

## BINOCULAR RIVALRY.

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In a former report on binocular rivalry<sup>1</sup> the average length of the normal rivalry phases for 10 mm. squares was reported to be 1.89 seconds with an average variation of .5 second. In the experiments upon which this report was based the stimuli — red and green squares with black lines running diagonally across them — were mounted upon a stereoscopic slide and placed in the stereoscope so that the red square was presented to the right eye and the green square to the left eye. The background of both squares was a uniform black. The length of time each field remained in consciousness was registered by means of electric keys connected with the recording pens of a kymograph drum. The observations were made upon myself ten years ago.

Within the last year I have repeated the experiments under the same conditions except that the squares were crossed by vertical and horizontal instead of by diagonal lines; vertical on the green and horizontal on the red squares. These squares were mounted as before on a uniformly black stereoscopic slide. Registration of the length of the phases of the rivalry was made upon a revolving drum by means of keys electrically connected with pens, one for each hand. The right key was pressed down when the right (red) field was in consciousness and the left key when the left (green) field was in consciousness. The kymograph drum carried a tuning fork marker which registered the time in hundredths of seconds.

Three hundred changes in the rivalry showed an average phase length of 1.84 seconds with an average variation of .5<sup>2</sup>

<sup>1</sup> 'On Inhibition,' Vol. III., No. 1, Monograph Supplement, PSYCHOLOGICAL REVIEW.

<sup>2</sup> There is considerable variation in the lengths of the rivalry phases for different individuals under the same conditions. This was found to be true in previous experiments. See also 'A Study of Retinal Rivalry in the After-image,' by Alma de Vries and Margaret F. Washburn, in the January number of the *American Journal of Psychology*, p. 131.

second. Between 54 and 55 changes occurred in the red and green fields during every 100 seconds, practically the same rate of fluctuation in the rivalry as that of ten years ago. The following account gives the time of the rivalry phases and rate of fluctuation under new conditions not yet reported upon.

THE EFFECT OF VARIATION IN THE SIZE OF THE STIMULI.

Five slides were prepared like the one used in the previous experiment except that they varied in size from 3 mm. to 30 mm. One hundred changes were recorded in each case. Tables I. and II. give the results

TABLE I.

Size of Squares	Length of Time of 100 Changes.	Average Length of Phase.
3 mm. squares.	317 seconds.	3.17 seconds.
8 " "	240 "	2.40 "
10 " "	184 "	1.84 "
20 " "	152 "	1.52 "
30 " "	130 "	1.30 "

The rate of fluctuation per 100 seconds is given in Table II.

TABLE II.

3 mm. squares.	31-32 changes in 100 seconds.
8 " "	41-42 " " " "
10 " "	54-55 " " " "
20 " "	65-66 " " " "
30 " "	76-77 " " " "

In one of the experiments already reported the stimuli were of different sizes for the two eyes. A 10 mm. square was presented to the right eye, a 5 mm. square to the left eye. This change in the size of the stimuli resulted in lengthening the average phase for the smaller square by .34 of a second. The normal rivalry, when 10 mm. squares were used for both eyes, showed 53-54 changes in 100 seconds and an average phase length of 1.89. But when one of the squares was reduced to 5 mm., the rivalry was reduced to 44-45 changes in 100 seconds and the phase corresponding to the smaller square was lengthened to 2.23 seconds while the phase for the larger square remained the same.

The effect of increasing the size of the squares is analogous to that which resulted from increasing the light intensities of

the stimulating squares. Experiments with the 10 mm. squares showed that the rate of fluctuation in the rivalry increased and decreased with the increase and decrease of the intensity of the lights used to illuminate the squares.<sup>1</sup> These lights varied from a very dim light just sufficient to make the lines upon the squares clearly perceptible to that of a 100 c.p. arc light. Table III. is compiled from the data of previous experiments.

TABLE III.

Light Intensities.	Rate per 100 Seconds.	Phase Length.
Dim light.	24-25	4.24 seconds.
16 c.p. at 400 cm. (Inc.).	46-47	2.15 "
16 c.p. " 50 " "	58-59	1.70 "
80 c.p. " " " "	67-68	1.48 "
100 c.p. " " " (Arc).	83-84	1.20 "

In the data given above the light intensities for each eye were equal in every case. But if the squares were unequally lighted, it was found that the phase length corresponding to the brighter square was lengthened instead of shortened. In every case where there was an equal increase in the light intensities of both squares there was an increase in the fluctuation of the rivalry and a decrease in the phase lengths, but when one square only was increased in light intensity, the rate of fluctuation was decreased, due to the increase in the phase length of the brighter square.

#### THE EFFECT OF DISTINCTNESS OF THE IMAGES UPON RIVALRY.

In the above experiments the stereoscopic slides were so adjusted that the retinal images were brought to a sharp focus on the retina. In order to determine what effect a change in the distinctness of the images would have upon the rivalry 400 changes were measured, 200 in focus and 200 out of focus. The slide with the 10 mm. squares was used.

##### IN FOCUS.

200 changes in 363 seconds.  
 Average length of phase 1.81 seconds.  
 Average variation .5 second.  
 55-56 changes in 100 seconds.

<sup>1</sup> 'On Inhibition,' page 39, Sec. 9.

Pushing the slide out 70 mm. from its position of sharpest focus, or until the black lines on the squares were just distinguishable, the following results were obtained :

OUT OF FOCUS.

200 changes in 748 seconds.

Average length of phase 3.74 seconds.

Average variation .5 + second.

26-27 changes in 100 seconds.

PERIPHERAL RIVALRY.

So far, only the rivalry of the central parts of the retina has been considered. For comparison of central with that of peripheral rivalry the slide with the 8 mm. squares was used. When placed in position in the stereoscope for clearest vision the slide was found to be 200 mm. from the principal foci of the eyes. In order to keep the distances from all parts of the slide to the retina uniform when the fixation points were changed, each half of the slide was mounted upon sections of spheres whose radii were 200 mm. The 8 mm. squares were each placed in the central parts of the sections and around each were placed eight fixation points, two to the right, two above, two to the left, and two below. All the points to the right and left of the squares were in the horizontal plane which cuts the eyes into upper and lower halves, and all the points above and below were placed in the median planes of each eye when they fixated the centers of the squares. The arrangement was such that there was a fixation point directly to the right, directly above, directly to the left and directly below the center of each square and at an angular distance of  $3.6^\circ$  from the centers. Similarly a second set of fixation points was placed at a distance of  $7.2^\circ$  from the centers.

When placed in the stereoscope the red square and the eight fixation points of the right field and the green square and eight fixation points of the left field were superimposed. Fixation of the points to the right resulted in projecting the images of the squares upon the temporal half of the right retina and upon the nasal half of the left retina, the right square upon the right eye and the left square upon the left eye respectively. If the first point were fixated the images of the squares were

approximately  $3.6^\circ$  from the foveæ and upon corresponding areas of the retinal surfaces. The rivalry then took place upon the peripheral parts of the retina. If the second point to the right were fixated then the images of the squares were approximately  $7.2^\circ$  from the foveæ. When the points to the left were fixated the images were thrown upon the left halves of the eyes; when the points above were fixated the images were thrown upon the upper halves; when the points below were fixated the images were on the lower halves of the eyes and at the distances from the foveæ represented by the distances of the fixation points from the centers of the squares. This gave an opportunity to measure eight sets of rivalry images upon the peripheral parts of the retina, and to compare the rates of rivalry and the lengths of the phases with that upon the central parts of the eyes. The rivalry was found in every case to be very much slower on the periphery and consequently the phases of the fluctuation were very much lengthened. The phase length was more than doubled while the rapidity of the fluctuations was less than one half that of normal central rivalry. The zones further from the foveæ gave a slower rivalry rate than the zones nearer the fovea. Table IV. gives the results of this experiment.

TABLE IV.  
Central Rivalry, 8 mm. Squares.

	Number of Changes Recorded.	Total Time of Changes.	Average Length of Phases.
	62	149 seconds.	2.44 seconds.

Peripheral Rivalry, 8 mm. Squares.

Fixation points $3.6^\circ$ from center of squares.	Right.	28	134.8 seconds.	4.80 seconds.
	Up.	40	236.9 "	5.92 "
	Left.	28	120.2 "	4.30 "
	Down.	40	208.7 "	5.22 "
Fixation points $7.2^\circ$ from center of squares.	Right.	24	121.5 seconds.	5.06 seconds.
	Up.	22	131.6 "	5.98 "
	Left.	22	125.7 "	5.71 "
	Down.	22	127.2 "	5.78 "

The average variation for the central rivalry was .5 second; for peripheral rivalry it was 1.1 seconds. The general average

of the length of the phases for the zones  $3.6^\circ$  from the foveæ was 5.05 seconds, while that for the zones  $7.2^\circ$  from the foveæ was 5.64 seconds. The rate of rivalry per 100 seconds was as follows :

TABLE V.

Central Rivalry.		40-41 changes in 100 seconds.					
Peripheral Rivalry.	{ Fixation point $3.6^\circ$ from center of squares.	Right.	20-21	"	"	"	"
		Up.	16-17	"	"	"	"
		Left.	20-21	"	"	"	"
		Down.	19-20	"	"	"	"
Peripheral Rivalry.	{ Fixation point $7.2^\circ$ from center of squares.	Right.	19-20	"	"	"	"
		Up.	15-16	"	"	"	"
		Left.	17-18	"	"	"	"
		Down.	17-18	"	"	"	"