

## DEPTH CUES EFFECTS ON THE PERCEPTION OF VISUAL ILLUSIONS

S. J. MERCADO, EMILIO RIBES I., AND FRANCISCO BARRERA R.

*University of Veracruz, Mexico*

The existence of geometric visual illusions such as Muller-Lyer's, posed a central problem in perceptual theory. If we presume to understand the functioning of the perceptual processes, then we must be able to predict existing discrepancies between the perceptual and the physical worlds (the latter as defined by physical measurement operations) from our more general postulates (11).

From an evolutive viewpoint, perception, as an adaptative function, must stay as close as possible to the real world. Whatever discrepancies exist between perception and reality events must therefore be looked for within the limitations of the mechanisms which are used for such a purpose. Probing this possibility we find that the visual apparatus, because of its particular structure, presents certain unavoidable weak spots. The most striking one is the information loss which occurs when a tridimensional system (in the physical world) is projected onto a bidimensional surface—the retina—and then is remodeled or reconstructed from it (18).

The theory that we hold is the very old and well known "Perspective Theory of Geometrical Visual Illusions" (1, 7, 8, 17, 18) proposed by Theyry in 1896. Since the Italian Renaissance it has been known that convergent and divergent lines induce depth perception (linear perspective), this being a particular case of the size-distance relation principle (2). If we tentatively accept that the arrows of Muller-Lyer illusion act as depth cues, we can understand the differences in perceptual size as a constancy phenomenon induced by a false constancy scaling (7). This hypothesis could be applied to almost all the geometric visual illusions which have converging lines or other forms of depth induction, such as concentric figures or gradients of texture.

There is some evidence supporting this theory. Leibowitz and Heisel (1958) found a similar rate of increment between size constancy and the degree of Ponzo's Illusion<sup>1</sup> with increasing age. Gregory (7) found that Muller-Lyer figures seen in darkness are perceived as in third dimension. He has also shown that Muller-Lyer illusions are seen at different distances when compared with a light. Segall and Campbell (15) found that people who live

<sup>1</sup> Ponzo's illusion consists of a constancy error produced by the convergency of perpendicular lines on the perception of two horizontal lines of equal length.

in round environments do not have the Muller-Lyer illusion. Also there exists certain evidence of visual illusions in fishes and birds, classes which have well-developed depth perception (16).

#### HYPOTHESIS

The specific hypothesis dealt with in this work is the following one: if we display certain other patterns, instead of the arrows (diagonal lines) of the Muller-Lyer illusion, in such a way that these patterns start and finish in the same place without following a diagonal trace, the illusion should be considerably diminished. This hypothesis should not hold in the case of eye movement, confusion, or pragnanz theories (18).

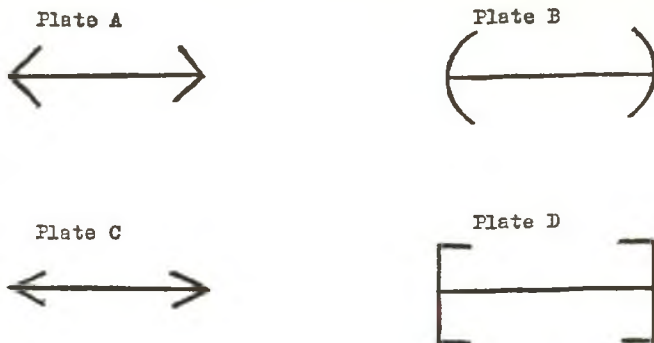
#### METHOD

*Subjects:* Twenty ten year old Ss (ten boys and ten girls) were selected from children in the Primary School adjunct to the Escuela Normal Veracruzana. None of them had any visual defects.

*Material:* Two forms of Muller-Lyer illusion were used together with two other variations designed by the authors, which consisted of semicircular lines or rectangular configurations instead of the conventional arrows (See Fig. 1).

*Design and Procedure:* We chose Duncan's Random Multigroup Design and the Adjustment Psychophysical Method. The instructions given were the following: "Here you have on this fixed card a line of certain size. In this other card, which you may move as you please (demonstration from left to right and from right to left), there is another line of a different size. What I want you to do is to try and make this line, moving the card by yourself, the same size as the line on the fixed card." The scoring was done by means of measuring the centimeters and/or millimeters in the mistaken size estimation by the Ss. The

FIGURE 1



display of the cards was carried out in rotation, to avoid contamination of learning effects on the results. To the first group, consisting of five boys, the cards were shown in an A, B, C, D sequence. The order of card presentation was shifted in the following groups by merely rotating the initial card. Therefore, the cards were displayed to the second group of five boys in a B, C, D, A, order. To the first five girls of the third group, the display followed the C, D, A, B order, while the last five girls received the D, A, B, C, sequence. In those cases where Ss did not understand or adequately carry out the instructions, due to various reasons, their results were nullified and the test was passed on to another subject.

*Statistical Analysis and Results:* The means obtained from each one of the four illustrated cards is as follows. (See Table 1.)

TABLE 1

*This table shows the means obtained in the four cards.*

Cards	A	B	C	D
Masculine	-0.29	0.1	-1.92	1.05
Feminine	-1.90	-0.67	-2.79	-0.75
Total	-1.10	-0.29	-2.36	0.1

Plate or card A gave a total mean of -1.10. The boys' subgroup was -0.29 and the girls' subgroup was -1.90. Card B had a total mean of -0.29. Boys' subgroup was 0.1 and the girls' was -0.67. Plate C rendered a total mean of -2.36. Boys' subgroup was -1.92 and that of the girls' was -2.79. Finally, plate D had a total mean of 0.1. The masculine subgroup reached 1.05 and the feminine one -0.75.

The F test was used to explore the significance level between the diverse means and we obtained in this way an F value of 3.9, *p* at a 0.05 level confidence. Afterwards, an analysis was carried out with Duncan's test between each one of the four groups and we obtained significant differences at the 0.05 level between the total means of our C and B plates, and also between our C and D cards. As an additional analysis, the *t* test was made between the partial means of boys and girls that had been obtained from each one of the four cards and we found the following results. In card A, the difference between the masculine and the feminine subgroup means gave a *p* value of 0.20, being *t* = 1.2 and *df* = 18. In card B the mean difference between the subgroups was *t* = 2.9 and *df* = 18, with a *p* value of 0.01. With card C, the mean difference of both subgroups had a *p* value of 0.4, being *t* = 0.915 and *df* = 18. Plate D gave in the mean difference of its subgroups a *p* value of 0.2, being *t* = 1.31 and *df* = 18.

DISCUSSION

Upon analyzing the outcomes of the present experiment, we observed that the data shifted in the expected direction. That is, in accordance with our initial hypothesis, the plates that induced less depth clues would be the ones that would produce a lesser visual illusion. As we can easily appreciate, the total means of groups A, B and D are much smaller than card C's (Muller-Lyer central plate), although the only significant differences occurred between our control card and our B and D plates. It is precisely in these two plates where the convergent lines are modified and are presented in semicircular or rectangular lines instead. The differences that were found not to be significant in Plate A indicate the need to carry out further research with a larger number of subjects in order to determine as accurately as possible the results obtained in this experiment. On the other hand, new perspectives arose when we observed that there exists differences between the masculine and feminine subgroups of each card. The only case where differences are significant at a 0.01 level of confidence is plate B. All other cases present a systematic variation in the same direction. This indicates the possible presence of sociocultural variables that might be determinants of a differentiated perception (in relation with sex, status, age, etc.) of objects and reality events in accordance with cultural patterns that modify their estimation. Even if the results are not altogether reliable, they do however encourage us to proceed with this type of research so as to determine more precisely the effect of these variables. Besides, there exists evidence (12) of cultural variations in relation to the utilization of cognitive control principles between children from USA and Mexico in respect to the degrees of conceptual differentiation (equivalence range). Possible relationships between cognitive controls that regulate the deployment of attention (centration effects) as field articulation and scanning must be equally explored together with the factors that rule depth perception (4, 5, 6, 13, 14).

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#### SUMMARY

An hypothesis was postulated stating a possible relationship between the degree of estimation-error, induced in perception of visual illusion as in the case of Muller-Lyer's, and the depth cues produced by line convergency. In order to test this hypothesis, twenty children of both sexes were used with the original Muller-Lyer Illusion and three variations designed by the authors. The result obtained confirmed our hypothesis at the 0.05 level confidence with a lesser illusion being found in those plates where the contextual depth cues were modified. Likewise, possible cultural differences were found between the individuals of each sex in the perception of the four plates. These results lead us to expect certain potential relationships between cognitive control principles and depth perception as well as variations in illusion degree among subjects from different countries.

#### RESUMEN

Se formuló una hipótesis para establecer posibles relaciones entre el grado de estimación de error, ocasionado por la percepción de ilusión óptica en el caso de Muller-Lyer y las indicaciones de profundidad producidas por las líneas de convergencia.

A fin de verificar esta hipótesis, se seleccionaron veinte niños de ambos sexos a quienes se les aplicó la prueba de Muller-Lyer y tres variaciones diseñadas por los autores. Los resultados obtenidos confirman nuestra hipótesis con un nivel de probabilidad del 0.05. Una ilusión menor se encontró en las figuras en que la profundidad contextual había sido modificada. Así mismo, posibles diferencias culturales se encontraron entre los individuos de diferentes sexo en

la percepción de las cuatro figuras. Estos resultados nos hacen pensar en ciertas relaciones potenciales entre principios cognoscitivos controlados y la percepción de profundidad al mismo tiempo que en variaciones en el grado de ilusión entre sujetos de diferentes países.

#### RESUMO

Formulou-se uma hipótese para estabelecer possíveis relações entre o grau estimado do erro, ocasionado pela percepção de ilusão ótica no caso de Muller-Lyer e as indicações de profundidade produzidas pelas linhas de convergência.

A fim de verificar esta hipótese, foram selecionadas vinte crianças de ambos os sexos a quem foi apresentado o teste de Muller-Lyer e três variações desenhadas pelos autores. Os resultados obtidos confirmam nossa hipótese com um nível de probabilidade de 0,05. Uma ilusão menor foi encontrada nas figuras nas quais a profundidade contextual havia sido modificada. Da mesma maneira, possíveis diferenças culturais foram encontradas entre os indivíduos de diferentes sexos na percepção das quatro figuras. Estes resultados nos leva a esperar certas relações possíveis entre princípios cognitivos controlados e a percepção de profundidade, bem como variações no grau de ilusão entre Sujeitos de diferentes países.