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THE HERMANN GRID EFFECT UNDER DIFFERENT CONDITIONS OF ILLUMINATION AND INTERSQUARE DISTANCE

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The aim of this paper is the study of the conditions which optimize the phenomenon of the illusory spots which are perceived at the intersections of the Hermann grid (1870) (see Fig. 1), and which may be explained in terms of the excitatory and inhibitory receptive fields of the ganglion cells, as suggested by Jung and Spillmann (1970).

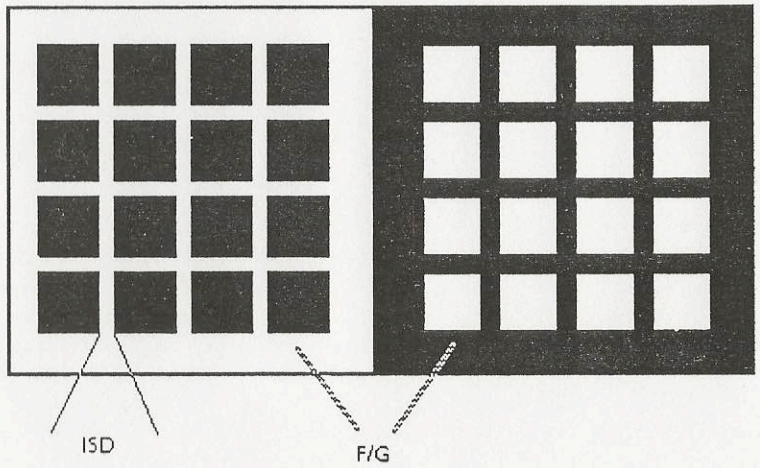

Figure 1 The Hermann grid: the illusion consist in the perception of illusory spots at the intersections of the bars if they are not observed foveally. ISD = intersquare distance; F/G = figure-ground relation, Black square over white background (B/W) or vice-versa (W/B).

Baumgartner (1960) used the Hermann grid for the psychophysical estimation of the perceptive fields in the retina, and further studies have been carried out by Schepelmann, Aschayeri and Baumgartner (1967),.

Spillmann (1971), Spillmann and Levine (1971), Berbaum and Chung (1981), Troscianko (1982a,1983), Wolfe (1984).

Wist (1976) found that the illusion diminishes after dark adaptation and reappears after light adaptation. He suggested that the reduction of the evidence of the spot can be explained by the attenuation of the lateral inhibition in the eye which is light adapted. His results seem to indicate the direct implication of the retina in the process by which the grid is analysed.

In a previous experiment in which grids with black squares on a white background, and white squares on a black background, respectively, were presented by means of tachistoscope, Savardi and Saviolo (1984) confirmed Wist's observations and found that a short preadaptation time of 9 sec. is enough to elicit the illusion. Moreover, the time required for the presentation of both grids was longer if the preadaptation field was black.

The aim of this research is to clarify further how sensitivity to the illusion varies not only in relation to preadaptation conditions and figure-ground relationships but also in relation to levels of luminance of the grid and the distance between the squares.

Troscianko (1982 b) tested the sensitivity to the spot in modified "hollow" grids with an intersquare distance subtending angles of 0.25 to 1.9 degrees and with three background luminance:mesopic (0.1 cd/m2) and scotopic (0.01 cd/m2). The task of the subject was to estimate the intensity of the spot by a cancellation tecnique, adding a measurable amount of light to the intersections. His results indicate that the estimation of the spot's intensity, and hence, indirectly, the size of the perceptive fields, varies with the eccentricity of the retina (from 3 to 15) and with the luminance of the background, since the illusion is perceived with more evidence at 15 deg. of eccentricity in photopic conditions and using grids with intersections of about 2. In mesopic conditions perceptive fiels of 0.71 appear to elicit maximum stimulation, but only at eccentricity of 3 deg.. In scotopic conditions (also at 3 deg. of eccentricity), the subjects do not see the illusion; only large perceptive fields are barely stimulated. Troscianko agrees with Ransom-Hogg and Spilmann (1980) thath the centre-surround ratio size of the perceptive fields increases with the eccentricity of the retina in scotopic conditions and that the inhibitory surrounds become much less effective, exept in the case of some large field sizes.

We have carrie out our experiment bearing this research in mind.

SUBJECTS

The experiment was carried out on 20 subjects. These were psychology students chosen at random, ten of whom underwent the experiment in adaptation conditions to a white field, the other ten to adaptation conditions to a black field.

APPARATUS

A Harvard tackistoscope was used (mod.T3-313-1) with three fields. Two fields were used: the first was used for the presentation of the stimuli; the second for the presentation of a white or black background according to the experimental conditions. The two fields provided the conditions of the two modalities of dark and light adaptation. The grids were presented in the first field for an exposure period of 5 sec., followed by the adaptation field with an exposure period of 9 sec.; the sequence was continued until all presentations were completed.

The stimuli used were 8 photographs, 4 of which had black squares on a white background (B/W), the other 4 having white squares on a black background (W/B), varying in inter-square distance from 1, 2, 4, and 8 mm. The visual angle calculated on the distances between the sides of the squares for the various grids was 4.3', 8.7', 17.6' and 35,24' at an eccentricity of about 3 deg.

The luminance of the fields of the tachistoscope was provided by two standard B4 4 Watt 4200 k fluorescent lamps: X = .372 and Y = .365 in the diagram of ICI chromaticity for both grids.

The stimuli were presented in varying conditions of luminance according to the field of the tachistoscope, i.e. with a maximum quantity of the light (100%), average (75%) and minimum (50%).

PROCEDURE

The subjects were asked to judge the degree of evidence with wich they perceived the illusion of grids presented to them, and to indicate variations from zero evidence to to maximum evidence on a scale of 1 to 5.

The 24 stimuli were repeated four times and presented in random order for a total of successive presentations.

RESULTS

The mean values of the subjects' responses to all the trials of the experiments consisting of the degrees of the evidence with which they perceived the illusion, were calculated.

Figure 2a shows the results of the figure-background relationship in the case of black squares on white background; figure 2b shows results of the pattern-background relationship in the case of white squares on a black background. The graphs show that the degree of evidence for the illusion is greater in the case of an inter-square distance of 2 and 4 millimeters in both B/W and W/B grids. An ANOVA was carried out on a mixed design comprising four factors, field of adaptation (black vs white), level of luminance (100%, 75%, 50%), figure-background relationship (B/W vsW/B), intersquare distance (1, 2, 4, 8 mm), and the sum of the responses

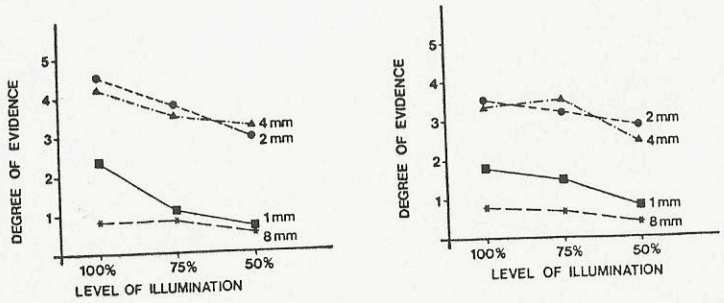

Figure.2a The figure shows the figure-background relationship of B/W grid.
Figure.2b The figure shows the results of the figure-background relatioship of W/B grid.

given to the four trials in each of the test condition considered as dependent variable. The ANOVA was significant for the following main factors: 1. amount of illumination of the field presented ($F2,36=194.78$ $p<.001$); the illusion is more evident with 100% of luminance ($x=2.48$) than with 75% and 50% of luminance ($x=2.26$ and $x=1.77$ respectively); 2. the pattern-background relationship of the grids ($F1,18=223.13$ $p<.001$);infact the illusion is more evident in B/W grids ($x=2.4$) than in W/B grids ($x=1.9$); 3. the distance between the squares of the grids ($F3,54=3289.37$ $p<.001$); the illusion is more evident for the distances of 2 and 4 mm ($x=3.42$ and $x=3.38$ respectively) than for the distances of 1 and 8 mm ($x=1.43$ and $x=0.44$ respectively).

The main factor of preadaptation do not show any significance.

With regard to the figure-background relatioship factor, the illusory effect was evidenced to a greater degree in the B/W grid than in the W/B grid, and a significant difference between these two levels was also obtained in interaction with the distance between the squares ($F3,54=42.64$ $p<.001$). Infact the illusion was more evident in the case of 2 and 4 mm than in 1 and 8 mm of distance between the squares and even more marked in the case of B/W grids (see Fig. 1a and 1b).

We may add that the difference between the two figure -background relationship varies in accordance with the degree of luminance ($F2,36=31.57$ $p<.001$). The conditions in wich the illusion is more evident is B/W grid with 100% and 75% of luminance ($x=2.82$ and $x=2.35$ respectively), and the W/B grid produce the better illusion when luminance is 75% and 100% ($x=2.18$ and $x=2.14$ respectively). Both B/W and W/B grids are less effective to produce illusion with 50% of luminance ($X=1.95$ and $x=1.59$).

DISCUSSION

Certain optimum conditions are required in the presentatio of the grid to maximize the effect of the illusion.

We have seen that the evidencing of the illusion to a greater extent concerns the presentation of B/W and W/B grids indipendently of the preadaptation field. This neurophysiological evidence, and some further experiments would be necessary. The differences observed in the perceptive evidence between grids with different inter-square distances and different figure-background relationship remain valid.

The effect of the luminance is extremely significant (Troscianko, 1982b) and the relative influence of different amount of light on the illusion suggests, in addition, that a low amount of light in the field of presentation although decreases the influence of the inhibitory surrounds of the receptive fields - as happens after dark adaptation (Wist, 1976) - does not negate it completely.

Therefore we agree with the conclusion of Fiorentini and Maffei (1973), holding that the effect of contrast and, in general, all those perceptive phenomena which may be explained by spatial excitatory and inhibitory interactions may also be present in scotopic conditions.

Finally, The results showing the higer evidence of illusion for 2 mm and 4 mm grids (visual angle 8.7' and 17.6') compared with those of 1 mm grids and 8 mm grids (visual angle 4.3' and 35.2') are in agreement with the hypothesis formulated by Baumgartner (1960), Spillmann (1971) and Troscianko (1982) concerning an optimum size of the receptive fields situated at the intersections. The2 mm and 4 mm grids correspond to a critical width of a visual angle of about 18'. This is in accordance with the results obtained by Spillmann (1971): when the bars are smaller or larger than this optimal value, the illusory spots diminish significantly.

The psychofisical results obtained reflect the activity of neuronal populations with similar functional properties which may be at the more peripheral stages of visual processing (retinal ganglion cells), if we take into account the variations of sensitivity in relation to certain parameters of the grids employed like the average luminance. For other more complex parameters in visual perception such as inter-square distance or the number of squares (Wolfe, 1984) a diagonal grid (Spillmann, 1977) or a "hollow" grid (Berbaum and Chung, 1981), visual processing probably occurs at higher levels of cortical neuronal structure with specific analytical properties.

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Summary. *This research verifies how sensitivity to the illusion of the Hermann grid varies with changes in preadaptation conditions, in the figure-ground relationship, in the level of luminance of the grids and in the distance between the squares. The experiment was carried out on 20 subjects according to a subjective method of evaluation on the degree of evidence of the illusory spots at the intersections of the squares in 24 stimulus conditions. The more significant conditions for the illusion seem to be indipendent of the preadaptation field. The conditions are on the other hand optimal for grids with black squares on white background, illuminated with maximum luminance and with a distance between the squares of 2 and 4 mm.(17,6' and 35,2' of visual angle respectively).*

Riassunto.*Questa ricerca prende in considerazione alcuni fattori che influenzano la percezione nella illusione della Griglia di Hermann: a) condizioni di preadattamento ad uno sfondo, bianco o nero, che precede la presentazione dello stimolo; b) la relazione di figura/sfondo nella griglia: quadrati neri su sfondo bianco (B/W) o quadrati bianchi su sfondo nero (W/B); c) quantità di illuminazione nella fase di presentazione dello stimolo; d) distanza tra i quadrati nella griglia. L'esperimento è stato condotto su 20 soggetti, studenti di psicologia, utilizzando un metodo di valutazione soggettiva dell'entità di evidenza dello spot alla intersezione dei quadrati. I risultati hanno mostrato: 1.l'indipendenza del fattore di preadattamento nella percezione degli spot; 2.la maggior facilitazione dei quadrati neri su sfondo bianco nel produrre l'effetto illusorio; 3.influenza della illuminazione nella percezione dell'effetto illusorio; 4.griglie che sottendono angoli visivi di 17,6' e 35,2' massimizzano l'effetto in accordo con i risultati ottenuti da Baumgartner (1960), Spillmann (1971) e Troschianko (1982) relativi alla grandezza dei campi recettivi nella percezione del fenomeno studiato.*