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Size contrast as a function of figural similarity*

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Size contrast occurs in numerous configurations where a test figure appears apparently larger when surrounded by small elements and apparently smaller when surrounded by large elements. Using the Ebbinghaus illusion, the magnitude of this effect is shown to vary as a function of apparent similarity between test and inducing element.

It has long been known that estimates of perceptual magnitude are never made in isolation, but rather are made relative to all of the other stimuli which form its context. Thus, a 5-ft 10-in. sports announcer looks very short when interviewing a team of basketball players, but very tall when interviewing a group of race horse jockeys. This effect was first introduced by Helmholtz (1866), who noted that clearly perceived sensory differences tend to be exaggerated, a general phenomenon which he called *contrast*. Thus, the apparent size of the sports announcer is affected by *size contrast,* which exaggerates his relative tallness or shortness against the surrounding context of athletes. Since Helmholtz introduced the concept, it has been elaborated by Wundt (1894) into the *law of relativity,* and given a quantiative formulation by Helson (1964), in terms of *adaptation level theory.*

The notion that we judge the sensory magnitude of stimuli against the magnitude of the surrounding context of stimuli has been used to explain some varieties of visual illusions. Thus, Fig. 1A shows the Ebbinghaus illusion (frequently called Titchner's circles), in which the central circle surrounded by large inducing elements appears smaller than the central circle surrounded by the small elements. Massaro and Anderson (1971) and Girgus, Coren, and Agdern (1972) have shown that the apparent size of the central test elements varies systematically with the size of the context elements. There is good evidence that such size contrast distortions are due to active comparative judgmental processes. Restle (1971) reports that size contrast illusions are reduced if the observer is instructed to ignore the surrounding context, while Coren (1971) has demonstrated that it is the apparent size of the inducing stimuli, not the actual retinal size, which determines the illusory effect.

It is surprising that, although size contrast has been used as an explanatory mechanism for visual illusions for over a hundred years, little is known about the factors which determine its appearance or nonappearance. Thus, in the example we have been talking about, you have probably noticed that a sports announcer does not look very diminutive when standing beside a race horse, and he is not the miniscule size you might expect him to be when imaged against a football stadium. If the comparison which results in size contrast were based simply upon the relative area or size of the context, we should also expect distortions to occur in these situations. It is certainly clear that if we looked at the sports announcer while a loud or soft tone was playing, we would not expect any distortion of his size, even though the context stimulation (the tone) was varying in magnitude. This latter fact implies that the stimuli that are compared must at least be in the same modality for size contrast to emerge. Extending this line of thought might lead us to conclude that one reason why the sports announcer does not look smaller when beside a race horse, while he does phenomenally shrink when placed beside the basketball player, is that both he and the basketball player are men, and hence similar along some phenomenal dimension. He probably does not look very much like the race horse, hence the comparison of sizes may not occur as readily in that situation.

The experimental implication which emerges from such speculation is that the magnitude of a size contrast illusion should vary as a function of the perceived

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similarity between the test and the inducing elements. The more similar they appear to be to each other, the greater the resultant size distortion which should be observed. To test this hypothesis, the following experiment was conducted.

METHOD

Scaling of the Stimuli

Since this experiment is designed to explore the effects of similarity of the test and inducing elements on the magnitude of a size contrast illusion, it is first necessary to construct a scale of similarity amongst the various figural elements. Twelve different figures, including a number of common regular geometric forms and a number of random closed outline configurations, were employed. Each figure was drawn on a 10 x 15 cm piece of white stiff paper with 1-mm black lines. All figures were equated for area. Each of the 15 Ss was asked to judge the similarity of each figure, presented one at a time, to the standard configuration of a circle, 14 mm in diam, which was continuously visible. Judgments were made using a 7-point rating scale labeled (1) extremely similar, (2) very similar, (3) fairly similar, (4) medium, (5) fairly different, (6) very different, (7) extremely different.

The mean ratings per stimulus can be used to indicate the perceived similarity between each stimulus and a circle. These ratings were used to select three forms which ranged from very similar to very different in their similarity to the circle. The requirement for selection was that the forms be statistically different from each of the other forms selected at $p < .05$ by means of a t test. Those forms selected were a hexagon with a mean rating of 2.03, a triangle with a mean rating of 4.65, and a random angular shape with a mean rating of 6.56. A similar methodology has been used by Coren and Girgus (1974) to scale the apparent similarity between varients of the Mueller-Lyer illusion.

Stimuli and Apparatus

The stimulus elements selected by the scaling procedure were used to construct four different pairs of Ebbinghaus figures. These are shown in Fig. 1. The central test circle was 14 mm in diam, hence had an area of 240 sq mm. The large inducing figures had an area of 450 sq mm and the small inducing figures had an area of 20 sq mm. Each stimulus consisted of a central test circle around which were four inducing elements each at a distance of 6 mm from the test element. All figures were drawn with 1-mm wide black lines on 20 x 28 cm white paper. The reflectance of the lines was 5.1% and of the background was 82.0%. Only one of the eight possible stimulus configurations appears on each sheet.

Responses were made by rotating a wheel that presented single comparison circles (with no surrounding elements) ranging in diameter from 8.0 to 19.5 mm in steps of 0.5 mm. Single circles appeared in a 26-mm aperture cut into the apparatus.

Twelve volunteers served as Os. Each judged the apparent size of the central test circle once for each stimulus in the set. Stimuli were presented in random order. The Ss were allowed free eye movements and could look back and forth between the stimulus and comparison figures.

RESULTS AND DISCUSSION

The magnitude of the illusion induced by each variety of context element may be computed by subtracting the apparent size of the test circle when surrounded by large inducing figures from the apparent size of the test circle surrounded by small inducing elements for each context shape. This difference, then, gives the magnitude of the size contrast effect for each configuration. The obtained data are shown in Fig. 2, where illusion magnitude in millimeters is plotted against the perceived dissimilarity between test and inducing element. It is clear that the magnitude of the illusion is considerably reduced when the inducing elements are seen as dissimilar to the test element. The effect of perceived similarity of the inducer on the magnitude of the

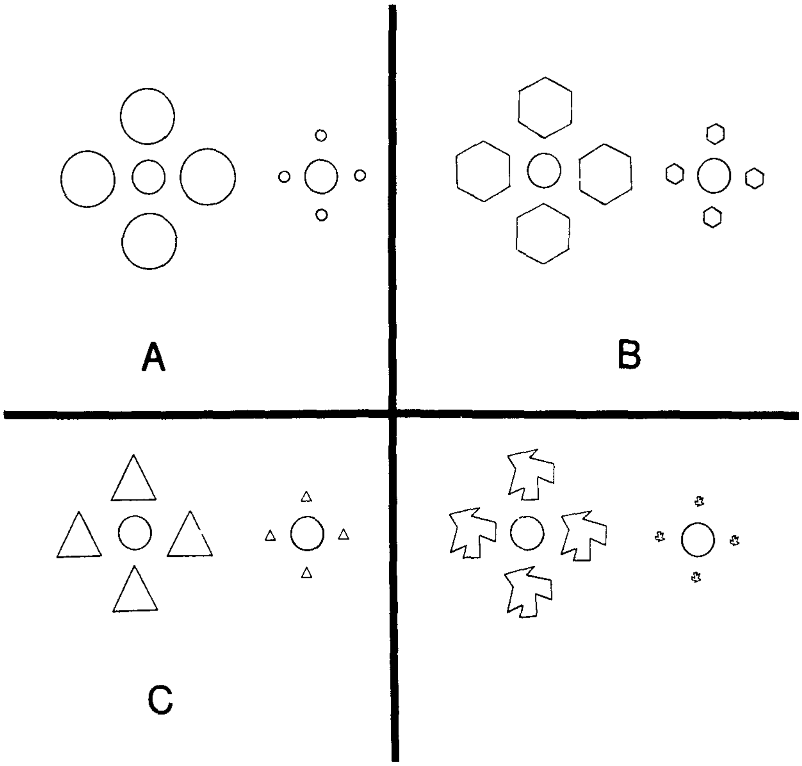

Fig. 1. Four variants of the Ebbinghaus illusion with inducing elements of differing apparent similarity to the central test circle.

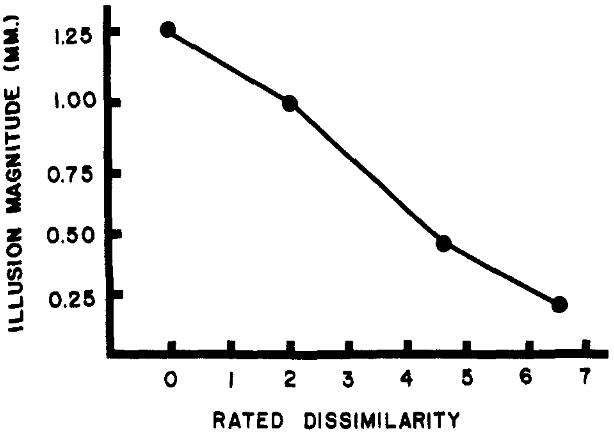

Fig. 2. The magnitude of the illusory distortion in millimeters, plotted against the scaled dissimilarity between the test circle and the inducing element.

illusion is statistically significant ($F = 22.95$, $df = 3/33$, $p < .001$).

These findings are clearly in accord with theoretical positions which contend that the Ebbinghaus illusion is due to comparative judgmental processes since the magnitude of the distortion varies as a function of apparent similarity. They further suggest that the comparative mechanism responsible for such size contrast effects is rather selective. It is more likely to make comparisons among similar targets than among dissimilar ones. It is as if the observer is attempting to place the test stimulus in an appropriate relationship to other objects of its class, rather than making an absolute judgment of sensory magnitude.

There is a well-known analogue to this process in the tactual modality, where a given weight might feel heavy when it is the topmost stimulus in a series of weights while it feels light when it is the bottommost stimulus of another. Here the subjectively established frame of reference is the set of weights in the series. It is clear that the observer never takes into account the weight of the table upon which the stimuli rest, the weight of the E, or the weight of the building he is tested in, since they are clearly not relevant to the judgment at hand.

In a similar fashion, the judgment of the visual size of a stimulus is more likely to be affected by objects seen as similar, and thus providing a useful judgmental context. No researcher would expect an E working on the Ebbinghaus illusion to take into account the size of the walls of the room in which the experiment was conducted, yet surely these provide a surrounding visual context of large elements. Nor would many require that he conduct the experiment with the configurations printed on glass in order to eliminate texture from the field. Certainly it is possible for each textural element to act like a small surrounding inducer, thus inflating the apparent size of the target. Such considerations do not enter our consciousness since, although these are stimuli presented in the visual field, they are certainly ignored by the comparative processes as being irrelevant to the judgment of the size of an outline circle. Similarly, a random angular outline figure, such as that used in Fig. 1D, may be less likely to evoke comparison with a circle, than an octagon (Fig. 1B), since it seems to belong to a different class of stimuli. Thus, it is less likely to produce the distortions associated with the size contrast. As Helson put it, "A truly relativistic approach to behavioral phenomena must state to what frame of reference phenomena are relative [Helson, 1964, p. 31]."

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