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The Influence of Directionality on the Giovanelli Illusion

Michele Sinico

***Abstract*—**In the Giovanelli illusion, some collinear dots appear misaligned, when each dot lies within a circle and the circles are not collinear. In this illusion, the role of the frame of reference, determined by the circles, is considered a crucial factor. Three experiments were carried out to study the influence of directionality of the circles on the misalignment. The adjustment method was used. Participants changed the orthogonal position of each dot, from the left to the right of the sequence, until a collinear sequence of dots was achieved. The first experiment verified the illusory effect of the misalignment. In the second experiment, the influence of two different directionalities of the circles (-0.58° and +0.58°) on the misalignment was tested. The results show an over-normalization on the sequences of the dots. The third experiment tested the misalignment of the dots without any inclination of the sequence of circles (0°). Only a local illusory effect was found. These results demonstrate that the directionality of the circles, as a global factor, can increase the misalignment. The findings also indicate that directionality and the frame of reference are independent factors in explaining the Giovanelli illusion.

***Keywords*—**Giovanelli illusion, visual illusion, directionality, misalignment, frame of reference.

I. Introduction

At a phenomenological level of investigation, perceptual studies are usually concerned with which factors are relevant in determining the phenomenal organization [1]-[3]. Although phenomenological investigations are not oriented towards a functionalist model of explanation, as with cognitive science and neuroscience, the goal of the system within a functionalist model, reassessed as data from which the inferential process of the cognitive or neural functioning is triggered, must be phenomenologically defined [4].

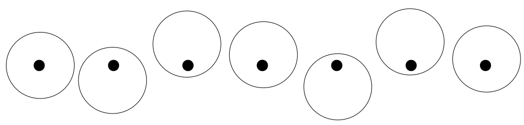

Fig. 1 Giovanelli illusion

The aim of the present phenomenological research is to verify the role of the directionality in the Giovanelli illusion [5]. This illusion consists of perceiving a sequence of collinear dots as misaligned, when each dot lies within a circle and the circles are not collinear (see Fig. 1). In this illusion, the role of the immediately super-ordinate (single circle for each dot) frame of reference is considered a crucial factor [6]. Other authors propose the accentuation principle of grouping as an explanation [7]. In accordance with this principle "all else being equal, elements tend to group in the same oriented direction of the discontinuous element placed within a whole set of continuous/homogeneous components" [7, p. 32]. Whereas the first explanation refers to an objective phenomenal factor (inherent to the external perceptual field), the second also refers to a subjective phenomenal factor. In fact, the accentuation principle is similar to a "subjective setting" [8], in which the observative conditions are crucial. Both explanations are based on a local factor: the influence of the single circle on each dot.

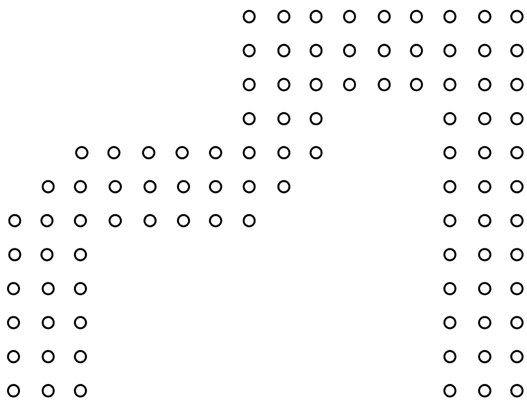

Fig. 2 Although all the dots are equally spaced, so that proximity may not function, they are grouped according to their direction

In the present research, three experiments were carried out in order to investigate the effect of directionality, as a global factor, on the misalignment. The directionality [9] refers to the tendency to perceive objects, which share the same direction, as wholes (Fig. 2). In the Giovanelli illusion, the directionality can, therefore, be regarded as a global factor of perceptual organization.

II. General Method

A. Participants

The observers were eight students (three females and five males), ranging in age from 22 years to 36 years, with normal or corrected to normal vision.

B. Apparatus and Stimuli

All the stimuli (Figs. 3-5) were displayed on an Apple Power PC G3/333 MHz I-Mac and presented on a monitor with a resolution of 1024×748 pixels, and at a viewing

Michele Sinico is with the Department of Design and Planning in Complex Environments, University IUAV of Venice. Santa Croce, 1957, 30135 – Venice, Italy (phone: +39 041 2572177; +39 041 2572424; e-mail: sinico@iuav.it).

distance six circles, with a diameter of 150 px, and six black dots with a diameter of 16 px (1 pixel = 1.25 mm). The dots were initially aligned above or below the circles, except for the first dot on the left, which was in the center of the circle.

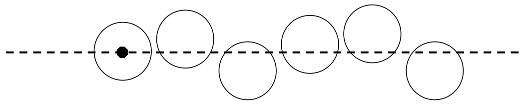

Fig. 3 Stimuli used in Experiment 1

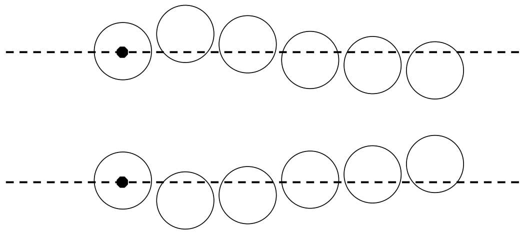

Fig. 4 Stimuli A and B used in Experiment 2

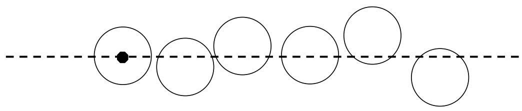

Fig. 5 Stimuli used in Experiment 3

The experiments were conducted under computer control, with a program written in True Basic 2.7 that arranged the order of stimuli, presenting them on the monitor, introducing alterations according to the subject's command, and recording the subject's responses.

C. Procedure

The experiment took place in an isolated and darkened room. The method of adjustment was adopted in order to establish the functional dependence of the Giovanelli illusion strength on the parameters of the stimuli. Participants sat in front of the screen and received oral instructions. The following instructions were given: "Please, adjust the vertical position of the black dots until they appear perfectly collinear. Use one key to gradually move up each dot, and another key to move it down. When you are satisfied with the adjustment, press the third key to continue."

Participants responded through the use of a computer keyboard. They pressed keyboard keys that moved the position of each dot in the preferred direction one pixel at a time.

To avoid response bias, the initial position of the black dot of each trial was not fixed but varied above or below the circles. The resulting two trials were presented to each participant in an individually randomized order.

III. Experiment 1

The first experiment verified the effect of misalignment. This is why inductive stimuli were not collinear. Using as a reference the spatial position of the first dot on the left, which was presented to the participants in the centre of the first circle on the left (see Fig. 3), the misalignment of the subsequent circles were: 18 px; -18 px; 14 px; 23 px; -18 px.

A. Results and Discussion

Results are shown in Fig. 6. An analysis of variance was applied to the collected data. The difference of misalignment between the five dots was significant ($F(4,28)= 2.72$, $p< 0.05$). The results thereby confirm the presence of the misalignment illusion. A post-hoc comparison showed that the measures of dots 2 and 5 do not differ from measures of dots 1, 2 and 3 taken together.

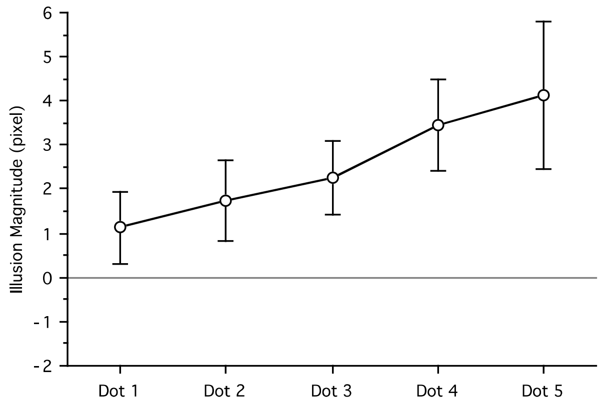

Fig. 6 Results of Experiment 1. The Illusion Magnitude as a function of dots. The errors bars represent standard errors

This result suggests an effect of the global directionality on the misalignment. In fact, the observers adjusted the sequence of the dots in a coherent direction. Therefore, a hypothesis can be formulated on the possible role of the orientation of the stimuli. Two orientations can be considered: i) the third, fourth and fifth circles are actually oriented upwards; conversely, ii) the virtual direction, from reference circle on the left to the last circle on the right, is oriented downwards (see Fig. 3).

IV. Experiment 2

As a result of the first experiment, the aim of the second experiment was to test the effect of two directionalities of the circles (A: -0.58° and B: +0.58°) on the misalignment. The misalignment of the circles were (see Fig. 4):

A) 23 px; 20 px; 14 px; -18 px; -23 px.
B) 23 px; -18px; 14 px; 20 px; 23 px.

A. Results and Discussion

Fig. 7 shows the results of Experiment 2. ANOVA showed that the Directionality factor of the circles (A and B) was not significant but the interaction of directionality and dots was significant ($(F(4,28))= 2.82$, $P. < 0.05$). These results indicated that directionality of sequences induces an over-normalization on the dots. However, two opposite directions of adjustment (upward and downward) can be noted in the responses given by the participants (See Fig. 7). This result suggests that the directionality of the circles, as inductive stimuli, can affect the illusion.

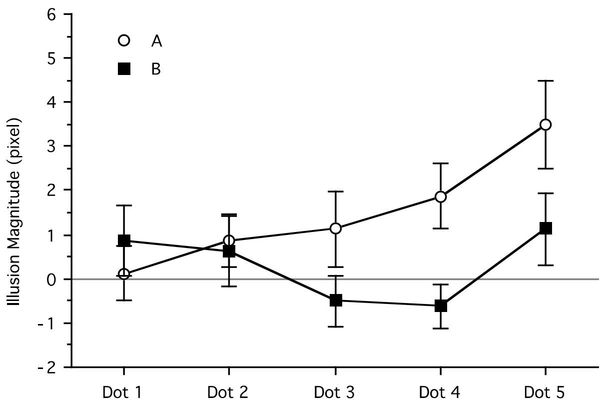

Fig. 7 Results of Experiment 2. The Illusion Magnitude as a function of dots. White circle and black square represent the directionalities A and B respectively. The errors bars represent standard errors

Another observation can be made about the adjustment of the last dot of the sequence. In each case there is an upward trend. This trend could be explained by the fact that the observers also directly matched the last dot with the first one on the left. The difference between the dots was also significant ($F(4,28)$)= 3.64, P. < 0.05).

V. Experiment 3

In the third experiment, the misalignment of the dots without any inclination of the sequence of circles (0°) was investigated. No effect of directionality on the local misalignment of the dots was hypothesized. The misalignment of the circles were (see Fig. 5): -23 px; 18 px; 0 px; 23 px; -18 px.

A. Results and Discussion

Results are illustrated in Fig. 8. The analysis of variance showed that the difference of misalignment between the five dots was significant ($F(4,28)= 7.49$, $p< 0.001$). The post-hoc comparison showed that the measures of dots 1 and 5 differ from the measures of dots 2 and 3 taken together ($F(1,28)= 3.47$, $p< 0.001$). Results show a local influence of the circles on the dots, although, as it has been hypothesized, there is no relevant directionality effect. As in previous experiments, the participants placed the last dot in the highest position of the sequence.

VI. Conclusions

The results of these three experiments demonstrate that directionality of the circles, as a global factor, increases the misalignment. These findings also point out that directionality and frame of reference are different factors in the Giovanelli illusion. On the basis of this experimental evidence, an explicative model of the Giovanelli illusion with both global and local factors is suggested.

This phenomenological level of explanation is useful for obtaining inferential models of a neural system (see, for example, the model of orientation maps [10] discussed by Giovanelli and Sinico [11]).

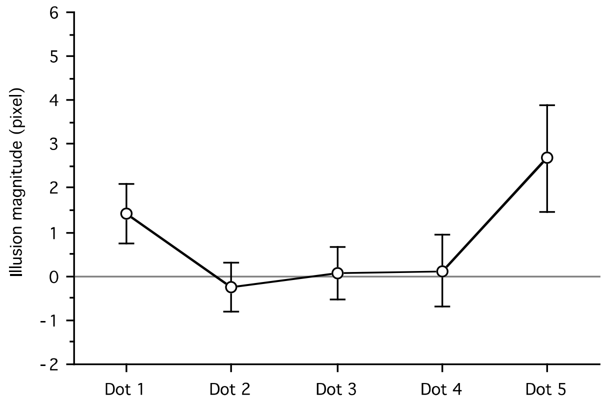

Fig. 8 Results of Experiment 1. The Illusion Magnitude as a function of dots. The errors bars represent standard errors

As for cognitive explanations, previous studies [12] have reported that alignment involves mechanisms used in pictorial depth perception. According to these authors, the observers' settings are influenced by implicit mental assumptions that are commonly necessary for extracting depth from pictures.

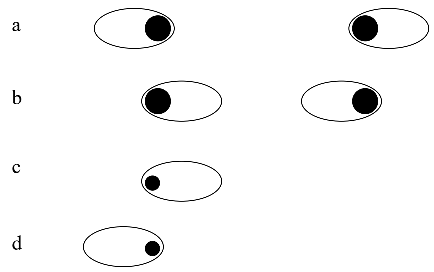

Fig. 9 Yang's iris illusion is illustrated in a and b. The distance between the black disks is underestimated but overestimated in b. The Giovanelli illusion is illustrated in c and d. The dot inside the ellipse, in c and d, appear to shift in a position away from the center of the ellipse

In particular, the authors take the following basic processes into consideration: "(1) The rough orientation of an object drawn in orthogonal projection is given by its principle axis. (2) The extended principle axes of two objects with the same depicted orientation should eventually converge on the horizon. (3) The extended principle axes of two objects with different depicted orientations should intersect one another in the picture plane." [9, p. 1172]. When there is a violation of the assumptions, an illusion of misalignment is perceived. These assumptions could be an additional factor in the explicative model of the Giovanelli illusion. However, the orientation of the reference axis (organized from the circle to the dot) necessarily involves the perception of a three-dimensional cone.

It was noted [13] that the Yang's iris illusion - neighboring external contours can lead to a distortion in length perception (see Fig. 9) - goes in the opposite direction to the Giovanelli illusion. In any case, unlike the Giovanelli illusion, in the Yang's iris illusion there is grouping of disks, which is a result of the law of proximity.

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Michele Sinico is Associate Professor of General Psychology at the Department of Design and Planning in Complex Environments (University IUAV of Venice). His main research interests are in psychology of perception, philosophy of science and history of experimental psychology.