The Sander illusion as a function of relative space and component lines*

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Magnitude of the Sander illusion was measured as a function of two variables: (1) the orientation of the line normally separating the two smaller parallelograms and (2) the presence or absence of the horizontal lines and of the diagonal test lines. The results showed that, as the angle of the dividing line varied so as to shift the relative sizes of the two parts of the figure toward equality, the illusion effect decreased, approaching zero when the two areas were equal. The illusory effect was enhanced by the removal of the two test lines. Results were discussed in relation to the problem of assimilation vs contrast effects.

Woodworth and Schlosberg (1954) describe the confusion theory of geometric illusions as stating that the S's judgment of part of the figure is influenced by the structure of the whole. Supporting this position, Benussi (1904), using the Mueller-Lyer figure, found conditions engendering a whole-perceiving attitude to produce a greater illusion than those favoring a part-isolating attitude. The confusion theory may also account for the Sander illusion where it is difficult for the viewer to separate his impression of the lengths of the test lines from the sizes of the areas surrounding them.

The primary purpose of the present experiment was to investigate the effects of manipulating the relative size of the two major areas of the Sander figure on the magnitude of the illusion. It was hypothesized that, as the areas surrounding the diagonal lines to be compared approached equality, the illusion effects commonly associated with the Sander parallelogram would be minimized. In other words, when the diagonal test lines are physically equal but are surrounded by unequal areas, as is the case in the conventional Sander parallelogram figure, the line surrounded by the smaller area (the right diagonal in Fig. 1, 1-A) should be perceived as shorter compared to the line surrounded by the greater area (the left diagonal). As the area surrounding the right diagonal increases, the perceptual estimation of this line relative to the left diagonal should likewise increase; and finally, when the two areas are equal, the lines should be perceived as equal. Thus the perceived length of the right diagonal can be considered as increasing relative to that of the left diagonal, as the two areas are altered from a state in which the left area is initially greater to one of equality of the two areas.

A second purpose of the study was to determine if the effects of manipulating the relative size of the two areas interacts with those of systematically removing critical sets of component lines from the standard Sander figure. Runyon and Cooper (1970), employing the latter variations, found that omitting the diagonal test lines maximized the illusion effects.

METHOD

Subjects

Seventy-two undergraduate students selected on a voluntary basis from psychology courses served as Ss. Each S was assigned to one of 12 treatment conditions, six to each condition.

Stimuli and Design

Figure 1 illustrates the 12 treatment combinations used, giving the basic dimensions of the stimulus figures. There were three levels of the relative space variable achieved by varying the angle of Line BD with the horizontal. Table 1 shows, for each level, the percent of the total parallelogram in the space surrounding the left and right test lines, as well as the ratio of left-to-right areas when the test lines are equal.

The four component line conditions used were the ones used by Runyon and Cooper (1970): the standard Sander figure (A), the standard figure without the horizontal lines (B), the standard figure without horizontals or test lines (C), and the standard figure without test lines (D). The combination of the two independent variables yielded a 4 by 3 factorial design, the 12 treatment combinations being identified as A_1, B_1, C_1, D_1, A_2, ... D_3.

For each of the 12 conditions, there were 10 variants of the Sander figure, in which the test line (or distance) AB was systematically shortened and BC concomitantly lengthened, keeping the total parallelogram area constant. This was accomplished by shifting the intercept of the two test lines, along with the dividing line, BD. Thus, Test Line AB varied from 2.875 in. to 2.00 in., while BC varied from 2.875 in. to 3.50 in.

Procedure

In each of the 12 treatment conditions, all 10 variants were displayed simultaneously on a table in a nonsystematic arrangement. The Ss stood at a distance of approximately 1 ft from the stimulus display. Each S was instructed to select the variant in which the distances AB and BC appeared equal in length. No time restrictions were imposed upon the Ss. Each session lasted approximately 2 min.

RESULTS

The mean and percent (relative to Distance AB) errors obtained under the 12 combinations of experimental conditions are presented in Table 2. An analysis of variance of the errors showed a significant effect of relative space, $F(2,60) = 60.01$, $p < .005$, and also of the removal of the component lines, $F(3,60) = 7.41$, $p < .005$, while the interaction between these two conditions was not significant, $F(6,60) = .97$, $p > .05$. The relative space manipulations accounted for 87% of the total variance.

Employing Duncan's multiple range test, all differences between relative space conditions within each component-lines condition (A_1 vs A_2 vs A_3, etc.) were found to be significant at beyond the .01 level. Significant differences between component-lines conditions overall were found only between A or B and C or D. Thus, shifting the relative space toward equality reduced the error under all component-lines conditions, and omission of the test lines increased the error.

DISCUSSION

The results clearly supported the hypothesis in that as the areas surrounding the test lines approached equality, the illusion effect associated with the Sander parallelogram was correspondingly reduced to a minimum. Within all component-lines conditions, percentage of error was an increasing monotonic function of the ratio of area in the left-to-right

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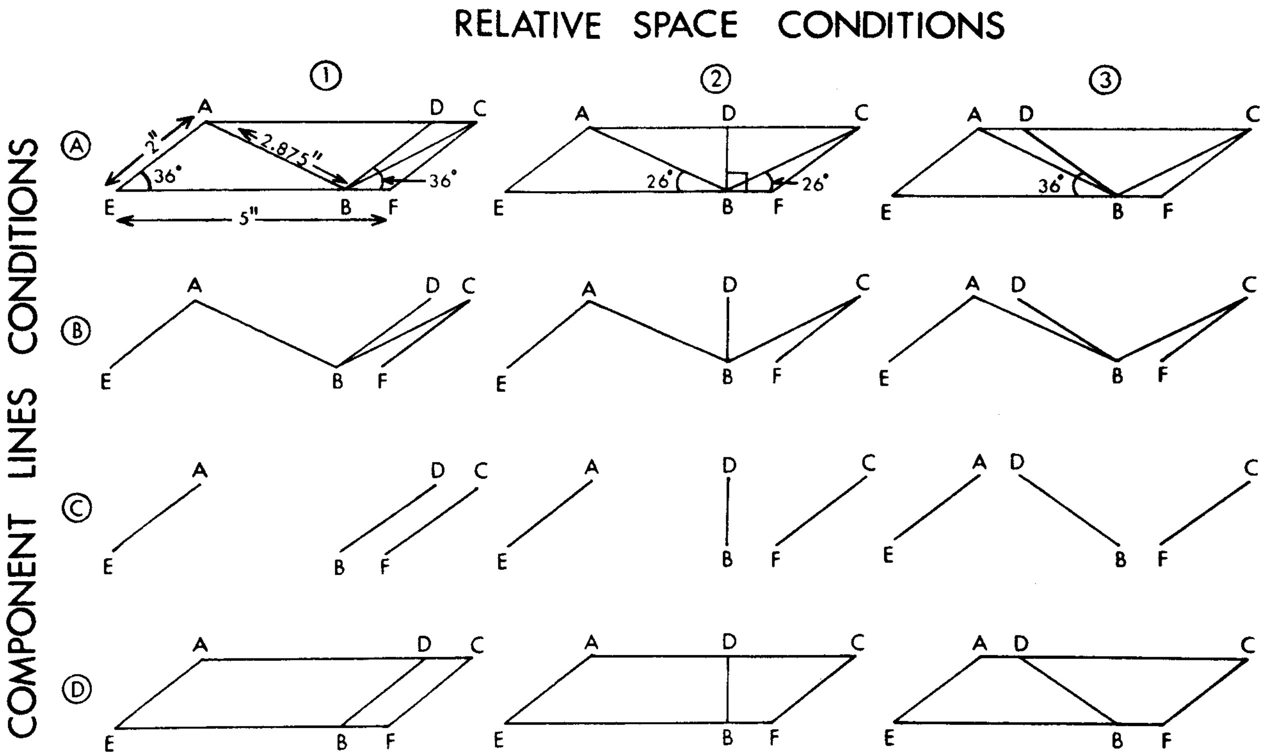

Fig. 1. Stimuli with equal test lines for the combinations of relative space (1, 2, 3) and component lines (A, B, C, D) conditions.

Table 1
Percent of Area in Left and Right Portions of Sander Parallelogram for the Three Relative Space Conditions

Relative Space Condition	Left Area (Percent)	Right Area (Percent)	Ratio (L:R)
1	82.6	17.4	4.75
2	66.3	33.7	1.97
3	50.0	50.0	1.00

portions of the total parallelogram figure. In addition, when the diagonal test lines were omitted, in the C and D conditions, the magnitude of the illusion was consistently greater than when these diagonals were present, in the A and B conditions, supporting the previous findings of Runyon and Cooper (1970).

In varying relative space, it was necessary to vary other factors concomitantly, and of these, one likely alternative cause of the results is the angles made by Line BD with the test lines. However, the facts that the relative space manipulation was effective across all component-line conditions and that the illusion effects were greater with the test lines absent (when such angles were also absent) than with them present seems to rule out the angles as an explanation.

The results obtained with the relative space variable agree with those of other studies (e.g., Künnapas, 1955; Rock & Ebenholtz, 1959) in their demonstration of a contextual effect on apparent length. They disagree with these studies, however, on the direction of the effect. While the present results constitute an assimilation effect in that the larger the frame, the greater the apparent length of the test line within it, the studies cited above yielded contrast effects. Künnapas (1955), for example, studying the effect of size of a square-shaped frame on the apparent length of a line in the middle of the frame, concluded that ". . . an increase in the size of the frame reduces the phenomenal length of the line . . . [p. 169]."

A resolution of this inconsistency is suggested by findings reported by Fellows (1967). He found a reversal in the direction of the Mueller-Lyer illusion when the shafts were replaced by shorter lines midway between each set of fins, that is, when the test lines did not touch the fins. Since in the Mueller-Lyer figure the fins can be considered as forming partial frames differing in the size of the areas they enclose, it appears that whether an assimilation or contrast effect emerges depends on whether or not the test lines are in contact with the frames. Thus, while the test lines in the standard Sander figure touch their frames, producing an assimilation effect, the test lines in comparable studies yielding contrast effects have gaps on one side (Rock & Ebenholtz, 1959) or both sides (Künnapas, 1955). Moreover, it has been shown (Litchford, 1970) that the normally assimilative effect of the Sander illusion can be transformed into a contrast effect when the test lines are separated from their frames by gaps of

Table 2
Mean Error in Inches and Percent Error as a Function of Relative Space and Component Lines

Relative Space Condition	Component Lines Condition									
	A		B		C		D		Row $\overline{X}$	
	$\overline{X}$	Percent	$\overline{X}$	Percent	$\overline{X}$	Percent	$\overline{X}$	Percent	$\overline{X}$	Percent
1	.65	26.8	.52	21.0	.81	34.2	.94	40.6	.73	30.6
2	.23	8.8	.16	6.2	.48	19.1	.42	16.5	.32	12.7
3	.03	1.1	.04	1.5	.23	8.8	.08	3.0	.10	3.6
Column $\overline{X}$	.30	12.2	.25	9.5	.51	20.7	.48	20.0		

intermediate size. It is suggested that the critical variable is the ratio of the size of the enclosing frame to the length of the enclosed test line. Comparisons of test lines where the ratio is small yield assimilation effects, whereas such comparisons with larger ratios yield contrast effects. The situation in which the enclosed line is in contact with the enclosing frame is thus a special case at the lower limit of this continuum. This hypothesis is supported for the condition where the line length is constant and frame size varies, as in the data reported here, as well as for the condition where frame size is constant and line length varies, as in the results of Fellows (1967, 1968) and Litchford (1970).

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