Tactual field dependence*

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The present experiment demonstrates a new phenomenon—tactual field dependence. The tactually perceived orientation of a vertical or horizontal bar located behind a tilted grid is influenced by the orientation of the grid. Although tactual field dependence is analogous in some respects to visual field dependence, there are important differences between the two phenomena. There is no significant correlation between the two varieties of field dependence, and the sex difference found in studies of visual field dependence does not occur in tactual field dependence.

There are many parallels between visual and tactual, or haptic, perceptual phenomena. In both modalities, for example, form and size discriminations are made (Gibson, 1966); the orientation of objects can be perceived (Pick & Pick, 1970), and various aftereffects occur (Köhler & Dinnerstein, 1947; Day & Singer, 1964). Most of the classical spatial illusions occur in both modalities (Revesz, 1934, 1953; Rudel & Teuber, 1963), which show that contextual stimuli influence tactual as well as visual judgments.

A number of studies have demonstrated a phenomenon called field dependence, where the visually perceived orientation of a horizontal or vertical bar is influenced by the orientation of a surrounding tilted frame (Witkin & Asch, 1948; Witkin et al, 1962). In the present experiment, a horizontal or vertical bar is displayed behind a tilted grid (see Fig. 1). Thus, the bar-and-grid arrangement combines features of the rod-and-frame display and the Zöllner illusion, a weak form of which has been shown to occur tactually as well as visually (Revesz, 1934, 1953). Since the bar and grid can be perceived tactually as well as visually, the display should produce both tactual and visual field dependence.

SUBJECTS

Forty introductory psychology students (20 men and 20 women) at the University of Missouri—St. Louis took part in this experiment as a course requirement. Two women and 5 men were left-handed.

APPARATUS

The apparatus, shown in Fig. 1, was designed to measure the influence of a tilted grid on both the tactually and visually perceived orientation of a bar located behind the grid. The grid, made of transparent fluorescent orange Plexiglas strips, could be oriented in any direction in the frontal plane. The strips comprising the grid

were 1.9 cm wide and .3 cm thick and were separated by gaps of 2.5 cm. The strips were mounted in a circular frame which the S could not see. The grid was located within easy reach at a distance of about 48 cm from S's eyes. The aluminum bar, 1.9 x .3 x 22.8 cm, was mounted 2.5 cm behind the grid. The grid and bar, lighted by two 7½-W white frosted candelabra bulbs, were viewed through a 20.3-cm circular aperture 10 cm in front of the grid. All portions of the apparatus visible to S, except the grid and bar, were painted flat black. No vertical or horizontal edges inside the apparatus were visible to S.

For visual measurements, S adjusted the bar to the apparent horizontal or vertical by turning the knob shown in Fig. 1. For tactual measurements, S reached the preferred hand through the grid, which was securely locked in place, and directly adjusted the bar to the apparent horizontal or vertical. A shutter occluded the grid and bar while tactual measurements were made. The E read the orientation of the bar to the nearest ½ deg on a scale at the rear of the apparatus.

PROCEDURE

Repeated tactual and visual measurements were made on all Ss. Tactual measurements were made first and visual measurements second on half the S, and, for the other half, the sequence of measurements was reversed. Measurement sequences were balanced across the sexes. Thus, the experimental design conforms to a 2 by 2 Latin square with repeated measures, where the rows consist of the two sequences of modalities (tactual-visual and visual-tactual) and where the columns represent temporal order of measurements (first and second); this Latin square was replicated at the two levels of the sex factor (Winer, 1962).

Each S made eight tactual and eight visual adjustments. S was instructed to adjust the bar to the apparent horizontal in half the tactual measurements and to the apparent vertical in the other half, and the visual measurements were similarly

divided between horizontal and vertical. Half the Ss made all four horizontal tactual or visual adjustments first and the four vertical adjustments second, and, for the other half of the Ss, the sequence of horizontal and vertical adjustments was reversed. Sequences of horizontal and vertical adjustments were balanced across rows of the Latin square (tactual and visual sequences) and also balanced across the sexes.

Before the S made each adjustment, whether tactual or visual, the grid was tilted either 20 deg clockwise (C) or counterclockwise (CC) from the horizontal or vertical and the bar was also tilted to one of these positions. A single sequence of combinations of starting positions of the grid and bar, shown as follows, was used under all conditions: grid—20 deg CC, 20 deg CC, 20 deg C, 20 deg C; bar—20 deg CC, 20 deg C, 20 deg C, 20 deg CC.

The experiment was run with the room lights off. For visual adjustments, S viewed the bar and grid binocularly through two holes in the front of the apparatus. A shutter was closed while the E adjusted the bar and grid to their starting positions. For tactual adjustments, the shutter was always closed and E guided S's hand through the grid, placing the thumb on one side of the middle Plexiglas strip and the fingers on the other so that S could grasp the bar located behind the grid. Under tactual and visual conditions, S was instructed to adjust the bar to the "... horizontal, that is, level, like the floor of this room," and to the "... vertical, that is, straight-up-and-down, like the walls of this room." For scoring purposes, bar adjustments in the direction of the

Fig. 1. Apparatus. Additional dimensions are given in text.

*I am grateful to Kathleen Killoren for running all the Ss in this experiment and for her help in analyzing the data.

Fig. 2. Bar adjustment error for women and men under visual and tactual conditions.

grid tilt were given a positive sign and those in the opposite direction a negative sign.

RESULTS

The tilt of the grid influenced tactual as well as visual adjustments of the bar. Thus, field dependence occurs in both modalities.

The basic results are shown in Fig. 2. Since the means for horizontal and vertical adjustments did not differ significantly within either tactual or visual measurements, horizontal and vertical measures were combined.

The means for men and women under tactual and visual conditions, shown in Table 1, are all significantly greater than zero (all t values > 9.00 , $df = 19$, $p < .001$). Under visual conditions, women are more field dependent than men ($t = 2.45$, $df = 38$, $p < .02$), a finding that is consistent with the results of earlier studies (Witkin et al, 1962). Under tactual conditions, however, the difference between men and women does not approach significance ($t = .40$, $df = 38$, $p > .60$). Tactual field dependence is highly significantly greater than visual field dependence, as shown by the analysis of variance described below. Thus, the sense of vision is significantly more accurate than the tactual modality, insofar as constant errors are concerned.

The variances for men and women shown in Table 1 do not differ significantly under either tactual or visual conditions. Within both sexes, however, the variance of tactual measures is greater than that of visual, yielding F ratios for men and women, respectively, of 5.32 and 5.20 ($df = 19/19$, $p < .01$). Thus, the sense of vision is significantly more accurate than the tactual sense in terms of variable errors, a finding consistent with earlier studies where visual and tactual measures have been compared

in other contexts (e.g., Fisher, 1962; Walker, 1972).

The data were subjected to a repeated-measures Latin-square analysis of variance (Winer, 1962). There were no statistically significant between-Ss effects. The F ratio was less than 1.00 for the row effect (tactual-visual and visual-tactual sequences), which shows that tactual field dependence is not merely the result of some carry-over effect from prior visual measurements. Since the F ratio was also less than 1.00 for the Row by Sex interaction, the variances from this source and from the row effect were combined with the variance between Ss within groups to form a pooled error term. Using the pooled error between Ss, there was no significant sex effect ($F = 1.57$, $df = 1/36$, $p < .25$). Among the within-Ss effects, only the effect of modality (tactual and visual) was significant ($F = 34.61$, $df = 1/36$, $p < .001$). F ratios were all less than 1.00 for the temporal order effect, the Sex by Temporal Order interaction, and the Sex by Modality interaction.

Split-half reliability coefficients for odd vs even trials were found separately for each combination of sex and modality. Reliabilities corrected by the Spearman-Brown formula (Guilford, 1954) ranged from .68 to .77 and averaged .72. These reliabilities are considerably lower than the split-half reliabilities reported in some studies of field dependence using the rod-and-frame test (Witkin et al, 1962).

The correlation between tactual and visual field dependence is .11 for men and .16 for women. Neither correlation approaches statistical significance. In view of the reliability coefficients above, the low correlations between tactual and visual field dependence cannot be attributed entirely to unreliable measures.

DISCUSSION

The magnitude of the visual field-dependence effect in the present experiment is substantially less than the effect reported in earlier studies using the rod and frame, as in Witkin & Asch (1948). At least two major differences between the present experiment and earlier rod-and-frame studies may have influenced the

present results: (1) the visual field in the present experiment consisted of a tilted grid, as opposed to a tilted frame; and (2) the displays in the present experiment were enclosed in a box-like apparatus, the lower inside horizontal surface of which may have provided tactual cues not present in the rod-and-frame studies. The apparatus might be improved by eliminating all tactual cues, insofar as possible, except those associated with the bar and grid themselves.

Two lines of evidence suggest that different factors may underlie tactual and visual field dependence: (1) tactual and visual measures in the present experiment are not significantly correlated; and (2) there is no significant sex difference within tactual measures, while there is a sex difference within visual measures. In developmental studies using the rod-and-frame test, no significant sex differences are found until the age of about 10 years. Field dependence decreases with age in both sexes until adulthood, but at a faster rate in males from about the age of 10 (Witkin, 1949; Witkin et al, 1962). Witkin and his coworkers have argued that the sex differences in visual field dependence which develops with age may be due to environmental factors associated with sex roles. No matter what factors may account for the sex difference in visual field dependence, whether environmental or otherwise, it seems initially puzzling that those same factors do not also produce a comparable sex difference in tactual field dependence. However, the human organism is in many respects a decidedly visual animal—as witness the greater accuracy of visual judgments (noted above) and the extent to which the sense of vision dominates other modalities in sensory conflict situations (Walker, 1972; Rock, 1966). The visual modality in the human organism seems to play a much greater role than the tactual, and it seems likely that visual and tactual field dependence follow different developmental courses.

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Table 1
Mean Adjustment Errors in Degrees*

	Men		Women	
	Tactual	Visual	Tactual	Visual
Mean	3.734	1.741	3.960	2.366
Variance (Between Ss)	2.618	.492	4.229	.814

*All means differ significantly from zero ($p < .001$). Variances differ significantly between modalities within sexes ($p < .01$) but do not differ between sexes.

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