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A QUANTITATIVE APPROACH TO FIGURAL "GOODNESS"[1]

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Empirical study of the Gestalt principles of perceptual organization is, despite their great heuristic value, frequently made difficult by their subjective and qualitative formulation. We wish to suggest here that it may be possible to achieve *parallels* to these "laws" of organization through analysis of the objective stimulus pattern. This approach differs from similar ones (**1**, **6**) in the orienting hypothesis that, other things being equal, the probabilities of occurrence of alternative perceptual responses to a given stimulus (i.e., their "goodness") are inversely proportional to the amount of information required to define such alternatives differentially; i.e., *the less the amount of information needed to define a given organization as compared to the other alternatives, the more likely that the figure will be so perceived.*[2] However, to make this hypothesis meaningful, it is necessary to determine empirically the stimulus dimensions in which such "information" is to be measured. Therefore, we are concerned here mainly with so-called ambiguous stimuli (which evoke no single response with a probability of 1.0), although we will consider a possible theoretical bridge to the conditions of what Gibson and Waddell (**2**) call "determining stimuli."

An objective definition of perceptual "goodness" requires some measure of *Ss'* responses to stimulus figures. One such index might be the *threshold* (illumination, tachistoscopic, etc.), the "best" pattern having the lowest limen; however, this measure is too laborious for any really extensive survey of stimuli, and restricts the variety of stimuli which can be tested, being highly sensitive to recognition effects. Instead, we propose to use as a measure of "goodness" the response frequency or the relative span of time devoted by *S* to each of the possible perceptual responses which may be elicited by the same stimulus. This seems close to the intuitive meaning of "goodness" (**3**), and its probabilistic nature may permit rapprochement between perceptual laws on the one hand, and "information theory" (and, eventually, behavior theory) on the other (**5**).

That the concept of "information" (here meaning the number of different items we must be given, in order to specify or reproduce a given pattern or "figure," along some one or more dimensions which may be abstracted from that pattern, such as the number of different angles, number of different line segments of unequal length, etc.) may be useful in approximating figural "goodness" is suggested by almost any random selection of Gestalt demonstrations. The illusion of transparency obtains in Fig. 1a when less information is required to specify the pattern as *two* overlapping rectangles (number of different line seg-

[1] A slightly shorter version of this paper was read at the April 1953 meeting of the Eastern Psychological Association.

[2] After preparation of this paper, we have been privileged to see the manuscript of a paper by Dr. F. Attneave, which contains a much more detailed theoretical discussion of the tendency of the organism to perceive in terms of "maximum redundancy"; although this formulation is probably not precisely equivalent to the one proposed here, and the experimental techniques employed are quite different in method and assumptions, we are agreed as to the basic similarity of our general approaches.

ments: 8, plus one for notation of locus of intersection; number of angles to be specified: either 8, plus one for notation of angle of intersection or, more simply, one right angle plus the repetition implied in the notation of rectangularity, plus one for notation of angle of intersection; etc.) than, alternatively, as *five* irregular shapes (number of different line segments: 16; number of angles: 16; etc.). In Fig. 1b, less information is necessary to specify the symmetrical central black area as figure (number of different angles or points of inflection: 10, plus notation of duplication by bilateral symmetry) than the irregular white areas (number of different angles: 17). Listing the organizational "laws," from "good continuation" and "proximity" to the more general "simplicity" or "homogeneity," one finds translation impressively easy; the eventual utility of such translation depends, however, upon empirical determination of the dimensions of abstraction along which "information" is to be scored (shall we use "number of angles," "number of line segments," a weighted combination of these, or entirely different dimensions?), and upon the demonstration of a quantitative dependence of response frequency on the "information scores."

But can we approach the study of *determinate* (2) perception in this manner? Consider the task of representing spatial depth in two dimensions (Fig. 1c). Stimulus part *i* requires less specification as two overlapping rectangles than as L and rectangle; part *ii* requires less specification as a rectangle at a given slant (say 45°) than as a trapezoid at other slants; finally, in one way part *iii* requires less specification as three identical rectangles at the appropriate distances than as different sized rectangles at other distances (although here rather involved assumptions are necessary about a size-distance relationship "built in" to the specifying coordinate system, etc.). Now, although each part is ambiguous, if we take all the parts together and if the slant and depth relationships associated with the "best" response to each stimulus part should coincide, the probability of obtaining just these slants and depths will be reinforced. As we add more such "cues," the probability of obtaining alternative depth responses approaches zero, and we may therefore consider *determinate* perception as different from the ambiguous variety, with which we are concerned at present, not in kind, but in degree.

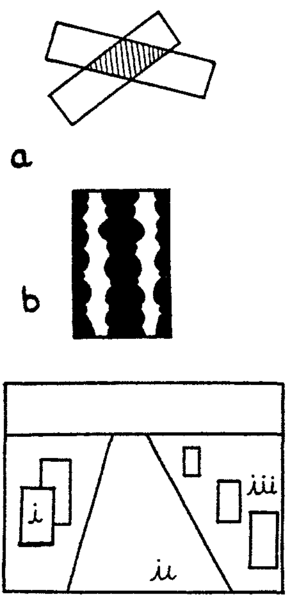

FIG. 1. Transparency, symmetry, and depth

METHOD

The approach outlined above is of little use unless it is possible to select dimensions for scoring "information" which are in correspondence with empirically obtained response-probabilities. The relative durations of alternate classes of response may be obtained by the usual method

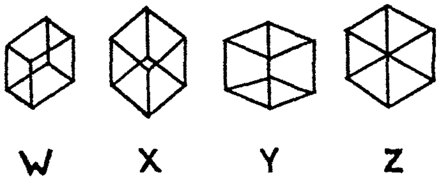

FIG. 2. The Kopfermann "cubes"

of pressing telegraph keys for each phase, but with this procedure Ss often report that the act of key-pressing altered the percept, which often fluctuated too rapidly to record; moreover, only one S can be used at a time. For these reasons, a sampling method was devised in which signal tones were presented by tape recording at "random" intervals and Ss indicated the phase they had perceived at the time each signal tone sounded. The frequency with which a given response is obtained is assumed to be proportional to the amount of time that response would have been obtained by "ideal" continuous recording.

The problem here was to apply this method to the case of Kopfermann cubes (Fig. 2) which may all be seen either as bidimensional patterned hexagons, or as tridimensional cubes (4). Drawings of each cube were presented in balanced order for 100 sec. each to 80 college students, providing a pool of over 2,600 responses for each stimulus; Ss indicated by pencil code marks which phase they had experienced just prior to each of the 33 signal tones presented at random intervals during the 100 sec.

Results and Discussion

The results obtained correspond roughly to Kopfermann's more subjective findings: that figure which possesses the best phenomenal symmetry as a two-dimensional pattern was obtained least often as a cube (see Table 1). In terms of Gestalt theory, we would expect that the likelihood of seeing a figure in two dimensions would not only vary directly with its "goodness" in two dimensions, but, in addition, would vary inversely with its "goodness" in three dimensions. However, in this study, we may consider the "goodness" of the bidimensional patterns alone, since the tridimensional phase of each figure is more or less the same cube, the only appreciable difference being the apparent angle with respect to S. That is, we take the relative duration of two-dimensional responses to be proportional to the "goodness" of the two-dimensional patterns, the "goodness" of the tridimensional phases being approximately constant.

The bidimensional patterns may be analyzed for a large number of stimulus properties whose values will yield a relationship similar to that of the four points of bidimensional "goodness" response measures (Table 1), and the relationships fit quite well if these properties are differentially weighted. However, data are still needed on many other stimulus figures before a general system of factors and weights can be attempted, so that we are probably safer, at this stage, in merely noting stimulus variables which match the response relationships without employing differential weights. Two such stimulus dimensions fit the responses quite well, namely the number of angles and the number of line segments (Table 1). (Note that with the present figures, both dimensions represent the same geometrical fact.) Another dimension is the number of points of intersection required to define each bounded shape in the flat pat-

TABLE 1

BIDIMENSIONAL RESPONSES TO THE KOPFERMANN "CUBES" AND SOME TWO-DIMENSIONAL STIMULUS CHARACTERISTICS OF THE CUBES

"Cubes"	Bidimensional Responses (%)	Stimulus Characteristics		
		Line Segments	Angles	Points of Intersection
W	1.3	16	25	10
X	0.7	16	25	10
Y	49.0	13	19	17
Z	60.0	12	17	7

terns. Any of these scores would be consistent with an inverse relationship between response probability and the amount of "information," as discussed above, required to *specify* a given pattern; it is simple, however, to construct other figures whose relative strengths in alternate response phases may appear, at least intuitively, to be poorly handled by these dimensions, and we will need quantitative data from a wide sample of such figures before general stimulus dimensions can be chosen.

Summary

Probability of alternate perceptual responses is suggested as an approximate quantitative index of "goodness" of figure, and a group technique is presented by which this score can be obtained for ambiguous stimuli. Using the technique to obtain group scores for relative duration of tri- and bidimensional phases of four Kopfermann cube figures, the resulting responses are not inconsistent with the working hypothesis, namely that the probability of a given perceptual response to a stimulus is an inverse function of the amount of information required to define that pattern.

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