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A magnitude estimation study of the inverted-T illusion

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The inverted-T illusion was studied by the magnitude estimation method. The horizontal line in the inverted T is perceptually shorter than the same horizontal line presented singly, and the vertical line in the inverted T is perceptually longer than the same vertical line presented singly. Thus, the inverted-T illusion is due to both a perceptual lengthening of the vertical line and a shortening of the horizontal line. In the light of these findings, current theories of the illusion seem to give unsatisfactory explanations.

Systematic studies of the inverted-T illusion (Finger & Spelt, 1947; Künnapas, 1955) show that, in the adult, the vertical line is perceived as about 5%-10% longer than the horizontal one. However, the classical methods of psychophysics (the methods of limits, of adjustment, and of constant stimuli) do not seem to answer one important question: Is the illusion due to a perceptual change in the vertical line alone, a change in the horizontal line alone, or concommitant changes in both. The experiment reported here was undertaken in order to find an answer to this question.

Suto (described by Oyama, 1960) tried to solve the problem by asking subjects to compare the vertical and horizontal lines in the inverted T with an adjustable plain horizontal line. To assess any systematic effect due to the vertical-horizontal illusion, Suto omitted the necessary control observations in which an adjustable plain vertical line would have been matched with the lines in the inverted T.

The answer to the question at issue, we think, may be given using a direct estimation procedure such as magnitude estimation. Coren and Girgus (1972, p. 243) showed that scaling techniques for illusion measurement, even if they seem to be a bit less efficient, provide results that are comparable in validity and reliability to those obtained by the classical methods of psychophysics.

In a factorial experiment using a direct estimation procedure, Coren, Girgus, Erlichman, and Hakstian (1976) showed that visual illusions are reducible to five classes. They found that the horizontal line in the inverted-T illusion misses the cutoff for entering the underestimation illusions class. In other words, the horizontal line, it might be suspected, is not underestimated. Thus, previous studies are consistent with the hypothesis that it is the vertical line that is perceptually lengthened, with the horizontal line being unaffected, in the inverted-T illusion.

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METHOD

Subjects

There were 74 subjects with normal visual acuity. They were asked to participate in the experiment as they entered the Institute.

Stimuli

Five values (20, 25, 30, 35, and 40 mm) were used for the length of the horizontal and vertical lines in the inverted-T configuration. Thus, 25 inverted Ts were constructed, combining the five lengths of the vertical and horizontal lines; each of the 25 was attached to a white cardboard square (25 × 25 cm). To 10 additional white cardboard squares of the same size were attached 10 single lines, 5 horizontal and 5 vertical. The lengths of these lines were also 20, 25, 30, 35, and 40 mm. All lines were black. Their thickness was 0.5 mm.

Procedure

The 35 stimulus figures were shown, one after the other, to the subject at a distance of 1 m and were kept by the experimenter on a plane frontoparallel to the subject. No standard stimulus was used. Half the subjects were first asked to estimate in millimeters the length of the vertical lines, both when the lines were in the inverted Ts and when they were shown singly; then the 35 stimulus figures were presented again, and the subjects were asked to estimate in millimeters the length of the horizontal lines. The remaining half of the subjects were first asked to estimate the horizontal extents and then to estimate the vertical extents. Pitz (1965) showed that estimates in inches without any standard stimulus give a psychophysical power function with exponent 1. The order of presentation of the stimuli was randomized for each subject. A session lasted about 15 min.

RESULTS

Figures 1 and 2 show the average subjective estimates (decimaks) of the vertical and horizontal lines, respectively. The estimates of the length of lines presented singly are represented by open circles. The data points from single vertical lines are fitted by the

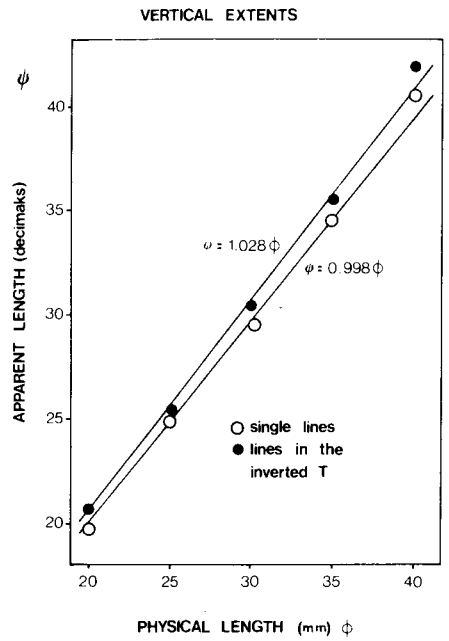

Figure 1. Apparent length of vertical lines shown singly (open circles) and in an inverted-T configuration (filled circles).

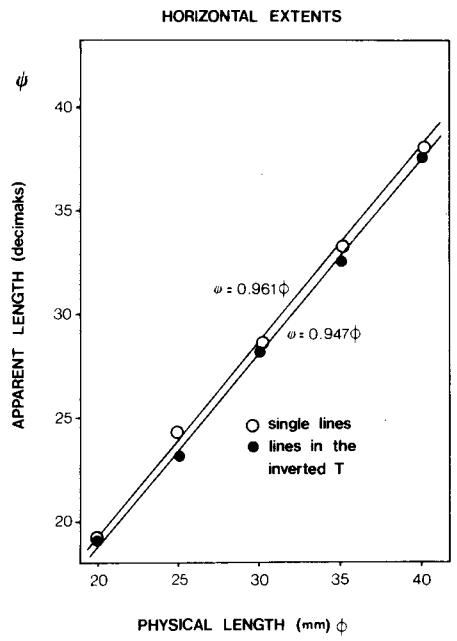

Figure 2. Apparent length of horizontal lines shown singly (open circles) and in an inverted-T configuration (filled circles).

straight line $\psi = 0.998\phi$; those from single horizontal lines are fitted by the straight line $\psi = 0.961\phi$. The orientation, vertical or horizontal, of a single line has a significant effect on the subject's magnitude estimates; that is, the two straight lines are not coincident statistically [$F(1,73) = 5.17$, $p < .05$]. Furthermore, the difference in slope is statistically different from zero [$F(4,292) = 3.00$, $p < .05$]. This result indicates a "pure" horizontal-vertical illusion, without a component added by configurational effects, as in the inverted-T and L displays, or even effects that may be produced by the presence of a standard line (Künnapas, 1958; Pollock & Chapanis, 1952; Shipley, Nann, & Penfield, 1949). Teghtsoonian (1972), using the method of adjustment, demonstrated the illusion when the lines were presented singly; she reported an effect of 11%. Verrillo and Irvin (1979) showed the same thing using magnitude estimation; their effect (36%) was unusually large. The magnitude of the illusion in the present study was 3.9% and is given by the ratio between the slopes of the fitted straight lines (see Discussion).

An analysis of variance shows that the vertical line in the inverted T is *overestimated* with respect to the single vertical line [$F(1,73) = 37.61$, $p < .001$], and that the horizontal line in the inverted T is *underestimated* with respect to the single horizontal line [$F(1,73) = 5.44$, $p < .05$].

In the inverted T, the magnitude estimates of the length of a given target vertical (horizontal) line are statistically invariant over the length of the accompanying horizontal (vertical) lines [$F(4,292) = 0.64$]. Neither interaction between the line orientation and the length of the accompanying lines [$F(4,292) = 2.14$] nor the interaction between the length of the target and the length of the accompanying lines [$F(16,1168) = 1.57$] is significant.

The filled circles in Figures 1 and 2 represent the average estimates of the length of target lines in the inverted T. The data points from vertical lines in the inverted T (Figure 1) are fitted by the straight line $\psi_v = 1.028\phi_v$; those from the horizontal lines in the inverted T (Figure 2) are fitted by the straight line $\psi_h = 0.947\phi_h$. These two straight lines are not statistically coincident [$F(1,73) = 32.10$, $p < .001$]; the difference in slope is statistically different from zero [$F(16,1168) = 7.14$, $p < .001$].

DISCUSSION

We are now in a position to obtain an estimate of the magnitude of the inverted-T illusion only from subjects' magnitude estimates. The magnitude, I, of the illusion may be defined as follows:

$$I = \frac{\psi_v - \psi_h}{\psi_h} 100 = \left(\frac{\psi_v}{\psi_h} - 1\right) 100,$$

where ψ_v and ψ_h are the magnitude estimates of the vertical and horizontal extents in the inverted T. We found that $\psi_v = 1.028\phi_v$, and $\psi_h = .947\phi_h$ (Figures 1 and 2); consequently,

$$I = \left[\left(\frac{1.028}{0.947} \cdot \frac{\phi_v}{\phi_h}\right) - 1\right] 100.$$

Since $\phi_v = \phi_h$, it follows that the magnitude of the inverted-T illusion is $I = 8.6\%$, which is in keeping with the results obtained by the methods of classical psychophysics (e.g., Künnapas, 1955). The horizontal-vertical illusion alone has a magnitude of 4%. Thus, the inverted-T configuration is responsible for an additional 4%-5% of the effect. The *overestimation* of the vertical line in the inverted T with respect to the single vertical line is 3.0%, and the *underestimation* of the horizontal line in the inverted T with respect to the single horizontal line is −1.5%. Thus, both contribute to the configurational illusion effect.

At this stage of research, these findings do not permit us to reach a general conclusion about the inverted-T illusion, since the inverted T was studied in only one spatial position. The effects of different tilts, different displacements of a line with respect to the other, etc., should also be studied. These findings do, however, permit an evaluation of current descriptions of the illusion.

According to Künnapas (1955), the inverted-T illusion is produced both by the overestimation of the vertical line as compared with the horizontal line (horizontal-vertical illusion), and by an overestimation of the vertical line only because of its bisection of the horizontal. But our results show that there is, in addition, a slight contraction of the horizontal line.

Unlike Künnapas, Robinson (1972, p. 98) claims that the horizontal line is underestimated because of its bisection. This bisection effect seems to be a special case of the Oppel-Kundt illusion (Coren & Girgus, 1978), which is in fact reversed when only one dividing element is used.

Coren and Girgus (1978) asserted that the bisection effect should be considerably stronger than the horizontal-vertical effect and that the inverted-T illusion is the sum of these two effects. That this may not always be the case is indicated by our results, showing that the two effects are roughly equal. The relative sizes may depend upon details of the stimulus display.

In summary, the method of magnitude estimation showed that (1) there is a horizontal-vertical illusion of about 4% when the lines are presented singly, and (2) there is an added enhancement of the apparent vertical length (about 3%) and diminution of the horizontal (about 1.5%) when the lines are presented in an inverted-T configuration. The study confirms previous work showing that the horizontal-vertical illusion does not depend on the simultaneous presence of lines in two orientations, and points out that the effect of configuration on the horizontal element in the inverted T has gone unnoted in previous research.

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