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INDIVIDUAL AND INTERINDIVIDUAL DIFFERENCES IN BINOCULAR RETINAL RIVALRY IN MAN

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ABSTRACT

In a group of 12 male and female subjects of ages between 18 and 45 years the alternation frequency of binocular retinal rivalry (BRR) has been found to change depending upon the durations of the periods for which the target is fixated, and of the intercalated resting time. Analysis of variance indicated significant interindividual differences in level of mean frequency and in rate of increase.

DESCRIPTORS: Man, Vision, Binocular retinal rivalry, Perception-personality. (M. Aafjes, J. E. Hueting, P. Visser)

In 1760 du Tour described the effect of the use of two differently colored glasses upon the binocular observation of the environment. The two monocular excitation patterns appear to alternate in somewhat unpredictable ways when the two fields of vision differ sufficiently in at least one aspect (color, texture, etc.). Either one excitation is operative for a time and the other is inhibited (suppression), and vice versa, or fusion of the monocular excitation patterns is prevented. The literature on binocular retinal rivalry (BRR) is contradictory on this point.

Breese (1899; 1909) published two papers on the variables influencing the alternation frequency, such as luminance, eccentricity, and size of the test target, and blurring of contours. Chauveau (1911) described the role of BRR in stereopsis and was challenged by Linschoten (1956) in his thesis. Hamburger (1949; 1952), however, used the BRR as an indicator of the keenness of stereoscopic depth perception, and found a high negative linear correlation in his subjects between their capability in binocular range measuring and their BRR alternation frequency. Kaufman (1963) studied the spread of suppression during BRR. Levelt (1965a; 1965b) in a thorough experimental study attributes the perceptual conflict in binocular rivalry to the incompatibility of two mechanisms: (1) *binocular brightness averaging* and (2) *contour mechanism.* The *binocular brightness* is constant when the sum of the two weighted monocular energies is constant. The weighting coefficients (w) giving the proportional shares of the eyes (de-

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pending upon eye dominance and presence of monocular contours) add to unity (law of complementary shares). The *w*s are relatively constant, provided the contour information does not change. When the *w* for one eye is increased artificially, the *w* for the other decreases by the same amount.

The second mechanism is called the *contour mechanism*: the presence of a contour in the field of vision of one eye enhances the *w* for that part of the monocular field, the enhancement being greater the nearer the contour to the fixation point. When the distance to the fixation point tends to zero, the *w* tends to unity. When two non-corresponding but adjacent contours are presented to the eyes, both of the *w*s tend to unity, whereas according to the law of complementary shares, the sum of the *w*s tends to unity, and a perceptual conflict arises. According to Levelt, the law of complementary shares may be retained unchanged by the assumption of an alternation process by which the *w*s reach unity *in turn*. The model proposed by Levelt is an attempt to bring the factors of frequency and dominance of the alternation process in close relation.

As perception is not at all independent of personality parameters, it is assumed by many authors that the BRR should be a useful variable in psychodiagnostic and personality research. BRR may trace "rigidity" (Barendregt, 1961), "neuroticism" (Brengelman, Eysenck, & Granger, 1957), or other parameters of human personality.

In view of the lack of consistency in the experimental results given in psychodiagnostic literature, the present authors attempted to achieve a prediction and an evaluation of the following three aspects of BRR: (1) intraindividual consistency; (2) interindividual differences in mean BRR frequencies; (3) intra- and interindividual differences in the rate of increase (if any) of the perceived BRR frequency.

Procedure and Data Scoring

A normal stereoscope is adapted to present, one to each eye, two circular target images consisting of parallel lines, the directions of which are mutually perpendicular. The subjects are asked to mark the BRR by tapping the table each time

TABLE 1

Analysis of variance

Source	Sum of Squares	*df*	Mean Squares	*F* Ratio	0.01 Critical *F* Value	*p*
Factor A	1.7955	4	0.4488	0.978	3.35	N.S.[a]
Factor B	32.4466	2	16.2233	35.359	4.64	≪0.01
Factor C	2117.9788	9	235.3309	512.904	2.44	≪0.01
Interactions						
A·B	7.1312	8	0.8914	1.943	2.54	N.S.
A·C	18.7601	36	0.5211	1.136	1.68	N.S.
B·C	95.5312	18	5.3072	11.567	1.90	≪0.01
A·B·C	92.7799	72	1.2886	2.808	1.45	<0.01
Residual	344.1667	750	0.4588			

[a] Not significant.

the target reappears in the field of vision of the right eye (or left, as the case may be). For this stage of our investigation the BRR has been expressed only as a frequency per minute, although we are fully aware of the fact that it would be better to record also the times during which the target is seen in the right (or left) field of vision.

After the orienting phase of the investigation, a standard procedure was followed. Three blocks of 9-min duration each were given, composed of five 1-min periods of target observation separated by four 1-min periods of rest. Resting periods of 5-min duration were intercalated between the blocks.

This standard method has been tested in 10 subjects. The BRRs were scored in periods of 10 sec, giving six replications for each minute's score. A three-factor analysis of variance has been calculated (Table 1).

Results and Discussion

Table 1 summarizes the results of the test group. Factor A, the 1-min score, measures the within-block variance; factor B, the 9-min blocks, measures the between-block variance; factor C measures the interindividual differences, giving the between-subjects variance. The interactions measure the lack of additivity in the variances of the three effects, A, B, and C. The F ratio for factor A indicates that the within-block variance does not exist, whereas the variances between blocks and between subjects really exist in accordance with the F ratios for factors B and C respectively. In view of the fact that the variances of factor A, and the variances of the interactions A·B and A·C apparently do not exist, we pooled these variances together with the original residual variances and added the respective degrees of freedom, so that a re-estimation of F ratios was possible. This sharpening of the estimation did not change the above-mentioned conclusions.

The reproducibility of the BRR patterns was matched in our series of 10 subjects, and the patterns were found to be intraindividually consistent to a reasonable extent, provided the standard procedure had been followed. Peculiar interindividual differences were found, however, when the mean frequencies were compared in the three consecutive blocks of one session.

In most of the subjects these subsequent mean block frequencies increased systematically in succession (the "climbers"); in a few, however, these three mean block frequencies remained approximately constant (the "non-climbers").

In order to ascertain whether this distinct augmentation was due to the intermittent method of target viewing in 1- and 5-min periods, a continuous method was tested in two other subjects. Each showed a steep "climbing" in the three subsequent block frequencies of the intermittent method. These subjects viewed the target for ½ hr, and they had to indicate the BRR continuously.

The result of this rather awkward test was that no systematic enhancement in frequency was found. Thus, these results apparently suggest that the main cause of the systematic increase must be sought in the discontinuous method of obtaining BRR observations.

Breaks of 5 min or more resulted in significant "climbing" in those subjects apparently susceptible to the intermittency of the procedure, a tendency to "climbing" only having been caused in this group by the 1 min intermittency. The *F* value for the factor B variance leads us to reject the hypothesis that the differences between block frequencies are due to chance only, and this supports our conclusions regarding the influence of longer resting periods intercalated between the blocks.

All the subjects were tested with a Minnesota multiphasic personality inventory (MMPI). No correlations, however, were found either between the MMPI profile and the "climber" or "non-climber" status, or between the profiles and the starting levels of BRR frequency.

During this investigation the subjects indicated that the speed of decision about the change in "dominance" of one field of vision to the other was apparently of prime importance. We looked for a correlation between the "?-score" of the MMPI and the level of BRR frequency. A Spearman's rank-difference correlation coefficient (ρ) of -0.40 was found, which is not significant at the 0.05 level.

The influence of external periodic stimuli has been studied. The mean level of the BRR frequency was found to be enhanced significantly by a metronome set at different frequencies between 30 and 100 cycles/min as an external source of auditory stimulation during the 9-min blocks. Stepwise increase of the metronome frequency every minute by 10 cycles/min was paralleled by a rise in BRR frequency. There was, however, no consistent proportion between the metronome frequency and the BRR level reached. The assumption of a "driving" of the BRR by the metronome had to be rejected, as a stepwise decrease in metronome frequency still produced a "climbing" of the BRR frequency, provided the subjects were found to be susceptible to "climbing" causes. So far, it may be concluded that the speed of decision was significantly facilitated by the presence, as such, of an external stimulus of a periodic character, independent of any falling or rising in the external stimulus frequency.

The BRR frequency is based upon a perceived periodic disappearance of the target image from the field of vision. In the course of the present investigation, we tried to find other objectively matchable periodic variables, such as electroencephalographic (EEG) waves (Lansing, 1964) or eye movements (Peckham, 1936; Kaufman, 1963), in relation to the BRR frequency, but until now no useful correlations have been found by us.

Summarizing these results, the authors wish to stress that, in their experience, for the determination of the BRR frequency, the results of two fixation periods of 1-min duration each, separated by 1 min of rest, did not give consistent and reproducible results in a group of subjects. The standard procedure as described here gave consistent results, but it brought to light in a number of subjects a consistent tendency to enhance the BRR frequency from block to block ("climbing"). The "non-climbers" apparently have a lower BRR frequency than the starting level of the "climber" group. The significance of a "climbing" or "non-climbing" BRR pattern and of the physiological functions of the BRR itself remain to be elucidated.

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