Retinal rivalry and Troxler's effect: A correlation

ALVIN G. GOLDSTEIN
UNIVERSITY OF MISSOURI, COLUMBIA

Retinal rivalry and Troxler disappearances were measured in 30 Ss. Correlations suggesting a significant relationship between the two phenomena are reported. Tentative interpretation of the data are presented.

In an earlier investigation (Goldstein, 1967) of Troxler's effect, where stimulus disappearances were measured in one-eyed and in normal Ss, more image persistence was found in the one-eyed Ss. This reduction in disappearance frequency of a parafoveal stimulus was accepted as evidence that Troxler's disappearances in normal Ss were partially caused by retinal rivalry between the occluded and nonoccluded eyes.

Because of certain obvious limitations of the interpretation of these data, imposed by the logic of the experiment (e.g., perhaps relevant changes in the functions of the remaining eye occur as a result of loss), it would be valuable to obtain from another source confirming evidence bearing on the Troxler-rivalry relationship. The present report offers this evidence, obtained by correlating Troxler disappearance rates with a measure of binocular rivalry in normal Ss.

From one extreme viewpoint, it may be reasoned that if the two phenomena are actually related to identical processes, or if both are interactive processes, then there should be a positive correlation between rivalry and Troxler measured in the same individuals. Reasoning from a contrary assumption, if Troxler is a spontaneous, random process (Levelt, 1965) occurring at the retinal level, and rivalry is an interactive, central process, then no correlation between rates of Troxler and rates of binocular rivalry should be observed. It should be pointed out that traditionally the Troxler effect has been assumed to be found only in the peripheral retina (e.g., Granit, 1930) whereas rivalry can readily be demonstrated in either the fovea or the periphery. Were this indeed the case, there would be little point in attempting to find a relationship; two phenomena which do not overlap in retinal locus would be unlikely to be otherwise closely related. Contrary to expectation, recent research has shown that the Troxler effect can be demonstrated in the rod-free area of the fovea (Porter & Wiseman, 1967).

METHOD

Rivalry and Troxler measures were obtained from 15 men and 15 women students at the University of Missouri. Only Ss with uncorrected vision were permitted to take the visual screening tests, administered prior to the experiment. Any S was rejected if

Fig. 1. Visual angle subtended by stimulus figure used in measuring Troxler effect.

Snellen acuity was poorer than 20/30 in each eye, or if he could not fuse and hold for 60 sec a stereoscopically presented monocular "x" within a monocular circle. The latter test stimuli lacked the typical binocular fusion contours. Thus, poor muscle balance between the two eyes was more readily discovered as evidenced by Ss' inability to "hold" the "x" within the circle.

Transilluminated binocular rivalry and Troxler stimuli were presented by means of a synoptophore (a type of haploscope similar to the AO Troposcope). The rivalry stimuli were monocular vertical and horizontal lines 2.6 deg in retinal extent surrounded by a circular, binocular fusion stimulus. All Ss were tested for 2 min of continuous viewing on two sets of rivalry stimuli; black lines on a white field (15 ft-L field luminance), and white lines on a black field (.008 ft-L). The Troxler stimulus, with visual angle measurements, is illustrated in Fig. 1. Troxler disappearances were recorded during 2 min of continuous viewing for each of eight orientations: 0 deg, 45 deg, 90 deg, 135 deg, 180 deg, 225 deg, 270 deg, 315 deg, (0 deg = 12 o'clock, 90 deg = 3 o'clock, etc., see Goldstein, 1967).

In the rivalry condition, while fixating the center of the cross formed by the horizontal and vertical lines S depressed a switch at his right (left) hand to signify that the horizontal (vertical) line was perceptually dominant, i.e., disappearance of some part or all of the vertical (horizontal) line. Both switches were depressed if both lines appeared to be intact. In the Troxler condition only one switch was used to indicate disappearance and reappearance of any part or all of the stimulus line. All responses were recorded on either one or two channels of an event recorder. A black eye patch was placed over the (sighting) non-dominant eye during the Troxler trials. Instructions for these trials have been reported elsewhere (Craig & Lichtenstein, 1953), but basically, S was asked to visually fixate the center of the circle (Fig. 1) and "pay attention" to the line extending into the periphery of his visual field. He was warned to inhibit the strong tendency to move his eyes to get a clearer view of the "missing" piece of the line.

All six possible sequences of the three conditions (Troxler, rivalry with black or with white figure) were employed; a random number table dictated the sequence for each S in the eight trials within the Troxler condition.

RESULTS AND DISCUSSION

The traditional measure of retinal rivalry has been supplanted by a measure more suited to the realities of the task. The dependent variable here was the number of perceptual changes

Fig. 2. Number of changes reported during two retinal rivalry tasks. Each curve is derived from responses of 30 Ss.

reported by S, a measure which takes into account the fragmenting of the rivalry targets, a ubiquitous finding in these experiments. Instead of simply counting the number of regular disappearances of the right and left eye targets—alternations or cycles in the traditional method—any major change in the perceptual situation was counted as an instance of rivalry. Thus, all or part of the left eye target could fade and return three times in, say, 10 sec and in terms of cycles this would be scored as zero; in the present measuring system this would be scored as three changes. We will return to this question in a moment.

The correlation between the two rivalry conditions was $+0.71$, ($p < .001$), which represents, for these data, the value of r to which the Troxler-rivalry comparisons should be contrasted. Overall, Troxler scores correlated $+0.42$ ($p < .01$) with combined rivalry scores, $+0.51$ ($p < .01$) with the black on white rivalry condition, and $+0.30$ ($p < .05$) with the white on black condition. Although further analysis of these data, by sex of S, was justified on the basis of earlier research (Goldstein & Cofoid, 1965), the small number of cases of each sex precludes any firm conclusions. It is interesting to note that the 3 Troxler-rivalry correlations ranged between $+0.65$ to $+0.78$ for men, and between $+0.37$ to $+0.13$ for women. No explanation can be offered for this finding except to mention that sex differences in rivalry rates has consistently been found in this laboratory.

Inspection of Fig. 2 illustrates the number of changes tallied for each of the rivalry conditions as a function of duration of observation. The close relationship between the mean responses in two rivalry conditions is somewhat surprising, since, typically, variability of response—especially from untrained Ss—is very great in rivalry situations. Notice, also, the characteristic (Cogan & Goldstein, 1967) increase in number of changes as observation time increases.

Figure 3 depicts the reported Troxler disappearances as a function of the spatial orientation of the stimulus line. The unusual shape of this curve, clearly indicating that the incidence of Troxler's effect is not equally probable at all retinal areas, has been reported earlier (Craig & Lichtenstein, 1953; Goldstein, 1967), and the basic wave-like pattern has since been repeatedly verified in this laboratory. Graphical analyses of these data for each of the eight stimulus conditions as a function of observation interval was performed, and Fig. 4 illustrates typical examples of

Fig. 3. Mean frequency of disappearance of stimulus line as a function of angular orientation. See text for explanation.

Fig. 4. Number of disappearances of Troxler stimulus as a function of time of observation for two spatial orientations.

the resultant curves from two spatial positions (270 deg and 315 deg). Notice that the curve showing an increment in number of disappearances as a function of duration of observation resembles the rivalry data illustrated in Fig. 2, again suggesting a similarity between the two processes.

Evidence of the reliability of the correlations reported here has been obtained in a study (unpublished) employing a different optical instrument (Keystone telebinocular). Responses of 28 Ss to two Troxler stimuli, differing in angular extent, were correlated with responses to two sets of rivalry stimuli differing in angular extent. Correlations of $+0.50$ to $+0.19$ were observed, with the highest correlations, as expected, between those conditions where Troxler and rivalry targets were closely related in visual extent.

Several interpretations of these correlations and the earlier data from one-eyed Ss (Goldstein, 1967) come to mind. Rivalry and Troxler could be caused by completely different mechanisms and still show a moderate correlation, simply because many functions within the same individual are, indeed, moderately correlated. This interpretation is not convincing when it is recalled that the men's correlations of rivalry with Troxler were quite as large ($.65$, $.75$, and $.78$) as the correlation between the two rivalry tasks ($.77$). One is almost tempted to conclude that the process may be different in men than it is in women. Before this rather unlikely explanation is offered, however, the question of response differences between men and women should be carefully investigated. What is implied here is the possibility that men and women do not interpret perceptual changes in the same way.

The observed correlation may illustrate the fact that more basic mechanisms control the neurological activity level and both phenomena are governed by this general pace-setter. This latter interpretation has some empirical support. Significant correlations between rivalry and number of perceptual shifts of the Necker cube have been reported (George, 1936), yet there is almost no reason to believe that the same process controls Necker cube fluctuations and retinal rivalry fluctuations.

At this time no clear picture emerges, so no attempt will be made to develop a comprehensive interpretation of all the data. Certain aspects of the problem appear to be consistent with the notion that rivalry and Troxler are intimately related. For example, Troxler is greatly reduced in the remaining eye when the other eye is removed or is completely non-functional (Goldstein, 1967). However, the low correlation observed in the women's data tends to weaken this conclusion. If we set that problem aside for a moment, it would be fruitful to consider the proposition that

rivalry and Troxler are not identical phenomena, that is, Troxler is not the limiting case of rivalry where only one eye is stimulated with a contoured stimulus. Instead, the two phenomena may be reflecting what occurs when stimulus failure takes place as a function of visual fixation, a condition which provides for increased image stabilization. This line of thought will be expanded in a subsequent report.

Some additional discussion of the measurement technique employed in this investigation is warranted. As explained earlier, the rivalry response measure differed from the traditional measure of perceptual alternation (cycles). The present measurement has been employed with success in earlier studies (Goldstein & Cofoid, 1965; Cogan & Goldstein, 1967). The notion that there are regular alternations in the momentary perceptual dominance of each visual field does not square with what is actually seen in a rivalry situation. Careful observation makes it clear that "clean" alternation often is seen but is not the *only* perceptual event occurring. To some degree, this ambiguity of the phenomenal activity can be reduced by using small targets and also by using stimuli which lack detail. For example, Ogle used a concentric black disc and annulus as a stereoscopic target (Ogle, 1967). But even with these targets, fragmentation is still seen, albeit lessened in severity and somewhat more difficult to report. This lack of clean alternation has been ignored by many, but not all, investigators in order to simplify the Ss' task of reporting his experience, and thereby make it possible for E to obtain scoreable data. Ignoring fragmentation seems, to this investigator, to be an expensive loss of data. Incomplete disappearances, although difficult to understand when viewed from the theoretical standpoint of alternating dominance

of visual inputs, are apparently experienced rather frequently when each eye is simultaneously stimulated with very different stimuli. If the incomplete disappearances are not rivalry, what else can they signify? No clear answer is evident, but we might speculate on the possibility that we have a few too many terms describing visual events which only look different, but are actually various expressions of the same mechanism under changing conditions of input and sensory interaction.

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