Instructions and the magnitude of an illusion: Cognitive factors in the frame of reference*†

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Ss judged the length of a horizontal line having vertical lines at the ends and a vertical line crossing at the middle. As has often been shown, judgments of the horizontal line varied inversely with the length of the vertical segments. One group of Ss were told to use the end lines as frame of reference and ignore the center line, and the estimated weights of end and center line were .22 and .02. The other group were told to ignore the end lines and use the center line as frame of reference. The weights of end and center line for this group were .06 and .22. It was concluded that the Helson AL equations are valid, but that the weights of parts of the field are partly under voluntary control and are not simply a function of the visual field.

The magnitude of an illusion is greater when S adopts a "whole perceiving" attitude than when he uses a "part isolating" attitude (Woodworth & Schlosberg, 1954). This might be because S can correct his responses so as to compensate for the illusion without changing the appearance of the stimuli, or it might be because S can voluntarily change his probabilities of sampling various elements of the field, and thereby affect his frame of reference.

Several recent papers (Restle & Merryman, 1968, 1969; Merryman & Restle, 1970; Restle, 1970; Restle & Greeno, 1970) have used a mathematical model (Helson, 1964) of the frame of reference to explain contrast illusions and the moon illusion. The two equations of this theory are as follows: The judgement, J_X , of a stimulus of physical value, X , is given by

$$J_X = X/A \quad (1)$$

where A is the average level of the frame of reference. If the stimuli in the field are of magnitudes $S_1, S_2, \dots, S_n$, then A is a weighted geometric mean

$$A = S_1^{w_1} \cdot S_2^{w_2} \cdot \dots \cdot S_n^{w_n} \quad (2)$$

The response is taken to be a linear function of J_X , provided the S uses a rating scale with the usual instructions.

An illusion arises when a given stimulus is observed in two different frames of reference differing with respect to some

stimulus, S_1 . The magnitude of the illusion depends upon the weight w_1 given S_1 , the illusion-inducing stimulus.

If the weights of the elements of the frame of reference are determined by the visual array interacting with receptors, then instructions should not affect them, and the effect of instructions must be through response compensation. If, on the contrary, the weights are partly under control of the S, then it should be possible to influence them through instructions.

In the present experiment Ss judged a horizontal line of length L having vertical lines of length E at the ends, and cross-line of length C . One group of Ss were told to use E and ignore C , the other were told to use C and ignore E . If the weights are under voluntary control, these two groups should show different illusions, each placing more weight on the stimulus to which attention was directed.

METHOD

Subjects

Twenty-eight students enrolled in introductory psychology courses at Indiana University participated in the experiment to fulfill a course requirement. Ss were run in groups of four, and each such group was assigned to one of two conditions, resulting in 12 Ss in Group 1 and 17 Ss in Group 2.

Apparatus and Materials

Stimuli were slides of white lines on a dark background. Each display consisted of a horizontal line of length $L = 8, 10$, or 12 cm; vertical lines at the ends of the horizontal line of length $E = 12, 14$, or 16 cm; and a vertical line bisecting the horizontal line of length $C = 6, 8$, or 10 cm. The combinations of L, E , and C produced $3 \times 3 \times 3 = 27$ displays. The 27 slides were projected from a Kodak RA-750 random-access slide projector onto a screen 3 m from S. The screen was 130×130 cm and its edges were masked so

as to contrast but little with the wall behind.

Procedure

On each trial S was shown a slide and he then made a judgment of the length of the horizontal line (L) by pressing one of a row of six buttons, the leftmost corresponding to "quite short," the rightmost to "quite long," and the other four to "intermediate lengths."

Group 1 Ss were told to "Try to disregard the center vertical line that crosses right through the test line. Pay attention to the vertical lines at the ends of the test line and use them as a frame of reference to help you in your judgments." The instructions were given verbatim as above and then paraphrased again after Ss were told about the responses. Group 2 Ss were told to "Try to disregard the vertical lines at the ends of the test line. Pay attention to the center vertical line that crosses right through the test line and use it as a frame of reference to help you in your judgments."

When a stimulus was presented, an amber light on S's response panel was lit. That amber light went off when the response was made. Whenever all Ss responded, the slide went off and a new slide was searched for. The maximum time allowed was 6 sec to respond, and there was a 5-sec wait between slides. The 27 slides were shown seven times in seven random permutations to each group of Ss, and responses to the last five trials are reported. All programming of stimuli, presentation of slides, and data collection were done by an IBM 1800 on-line computer.

RESULTS

The first step of analysis is to reduce the data to parameter estimates. Eqs. 1 and 2 imply that

$$J_L = L/C^c E^e K^{1-c-e}$$

where c and e are the weights of the cross line and end lines, respectively, and K is the unknown resultant of all constant or random factors in the experiment. Taking logarithms,

$$\begin{aligned} \log J_L &= \log L - c \log C - e \log E - (1-c-e) \log K \\ &= \log L + \text{constant} \end{aligned} \quad (3)$$

If the raw responses are taken as the judgments, calling the leftmost button 1, etc., then Eq. 3 is not satisfied since the slope of $\log J_L$ vs $\log L$ is not unity. For each S, a constant Z was found so that his response, R_1 , satisfied the equation

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$$\log(R_L + Z) = \log J_L = \log L + \text{constant},$$

with J_L defined as above. The value of Z may be interpreted as the "zero point" of the scale used by S . Determination of such a zero point reduces individual differences considerably and provides a close agreement between model and data for every S .

A standard linear multiple regression of $\log J_L$ on $\log C$ and $\log E$ was then performed for each S , and the parameters c and e estimated for each S .

The main experimental hypothesis was that Group 1 S s, instructed to use E and ignore C , would yield larger values of e than of c . The mean values were .221 and .056, respectively. Group 2 S s were instructed to ignore E and use C , hence should yield smaller values of e than of c . Their mean values were .024 and .219, respectively. The difference between groups in $e-c$ was statistically significant [$t(27) = 2.96, p < .01$].

DISCUSSION

S s can voluntarily change the relative weights of various stimuli in their frame of reference if instructed to do so. The resulting difference in weight leads to different measured illusions in the visual field.

This result supports the position taken by the author (Restle, 1970) with respect

to individual differences in the magnitude of the moon illusion, that various S s might use different frames of reference (the magnitude of objects on the horizon, the total extent of the visual field, or their own noses), employing different strategies, and for that reason make consistently different judgments.

It might be objected that the present results are contaminated, because the visual fixation point was not controlled, and no direct observations of the S s' ocular orientations were made. However, our sampling theory of the frame of reference holds that perceiving involves active search, and that the frame of reference depends upon where the S centers his viewpoint. In this experiment, we have measured the judgmental consequences of instructions. The final result is what is of interest here, though it would be interesting to learn the results of studies of visual fixation in this task. If fixation were controlled, then our effect might be sharply attenuated, even though the effect is large under normal viewing conditions. If it were found that ocular orientation depends on instructions, in this task, then it would still be necessary to show that those visual fixations produced the observed difference in judgment.

The notion of perceptual sampling employed in this paper is similar to Piaget's (1961) except that Piaget says that the part

of the field centered by the S is thereby made larger, whereas in the present model, the part of the field centered is merely thereby made part of the frame of reference. Since S s were not judging the parts of the field emphasized by instructions, Piaget's concept would not predict any differences in performance between the groups of the present experiment.

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