Binocular fusion not affected by observer's interpretation of the stimulus¹

Samuel C. McLaughlin and Kenneth I. Rifkin
TUFTS UNIVERSITY

Abstract

Prism vergence thresholds were compared under two conditions: (a) in which each subject believed that he was looking at a single object with both eyes; and (b) in which each subject believed that he was looking at two different objects, one seen from each eye. Thresholds were not significantly different under the two conditions.

Problem

Two visual stimuli, one seen from each eye, tend to be combined in binocular vision if they are similar in visual properties (size, shape, brightness, color). It has recently been suggested (McLaughlin, 1964, pp. 16-17) that another factor, having to do with the observer's interpretation of the two images rather than with their visual characteristics, might be an important determinant of binocular fusion. This factor is the observer's decision as to whether or not the two images have a common referent in external space—that is, whether they are in fact the two monocular views of a single object.

The present experiment was an attempt to evaluate the importance of this interpretative factor as a determinant of the strength of binocular fusion. In this experiment, the strength of binocular fusion was measured under each of two conditions: Condition A, in which the subject believed that he was looking at a single object with both eyes; and Condition B, in which the subject believed that he was looking at two identical objects, one seen from each eye. The measure of strength of fusion was the amount of base-in prism required to interrupt binocular vision—that is, the angle to which the eyes would diverge in an effort to maintain fusion.

Method

Six subjects, three male and three female, ranging in age from 17 to 55 years, served in this experiment. They were selected as having no manifest defects in binocular vision, and as having visual acuity of 1.0 or better in each eye in the near vision test on the AO ortho-rater.

Figure 1 is a schematic diagram of the apparatus in plan view. The subject viewed the two stimuli (S_R and S_L) through a pair of Risley adjustable prisms (P_R and P_L) and via two front-surface mirrors (M_R and M_L). S_R and S_L were vertical white rods 0.8 cm in diameter and 12.3 cm in length, having a brightness of 38 mL., and seen against a uniform black background that had a brightness of less than 0.7 mL. The viewing distance was 50 cm. S_R was seen only from the subject's right eye, and S_L was seen only from the subject's left eye. With the prisms set at zero, S_R and S_L appeared to the subject to be superimposed. The shutter Sh was operated by a solenoid which the experimenter could actuate. An automatic timing device ensured that each stimulus presentation was 7.5 sec. in duration.

The apparatus was enclosed so that its internal construction was concealed from the subject, except for a hinged door over the false stimulus compartment. The subject could see the false stimuli (S' in Fig. 1) only when the hinged door was open and then only by looking

over the top of the apparatus. The stimuli at S' were identical in size and shape to S_R and S_L , and had a similar black background. When the hinged door was open, the experimenter could place either one rod or two rods in the compartment; and, if two rods were used, he could adjust the separation between them.

Each subject's interpupillary distance was measured at a viewing distance of 50 cm, using a standard clinical procedure (Kramer, p. 223). At the beginning of each experimental session, the distance between the Risley prisms was adjusted to conform to the measurement. Before each stimulus presentation, the Risley prisms were set to the desired prism value, the total prism power being divided equally between P_R and P_L . All prism settings were "base in" —i. e., with the bases of the prisms adjacent, as illustrated in Fig. 1.

Procedure

Immediately prior to each stimulus presentation, after having adjusted the prisms, the experimenter opened the hinged door over the compartment S' . He then placed either one or two rods in the compartment; and, if two rods were used, he adjusted the separation between them to correspond to the prism setting. The subject was asked to note, by actually looking, whether the compartment contained one rod or two rods. The hinged door was then closed, the subject lowered his head to the proper viewing level, and the experimenter initiated a stimulus presentation. At the end of each stimulus presentation, the subject was asked to report "one" or "two," indicating whether or not fusion had occurred at any time during the 7.5 sec. period.

The purpose of the false stimulus compartment was to deceive the subject into believing that the white rods which he saw during each stimulus presentation were those at S' rather than those at S_R and S_L . As a means of checking on the effectiveness of the deception, the subject was occasionally asked to report not only how many rods he had

Fig. 1. Schematic diagram of apparatus in plan view. With the adjustable prisms P_R and P_L set at zero, the identical stimuli S_R and S_L (seen via the mirrors M_R and M_L) appeared to the subject to be superimposed. The strength of fusion was measured by finding the magnitude of prism required to break fusion. The subject was deceived into believing that it was the false stimulus (or stimuli) at S' , rather than S_R and S_L , which he saw during each test presentation. Thus, depending on whether the experimenter placed one stimulus or two stimuli at S' , the subject could be led to believe that he was looking at one object with both eyes or at two identical objects, one seen from each eye.

seen, but how many there "really were." In every instance, the subject's response to this question was in accord with the number of rods at S'. As a further check, at the end of the experiment, each subject was shown the internal construction of the apparatus. All subjects reported that the deception had been complete. No subject perceived the inconsistency in the fact that, with two rods at S', only one rod was seen from each eye despite the absence of any visible median partition.

The first 15-20 presentations were used to ensure that the subject was actually fusing the two stimuli rather than merely suppressing one of them. These preliminary trials were also used to determine two prism values, one larger than the other by exactly two prism diopters: a smaller value, such that fusion occurred in more than half of the presentations; and a larger value, such that fusion occurred in less than half of the presentations. These two prism values, when confounded with the two conditions (A and B) gave four types of stimuli: the smaller prism value with Condition A, the smaller prism value with Condition B, the larger prism value with Condition A, and the larger prism value with Condition B. These four were presented in random sequence until each had appeared at least 20 times, so that a total of at least 80 presentations were made in each experimental session. The subject was given a rest period of about 5 min. duration after each 20 presentations.

The "probability of fusion," P_f , was calculated for each of the four types of stimulus, using the formula

$$P_f = N_f / N,$$

where N = total number of stimulus presentations, and N_f = number of stimulus presentations to which the subjects responded "one."

Thresholds were computed graphically by plotting P_f against prism magnitude on Gaussian integral x linear coordinates (Normal ruling No. 32451, Codex Book Co., Norwood, Mass.) Since only two values of P_f (one greater than 0.5, the other less than 0.5) contributed to each threshold, the resulting frequency-of-seeing functions (straight lines on the coordinates used) were objectively determined without the use of any curve-fitting technique. The .50-intercept of this line was taken as the threshold amount of prism required to overcome fusion. The abscissal distance between that point and the .16-intercept was taken as the standard deviation of the threshold.

Results

The results are summarized in Table 1. For no subject was there a statistically significant difference in threshold between Condition A and Condition B. In fact, in no instance did the two thresholds for a single subject differ by as much as one standard deviation. Such differences between Condition A and Condition B as did appear failed to show any consistent trend in favor of one condition or the other.

Discussion

The results are unequivocal: under the conditions of this experiment, the observer's interpretation of two contra-ocular stimuli as having or not having a common external referent has no effect on strength of fusion as measured by base-in prism vergence amplitude.

The suggestion that gave rise to this experiment was based on the fact that strabismic patients, in whom binocular fusion is lacking, exhibit a specific disorder of the binocular interpretative mechanism. In strabismus, an object as seen from one eye is perceived as having a referent in external space (i. e., is perceived in the normal fashion); while the same object, as seen simultaneously from the other eye, is perceived as having no such referent (McLaughlin, 1964, p. 8). Since this disorder appears to account in part for the absence of fusion in strabismus (McLaughlin, 1960), it seemed reasonable to expect that, in normal binocular individuals, the interpretation of two contra-ocular

Table 1. Base in vergence thresholds for six subjects under two conditions of viewing. In Condition A, the subject believed that he was looking at a single object with both eyes; in Condition B, the subject believed that he was looking at two identical objects, one seen from each eye.

Subject	Condition	Threshold	SD of threshold
SM	A (one rod at S')	13.75	.67
	B (two rods at S')	13.43	1.25
WM	A (one rod at S')	15.72	1.67
	B (two rods at S')	15.50	1.03
FG	A (one rod at S')	20.15	.85
	B (two rods at S')	20.55	.85
LD	A (one rod at S')	29.58	1.22
	B (two rods at S')	28.80	1.45
RL	A (one rod at S')	14.79	1.15
	B (two rods at S')	15.03	1.17
CL	A (one rod at S')	21.25	2.70
	B (two rods at S')	21.55	2.74
Mean	A (one rod at S')	19.21	1.38
	B (two rods at S')	19.14	1.42

images as having a common referent might contribute to the stability of normal binocular vision. The present findings run counter to that prediction.

However, unless one adopts an extreme nativistic position with regard to the structural and experiential basis of binocular vision, it would appear to be almost a logical necessity that, at some stage in the genesis of normal binocular coordination, the observer's interpretation of two contra-ocular stimuli as having a common external referent must play a crucial developmental role. In fact, it is difficult to account for the etiology of nonparalytic strabismus unless one postulates such a development stage as the point of choice between normal and abnormal binocular vision (McLaughlin, 1960; Alpern, 1962).

Thus, while the results reported here appear to be conclusive with regard to individuals in whom normal binocular vision is well established, they do not rule out the possibility that the interpretative factor may contribute to the maintenance of the less stable binocularity which is present in infants and young children. This possibility is being investigated.

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Note

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