Notes and Comment

Binocular rivalry: The effects of orientation and pattern color arrangement

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When two grating targets which differ in orientation are simultaneously presented one to each eye, they appear to alternate. This transitory condition is commonly referred to as binocular rivalry.

Wade (1974) found that binocular rivalry was non-selective to orientational differences between the two monocular grating targets. That is, a vertical grating remains visible for about as long as an inclined one. His dependent measure was predominance time (i.e., the overall duration for which each grating in a given configuration was visible in its entirety). Other evidence indicates that the phenomenal suppression component of binocular rivalry is also nonselective to orientational differences (Blake & Fox, 1974). Though dealing with separate aspects of the phenomenon, these studies imply that the duration phase of predominance and the release from a suppression state are insensitive to the relative orientational separation of the grating targets. It is not clear from these studies, however, if orientation nonselectivity in binocular rivalry is limited to these aspects of the phenomenon alone.

The present study investigated the effects of orientation between dichotopically viewed grating targets, over a wide range of orientations, using predominance duration and predominance frequency (number of alternations) as dependent measures.

An additional variable in this investigation was color. Wade (1975) has shown that the distribution of responses, in a rivalry situation, varies with homochromatic and heterochromatic grating targets. Furthermore, it was shown that the differences in response distribution with pattern color arrangement was similar to those found in monocular pattern alternation. Rauschecker, Campbell, and Atkinson (1973) found that the greatest difference in alternation rate for monocular pattern alternation was found between achromatic and heterochromatic targets. Therefore, achromatic and heterochromatic targets were compared in this study to emphasize any color differences which might be found under binocular rivalry conditions.

METHOD

Subjects

Ten undergraduates served as observers in this experiment. All observers had 20/20 or corrected-to-20/20 vision with no astigmatism or color defects and were naive about the purpose of this study.

Apparatus

The stimuli, which were presented in a two-channel optical system, were photographic transparencies of sine-wave gratings generated on the face of a Tektronix 561B oscilloscope with a P-31 phosphor. The two channels were fitted with holders capable of rotating the transparencies through different orientations. At a viewing distance of 76.5 cm, the spatial frequency of the gratings was 5 c/deg. The stimuli were transilluminated by the lamps of two Kodak Ektagraphic projectors. The gratings were seen within circular apertures subtending a visual angle of 1.5°. The subjects' left and right eyes viewed the gratings separately by reflection on two plane mirrors placed in front of the eyes. The mirrors were adjusted to allow fusion of the two monocular patterns. The contrast of the gratings (maximum luminance - minimum luminance / maximum luminance + minimum luminance) was 0.6. The adapting field luminance and the space average luminance of the gratings was 10 cd/m² measured with an S.E.I. photometer. The apparatus was kept in a soundproofed and dimly lit room.

Procedure

The subjects were randomly assigned to one of the two experimental conditions (red-green, black-white) of five subjects each. At the beginning of the experimental session, the subjects were dark-adapted for 5 min and light-adapted to the adapting field. The subjects were told that they would view a circular aperture containing vertical lines in one eye and an aperture containing lines in a variety of inclined orientations in the other eye. They were told to report the dominance of the lines by depressing one of three telegraph keys. One key was to be depressed when the vertical lines were dominant, another key when the inclined lines were dominant, and a third key when both the vertical and inclined lines were visible (composite). They were instructed to change to the appropriate key whenever the dominance state changed during the 60-sec viewing period.

A trial consisted of a ready period followed by the offset of the adapting field and the presentation of the pattern for 60 sec, after which the pattern was extinguished and the adapting field turned on again. Fifteen seconds intervened before the next trial. Each subject judged the pattern for five trials.

Wratten filters No. 33 and 61 were used to produce the colors of red and green, respectively. The Wratten filters were used with the appropriate neutral density filters to equalize the luminance (10 cd/m²).

One grating was maintained in a vertical orientation, while the other grating was varied over the following relative (to vertical) orientations: 10°, 20°, 30°, 45°, 60°, and 90°.

The total number of responses made during each predominance state (predominance frequency) and the total amount of time (predominance duration) spent in a predominance state were the dependent measures in subsequent analyses.

RESULTS

Predominance Frequency

The results of this experiment are presented in Figure 1. In this figure, the number of keypresses is

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Figure 1. The number of keypresses is plotted as a function of the relative orientational difference between the grating targets, averaged over pattern color arrangement. The parameter of this figure is component category.

plotted as a function of the relative orientational difference between the gratings. The parameter of this figure is component category, i.e., vertical, inclined, or composite. The results of the two groups (red-green, black-white) have been combined in this figure.

An analysis of variance conducted upon these data indicated that the number of keypresses increased with a concomitant increase in relative orientational differences between the gratings [$F(5,60) = 11.22$,

$p < .01$]. The number of keypresses increased at a faster rate for vertical and inclined component groups than for the composite [$F(10,120) = 5.69$, $p < .01$]. In fact, there was relatively little change in the number of keypresses to the composite category over orientation. Significantly fewer responses were made to the composite category than to the other two response categories [$F(2,24) = 22.04$, $p < .01$].

Predominance Duration

The results for the duration measure are presented in Figure 2. Here, the total amount of time spent viewing a particular component of the pattern is plotted as a function of the relative orientational difference between the gratings. The parameter of this figure is component category. Again, color groups have been combined.

The Orientation by Component interaction was significant [$F(10,120) = 3.58$, $p < .01$]. This interaction is due to the relatively longer vertical response duration. In addition, there was also a significant component effect [$F(2,24) = 25.26$, $p < .01$]. More time was spent viewing the vertical and inclined gratings than the composite. When the relative orientational difference was greater than 30° , there was equal predominance times for the vertical and inclined gratings.

Comparison Between Chromatic and Achromatic Patterns

In Figure 3, the total number of alternations (collapsed across component category) is plotted as a function of the relative orientational differences between the gratings. The parameter of this figure is pattern color arrangement.

Figure 2. Predominance duration is plotted as a function of the relative orientational difference between the grating targets, averaged over pattern color arrangement. The parameter of this figure is component category.

Figure 3. The number of alternations is plotted as a function of the relative orientational difference between the grating targets, averaged over component category. The parameter of this figure is pattern color arrangement.

The Color by Orientation interaction was significant [$F(5,40) = 2.73$, $p < .05$]. Below a relative orientational difference of 30° , the total number of alternations was greater for the chromatic than for the achromatic patterns. At orientational differences above 30° , there was no apparent difference in alternation rate for the two color groups.

DISCUSSION

The results of this experiment indicated that the alternation rate of binocular rivalry increased as the relative orientational difference between the dichoptically viewed grating targets approached 90° . The failure to find binocular rivalry orientational sensitivities in previous studies (Blake & Fox, 1974; Wade, 1974) may be due in part to the particular response measures employed. If similar response measures (e.g., Wade, 1974, and the predominance duration measure of this study) are compared, orientation results resembling one another may be obtained. For example, it can be seen in Figure 2 of this study that the durations for the vertical and the inclined gratings were essentially equal when the gratings were separated by relative orientational differences greater than 30° . This is in direct agreement with Wade (1974). Wade also found duration differences, between a vertical and an inclined grating, for gratings separated by orientations of less than 30° . It was suggested by Wade that at these lesser orientational differences the processes of central fusion and cyclofusion were in operation (Kertesz & Jones, 1970). A fused percept would have the effect of favoring either the vertical or the inclined grating and therefore display a decrement in rivalry rate.

This cyclofusional¹ hypothesis receives additional support when one examines the chromatic-achromatic comparisons made in Figure 3. Notice that the decrement in alternation rate is considerably greater over the range of 10° - 30° for the achromatic patterns. Cyclofusion in this case is facilitated by stimulus similarity, namely achromaticity.

If cyclofusional processes are in operation within the range of 10° - 30° and there are no color differences noticed beyond this range, it would appear that the alternation rate, as well as the duration of the predominance phase of binocular rivalry, is insensitive to pattern color arrangement.

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NOTE

1. There is no way to separate out the motor and the sensory components of the fusional response given the present methodology. Therefore, the term "cyclofusion" is used in the discussion rather than central fusion.

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