Visual capture in visual illusions*

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Visual capture is the resolution of visual-tactual conflicts in favor of vision. In each previous demonstration of this phenomenon, a distorted optic array, or some mechanical analog for a distorted optic array, has produced a conflict between erroneous visual information and presumably veridical tactual information. The present experiments demonstrate visual capture in the Müller-Lyer and Ponzo illusions in the absence of any distortions of the optic array.

The resolution of visual-tactual conflicts in favor of the sense of vision has been called visual capture (Hay, Pick, & Ikeda, 1965). In the earliest demonstration of visual capture (Gibson, 1933), when the O viewed a straight rod through curvature-producing prisms while stroking the rod with the fingers, the rod looked curved and felt curved as well. Tastevin (1937, pp. 67-68) showed an O a plaster replica of one of his fingers while the O's real finger was hidden from view some distance away. The conflict between the visual position of the plaster replica, which the O took to be his own finger, and the veridical position of the real finger was resolved in favor of the sense of vision: the felt position of the O's own finger coincided with the seen position of the replica. Hay, Pick, and Ikeda (1965) showed that the felt position of the hand is strongly influenced by the position seen through displacement-producing prisms; these workers considered the earlier demonstration of Tastevin "... a kind of mechanical analogue to the prism situation ...". In another demonstration, Tastevin (1937, p. 60) showed an O plaster replicas of his index and middle fingers, holding between them a small box 1 cm long, while the O's own index and middle fingers, hidden from view, held between them a larger box, 5 cm long. The tactually perceived size of the larger box held by the O's own fingers came to coincide with the visually perceived size of the smaller box held by the plaster fingers. This result is analogous in important respects to the later findings of Rock and Victor (1964), who showed that an object viewed through a minifying optical system felt, as well as looked, smaller than it really was.

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Every prior demonstration of visual capture (see, for example, Rock, 1966; Kinney & Luria, 1970; Pick & Pick, 1970) has utilized a distorted optic array (Gibson, 1966) or some mechanical analog for a distorted optic array. It is possible, however, to arrange a conflict between vision and touch in the absence of any distortion of the optic array by slightly modifying some of the classical visual illusions. Each illusion shown in Fig. 1 consists of two parts: (1) the *induction lines*, the radiating lines in the Ponzo illusion and the short converging lines in the Müller-Lyer; and (2) the *test lines*, the vertical lines in both illusions. The essential feature of these visual illusions is the O's overestimation of the length of one test line relative to the other, in spite of the fact that both test lines subtend the same visual angle. Thus, these illusions occur in the absence of any distortions of the optic array. If the test lines were three-dimensional blocks that the O could feel as well as see, and if the induction lines were simply two-dimensional lines that could not be felt, then if the O looked at the test blocks and induction lines while grasping the blocks with the left and right hands, the visual illusion would conflict with the presumably veridical tactual information.

EXPERIMENT I

The purpose of this experiment was to investigate the occurrence of visual capture in the Müller-Lyer and Ponzo illusions. Adjustment methods were used to measure the magnitude of these illusions and the amount of visual capture produced by each.

Observers

Thirty-two introductory psychology students (16 men and 16 women) at the University of Missouri—St. Louis participated in this experiment as a course requirement.

Materials and Apparatus

Figure 2 illustrates the apparatus. The induction lines were made of black chart tape attached to sheets of white poster board; the lines were 12.8 mm wide in the Müller-Lyer

illusion and 6.4 mm wide in the Ponzo. The induction lines were displayed on a surface inclined 15 deg from the horizontal. The front edge of the display surface was 83.8 cm above the floor. A thin sheet of Plexiglas covered the induction lines; thus, the induction lines could be seen but not felt. The test blocks, various lengths of black-lacquered Plexiglas about 12.5 mm in cross section, were presented, a pair at a time, 30 cm apart on the clear Plexiglas covering the induction lines. Two *visual variables*, vertical pieces of black-lacquered Plexiglas about 12.5 mm in cross section, could be adjusted to indicate how long the test blocks looked. Two *tactual variables* were located out of sight, directly below the test blocks, on a horizontal surface; each was a modified pair of calipers which O adjusted to indicate how long the test blocks felt. On each tactual variable, two vertical metal tabs were grasped between the thumb and middle finger. The thumb tab, the tab nearest O, was immovable, while the finger tab could be adjusted.

Procedure

The experimental design was a three-way factorial, with sex, illusion (Müller-Lyer and Ponzo), and modality (vision and touch) constituting the three factors. Repeated measures were made on the third factor. Each O was shown only one illusion, which was presented in two orientations. The Ponzo illusion

Fig. 1. Illusion magnitude as a function of adjustment method in (A) and instruction condition in (B). Tactual measures in both experiments indicate visual capture.

Fig. 2. Apparatus.

was presented with the radiating lines (1) converging toward the left and (2) converging toward the right. The Müller-Lyer illusion was presented analogously. A set of five visual adjustments and a set of five tactual adjustments were made with the illusion in one orientation; then the orientation was changed, and the procedure was repeated. All four possible combinations of orientation orders and visual and tactual adjustment orders were used.

Os were instructed to adjust the two visual variables until each looked the same length as the corresponding test block looked; these adjustments were made by turning knobs on the front of the apparatus. Both visual variables were in sight while visual adjustments were made; after each adjustment, they were lowered out of sight. All adjustments ascended from an initial length of zero.

In making tactual adjustments, Os grasped the test blocks simultaneously with the thumbs and middle fingers of both hands and then moved their hands to the tactual variables, which they were instructed to adjust until each felt the same length as the corresponding test block felt. In order to make satisfactory adjustments, Os were allowed to move their hands back and forth between the test blocks and the tactual variables as often as they needed. The finger tabs on the tactual variables were adjusted by pushing with the index fingers and pulling with the middle fingers. All adjustments were made from an initial separation of 25 mm between the tabs.

For each set of visual or tactual adjustments, the following five pairs of

left and right test blocks (lengths in millimeters) were presented in an individually determined random order: 90-100, 100-110, 100-100, 110-100, and 100-90. Since the sum of the lengths of test blocks presented on the left is equal to the sum of the lengths on the right, a difference in the appropriate direction between an O's adjustment of the left and right visual variable is evidence of a visual illusion. An analogous difference between the left and right tactual variables is evidence of visual capture.

For each of the two orientations of each illusion, the difference between mean left and right visual adjustments was expressed as a percentage of the smaller mean. Each O's visual adjustment score is the mean of the percentages, above, for the two illusion orientations. A tactual adjustment score was similarly derived for each O. A positive visual score indicates a visual illusion in the expected direction, and a positive tactual score indicates the occurrence of visual capture.

Results

The results are shown in Fig. 3A. A repeated-measures analysis of variance (Winer, 1962) shows a statistically significant effect of visual vs tactual adjustments ($F = 10.43$, $df = 1/28$, $p < .01$). No other effect approaches significance. Since there was no significant difference between the sexes and no interaction with the sex factor, the results presented below were pooled for men and women. The mean tactual adjustment scores for the Müller-Lyer and Ponzo illusions (4.07% and 5.54%, respectively) are

significantly greater than zero ($t = 4.46$, $df = 15$, $p < .001$; $t = 6.53$, $df = 15$, $p < .001$). Thus, both illusions produce visual capture. As shown by the analysis of variance, the magnitude of the visual capture effect is significantly less than the visual illusion magnitude in both the Müller-Lyer and Ponzo illusions (7.76% and 8.24%, respectively).

EXPERIMENT II

The purpose of this experiment was to measure visual capture in the Ponzo illusion, using a different psychophysical method, the method of limits, and a different experimental design.

Observers

Twenty-four students (12 men and 12 women) enrolled in undergraduate psychology courses at the University of Missouri—St. Louis participated in this experiment as a course requirement. No O had previously taken part in Experiment I.

Materials and Apparatus

The Ponzo illusion induction lines used in Experiment I were also used here. In Experiment II the induction lines always converged to the right, as shown in Fig. 1B. The same basic

Fig. 3. Open vertical rectangles indicate test blocks. Rectangles are of equal length. Solid black lines are induction lines.

apparatus was used as that in Experiment I. The left test block, the *standard*, was 100 mm long. The right test block, the *comparison*, was selected from a graded series of blocks differing by 2-mm steps. Since the tactual variables were not used in this experiment, they were removed from the apparatus, making it possible to lower the display surface to a point where its front edge was 65.8 cm above the floor.

Procedure

Six men and six women were run with the Ponzo induction lines present (Ponzo group); the remaining six men and six women were run with a blank sheet of white poster board in place of the induction lines (control group). Os grasped the standard and comparison blocks simultaneously between the thumbs and middle fingers of the left and right hands. While grasping and looking at the blocks, all Os compared the length of the right test block with the standard block under three instruction conditions: (1) visual, (2) tactual, and (3) objective. Os made a practice judgment under each condition before the start of the experiment proper. No information as to accuracy was given at any time. Instructions emphasized that three kinds of judgments were to be made. Under the first condition, above, O was instructed to indicate "... whether the right block *looks* longer or shorter than the left, not whether it *feels* longer or shorter, or whether you think it *really* is longer or shorter, but whether the right *looks* longer or shorter than the left." Analogous instructions were given under the other instruction conditions. Judgments of equality were permitted but not encouraged. Sequences of instruction conditions were determined for all Os by the rows of a single 3 by 3 Latin square. Each O made two ascending and two descending judgments in ADDA order under each instruction condition. The point of subjective equality, the middle of the C's interval of uncertainty, was averaged for each judgment condition and subtracted from the length of the standard block (100 mm); the difference was expressed as a percentage of the standard block.

Results

The results are shown in Fig. 3B. A repeated-measures Latin-square analysis of variance (Winer, 1962) shows a statistically significant main effect of illusion vs control ($F = 34.93$, $df = 1/12$, $p < .001$). A comparison between means for illusion and control groups under visual instructions (10.04% vs 3.14%) shows that the

Ponzo illusion occurred ($F = 31.02$, $df = 1/20$, $p < .001$); such a comparison under tactual instructions (9.67% vs 2.50%) shows that the Ponzo illusion produced visual capture ($F = 33.50$, $df = 1/20$, $p < .001$), and a similar comparison under objective instructions (9.43% vs 2.50%) shows that objective judgments were also influenced by the illusion ($F = 31.35$, $df = 1/20$, $p < .001$). The absence of any statistically significant effects of instruction conditions shows that visual, tactual, and objective judgments are not differently influenced by the visual illusion. Of the numerous possible interaction effects, only one was statistically significant—the triple interaction between temporal order of judgment, sex, and illusion vs control ($F = 5.16$, $df = 2/24$, $p < .05$); this interaction implies that the pattern of illusion magnitude as a function of judgment order differs slightly across male and female illusion and control groups.

DISCUSSION

The visual magnitudes of the Müller-Lyer and Ponzo illusions in the present experiments are somewhat lower than the magnitudes typically reported (see, for example, Mountjoy, 1958; Leibowitz et al, 1969). In most earlier studies, the illusions were presented essentially perpendicular to the O's line of sight. In the present experiments, the illusions had to be viewed obliquely because of the design of the apparatus. The oblique angle of regard may have depressed the magnitude of the illusions.

An apparent discrepancy between the results of Experiment II and some earlier studies of left-right visual and tactual comparisons must be pointed out. Earlier studies have shown that the size of an object held in the right (or dominant) hand is significantly underestimated by touch alone (McPherson & Renfrew, 1953; Wertheimer, 1954), while, by vision alone, the size of an object in the right visual field may be overestimated (Brown, 1953) or slightly, but not significantly, underestimated (Hochberg & Bitterman, 1951). Thus, a conflict between vision and touch might occur naturally, that is, in the absence of any experimentally produced illusion or distortion. If such a conflict were resolved in favor of vision, then the control Os in Experiment II might be expected to overestimate tactually the length of the right test block, as was the case, rather than underestimate its size, as might be predicted from the earlier tactual studies. The control group means under visual and tactual instructions (3.14% and 2.50%, respectively) indicate significant

overestimation of the length of the right test block ($t = 4.65$, $df = 11$, $p < .001$). Since there were no independent measures in the present study of perceived size by vision alone and by touch alone, these results provide weak evidence—no more than a suggestion—of the occurrence of a natural, nonexperimental visual capture phenomenon.¹

Visual capture was demonstrated in the Müller-Lyer and Ponzo illusions in Experiment I, where a psychophysical method of adjustment was used. In Experiment II, which used a different experimental design and a different psychophysical method, the method of limits, the Ponzo illusion was again shown to produce visual capture. The present experiments show that visual capture can be produced by visual illusions, as well as the visual distortions that have previously been shown to produce this phenomenon.

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NOTE

1. Note added in proof: After this paper was accepted for publication, a very clear demonstration of a related natural visual capture phenomenon came to the writer's attention. See Teghtsoonian, R., &

Teghtsoonian, M. Two varieties of perceived length. *Perception & Psychophysics*, 1970, 8, 389-392.

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