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STUDY ON THE EFFECT OF TRIDIMENSIONALITY IN THE HERMANN GRID

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Introduction

Contrast phenomenon like the Mach bands, the Koffka ring and the Gelb effect, which are conventionally explained on the basis of the concept of lateral inhibition or Gestalt psychology principles, elude such explanations when presented in a tridimensional manner, that is, with the parts reciprocally inducing dislocated on various depth levels (Gogel and Mershon, 1969; Wist and Susen, 1973; Wist, 1974). In such conditions the most suitable explanation seems to be supplied according to the terms of the adjacency principle (Gogel, 1965), according to which the effectiveness of the cues among the objects in determining their perceptive features depends on their spatial separation perceived both on the parallel plane in front and in depth: the larger their separation the less their effectiveness.

Wist (1974) discovered that the introduction of depth to the Hermann grid has no effect on the illusion. This result was obtained by building a grid so as to obtain an 8 min. arch of binocular disparity between the white bars and intersecting the black background. A result of this type, that is, that the illusion of the Hermann grid is a particular case of simultaneous contrast of clearness not susceptible of depth adjacency, is plausible if the Jung and Spillmann (1970) explanation is to this phenomenon is appropriated. The said authors explain the illusion spot in

purely retinal terms using the lateral inhibition concept between the exciting and inhibiting fields of the retinal ganglionic cells.

Troscianko (1982) also noticed that in a dichoptic introducing a slight binocular disparity (approx. an 8 min arch) the evidence of the illusiory spot does not significantly reduce, even though the depth of the grid is clearly visible, but its difficult to establish the depth of the spot. By increasing the disparity to an 18 min. arch the author noticed that the strength of the illusion decreases and the depth of the grid remains clearly visible, but the depth of the illusionary spot remains difficult to judge.

This study extends the investigation of the displacement effect in depth of the Hermann grid phenomenon. This research does not use particular equipment to present the grid, it realises a more "ecological" experimental situation with respect to previous researches

THE EXPERIMENT

Experimental equipment

The experiment equipment is shown in fig. 1 and includes: two dimensional grids placed on the sides of a tridimensional grid which is placed in the centre, which is advanced by means of a micrometric screw. The three grids consist of black squares having 19 mm. sides separated by 4 mm. between themselves. The

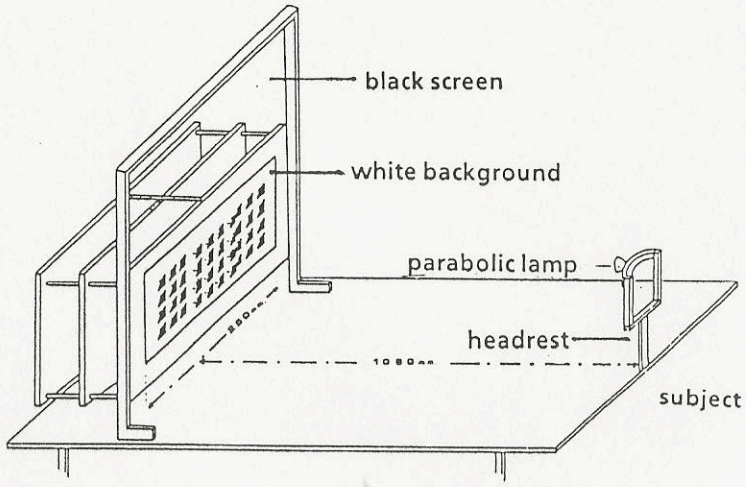

Figure 1. Experimental set up.

background consisting of a single white surface is completely surrounded by a black screen. The illumination of the squares is obtained by means of a 40 W translucent parabolic lamp, fitted to the upper central part of the headrest in order to eliminate completely the shadows in the 3D grid.

The whole system is situated in an appropriate darkroom. The experimental distance is characterised by a set distance of 1080 mm. between the eyes of the subject and the white background of the grid. The black squares of the grid were placed at the following distances, expressed in mm. 5-15-25- 35-45. The contrast, figure background , of the grid was 0.85.

Subjects

The 40 subjects, students in psychology,who underwent the experiment did not know the aim it had. Every subject has normal visual acuity.

Experimental procedure

The experimental session was preceded by and adaptation phase in which the subject was made to identify the illusionary spot within an ambit of variations of depth of the tridimensional grid; this to further clarify the tasks required from the subject consisting in:

- evaluation on a rating from 0 to 4 of the tridimensionality of central grid according to the estimation of the perceived depth.
- evaluation of the degree of definition of the perceived spots in the 3D grid by comparison to those perceived on the two dimensional grids; the judgment had to be drawn according to a rating from -4 to +4, in which the equal (=) point corresponded to an equivalent spot.
- evaluation of the position of the spots of the 3D grid within in the space between the white background and the surface of the squares; in the evaluation rating "=" corresponded to a spot positioned on the white background and 4 corresponded to surfaces of the squares at the maximum distance figure-background.

It was suggested to the subject that she/he carry out the tasks by maintaining the visual axis along the central horizontal axis of the grids.

The five stimulation conditions were repeated five times in randomised sequence for a total of 25 successive presentations.

RESULTS

Table 1 shows the averages of the evaluations given by the 40 subjects in the three sessions of the experimental condition for the five different physical distances used figure- background.

physical distance (mm) figure-background	5.00	15.00	25.00	35.00	45.00
phenomenal distance (values from 0 to 4)	0.18	1.03	2.13	3.15	3.73
spot evidence (from -4 to +4)	0.29	0.15	-0.37	-1.50	-2.36
spot positioning (from 0 to 4)	0.04	0.35	0.84	0.97	0.76

Table 1. Average of the evaluation given by the subjects in the 3 different experimental conditions.

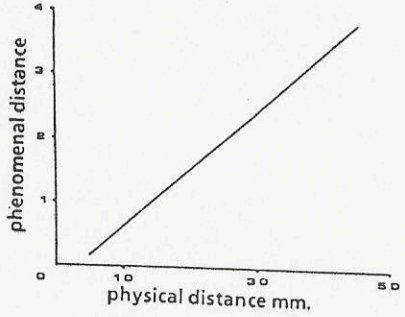

Figure 2. shows the straight line of linear regression of the dependant variable phenomenal distance figure-background, on the independent variable physical distance figure-background. There is a high relation between these two variables (correlation coefficient r = 0.957; fidelity coefficient r2 = 0.915). The ANOVA at fixed effects on one means of repeated observations proves that the influence of uncontrolled variables is irrelevant (F = 922.515, 4-156 p < 0.001).

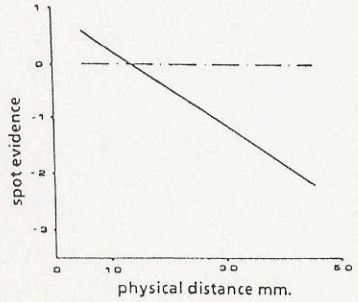

Figure. 3 shows the linear regression's straight line of the degree of evidence of the spots on the physical distance figure-background. There is a strong inverse relation between the two variables (r = -0.964; r2 = 0.930). The intermittent line parallel to the abcissa axis which leaves the ordinate in the point Y = 0, indicates the constant evidence of lateral spots. The ANOVA at fixed effects on one means of repeated observations highlights that the experimental treatments are determinant for the results (F = 53.194, 4 - 156 p < 0.001).

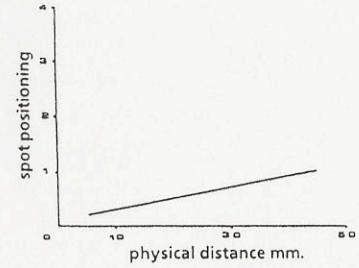

Figure 4. shows the straight line of linear regression of the dependant variable spot positioning on the independent variable of the physical distance figure-background (r = 0.843; R2 = 0.712). The ANOVA carried out according to the model used pr.

Verification of the hypothesis by means of sample distribution of the averages highlights that the spot are effectively placed along the third dimension. In fact, the averages of positioning for the different distances considered result to be significantly different from 0 for p = 0.01, except for the average at 5 mm. which results to be significant for p = 0.05.eviously confirms the incidence of the treatment on the results (F = 20.193, 4 - 156 p < 0.001).

Verification of the hypothesis with the model of sampling means distribution allows to determine that the averages at the various items are significantly different from the 0 value; the only one values non different from 0 is that of distance, 15 mm., figure-background. For p = 0.01 the differences at the distances 5-15-25 mm. result to be irrelevant.

COMMENTS

The first conclusion rising from the experiment that was conducted is that the subjects clearly perceive the central grid's 3D and are able to give a particularly accurate evaluation of the figure-background distance. Seeing the experimental condition used the only depth indexes that the subject has are probably the binocular disparity and the relative angular size.

The second and most important conclusion, consists in the fact that the grid's 3D influences the evidence of the illusionary spot. In other words, the distance between the squares and and the background influence the perception of contrast of clarity connected to the Hermann grid. This result is particularly interesting for at least two reasons:

- the modification of spot evidence is obtained in more ecological conditions with respect to other studies (Troscianko, 1982);
- the variation of contrast does not occur in one direction only. Fig. 3 highlights that for distances between 5 and 15 mm the spots present on the central grid are more evident than the "control spots" on the lateral grids, the opposite occurs for distances between 15 and 45 mm. Seeing that the variation of evidence is significant for p = 0.05 in both directions, there is some difficulty in interpreting the results at this point. The most simple explanation could be that the variation of distance of the squares consequent to the variation of depth, modifies the visual angle's amplitude subtended by the intersection in such a way as to obtain an optimum visual stimulation of the retinal perceptive fields for the smaller distances figure-background and that the opposite occurs for distances over 15 mm. But this hypothesis is not plausible for two reasons:

a) the variations of the subtended visual angle is 50" arch overall (18'00" - 18'50"), that is, too small to produce intense modifications of the spot's evidence. This is in agreement with what was formulated by other authors regarding the optimum size of perceptive visual fields situated at the intersections (Baumgartner, 1960; Spillmann, 1971).

b) The same stimulation should be obtained at a figure- background distance equal to 0 (subtended visual angle 18'00") and at a distance of approximately 15 mm (subtended visual angle 18'15"). If this small variation (15") influences the same perceptive fields the increase in the evidence of the spot for the variation of the visual angle of 5" present at a distance of 15mm. has no explanation.

A more suitable explanatory hypothesis is founded on the properties of portions of field. An HG 2D consists of 3 elements: the black squares, the "white grid", the spot. Usually from a figurative point of view, the black squares stand out and the white grid is the background. The fact that the black squares stand out is an indication that from a functional point of view they are dislocated in the third dimension, because it is a quality of the portions of fields which appear as figures which appear to be spatially towards the observer (Rubin, 1921). The spot tends to locate itself, apparently at least, between the squares and the background. Therefore an apparent stratification on three levels (square- spot-grid-background or grid). It's not far wrong to presume that if this stratification is physically achieved it can favour the Hermann phenomenon. In other words, physically positioning the squares from the background, maybe it favours on a level of reality that differentiation in layers that the conventional grid apparently gives. In this manner it is possible that we contribute to the evidence of the spot if it arises from, among other things, from the dislocation in the tridimentional space of the squares. Within certain limits, the increase of evidence of the spot would thus be determined by the physical realisation of something that is habitually given in terms of appearance observing the Hg.

In regard to the decrease of spot evidence for separations in depth over 15 mm., an explanation could be formulated in terms of the principle of depth adjacency. In fact, this principle states the effectiveness of the cues among the objects is the inverse function of their spatial separation perceived both on a frontal-parallel plane and in depth.

The HG effect would in this case combine with other visual effects such as the Gelb effect, the Koffka ring and the Mach bands (Gogel and Mershon, 1969; Wist and Susen, 1973; Wist, 1974). We must nevertheless notice that these perceptive phenomenons uniquely show one of the contrast forces of induction in function of the separation in depth, the HG 3D shows an initial increase of the contrast, at least in the conditions used in this research.

For the visual system the 3D is a primary data, fundamental is the nervous system which subtends it, it's almost exclusively central.

The elaboration of the contrast instead, seems to be caused by mechanisms operating at more peripheral level (Baumgartner, 1960; Spillmann, 1971; Wist 1974; Troscianko, 1982). Nevertheless Maffei and Fiorentini (1972) state that the different physiological properties of the retinal receptive fields and the geniculated fields, the mechanisms which explain the simultaneous contrast must be bound with a restructure which begins at a geniculated level.

The results of the study presented here could agree with the hypothesis that the neurophysiological mechanisms delegated to perception of depth influence those delegated to the perception of contrast.

The last observation is that the simultaneous spatial contrast of brightness attemptable with the Hg 3D, is a visual phenomenon which is dislocated along the third dimension; the illusionary ones are in fact located in the intermediate space between the surface of the squares and the background.

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Summary. *Il presente lavoro si interessa della percezione del contrasto nella terza dimensione 3D. Wist (1974) ha trovato che l'introduzione della profondità nella griglia di Hermann, diminuiva significativamente la percezione della illusione. Simili risultati sono stati ottenuti da Troscianko (1982), il quale trovò che i soggetti, pur in grado di identificare la tridimensionalità della griglia, trovavano difficoltoso collocare lo spot lungo l'asse della 3D.*

Usando un'apparecchiatura sperimentale appositamente costruita e utilizzando un metodo psicofisico, il presente lavoro offre indicazioni su: a) una stima della localizzazione della griglia nella terza dimensione; b) una stima della localizzazione degli spot illusori nella 3D; C) il grado di evidenza degli spot in funzione della dislocazione della griglia nelle 3D.

Riassunto. *This work aims at studying the perception of contrast in the third dimension. Wist (1974) found that the introduction of depth into Hermann's grid significantly changed the perception of the illusion. Similar results were obtained by Troscianko (1982), who also found that, although the depth of the grid is obvious, subjects found it difficult to locate illusory spots.*

Using a specially constructed experimental structure and methods of psychophysical estimation, the present work provides: a) an estimation of the location of the grid in the third dimension; b) an estimation of the location of spots in the third dimension; c) the degree of evidence of spots in the third dimension when the grid is displaced with respect to its background.