampson, 1971; Kuroda, 1926; Porac, 1974; Porac & Coren, 1975a; Smith, 1933; Woo, 1928; Woo & Pearson, 1927). Experiments with monkeys, who demonstrate both eyedness and handedness, have also failed to demonstrate any significant relationship (Cole, 1957; Kruper et al., 1967).

Studies reporting relationships between eyedness and handedness may be slightly artifactual, since they have used sighting dominance as their measure of eyedness. Most people are right-handed and sight with their right eyes. Hence, experimental samples contain large numbers of right-handed and right-eyed subjects even if these are independent phenomena. Such findings are rendered even more likely by the common tendency to use dichotomous (left vs. right) or trichotomous (left, right, and mixed) scoring procedures to indicate dominance. As Collins and Collins (1971) have pointed out, it is difficult to avoid such an artifact under these conditions. Studies that have used graded numerical ratings to establish both side and strength of dominance have managed to avoid these difficulties. Under these measurement procedures, one does not find a significant correlation between eyedness and handedness (Coren & Kaplan, 1973; Porac & Coren, 1975a). The issue is complicated by the fact that there appear to be sex differences in the consistency of lateralization. Porac and Coren have recently reported that males are more likely to have ipsilateral hand–eye dominance than are females. The implications of this report for issues of cerebral dominance are not at all clear.

A number of investigators have attempted to test directly the relationship between eye dominance and cerebral dominance. These procedures take into account the fact that each hemi-retinae projects to only one cerebral lobe. Researchers have looked for relationships between hemi-retinal or visual field dominance and the whole eye dominance normally measured. Typical of such procedures are those of Jasper and Raney (1937) and Spreen, Miller, and Benton (1966). They used an ambiguous apparent movement task and measured whether the observer resolved the movement in favor of the dominant visual field (i.e., cerebral hemisphere) or whether an entire eye was favored. Jasper and Raney found that observers display both behaviors, whereas Spreen et al. were forced to conclude that no relationship exists between visual field dominance and eye dominance. An alternative approach has involved tachistoscopic recognition tasks. Experimenters using these tasks have also found no relationship between visual field superiority and the sighting dominant eye (Hayashi & Bryden, 1967; Kussin & Harcum, 1967; Sampson, 1969; White, 1969).

There is one line of evidence that does suggest a link between cerebral and eye dominance. Following the ablation of an entire cerebral hemisphere, monkeys prefer to sight with the eye that is contralateral to the remaining hemisphere (Ettlinger & Dawson, 1969; Kruper et al., 1967; Kruper et al., 1971; Lehman, 1970). Equivalent studies have been conducted on humans who have brain lesions resulting in homonymous hemianopsia. These reports are somewhat mixed in their findings. Williams and Gassel (1962) reported data in accord with that obtained from monkey studies, while Rothschild and Streifler (1952) presented opposite results. Although such results seem to indicate a relationship between cerebral dominance and eye dominance, they might simply reflect the relative processing dominance of the nasal or crossed fibers over the temporal or uncrossed ones. There is considerable evidence for such dominance in normal observers (Crovitz, 1964; Crovitz & Lipscomb, 1963; Doty, 1958; Hubel & Weisel, 1959, 1962; Polyak, 1957). As we have indicated, there is no necessary physiological relationship between a single eye and a single cerebral lobe. Furthermore, the absence of stable correlations between indicators of cerebral dominance, such as handedness or visual half-field superiority, and the dominant eye suggests that there is little relationship between cerebral and ocular lateralization.

Sensorimotor Coordinations and the Dominant Eye

Although there is no physiological evidence linking the dominant hand with the dominant eye, one could speculate on the functional advantage of having ipsilateral hand–eye dominance. In many sensorimotor coordinations, it would be useful to have the dominant eye aligned with the dominant hand, such as in aiming a pointer or throwing a ball. A rather lyrical theory presented by Parsons (1924) elaborates on this point. Parsons suggested that the preponderance of individuals with a dominant right hand and dominant right eye is due to natural selection. He reasoned that a right-handed warrior would carry his weapon in his right hand with his shield in his left. This arrangement would provide maximal defensive protection to the heart and, hence, increase his survival advantage. He further argued that a warrior with a dominant eye on the same side as his dominant hand would be more accurate in the placement of his weapon in offensive actions. The highest probability of survival rests with the right-handed and the right-eyed warrior. Hence, dextral laterality combinations overcontribute to the genetic pool as other laterality combinations fall by the wayside. Although Parson's explanation is amusing from a contemporary point of view, there is evidence which links accuracy in sensorimotor coordinations with the dominant eye. Lund (1932) empirically verified that greater target striking accuracy is found when the dominant eye is used. Some investigators have studied the effect of ocular dominance on rifle marksmanship. Although Simpson and Sommer (1942) reported no relationship between eye dominance and accuracy with a rifle, Banister (1935), Crider (1943), Doyne (1915) and Lebensohn (1942) all reported better accuracy with the dominant eye.

A number of studies have looked at the interaction between eye dominance and various motor behaviors. It seems that in tasks involving continuous visual monitoring and control, such as mirror tracing, the use of the dominant eye does not offer an advantage (Ong & Rodman, 1972; Schrader, 1971; Sinclair & Smith, 1957). However, when one looks at tasks involving ballistic movements or aiming, such as throwing a basketball or hitting a baseball with a bat, one finds an eye–hand effect. More accurate performance seems to be associated with a dominant eye and a dominant hand that are ipsilateral to each other (Adams, 1965; Mills, 1925; Shick, 1971). Ipsilateral hand and eye dominance has also been shown to provide benefits for sports performance in children (Lavery, 1944) and for driving ability in adults (Quinan, 1931).

Some of these sensorimotor effects may reflect postural differences that covary with eye dominance. Greenberg (1960) reported that the head is generally carried with a slight tilt so as to bring the dominant eye closer to the medial plane of the body. Since this shifts the center of gravity, it may give more freedom of movement to the ipsilateral hand. Alternatively, the dominant eye may be more efficient and thus provide better data upon which to base motor movements. Empirically, it is clear that better sensorimotor performance results when the dominant eye is used and when that eye is ipsilateral to the dominant hand.

Other Implications of Consistent Versus Crossed Dominance

There is another body of data that deals with the relationship between the dominant eye and the dominant hand. The issues revolve around various types of neurological and behavioral impairments and the relationship to consistent (ipsilateral) or crossed (contralateral) dominance of the eye and hand.

Satz (1972) presented a model that attempts to account for the higher incidence of left-handedness in various brain-injured populations. One can formulate analogous hypotheses pertaining to the distribution of eye dominance. For instance, with reference to sighting dominance, approximately 70% of all individuals are right-eyed, while 30% are left-eyed. If one assumes that there is a physiological component to eye dominance, one can apply Satz's reasoning. For the purpose of argument, it is assumed that 10% of all individuals suffer central nervous system damage resulting in a switch from their normal eye dominance to the contralateral eye. Hence, 7% of this pathological population switches to the left eye, while 3% switches to the right. The resultant population contains 66% right-eyed sighters and 34% left-eyed sighters. As another example, out of a population of 100 left-eyed and right-eyed sighters, 20% of the sample manifesting left dominance are neurologically damaged (7 out of 34), while only 4% of the right-eyed sighters are impaired (3 out of 66). One might expect that in complex coordinations, such as reading, more difficulties would be found in the segment of the population that behaviorally manifests left-eyedness, since this group is likely to contain the higher percentage of pathologically induced manifest eyedness. A similar line of reasoning, which begins with the premise that ipsilateral hand and eye dominance is the norm, may lead one to expect difficulties in the crossed-dominance groups.

Direct assessments of the relationship between eye dominance and neurological damage tend to produce negative results (Crinella, Beck, & Robinson, 1971; Forness, 1968; Martin, Friedrich, Mortier, & Guignard, 1968). More consistent findings have been reported within clinical samples where the deficits are less clearly physiological. For example, more left-eyedness and crossed dominance have been found among hospitalized psychopaths (Quinan, 1930) and in samples of schizophrenics (Oddy & Lobstein, 1972; Walker & Birch, 1970). In addition, weak or inconsistent eye dominance and crossed dominance have been associated with differences along the dimension of field dependency–independency in nonpathological samples (Dawson, 1972; Oltman & Capobianco, 1967). Investigators who have looked at various behavioral and physiological anomalies in children have reported analogous results. There seems to be a higher proportion of left-eyedness and crossed dominance in children with various emotional problems (Castner, 1939), more left-eyedness in retarded children (Hughs, 1953), and more crossed dominance in children with learning difficulties (Wold, 1968).

The relationship between eyedness and reading disabilities has received the most concentrated experimental attention. It is felt that departures from consistent dominance patterns are representative of a neural maturational lag. This, in turn, may result in a tendency toward reading problems (De Hirsch, 1952). Several studies have linked left-eyedness with reading abnormalities (La Grone & Holland, 1943; MacMeeken, 1939, 1942; Monroe, 1932). However, the most commonly reported relationship finds crossed dominance associated with reading problems (Dearborn, 1931; Gilkey & Parr, 1944; Harris, 1957; Orton, 1928, 1937; Rengstorf, 1967; Teegarden, 1932; Vernon, 1957; Zangwill, 1962). Despite this mass of data, the issue is still not clear-cut. An equally impressive list of studies, including samples of both children and adults, have reported no relationship between eyedness and reading readiness or success (Balow & Balow, 1964; Belmont & Birch, 1963, 1965; Coleman & Deutsch, 1964; Hallgren, 1950; Harris, 1957; Imus, Rothney, & Baer, 1938; Stephens, Cunningham, & Stigler, 1967; Stevenson & Robinson, 1953; Vernon, 1957; Witty & Kopel, 1936). Similarly, there are reports showing no relationship between crossed dominance and reading abilities or problems (Beck, 1960; Capobianco, 1966; Forness, 1968; Silver & Hagen, 1960; Sparrow, 1969; Spitzer, 1959).

Hogg (1968) reported a case history of a dyslexic patient that suggests a reason for the conflicting data concerning eye dominance, crossed dominance, and reading. He found that his dyslexic patient switched his eye preference as a function of convergence and accommodation distance. Hence, the manifest eye dominance in impaired individuals may differ for the near and far convergence positions. This does not seem to be the case in nonpathological populations where the agreement between eye dominance patterns at near and far distances seems to be reasonably good (Coren & Kaplan, 1973; Miles, 1929; Washburn et al., 1934). Possible eyedness instability in anomalous groups must be taken into account before attempting to relate physiological and performance impairments to patterns of lateral dominance.

Perceptual Processing and the Dominant Eye

A number of perceptual processes have been linked to patterns of ocular dominance. Some of these center on motoric asymmetries between the dominant and nondominant eye and perceptual effects that may be linked to these asymmetries. Several investigators have shown that the sighting eye is motorically superior to the nonsighting eye. This linkage is so strong that the stability of nonconjugate eye movements has been used as a test for ocular dominance. It is a measure that correlates well with other sighting tasks (Coren, 1974; Coren & Kaplan, 1973; Crider, 1935; Mills, 1925).

Motor asymmetries between the two eyes result in a number of interesting phenomena. For example, Schoen and Schofield (1935) employed a paradigm in which a prism was placed before one eye. This laterally displaced one monocular image. A large displacement will disrupt fusion and result in diplopia; however, these authors noted that greater prismatic strength was required to disrupt binocular fusion when the prism was placed in front of the sighting dominant eye. They attributed this to its greater motoric strength. Clark (1935) measured convergence corrections following fixation changes during reading. Of his observers, 65% made larger corrective movements with the nonsighting eye. More recently, Money (1972) has shown the superiority of the dominant eye in scanning and post-eye movement recognition tasks.

Walls (1951) has elaborated the observation that there are motoric asymmetries between the dominant and nondominant eyes into a theory of visual direction. He stated:

> The essence of ocular dominance is the employment of the record of innervations to the muscles of one eye *only* for the construction of binocular percepts of visual direction. (p. 400)

Thus, the dominant eye is not only motorically superior, but its movements provide the primary information for the computation of visual direction. As supportive evidence, Walls offered a demonstration. A distant and a near target are placed along the line of sight of the dominant eye. Both eyes are open, but the view of one is occluded as convergence is changed from far to near. When the nondominant eye is covered, this fixation change does not result in any apparent movement. Yet, when the dominant eye is occluded, the fixation change causes an apparent movement of the far object. If both eyes were uncovered, such a fixation change would bring about diplopia of the far target. Walls's demonstration implies that in normal vision, the image to the nondominant eye is ignored during such fixation changes so that stable single vision and direction are maintained at all distances in view. When the dominant eye is covered and thus deprived of visual information to the contrary, its movement is centrally recorded and results in an apparent shift in target locus. Walls felt that the "visual ego" (the center point for egocentric localization) resides in the dominant eye, and the apparent movement phenomenon demonstrates that only its movements are monitored in the computation of visual direction.

There is other evidence linking egocentric direction to the dominant eye. Howard and Templeton (1966) reported that the egocentric straight-ahead direction is perceived in terms of the dominant eye. Charnwood (1949, 1965) also presented data showing shifts in the "visual ego" as a function of the dominant eye. Ogle (1964) demonstrated that fixation disparity (slight convergence error during fixation) most often occurs in the nondominant eye. In the presence of fixation disparities, he found that the locus of the fused target appears shifted in the direction of the line of sight of the dominant eye. Ogle's data would agree with Walls's (1951) contention that eye movement errors are more likely to be found in the eye whose movements are not crucial to any higher order perceptual function. Nonetheless, Walls's suggestion that only the movements of the dominant eye are monitored in the computation of visual direction has been challenged by Lederer (1961) and Ono, Wilkinson, Muter, and Mitson (1972), who reported that apparent movement can occur with either eye.

Charnwood (1965) has offered a different theory for the displacement of apparent direction toward the side of the dominant eye.

He suggested that the input from the nondominant eye is attenuated during binocular viewing. It has been experimentally demonstrated that when neutral density filters are placed before one eye, darkening its view, the apparent position of external targets shifts toward the contralateral eye (Diehl, 1942; Francis & Harwood, 1959; Verhoeff, 1935). Thus a diminution of the intensity of the view of the nondominant eye may account for the displacement of the "visual ego" toward the side of the dominant eye. In further support of this contention, Francis and Harwood (1959) and Watchurst (reported in Charnwood, 1965) have shown that one must employ darker neutral-density filters in front of the dominant eye before localization shifts can occur. This implies an extant intensity difference between the input to the dominant and nondominant eyes.

The observed shift in the locus of a target toward the dominant eye appears in a number of simple situations. Mefferd and Wieland (1969) had subjects bisect a line. They found that the locus of the midpoint was shifted toward the side of the dominant eye. This results in an overestimation of the segment on the side opposite to the dominant eye.

There are also apparent size distortions as a function of eye dominance. Targets placed before the dominant eye (Coren & Porac, 1976) or on the same side of the visual field as the dominant eye (Hirata, 1968) tend to be overestimated. Thus, overestimation probably accounts for Miles's (1954) and for Scott and Sumner's (1949) observations that targets on the same side as the dominant eye are frequently reported as being closer to the observer. Such interactions between perceived size and perceived locus may account for a report by Dawson (1963) that indicates differences in the magnitude of various geometric illusions as a function of eye dominance.

Some investigators have suggested that ocular dominance reflects an attentional rather than a perceptual mechanism. This is characterized by Davson (1949), who implied a certain attentional priority for the input to the dominant eye. Evidence to support such claims, however, are somewhat conflicting. On one hand, studies using dichoptic presentations at brief exposures have found either no difference between the two eyes in recognition rates or differences that can be accounted for on the basis of refractive asymmetries (Coren & Kaplan, 1973; Kephart & Revesman, 1953; Perry & Childers, 1972). On the other hand, when nondichoptic stimulus arrays are used, the dominant eye appears to perform with greater accuracy (Money, 1972; Sampson & Spong, 1962). Julesz (1971) has presented a provocative demonstration that may be related to the priority of the dominant eye's image in the binocular view. He found that attempts to disrupt monocular pattern organization met with greater resistance if the contours were imaged in the dominant eye.

Eye Dominance: Basis and Plasticity

The disparate evidence available concerning the interactions of the dominant eye with other aspects of perceptual processing evokes rather than answers questions about its basis and mechanism. Is eye dominance a casual visual habit as suggested by Gronwall and Sampson (1971), or is it an adaptive response arising out of a necessity to cope with diplopia and discrepant stimulation inherent in a visual system with a large degree of binocular overlap?

A number of researchers have addressed themselves to this issue by looking at the plasticity of eye dominance patterns. The rationale is simple. The ease with which eye dominance patterns can be changed should be a measure of the observer's dependence upon the monocular preference. The consensus from ophthalmological and optometric sources indicates that eye dominance is relatively immutable, and subjective discomfort arises when the dominance relationship is tampered with (Duke-Elder, 1952; Miles, 1930; Mills, 1925; Sheard, 1926).

Experimental interventions have met with some success in attempting to reduce the strength of dominance or to switch eye dominance to the contralateral eye. The rationale used in experimental intervention emanates from observations, such as that of Charnwood (1949), suggesting a reduction in the intensity of the input to the nondominant eye. One can assume that such an attenuation of input is analogous to the long-term suppression of visual stimulation that is observed in certain pathological syndromes, for example, in amblyopia ex anopsia (Coren & Duckman, 1975). In line with this assumption, a variety of training procedures that have been shown to alleviate pathological suppression (cf. Shapero, 1971) have been applied to the nondominant eye of normal observers. This approach was taken by Porac (1974) and Porac and Coren (1975b). They attempted to equalize the attentional saliency of the two monocular views. Under these conditions, 50 minutes of intensive practice weakened the previously observed eye dominance patterns. Toch (1960) used a similar paradigm but was unable to produce any shifts in eye dominance, probably due to his brief practice period, which amounted to only 10 minutes. A number of more clinically oriented studies have used prolonged periods of forced attention to the input from the nondominant eye, extending over periods of days or months, and they have reported that the dominance relationship can be shifted under these conditions (Berner & Berner, 1953; Hamburger, 1943). Such data suggest that eye dominance can be changed if sufficient time and effort is expended to force attention to the nondominant eye.

The fact that eye dominance lends itself to experiential intervention suggests a habitual component to the phenomenon. However, the fact that extensive training is necessary in order to institute any measurable change plus the frequent reports of prolonged subjective discomfort indicate that the eye dominance story is not quite that simple.

Eye dominance is characteristically associated with species who have large overlapping monocular fields of view. The functional advantage of placing the two eyes in the frontal plane of the head is obvious. It increases the degree of overlap and allows additional depth information through the processing of binocular disparity information. Unfortunately, it is possible to have too much of a good thing. A large degree of overlap between the fields, plus the fact that there is fusion only for objects stimulating corresponding retinal points, means that visual discrepancy between the two monocular views is a common occurrence. The eye dominance mechanism manages to avoid this chaos of interference by suppressing the image from the nondominant eye in order to clear the way for the information from the other eye to be processed. This is consistent with Porac and Coren's (Note 1) report that suppression of stimulus information from the nondominant eye is found in binocular but not monocular testing. The stability of population percentages of right- versus left-eyed individuals (see Table 1) and the early onset and absence of developmental trends (Coren, 1974) provide support for the notion that monocular viewing via the dominance mechanism is as natural and adaptive to the organism as binocular fusion.

Ocular Dominance: Conclusions and Questions

This review has brought us to a point where we can make several tentative conclusions and pose several important questions. To begin with, although there may be several important forms of ocular dominance, it appears that sighting dominance is probably the most behaviorally significant type. There are important motoric and perceptual asymmetries that are associated with sighting dominance. Although there is little evidence to link eye dominance with cerebral dominance, there seem to be performance advantages that accrue to those who possess consistent laterality of eye and limb. The evidence is conflicting at times, but there is a general suggestion that left-eyedness and crossed dominance are more probable in individuals manifesting a variety of behavioral anomalies.

Certainly, the existence of a dominant eye has been demonstrated. The available data show that 97% of all visually normal human observers manifest a sighting dominant eye. There also seems to be a reasonable agreement as to the functional significance of eye dominance. Yet the presence of a dominant eye does not in itself answer any questions; rather, it evokes new queries. One would like to specify the functional basis of eye dominance in a visual system that has evolved toward maximum binocularity and cooperative fusion. The nature and basis of the suppression of the nondominant eye has not as yet been empirically addressed. Furthermore, the importance of eye dominance in sensorimotor coordinations and information pickup, such as in reading, as well as its possible service as an indicator of neurological or behavioral impairments have yet to be explored. Bernard once wrote, "We are surrounded by phenomena which we do not observe." The pervasive and unconscious nature of eye dominance can be classified with such phenomena. The available data suggest that eye dominance is worth observing more closely.

REFERENCE NOTE

1. Porac, C., & Coren, S. *Suppression of vision in the nondominant eye during recognition.* Paper presented at the meeting of the Psychonomic Society, Denver, November 1975.

REFERENCES

Adams, G. L. Effect of eye dominance on baseball batting. *Research Quarterly,* 1965, *36,* 3–9.

Asher, H. *Experiments in seeing.* New York: Basic Books, 1961.

Balow, I., & Balow, B. Lateral dominance and reading achievement in the second grade. *American Educational Research Journal,* 1964, *1,* 139–143.

Banister, H. A study of eye dominance. *British Journal of Psychology,* 1935, *26,* 34–42.

Beck, H. S. Relationship of symbol reversals to monocular and binocular vision. *Peabody Journal of Education,* 1960, *38,* 137–142.

Belmont, L., & Birch, H. G. Lateral dominance and right-left awareness in normal children. *Child Development,* 1963, *34,* 257–270.

Belmont, L., & Birch, H. G. Lateral dominance, lateral awareness and reading disability. *Child Development,* 1965, *36,* 57–71.

Berman, A. Reliability of perceptual-motor laterality tasks. *Perceptual and Motor Skills,* 1973, *36,* 599–605.

Berner, G. E., & Berner, D. E. Relation of ocular dominance, handedness, and the controlling eye in binocular vision. *A.M.A. Archives of Ophthalmology,* 1953, *50,* 603–608.

Capobianco, R. J. Ocular manual laterality and reading in adolescent mental retardates. *American Journal of Mental Deficiency,* 1966, *70,* 781–785.

Castner, B. M. Handedness and eyedness of children referred to a guidance clinic. *Psychological Record,* 1939, *3,* 99–112.

Charnwood, J. R. B. Observations on ocular dominance. *Optician,* 1949, *118,* 85–88.

Charnwood, J. R. B. *Essay on binocular vision.* New York: Hafner, 1965.

Clark, B. The effect of binocular imbalance on the behavior of the eyes during reading. *Journal of Educational Psychology,* 1935, *26,* 530–538.

Cohen, J. Eye-dominance. *American Journal of Psychology,* 1952, *65,* 634–636.

Cole, J. Laterality in the use of the hand, foot, and eye in monkeys. *Journal of Comparative and Physiological Psychology,* 1957, *50,* 296.

Coleman, R. I., & Deutch, C. P. Lateral dominance and left-right discrimination: A comparison of normal and retarded readers. *Perceptual and Motor Skills,* 1964, *19,* 43–50.

Collins, R. A., & Collins, R. L. Independence of eye-hand preference in mentally retarded: Evidence of spurious associations in heterogeneous populations. *American Journal of Optometry and Archives of the American Academy of Optometry,* 1971, *48,* 1031–1033.

Coons, J. C., & Mathias, R. S. Eye and hand preference tendencies. *Journal of Genetic Psychology,* 1928, *35,* 629–632.

Coren, S. The development of ocular dominance. *Developmental Psychology,* 1974, *10,* 304.

Coren, S., & Duckman, R. Ocular dominance and amblyopia. *American Journal of Optometry and Physiological Optics,* 1975, *52,* 47–50.

Coren, S., & Kaplan, C. P. Patterns of ocular dominance. *American Journal of Optometry and Archives of the American Academy of Optometry,* 1973, *50,* 283–292.

Coren, S., & Porac, C. Ocular dominance: An annotated bibliography. *JSAS Catalog of Selected Documents in Psychology,* 1975, *5,* 229–230. (Ms. No. 922)

Coren, S., & Porac, C. Size accentuation in the dominant eye. *Nature,* 1976, *260,* 527–528.

Crider, B. The relationship of eye muscle balance to the sighting eye. *Journal of Experimental Psychology,* 1935, *18,* 152–154.

Crider, B. The importance of the dominant eye. *Journal of Psychology,* 1943, *16,* 145–151.

Crider, B. A battery of tests for the dominant eye. *Journal of General Psychology,* 1944, *31,* 179–190.

Crinella, F. M., Beck, F. W., & Robinson, J. W. Unilateral dominance is not related to neurophysiological integrity. *Child Development,* 1971, *42,* 2033–2054.

Crinella, F. M., Robinson, J. S., & Fish, S. E. Effects of brain bisection on eye and paw preference in cats. *Cortex,* 1972, *8,* 19–33.

Crovitz, H. F. Differential acuity of the two eyes and the problem of ocular dominances. *Science,* 1961, *134,* 614.

Crovitz, H. F. Retinal locus in tachistoscopic binocular color rivalry. *Perceptual and Motor Skills,* 1964, *19,* 808–819.

Crovitz, H., & Lipscomb, D. Dominance of the temporal visual fields at short duration of stimulation. *American Journal of Psychology,* 1963, *76,* 631–637.

Crovitz, H. F., & Zener, K. A group-test for assessing hand and eye dominance. *American Journal of Psychology,* 1962, *75,* 271–276.

Cuff, N. B. Eyedness and handedness-report of paper. *American Journal of Psychology,* 1930, *42,* 459–460.

Cuff, N. B. A study of eyedness and handedness. *Journal of Experimental Psychology,* 1931, *14,* 164–175.

Danielson, R. W. A study of unilateral, voluntary winking: Some modifying factors and associated phenomena. *University of Colorado Studies,* 1930, *18,* No. 2.

Davson, H. *The physiology of the eye* (1st ed.). London: Churchill, 1949.

Dawson, J. L. M. Psychological effects of social change in a West African community. Unpublished doctoral dissertation, University of Oxford, Oxford, England, 1963.

Dawson, J. L. M. Temne-Arunta hand/eye dominance and cognitive style. *International Journal of Psychology,* 1972, *7,* 219–233.

Dearborn, W. F. Ocular and manual dominance in dyslexia. *Psychological Bulletin,* 1931, *28,* 704.

De Hirsch, K. Specific dyslexia or strephosymbolia. *Folia Phoniatrica,* 1952, *4,* 231–248.

Delacato, C. H. *The treatment and prevention of reading problems* (the *neuro-psychological approach*). Springfield, Ill.: Charles C Thomas, 1959.

Diehl, H. T. An eye dominance gage and some of its uses. *Journal of General Psychology,* 1942, *26,* 181–184.

Dolman, P. The relation of the sighting eye to the measurement of heterophoria: A preliminary report. *American Journal of Ophthalmology,* 1920, *3,* 258–261.

Donders, F. C. *Accommodation and refraction of the eye.* London: Sydenham Society, 1864.

Doty, R. W. Potentials evoked in cat cerebral cortex by diffuse and punctate photic stimuli. *Journal of Neurophysiology,* 1958, *21,* 437–464.

Doyne, R. W. Eye in sport shooting. *Ophthalmoscope,* 1915, *13,* 119.

Duke-Elder, W. S. *Textbook of Ophthalmology* (Vol. 4). London: Henry Kimpton, 1952.

Ettlinger, G., & Dawson, R. F. Hand preferences in the monkey: The effect of unilateral cortical removals. *Neuropsychologia,* 1969, *7,* 161–166.

Eyre, M. B., & Schmeckle, M. M. A study of handedness, eyedness and footedness. *Child Development,* 1933, *4,* 73–78.

Flax, N. The clinical significance of dominance. *American Journal of Optometry and Archives of the American Academy of Optometry,* 1966, *43,* 566–581.

Forness, S. R. Lateral dominance in retarded readers with signs of brain dysfunction. Unpublished doctoral dissertation, University of California at Los Angeles, 1968.

Francis, J. L., & Harwood, K. A. The variation of the projection center with differential stimulus and its relation to ocular dominance. *Transactions of the International Optometric Congress,* 1959, *21,* 75–88.

Friedlander, W. J. Some aspects of eyedness. *Cortex,* 1971, *7,* 357–371.

Gahagan, L. Visual dominance-acuity relationships. *Journal of General Psychology,* 1933, *9,* 455–459.

Geldard, F. A., & Crockett, W. B. The binocular acuity relation as a function of age. *Journal of Genetic Psychology,* 1930, *37,* 139–145.

Gilkey, B. G., & Parr, F. W. Analysis of the reversal tendency of fifty selected elementary school pupils. *Journal of Educational Psychology,* 1944, *35,* 284–292.

Greenberg, B. Eye-dominance and head tilt. *American Journal of Psychology,* 1960, *73,* 149–151.

Groden, G. Lateral preferences in normal children. *Perceptual and Motor Skills,* 1969, *28,* 213–214.

Gronwall, D. M., & Sampson, H. Ocular dominance: A test of two hypotheses. *British Journal of Psychology,* 1971, *62,* 175–185.

Hall, K. R., & Mayer, B. Hand preferences and dexterities of captive patas monkeys. *Folia Primatologica,* 1966, *4,* 169–185.

Hallgren, B. Specific dyslexia ("congenital word-blindness"): A clinical and genetic study. *Acta Psychiatrica et Neurologica* (Supplement 65). Copenhagen: Munsgaard, 1950.

Halstead, W. C., Walker, A. E., & Bucy, P. C. Sparing and nonsparing of "macular vision" associated with occipital lobectomy in man. *Archives of Ophthalmology,* 1940, *24,* 948.

Hamburger, F. A. Monocular dominance in binocular vision. *Klinische Monatsblatter fur Augenheilkunde,* 1943, *109,* 1.

Harris, A. J. Lateral dominance, directional confusion, and reading disability. *Journal of Psychology,* 1957, *44,* 283–294.

Hayashi, T., & Bryden, M. P. Ocular dominance and perceptual asymmetry. *Perceptual and Motor Skills,* 1967, *25,* 605–612.

Hirata, K. Experimental study on right-left problems in visual balance. *Psychologia: An International Journal of Psychology in the Orient,* 1968, *11,* 139–142.

Hogg, W. F. Reversal of eye preference at reading distance, associated with specific reading disability (dyslexia). *Canadian Psychiatric Association Journal,* 1968, *13,* 85–86.

Howard, I. P., & Templeton, W. B. *Human spatial orientation.* New York: Wiley, 1966.

Hubel, D. H., & Wiesel, T. N. Receptive fields of single neurones in the cat's striate cortex. *Journal of Physiology,* 1959, *148,* 574–591.

Hubel, D. H., & Wiesel, T. N. Receptive fields binocular interaction and functional architecture in the cat's visual cortex. *Journal of Physiology,* 1962, *160,* 106–154.

Hughes, H. An investigation into ocular dominancy. *British Journal of Physiological Optics,* 1953, *3,* 119–143.

Hugonnier, R., & Clayette-Hugonnier, S. *Strabismus, heterophoria, ocular motor paralyses: Clinical ocular muscle imbalance.* Saint Louis, Mo.: Mosby, 1969.

Humphiss, D. The measurement of sensory ocular dominance and its relation to personality. *American Journal of Optometry,* 1969, *46,* 603–615.

Humphrey, G. M. *The human foot and human hand.* Cambridge, England: Macmillan, 1861.

Imus, H. A., Rothney, J. W. M., & Bear, R. M. *An evaluation of visual factors in reading.* Hanover, N.H.: Dartmouth College, 1938.

Jasper, H. H., & Raney, E. T. The phi test of lateral dominance. *American Journal of Psychology,* 1937, *49,* 450–457.

Julesz, B. *Foundations of cyclopean perception.* Chicago, Ill.: University of Chicago Press, 1971.

Kephart, N. C., & Revesman, S. Measuring differences in speed performance. *Optometric Weekly,* 1953, *44,* 1965–1967.

Kounin, J. S. Laterality in monkeys. *Journal of Genetic Psychology,* 1938, *52,* 375.

Kovac, D., & Horkovic, G. How to measure lateral preference: I. *Studia Psychologica,* 1970, *12,* 5–11.

Kovac, D., & Ley, I. Visual differentiation and lateral preference. *Studia Psychologica,* 1969, *11,* 237–239.

Kruper, D. C., Boyle, B., & Patton, R. A. Eye preference in hemicerebrectomized monkeys. *Psychonomic Science,* 1967, *7,* 105–106.

Kruper, D. C., Patton, R. A., & Koskoff, Y. D. Hand and eye preference in unilaterally brain ablated monkeys. *Physiology and Behavior,* 1971, *7,* 181–185.

Kuroda, G. Observations on right- and left-eye children. *Nippon Lakko Eisei* (*Japanese School Hygiene*), 1926, *11,* No. 6.

Kussin, J. E., & Harcum, E. R. Relative attensity of stimuli in left and right visual hemifields. *Perceptual and Motor Skills,* 1967, *24,* 807–822.

LaGrone, C. W., & Holland, B. F. Accuracy of perception in peripheral vision in relation to dextrality, intelligence and reading ability. *American Journal of Psychology,* 1943, *56,* 592–598.

Lavery, F. S. Ocular dominance. *Transactions of the Ophthalmological Society of the United Kingdom,* 1944, *63,* 409–435.

Lebensohn, J. E. Ocular dominance and marksmanship. *U.S. Navy Medical Bulletin,* 1942, *40,* 590–594.

Lederer, J. Ocular dominance. *Australian Journal of Optometry,* 1961, *44,* 531–574.

Lehman, R. A. Hand preference and cerebral predominance in 24 rhesus monkeys. *Journal of Neurological Science,* 1970, *10,* 185–192.

Lund, F. H. The dependency of eye-hand coordinations on eye dominance. *American Journal of Psychology,* 1932, *44,* 756–762.

MacMeeken, M. *Ocular dominance in relation to developmental aphasia.* London: University of London Press, 1939.

MacMeeken, M. *Developmental aphasia in educationally retarded children.* London: University of London Press, 1942.

Martin, F., Friedrich, G., Mortier, C. H., & Guignard, F. La lateralite chez l'epileptique. *Annales Medico-Psychologiques,* 1968, *2,* 665–692.

Mefferd, R. B., Jr., & Wieland, B. A. Influence of eye dominance on the apparent centers of simple horizontal lines. *Perceptual and Motor Skills,* 1969, *28,* 847–850.

Miles, W. R. Ocular dominance demonstrated by unconscious sighting. *Journal of Experimental Psychology,* 1929, *12,* 113–126.

Miles, W. R. Ocular dominance in human adults. *Journal of General Psychology,* 1930, *3,* 412–420.

Miles, P. W. Depth factors in anisopia. *American Journal of Ophthalmology,* 1954, *37,* 98–107.

Mills, L. Eyedness and handedness. *American Journal of Ophthalmology,* 1925, *8,* 933–941.

Mills, L. Unilateral sighting. *California and West Medicine,* 1928, *28,* 189–195.

Money, J. Studies on the functioning of sighting dominance. *Quarterly Journal of Experimental Psychology,* 1972, *24,* 454–464.

Monroe, M. *Children who cannot read.* Chicago, Ill.: University of Chicago Press, 1932.

Oddy, H. C., & Lobstein, T. J. Hand and eye dominance in schizophrenia. *British Journal of Psychiatry,* 1972, *120,* 331–332.

Ogle, K. N. *Researches in binocular vision.* New York: Hafner, 1964.

Oltman, P. K., & Capobianco, F. Field dependence and eye dominance. *Perceptual and Motor Skills,* 1967, *25,* 645–646.

Ondercin, P., Perry, N. W., & Childers, D. G. Distribution of ocular dominance and effect of image clarity. *Perception & Psychophysics,* 1973, *13,* 5–8.

Ong, J., & Rodman, T. Sex and eye-hand preferential difference in star-tracing performance. *American Journal of Optometry and Archives of the Academy of Optometry,* 1972, *49,* 436–438.

Ono, H., Wilkinson, A., Muter, P., & Mitson, L. Apparent movement and change in perceived location of a stimulus produced by a change in accommodative convergence. *Perception & Psychophysics,* 1972, *12,* 187–192.

Orton, S. T. An impediment in learning to read: A neurological explanation of the reading disability. *School and Society,* 1928, *28,* 286–290.

Orton, S. T. *Reading, writing and speech problems in children.* New York: Norton, 1937.

Palmer, M. F. Studies in clinical techniques. *Journal of Speech Disorders,* 1947, *12,* 415–418.

Parsons, B. S. *Left-handedness.* New York: Macmillan, 1924.

Pascal, J. I. The chromatic test for the dominant eye. *American Journal of Ophthalmology,* 1926, *9,* 357–358.

Penfield, W., & Rasmussen, T. *The cerebral cortex of man: A clinical study.* New York: Macmillan, 1950.

Perry, N. W., & Childers, D. Monocular contribution to binocular vision in normals and amblyopes. In G. B. Arden (Ed.), *The visual system: Neurophysiology, biophysics and their clinical applications.* New York: Plenum Press, 1972.

Polyak, S. *The vertebrate visual system.* Chicago, Ill.: University of Chicago Press, 1957.

Porac, C. Ocular dominance and suppressive processes in binocular vision (Doctoral dissertation, Graduate Faculty of the New School for Social Research, 1974). *Dissertation Abstracts International,* 1975, *35,* 4229B. (University Microfilms No. 75-2323)

Porac, C., & Coren, S. Is sighting dominance a part of generalized laterality? *Perceptual and Motor Skills,* 1975, *40,* 763–769. (a)

Porac, C., & Coren, S. Suppressive processes in binocular vision: Ocular dominance and amblyopia. *American Journal of Optometry and Physiological Optics,* 1975, *52,* 651–657. (b)

Porta, I. B. *De refractione.* Optics Parte: Libri Novem. Ex Officina Horatij Salvania. Naples: Apud Io Iacobum Carlinum & Anotnium Pacem, 1593.

Quinan, C. The principal sinistral types: An experimental study particularly as regards their relation to the so-called constitutional psychopathic states. *Archives of Neurology and Psychiatry,* 1930, *24,* 35–47.

Quinan, C. The handedness and eyedness of speeders and of reckless drivers. *Archives of Neurology and Psychiatry,* 1931, *25,* 829–837.

Rengstorff, R. H. The types of incidence of hand-eye preference and its relationship with certain reading abilities. *American Journal of Optometry and Archives of the American Academy of Optometry,* 1967, *44,* 233–238.

Rothschild, F. S., & Streifler, M. On eyedness in homonymous hemianopia. *Journal of Nervous and Mental Disease,* 1952, *116,* 59–64.

Sampson, H. Recall of digits projected to temporal and nasal hemi-retinas. *Quarterly Journal of Experimental Psychology,* 1969, *21,* 39–42.

Sampson, H., & Spong, P. Handedness, eye-dominance, and immediate memory. *Quarterly Journal of Experimental Psychology,* 1962, *13,* 173–180.

Sanford, H. C., & Bair, H. L. Visual disturbance associated with tumors of the temporal lobe. *Archives of Neurology and Psychiatry,* 1939, *42,* 21.

Satz, P. Pathological left-handedness: An explanatory model. *Cortex,* 1972, *8,* 121–135.

Schapero, M. *Amblyopia.* Philadelphia: Chilton Book Company, 1971.

Scheidemann, N. V., & Robinette, G. E. Testing the ocular dominance of infants. *Psychological Clinic,* 1932, *21,* 62–65.

Schoen, Z. J., & Scofield, C. F. A study of the relative neuromuscular efficiency of the dominant and non-dominant eye in binocular vision. *Journal of General Psychology,* 1935, *11,* 156–181.

Schrader, C. W. The effect of visual differences on hand-eye coordinated performance. *Western Carolina University Journal of Education,* 1971, *2,* 28–33.

Scott, R. B., & Sumner, F. C. Eyedness as affecting results obtained with the Howard and Dolman depth perception apparatus. *Journal of Physiology,* 1949, *27,* 479–482.

Selzer, C. A. Lateral dominance and visual fusion: Their application to difficulties in reading, writing, spelling, and speech. *Harvard Monographs in Education* (No. 12), Cambridge, Mass.: Harvard University Press, 1933.

Sheard, C. Unilateral sighting and ocular dominance. *American Journal of Physiological Optics,* 1926, *7,* 558–567.

Shick, J. Relationship between depth perception and hand-eye dominance and free-throw shooting in college women. *Perceptual and Motor Skills,* 1971, *33,* 539–542.

Silver, A. A., & Hagen, R. A. Specific reading disability: Delineation of the syndrome and relationship to cerebral dominance. *Comprehensive Psychiatry,* 1960, *1,* 126–134.

Simpson, R. G., & Sommer, R. C. Certain visual functions as related to rifle marksmanship. *School and Society,* 1942, *55,* 677–679.

Sinclair, C. B., & Smith, I. M. Laterality in swimming and its relationship to dominance of hand, eye, and foot. *The Research Quarterly,* 1957, *28,* 395–402.

Smith, J. W. The sensory function of the nonpreferred hand. *Journal of Experimental Psychology,* 1933, *16,* 271–282.

Smith, L. Eye dominance in a monkey. *Perceptual and Motor Skills,* 1970, *31,* 657–658.

Snyder, A. M., & Snyder, M. A. Eye preference tendencies. *Journal of Educational Psychology,* 1928, *19,* 431–435.

Sparrow, S. S. Reading disability and laterality. Proceedings of the 77th Annual Convention of the American Psychological Association, 1969, *4,* 673–674. (Summary)

Spitzer, R. L. The relationship between "mixed dominance" and reading disability. *Journal of Pediatrics,* 1959, *54,* 76–80.

Spong, G. Recognition and recall of retarded readers: A developmental study (Winifred Gimble Report). Auckland, New Zealand: University of Auckland, 1962.

Spreen, O., Miller, C. G., & Benton, A. L. The phi-test and measures of laterality in children and adults. *Cortex,* 1966, *2,* 308–321.

Stephens, W. E., Cunningham, E. S., & Stigler, B. J. Reading readiness with eye-hand preference patterns in first grade children. *Exceptional Children,* 1967, *33,* 481–488.

Stevenson, L., & Robinson, H. Eye-hand preferences, reversals, and reading progress. In Robinson, H. M. (Ed.), *Clinical studies in reading:* II. Chicago, Ill.: University of Chicago Press, 1953.

Suchman, R. G. Visual testing of preverbal and nonverbal young children. *American Journal of Optometry and Archives of the American Academy of Optometry,* 1968, *45,* 642–657.

Teegarden, L. Clinical identification of the prospective non-reader. *Child Development,* 1932, *3,* 346–358.

Toch, H. H. Can eye dominance be trained? *Perceptual and Motor Skills,* 1960, *11,* 31–34.

Updegraff, R. Ocular dominance in young children. *Journal of Experimental Psychology,* 1932, *15,* 758–766.

Van Biervlet, J. J. Nouvelle contribution a l'etude de l'asymetrie sensorielle. *Bulletins de l'Academie Royal des Sciences de Belgique,* 1901, *3,* 679–694.

Verhoeff, F. A new theory of binocular vision. *Archives of Ophthalmology,* 1935, *13,* 151–175.

Vernon, M. D. *Backwardness in reading: A study of its nature and origin.* Cambridge, England: Cambridge University Press, 1957.

Walker, H. H., & Birch, H. G. Lateral preference and right-left awareness in schizophrenic children. *Journal of Nervous and Mental Disease,* 1970, *151*, 341–351.

Walls, G. L. A theory of ocular dominance. *A.M.A. Archives of Ophthalmology,* 1951, *45*, 387–412.

Washburn, M. F., Faison, C., & Scott, R. A comparison between the Miles A-B-C method and retinal rivalry as tests of ocular dominance. *American Journal of Psychology,* 1934, *46*, 633–636.

White, M. J. Laterality differences in perception. *Psychological Bulletin,* 1969, *72*, 387–405.

Williams, D., & Gassel, M. M. Visual functions in patients with homonymous hemianopia. *Brain,* 1962, *85*, 175–250.

Witty, P. A., & Kopel, D. Sinistral and mixed manual ocular behavior in reading disability. *Journal of Educational Psychology,* 1936, *27*, 119–134.

Wold, R. M. Dominance—fact or fantasy: Its significance in learning disabilities. *Journal of the American Optometric Association,* 1968, *39*, 908–916.

Woo, T. L. Dextrality and sinistrality of hand and eye: Second memoir. *Biometrika,* 1928, *20*, 79–158.

Woo, T. L., & Pearson, K. Dextrality and sinistrality of hand and eye. *Biometrika,* 1927, *19*, 165–199.

Zangwill, O. L. Dyslexia in relation to cerebral dominance. In *Reading disability*. Baltimore, Md.: Johns Hopkins Press, 1962.

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