The assimilation theory of geometric illusions: An additional postulate*

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The assimilation theory of geometric illusions is extended to include an additional postulate which states that "assimilative effects increase with an increase in the range of contextual magnitudes." The effects of several stimulus variables on the Müller-Lyer and Poggendorff illusions are explained on the basis of this postulate.

The assimilation theory of geometric illusions (Pressey, 1967, 1971) employs two major postulates. The first is that "whenever judgments are made of a series of magnitudes, the smaller magnitudes in that series will be overestimated and the larger magnitudes will be underestimated." The second postulate states that "other things being equal, a context which falls within the attentive field will be more effective than a context outside that field." By a systematic application of these two postulates it is possible to explain the Müller-Lyer illusion, two variations of the Müller-Lyer illusion, the Sander parallelogram, the Ponzo illusion, Wundt's area illusion, the Poggendorff illusion, and the Hering illusion (Pressey, 1970, 1971).

Although the basic character of illusions such as the Müller-Lyer has been explained, no attempt as yet has been made to explain changes in illusions that occur as a result of changes in stimulus variables. For example, it is well known that in the Müller-Lyer illusion, the magnitude of the illusion increases as the angle of the oblique arms becomes more acute. In addition, up to a certain point, the illusion increases as the length of the oblique arms increases (Heymans, 1896; Lewis, 1909; Dewar, 1967). The purpose of this report is to attempt to explain, within the framework of assimilation theory, changes in two illusions (the Müller-Lyer and the Poggendorff) that result from changes in stimulus variables.

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THE MÜLLER-LYER ILLUSION

Figures 1A and 1B illustrate the arrowhead forms of the Müller-Lyer illusion, in which the angle formed by the oblique arms varies. According to assimilation theory, the arms trigger judgments not only of the criterion distance between the apices, but also of an indefinite number of distances which vary in length. This notion is expressed schematically in Figs. 1C and 1D. It will be noted that the lines ab and ef are embedded in contexts of shorter lines and, according to the first postulate, ab and ef should be underestimated. The question that next arises is why the more acute angled target produces a larger illusion than the less acute angled target. Inspection of Figs. 1C and 1D will reveal that changes in the angle produce changes in the *range of distances which form the embedding context*. That is, in Fig. 1 the difference between ab and cd is less than the difference between ef and gh. Now, if it is assumed that the degree of assimilation increases as the range of stimuli that form the context increases, then it would be expected that the more acute angle would produce a larger illusion.

Several investigators have shown that the variations in the range of stimuli have a profound effect on judgments of magnitude (Poulton, 1968). Generally speaking, it has been found that the slope of the function relating the subjective judgments to the objective values is steeper for the small ranges than for the large ranges. This fact is interesting because it is precisely the type of relationship that would be predicted if the statement that "assimilative effects increase with increases in the range of stimuli" were true. Thus, there is at least some

evidence to suggest that judgments of magnitudes are related to the range of the context in which they are embedded.

In order to provide more evidence on the relationship between range of context and magnitude of illusion, the targets used by Heymans (1896) in his study on the effect of angle on illusion were analyzed. Ten targets consisting of the arrowfeather form of the illusion were drawn, with the standard line in each case being 75 mm. The oblique arms were 20 mm long. The angle varied from 5 to 90 deg. For each target, the distance between the tips of the oblique arms was measured and the standard distance was then subtracted from this measure. The resulting changes that occur in the range of stimuli as angle increases are shown in Fig. 2A. The curve is clearly a positively accelerated decreasing function of the angle of the oblique arms. Heyman's data on the actual illusion obtained is shown in Fig. 2B, and it, too, is a positively accelerated decreasing function of angle. Thus, there is a striking parallel between the magnitude of illusion and the range of stimuli which form the context.

The functions illustrated in Fig. 2 are also important in view of a controversy that exists on the nature of the relationship between the Müller-Lyer illusion and the angle of the oblique arms. Both Lewis (1909) and Dewar (1967) argue that the relationship is a linear one, and indeed, on the basis of the data they present, a linear trend cannot be rejected. But Lewis only used two Ss, and Dewar used a limited range of angles, with the result that subtle deviations from linearity could not be assessed. In view of the fact that assimilation theory very specifically predicts a positively accelerated function, Heyman's data should perhaps be substantiated in an independent experiment.

It has already been noted that increasing the length of the oblique arms (while keeping angle constant) results in an increased illusion—up to a certain point. This fact can also be explained on the basis of increased range of stimuli. As illustrated in Fig. 3, the difference between ab and cd is less than the difference between ef and gh, and according to the assumption developed above, the illusion should be greater in Fig. 3B.

There is, however, an important fact

Fig. 1. Arrowhead forms of the Müller-Lyer illusion. See text for explanation.

Fig. 2. (A) Range of contextual magnitude as a function of angle of oblique arms in Müller-Lyer targets. (B) Magnitude of the Müller-Lyer illusion as a function of angle of oblique arms (based on data from Heymans, 1896).

Fig. 3. The effect of increased length of oblique arms on the Müller-Lyer illusion.

which assimilation theory, at this point, cannot handle. Both Heymans and Lewis found that as the length of the oblique arms becomes very great, the illusion then begins to *decrease*. This fact could be viewed as a disconfirming instance of assimilation theory. An alternative conception, which is preferred by the author, is that some other factor is responsible for the decrease. This would mean that the assimilation theory is incomplete rather than incorrect.

Finally, an experiment conducted by Erlebacher and Sekuler (1969) is relevant here. These investigators varied the angle of the obliques but, at

the same time, adjusted the length of the obliques so as to keep the distance between the tips of the obliques the same for all targets. It will be noted that this procedure produces a constant range, and according to our analysis, there should be no difference among the targets. Erlebacher and Sekuler did indeed find no difference in illusion produced by the various targets.

THE POGGENDORFF ILLUSION

The Poggendorff illusion is another configuration in which the angle formed by the oblique arm has a strong effect on the size of the illusion. In addition, the linear measure of illusion increases as the distance between the parallel lines increases (Cameron & Steele, 1905; Velinsky, 1925; Novak, 1966). On the surface, it would appear to be impossible to apply the notion of range of stimuli to explain the effect of these variables on the Poggendorff illusion, but in terms of the analysis of the illusion given by Pressey (1971), the application of the notion of range is not impossible; indeed, it is rather straightforward.

Assimilation theory states that, in projecting the oblique line in the Poggendorff target, attention is focused in a limited region. This field

Fig. 4. Hypothetical processes involved in perceiving the Poggendorff illusion.

Fig. 5. (A) Range of hypothetical contextual magnitudes in the Poggendorff illusion as a function of angle of oblique line and distance between parallel lines. (B) Magnitude of the Poggendorff illusion as a function of angle of oblique line and distance between parallel lines (based on data from Velinsky, 1925).

of attention is hypothesized to be a circle, as shown in Fig. 4. The diameter of this circle is defined by the distance *ab*. Now, when an *O* is asked to extend subjectively the oblique line, he extends a *series of lines*, as shown in Fig. 4. This series consists of lines that are shorter than the line of objective continuation.

Therefore, O's choice of line will assimilate to the mean of the series, which means that he will select a line shorter than the line of objective continuation. But if a shorter line is selected, the oblique line will appear to point above the point of objective continuation, which is precisely what occurs in the Poggendorff illusion.

Thus, in terms of the above analysis of the Poggendorff illusion, a series of magnitudes does exist and the range of this series can be obtained by subtracting *ac* from *ab*. Such an analysis was carried out for the targets used by Velinsky (1925), who employed a 9 x 5 factorial design in which there were 9 angles (ranging from 90 to 10 deg) and 5 distances between the parallel lines (5 to 25 mm). For each of the 45 targets, a circle was drawn with a diameter equal to *ab* (see Fig. 4). The distance *ac* was then subtracted from *ab* to yield a measure of range. The hypothetical range of stimuli as a joint function of angle of oblique and distance between parallel lines is shown in Fig. 5A. Velinsky's measure of illusion as a joint function of angle and distance between parallel lines is shown in Fig. 5B. Velinsky's data indicate that the illusion is a positively accelerated increasing function of angle and also that, as the distance between the parallel lines increases, the illusion

increases. Moreover, there is a pronounced interaction between angle and distance. Precisely the same functions are found in the hypothetical range of stimuli that form the embedding context, and, as can be seen, the family of curves in Fig. 5A is strikingly similar to the family of curves in Fig. 5B.

In summary, it appears that a new postulate for the assimilation theory of geometric illusions is warranted. This postulate can be stated as follows: the degree of assimilation (underestimation or overestimation of a magnitude which is embedded in a context of magnitudes) increases as the range of magnitudes which form the context increases. This postulate would explain (1) why the Müller-Lyer illusion increases as the angle of the oblique arms decreases, (2) why, in part, the Müller-Lyer illusion increases as the length of the oblique arms increases, (3) why the Müller-Lyer illusion remains constant when the distance between the tips of the obliques remains constant, (4) why the Poggendorff illusion increases as angle of the oblique decreases, (5) why the Poggendorff illusion increases as the distance between parallel lines increases, and (6) the interaction between angle of oblique and distance between parallel lines in the Poggendorff illusion.

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