Retinal rivalry and Troxler's effect

ALVIN G. GOLDSTEIN

UNIVERSITY OF MISSOURI, COLUMBIA

The proposition that Troxler's effect is an interactive process, that is, retinal rivalry between the occluded and non-occluded eye, was tested. It was assumed, that, in one-eyed individuals, binocular interaction was eliminated. Troxler disappearances were measured in monocular Ss and normal Ss. Monocular Ss reported fewer disappearances at each of eight visual meridians. Neither a strong interactive interpretation, nor a strong non-interactive interpretation is supported by these data.

This report is concerned with the relationship between retinal rivalry (RR) and Troxler's effect (TE), both primarily characterized by perceptual experiences of stimulus disappearances while S is viewing an unchanging visual stimulus. During RR part or all of the image in one eye disappears and is replaced phenomenologically by the image in the other eye. These alternations can occur in an almost regular cyclical manner. Troxler's effect, which is less well known but quite as venerable as RR (Troxler, 1804), can be demonstrated when an observer monocularly fixates a central point and attends to a parafoveal stimulus. The nonviewing eye may be covered by a black patch. After a short observation period, most Ss report transitory disappearances of part or all of the parafoveal stimulus. Figure 1 depicts one kind of stimulus which produces TE disappearances.

On the one hand, it is reasonable to hypothesize that TE disappearances are caused by rivalry between the occluded and nonoccluded eyes. This view essentially equates RR and TE. On the other hand, Levelt (1965) has proposed that TE is "...spontaneous and has nothing to do with the homogeneous stimulation of the other eye" (p. 19). He calls TE "spurious rivalry" and proposes that the two phenomena are due to different types of mechanisms. Data will be presented here suggesting that Levelt's interpretation should be reconsidered.

One inference of Levelt's interpretation seemed open to test. If TE is non-interactive, i.e., not caused by interaction between the occluded and non-occluded eye, then TE should be the same before and after the occluded eye is entirely eliminated. Thus, if one eye were removed and enough time elapsed to allow the optic nerve to degenerate, then binocular neural interaction would be eliminated. Severing of the optic nerve is one way to cause nerve degeneration; severe retinal damage or other pathology which completely obstructs light from stimulating the retina will also cause nerve degeneration. In keeping with this reasoning, TE was measured in a small group of monocular

Ss, that is, individuals who through accident or surgery have only one eye. A control group of normal Ss matched in age with the monocular group was also tested.

To recapitulate the problem and state the possible outcomes: If TE is interactive, and loss of one eye eliminates this interaction, then monocular Ss should not experience TE. If TE is non-interactive as Levelt believes, and loss of one eye eliminates the interaction which is normally present, then TE in binocular and monocular Ss should be indistinguishable. If, however, loss of one eye is assumed to reduce but not eliminate "binocular" interaction in centers higher than the lateral geniculate level, then monocular Ss should report TE, but less often than normal Ss. This means that cutting one optic nerve at the eye will cause degeneration up to the geniculate level, but innervation from both geniculates to the visual cortex will only be reduced, not eliminated.

Method

Obtaining Ss with only one, normally functioning eye proved to be a major problem. Six monocular Ss who satisfied the criteria could be located. Three of these had one eye surgically removed, and three had no responses to light in one eye because of some major pathological condition (e.g., punctured eye) which did not involve the other eye. At the time of testing, the shortest elapsed time from the onset of the monocular condition was nine years; the longest, 45 years (age range of Ss 18-55, mean=38). Visual testing of the functioning eye in each of these Ss indicated no obvious pathology. In fact, except for presbyopia in the older Ss, the group had excellent vision in the functioning eye. Comparison data were

Fig. 1. Visual angle subtended by stimulus figure. Transillumination produced a black figure on a white field (.75 ft. L).

Fig. 2. Mean frequency of disappearance of stimulus line as a function of angular orientation for two binocular groups and one monocular group of Ss. 0°, 90°, 180°, etc. refers to the 12, 3 and 6 o'clock positions, respectively, of the stimulus line.

collected from a control group of 17 normal Ss (age 18-57, mean = 38).

Using the stimulus described in Fig. 1, TE was measured when the stimulus line was presented in the eight positions listed on the abscissa of Fig. 2 (0° at 12 o'clock, 90° at 3 o'clock, etc.). This method of measuring TE was employed for reasons which will be clarified below. At each meridian the stimulus was presented for 2 consecutive min., and a fixation of the central dot was required. Binocular Ss viewed the target with their sighting dominant eye; the other eye remained open under a black eye patch. S was instructed to report disappearances of part or all of the stimulus line by a key press response which was recorded on an event recorder.

Results and Discussion

A "pure" interactive interpretation would be supported only if the monocular Ss reported zero TE; a "pure" non-interactive interpretation would be supported only if the monocular Ss' mean TE was not different from the matched group of binocular Ss. The results do not support either of these extreme interpretations. As shown in Fig. 2, the monocular Ss reported fewer disappearances ($\bar{X}=0.5$ per min.) than the normal Ss ($\bar{X}=2.7$ per min.) at each of the eight meridians. Only two of the monocular Ss failed to report TE. At least two interpretations could account for these data. TE is an interactive process, but disappearances may also be caused by another mechanism. Or, loss of one eye does not eliminate "interaction" at the cortical level (a view discussed briefly above), and therefore the present test of the interaction hypothesis was not adequate, hence TE was reduced instead of being eliminated in the monocular group. Neither of these interpretations is favorable to the non-interactive explanation of TE. In the light of the data and this discussion, it is tempting to speculate that in a "truly" monocular S—e.g.,

one with total destruction of, say, one lateral geniculate—TE will be eliminated.

The unusual wave-like shape of the normal Ss' curve, and, to a lesser degree, the monocular Ss' curve, is not random variability. In fact, adding Ss accentuates the wave-like pattern, as shown in the data of 30 additional normal Ss plotted in Fig. 2. Moreover, the relationship between retinal meridian and frequency of disappearance found here has been previously reported by Craig & Lichtenstein (1953).¹ Their method was employed in the present investigation because it afforded a way to sample responses from several retinal areas, in addition to providing an opportunity to replicate their original experiment.

Why are there so few disappearances in the left visual field of the binocular group? With only six cases, any answer is no better than a guess, but one may speculate that, as a consequence of the reduced (binocular) interaction, the natural sensory-perceptual dominance of the right cerebral hemisphere becomes manifest. This view, which is supported by several studies indicating the sensory dominance of the right hemisphere (Freedman, 1963, 1966; Gazzaniga, Bogen, & Sperry, 1965), makes sense only if it is assumed that lack of disappearances—uninterrupted perception—is a sign of cerebral dominance.

The complexities of the TE-RR relationship, already great, are not improved by one more fact. Normal, two-eyed Ss who do not report disappearances at any one of the eight meridians, have been tested. Although these cases are not common, they do pose a problem, inasmuch as no gross visual defect could be detected in either eye from routine tests, nor could they be distinguished from other normal Ss in terms of their responses on these tests. However, they did tend to be found more commonly in those Ss between 30 and 50 years of age than in college age Ss, suggesting that the relationship between age and TE should be examined.

References

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Note

1. Craig and Lichtenstein apparently were not aware of the relationship between their data and TE.