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APPARENT SPATIAL ARRANGEMENT AND PERCEIVED BRIGHTNESS

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The problems of brightness constancy (e.g., the constancy of perceived object color under different illumination conditions), and of the perceptual constancies in general, arise from the fact that changed sensory stimuli frequently elicit unchanged responses (and vice versa) which follow more closely the variations of distal stimuli (objects) than of the sensory-surface stimulus distributions. This raises difficulties for any formulation of a one-to-one correspondence between stimulus and experience (confusingly called the "constancy hypothesis," [**5**, p. 86]), which at first sight would seem essential to psychological prediction.

Such findings have been used in attempted ("nativistic") refutation of the constancy hypothesis and its associated stimulus-sensation units of analysis (**5**), and to demonstrate the importance of nonstimulus organizational "forces." Empiricist "inferential" explanations, on the other hand, retain the constancy hypothesis in *sensation*, and ascribe the obtained discrepancies to the effects of past experience in *perception*. Objections to the nativistic position are: (*a*) some evidence suggests that the accuracy of the perceptual constancies depends on past experience (**1**); (*b*) no well-defined analytic units have been presented to supplant the old "sensations," and in their absence precise prediction is difficult despite the considerable heuristic value of the more or less intuitive Gestalt "laws." General objections to the empiricist positions have been: (*a*) it is not possible to distinguish between "sensation" and "perception"; (*b*) there is some awkwardness involved in the doctrine of "unconscious inference" and its derivatives, especially when referred to the lower animals in which the constancies appear (**7**, pp. 605–607); (*c*) any attempt at precise prediction from this viewpoint must await as yet unperformed "ecological surveys" to determine what the past experiences of an organism are likely to have been; (*d*) the constancies also appear to exist without opportunity for past experience (**3**), and while demonstrated effects of past experience on the constancies do not necessarily refute the Gestalt position, evidence of the reverse seriously injures a thoroughgoing empiricist explanation.

An alternative formulation is appealing: responses may occur in one-to-one correspondence not to what we had previously taken to be the stimuli but to their relationship, without regard to central factors, whether of association or organization. In considering this possibility, we do not have to postulate innate knowledge; we need only seek new dimensions for analyzing the physical stimuli which *are* in correspondence with experience (or response). Gestaltists most frequently sought such invariant relationship not in the stimulus distribution, but in the as yet largely unmeasurable psychophysiologically isomorphic cortical processes; however, one may instead direct attention to the reanalysis of the proximal stimulus pattern as do Gibson (**2**), Helson (**4**), and Wallach (**6**).

Thus, Wallach (**6**) suggests that we

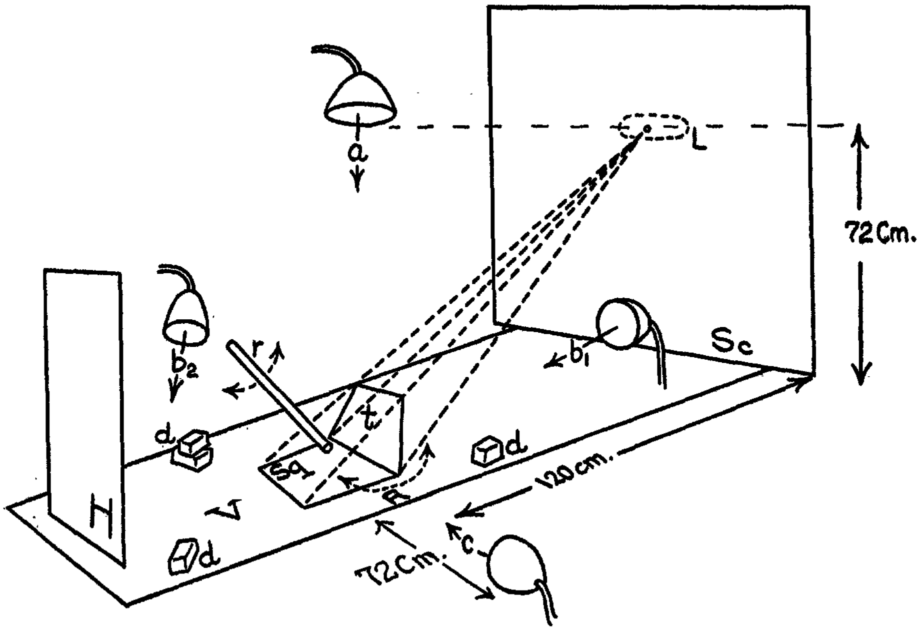

FIG. 1. Apparatus for presenting the same target at different apparent slants and illumination conditions

may understand brightness perception by taking as the stimulus not the intensity of illumination falling on a given retinal region, but the relationship of the intensities of illumination falling on adjacent regions. The relationship approximated a *ratio* of intensities in the situations he studied; i.e., the stimuli in the perception of brightness appeared to be the ratios of illumination intensities on adjacent areas, rather than the illumination intensities themselves. Thus, if *S*s viewed a variable disk surrounded by a ring of 180 illumination intensity units—degrees of episcotister opening—and were asked to match the variable disk to a disk of 90 units surrounded by a ring of 360 units, they set the variable disk to a mean value of 47 units, only 2 units away from the proportionate 4:1 intensity ratio, which would here be 90 ÷ 360 × 180, or 45 units. If this redefinition of the stimulus will explain all of brightness constancy, we can again effect a one-to-one psychophysical formulation of perceived brightness.

The constancy hypothesis was shaken since the same *absolute* stimulus intensities aroused different brightness responses (and vice versa); can conditions also be found in which the same *distributions* or relationships of stimulus intensity arouse different brightness responses? The object of the present experiments was to determine

TABLE 1

RELATIVE APPARENT BRIGHTNESSES OF THE TARGET WITH DIFFERENT APPARENT POSITIONS AND ILLUMINATION CONDITIONS

Exp.	Group	*N*	Light Source (Fig. 1)	*Ss'* Responses	
				Trapezoid Brighter	Square Brighter
I	A	6	*a*	5	0
	B	6	*a*	6	0
II	C	15	*a*	14	0
			b_1	0	14
III	D	5	*a*	5	0
	E	5	b_1	0	5
	F	5	*c*	0	0

whether a change in the apparent position of a target surface relative to an illumination source results in a change in the perceived brightness of that surface (cf. 7, pp. 600, 612), even though the actual illumination conditions remain constant.

Experiment I

The apparatus[1] is shown in Fig. 1: the main illumination (100 w.) came from above (*a*), this being "indicated" to *S*s by the shadow distribution on several cubes (*d*). These "cues" are of considerable importance since, in preliminary experiments, little or no success was achieved without them. The *S*s looked monocularly through a reduction screen (*Sc*) at an upright cardboard trapezoid target (*t*), covered with Number 8 Hering gray paper, cut so that its retinal image would be the same as that of a square (*Sq*) lying flat on the black cloth surface (*V*). All *S*s ($N = 13$) reported seeing a horizontal square, whose brightness they were then (Judgment I) asked to match quickly and unanalytically to a scale (*H*) of Hering gray paper patches (Nos. 1, 3, 5, . . . 19). A round rod, *r*, ⅜ in. in diameter, 22 in. long, painted white for Group A and black for Group B, was then waved behind the target (trying to avoid any cast shadows visible to *S*). This was kept up for some seconds, as it was difficult not to "see" the horizontal square (*Sq*) instead of the upright trapezoid (*t*); indeed, one *S* was dropped at this point, unable to see the target as upright. The *S*s again compared the target's brightness with the gray scale (Judgment II).

The results (Table 1) indicate that the target when apparently upright is reported as brighter than when apparently horizontal. Two questions may, however, be asked: First, while illumination of the rod is not likely to have been responsible for the brightness change since it was black for some *S*s and white for others, might not inadvertently cast shadows, or even the motion itself, have been the important factor? Second, if a stimulus is perceived as parallel to the line of regard, it should have a greater apparent area than when perceived as perpendicular to the line of regard (Fig. 1); may not the lower reported brightness in the former case be due to the smaller amount of *retinal* illumination per unit of *perceived* surface? The next two experiments were undertaken to test the first question by varying the means whereby the apparent shift in the target position is brought about, and to test the second by changing the direction of illumination while, of course, holding the apparent size change constant.

[1] Modified from one devised by Professor J. J. Gibson to study the relationship between perceived slant and perceived form.

Experiment II

The procedure of Exp. I was modified here in three ways: (*a*) When attempting to make the target appear upright, it was moved through short horizontal arcs (*R*) instead of having a rod (*r*) waved behind it. (*b*) The 15 *S*s (Group C) of this experiment ran through the procedure with the illumination coming from above (*a*), and then repeated the experiment with the illumination coming horizontally from in front of the trapezoid (b_1, Fig. 1), with a concealed supplementary source (b_2) to remove the shadow of the target (*t*) from the cues. (*c*) The *S*s were alternated in each part of the experiment as to the condition to which they were first subjected, the upright target or the horizontal square.

The results (Table 1) under illumination from above are the same as those in Exp. I: when seen upright, the target appears brighter than when seen flat. Under illumination from in front (b_1), the results are the reverse: with horizontal illumination, the target appears less bright when seen as upright than when flat. Since the change in perceived area consequent upon the change in perceived target position would be the same both when illumination comes from above and from the front, we can reject the amount-of-illumination-per-perceived-surface-area as a determining factor. This suggests that the brightness changes are due either largely or solely to the perceived change in target position with respect to the direction of illumination; this is supported by the results of the next experiment.

Experiment III

Two changes were here made in the procedures of Exp. I: (*a*) The target was changed from flat to upright appearance by shifting from monocular vision to binocular vision (through a larger hole, *L*). (*b*) Illumination was maintained from above (*a*) as in Exp. I, for Group D ($N = 5$), from in front horizontally (b_1) as in the second part of Exp. II, for Group E ($N = 5$), and horizontally from the side (*c*), for Group F ($N = 5$).

The results of Groups D and E show the same changes in brightness as were found in Exp. II. There is no evidence of any perceived brightness changes in Group F, in which there is no change in perceived orientation of the target with respect to the illumination, since the illumination is parallel to the target surface in either of the two perceived positions. These results again suggest that the brightness changes are obtained due to the change in the relationship of the perceived direction of illumination and the perceived position of the surface it falls upon.

Discussion

In general, the results of these experiments suggest that when a surface of a given illumination is perceived as being perpendicular to the direction of illumination, it appears less bright than when the same surface, with the same illumination, seems parallel to the direction of illumination. How does this fit the various approaches to brightness constancy?

A simple one-to-one correspondence of illumination and perceived brightness must as usual be rejected, since the same stimulus arouses different responses. Likewise, any attempt to bring the perception of brightness into one-to-one correspondence with illumination *ratios* is inadequate, since differing responses are here obtained with the same illumination relationships. Either we must view Wallach's ratio formulation (or, for that matter, Helson's "adaptation level" explanation) as incomplete, or hold that there are at least two different kinds of brightness constancy, one bound to the illumination conditions and the other not, an unparsimonious position. The general viewpoint may, however, be retained (as may also a Gestalt organizational one) if the determinants of perceived brightness include not only the peripheral illumination relationships but the "cues" to spatial position and the illumination direction (cf. **7**, p. 612). The empiricist or "inferential" position, disconcertingly enough, seems well able to explain the findings, at least by hindsight: thus, to reflect a given amount of light to the eye, a surface parallel to the incident illumination would have to have a higher albedo or brighter object color than would a surface perpendicular to the incident illumination, and would therefore be "inferred" to be brighter.

Summary

In order to determine whether perceived brightnesses can be brought into one-to-one correspondence with stimulus illumination *relationships* any more than with absolute illumination intensities, *S*s made judgments of the brightness of a target which, under constant or controlled conditions of illumination, was made to appear to be either perpendicular or parallel to the apparent direction of illumination. Since substantially the same illumination distributions produced different perceived brightnesses, analyses of brightness constancy in terms of stimulus illuminations cannot at present be considered complete explanations.

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