Disinhibition in concentric circles aftereffects as a function of luminance contrast

JOHN K. ADAMOWICZ AND ROBERT E. DEWAR
THE UNIVERSITY OF CALGARY

Disinhibition was examined in the concentric circles aftereffect. Three conditions of luminance contrast, test figure (TF) and three conditions of contour width of TF were incorporated in the design together with two contour-width conditions of the inducing figure (IF). The results were significant for the IF widths as well as for the TF luminance and width gradients–strength of the aftereffect showed a direct relationship to the IF contour width and an inverse relationship to the TF luminance contrast and contour width. The results support Ganz' simultaneous illusion theory of aftereffects.

A new mechanism of figural aftereffects (FAE) has recently been formulated by Ganz (1966a, b). He proposes that FAEs are actually a type of simultaneous illusion in which the afterimage of the inspection figure acts as the inducing figure. It exerts inhibition which displaces the test figure contour in space. Ganz (1966b) reviewed the evidence relevant to his theory and reports three lines of evidence which support his proposal. Simultaneous illusions and FAEs are influenced in similar ways by changes in the intensity of the inducing figure. The temporal characteristics of afterimages and FAEs are similar. Both appear to obey Emmert's Law.

According to Ganz' theory, the displacement of contours arises because the neural correlates of visual contours inhibit one another. The inhibition is proportional to the log of contour contrast above the background level (Ganz, 1966a). The inhibition is a decreasing linear function of the separation between the contours (Pollack, 1958). According to the theory, FAE characteristics should be similar to those of simultaneous visual illusions. Ganz (1966b) proposes that if the two involve similar processes, then they should both be prone to disinhibition. Disinhibition occurs "... when a contour A is strengthened to the point where it inhibits B so strongly that B's inhibition of A becomes weaker. Thus, A is less inhibited and is perceived as brighter; it becomes disinhibited." (Ganz, 1966b, p. 154). Thus, if disinhibition is present in FAEs, weaker displacements by Figure A should result on Figure B, if the contrast of B is increased, other things remaining equal. In the case of simultaneous illusions, Ganz (1966b) reports three studies which indicate that this is what happens. In the case of FAEs, Ganz reports only one relevant study.

The dearth of evidence in support of the disinhibition hypothesis prompted the present study, which examines the influence of test figure luminance contrast and contour widths on the concentric circles aftereffect.

Method

Eighteen University of Calgary students were used as Ss. Their ages ranged from 18 to 25 years.

Stimuli were presented in a modified Dodge three-channel tachistoscope. One channel of the tachistoscope was used to present a pre-exposure field, a white card with a red fixation point. The two stimulus pattern components were presented separately in the other two channels. Stimulus sequences and time intervals were controlled by the electronic control unit of the tachistoscope. The inducing figure (IF) and test figure (TF) time exposures were 200 msec and 500 msec, respectively, TF following the IF immediately. These values were higher than the minimum ones for which judgments could be made (Gibb et al, 1966).

Stimuli were drawn on smooth white cards 7 in. x 5 in. The standard diameters (outer border measures) of IF and TF subtended 132' 12" and 66' 6" of arc, respectively. IF contours subtended 2' 40" and 10' 34" of arc, whereas TF contours subtended 2' 40", 5' 20", and 10' 34" of arc for Conditions 1, 2, and 3, respectively. The stimulus was 52 in. from S's eye.

Luminance contrast was varied by drawing the IF circle black (Munsell value 1) and TF circles black, medium black, and gray (Munsell values of 1, 4, and 8.5, respectively).

The components of the stimulus pattern were: (a) two physically equal circles—TF and a comparison figure (CF)—horizontally equidistant from a red fixation point, and (b) a larger circle IF concentric to the TF. The distance between the red fixation point and centers of all circles subtended 98' 56" of arc. The red fixation dot appeared on cards in all channels of the tachistoscope.

Points of subjective equality (PSEs) were determined by the modified up-and-down method (Dixon & Mood, 1948). With this method, the TF diameter was held constant, while the CF diameter was varied systematically from 0.300 in. larger to 0.300 in. smaller than that of the TF, in steps of .025 in. In each presentation, the S responded "larger" or "smaller" to indicate the apparent size of the TF relative to that of the CF. S's response on each trial determined the direction of change of the CF diameter for the next trial. In each PSE series the pattern in which CF and TF diameters were equal was used for the first trial. All sets of trials were started at the same point in the stimulus series to insure that differences between the PSEs for the various conditions could not be influenced by differences between the starting points for those conditions.

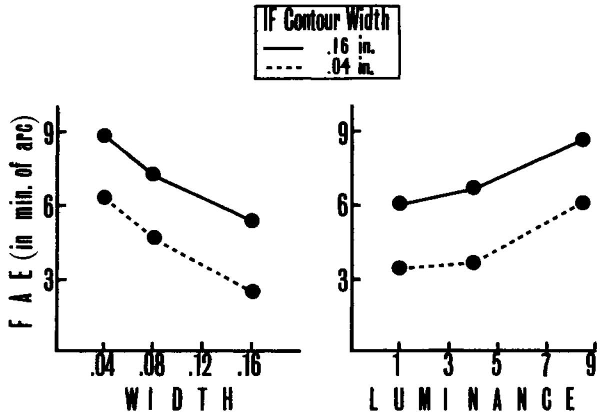

Fig. 1. Magnitude of figural aftereffect as a function of IF contour width (in in.), TF contour width (in in.) and TF luminance contrast (Munsell values).

Each S made judgments under two randomly chosen TF luminance contrast and width conditions, nine Ss for each of the two IF widths. Trials for the two conditions were randomly interspersed so as to minimize response bias due to set. Ss were individually tested in approximately one hour sessions. Before the testing session, Ss were pretested to determine their PSEs. During pretesting, Ss were presented with TF and CF alone with their luminance contrast and circle widths matching those to be used in the subsequent testing situation. For both the pretest and test series, nine trials were given after the first response change in the up-and-down series. A 1-min rest was given between trials, followed by a 10-sec fixation of the pre-exposure field before the next stimulus was presented. Pretest and test trials were separated by a 10-min rest period. Ss were instructed to fixate the red dot on all trials.

Results and Discussion

An analysis of variance showed all main effects to be significant (IF width—$F = 10.9$, $df = 1/18$, $p < .01$; TF width—$F = 5.7$, $df = 2/18$, $p < .025$; TF luminance—$F = 4.2$, $df = 2/18$, $p < .05$). Strength of the FAE was inversely related to TF contour width and TF luminance contrast (Fig. 1). No interactions were significant. The data are consistent across both IF widths, as can be seen from Fig. 1.

These results with respect to the width factors indicate that they play an important role in the aftereffect formation, just as they do in simultaneous illusions (Fry & Bartley, 1935). Going from wide IF to narrow IF there was a definite decrease in aftereffect. In the disinhibition framework, this is equivalent to increasing TF widths and, therefore, increasing contrast.

In effect, Ganz' disinhibition hypothesis is supported. Concentric circles aftereffects are similar to simultaneous illusions in this respect. Thus, it seems more reasonable to suggest that the FAE is a result of the residual stimulus process on the retina which exerts lateral inhibition on the TF and therefore contour displacement than it is to say that the aftereffect is a result of neural fatigue in the cortex.

References

Dixon, W. J., & Mood, A. M. A method for obtaining and averaging sensitivity data. *J. Amer. Statist. Assoc.*, 1948, 43, 109-126.

Fry, G. A., & Bartley, S. H. The effect of one border in the visual field upon the threshold of another. *Amer. J. Physiol.*, 1935, 112, 414-421.

Ganz, L. Mechanism of the figural aftereffects. *Psychol. Rev.*, 1966a, 73, 128-150.

Ganz, L. Is the figural aftereffect an aftereffect? *Psychol. Bull.*, 1966b, 66, 151-165.

Gibb, M., Freeman, I., & Adam, J. Effects of luminance contrast factors upon figural aftereffects induced by short fixation periods. *Percept. mot. Skills*, 1966, 22, 535-541.

Pollack, R. H. Figural aftereffects: Quantitative studies of displacement. *Austral. J. Psychol.*, 1958, 10, 269-277.