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PARALLELS AND TRANSVERSAL SUBJECTIVE CONTOURS IN THE POGGENDORFF ILLUSION

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Abstract

When the continuity of an obliquely oriented line is broken by a vertically oriented pair of parallels, the position of the line segment on the other side of the interruption does not seem to be collinear, but vertically shifted (i.e. the Poggendorff illusion). Evidences from literature proved that the Poggendorff illusion is still present when there are no parallels but Kanizsa-like subjective contours. The present study attempts to verify whether the Poggendorff illusion persists when both the transversal segment and the parallels consist of Kanizsa-like subjective contour. Eight participants were tested using the method of constant stimuli a) on a number of horizontal subjective parallels and transversal line segments, b) on both horizontal parallels and transversal segment Kanizsa-like subjective contours. The response bias in the direction of the classical effect and the threshold values for the two patterns are discussed.

Geometrical optical illusions have always aroused interest. Since the 19th century, scientists have engaged in systematic investigations with the aim of revealing something more about human perceptual limitations. However, this is not the only reason, beginning with the Gestalt school, illusions have often been used as an instrument for testing the theory. Some illusions by now are considered to be classic, they are taught in schools and they are widely used and recognized. The Poggendorff effect (1860) is a robust illusion usually observed when the continuity of an obliquely oriented line is broken by a vertically oriented pair of parallels. Although several explanations have been proposed to account for this effect, this remains one of the most controversial geometrical illusions. In the past, the account most frequently proposed that the illusion arises from a misperception of the angles in the stimulus (Blackmore, Carpenter & Georgeson, 1970; Burns & Prichard, 1971). According to this explanation an overestimation of the acute angles in the standard stimulus (and an underestimation of the obtuse ones) probably has an effect on the apparent orientation of the line segments. Gilliam (1971) formulated the depth-processing theory based on the hypothesis that the geometrical information in the retinal projection might be mistakenly detected by the observers. The depth-processing theory suggested that geometrical illusions arise from the tendency of the perceptual system to process a two-dimensional figure as a representation of a three-dimensional scene. In regard to the Poggendorff illusion, the oblique lines in the stimulus configuration are interpreted as line which extend in depth and are therefore perceived to be non-collinear (Gregory, 1963; 1997).

According to Morgan (1999) the Poggendorff illusion arises because of retinal and cortical processes involved in the processing of relative position, orientation, and the collinearity of spatial separated lines and the object in general. This model suggests that the collinearity in the Poggendorff configuration is judged by comparing the orientation of the visible oblique lines with that of the virtual line joining the points of their intersection with the verticals. Morgan (1999) stated that the orientation of the virtual line can only be estimated from its endpoints and he proposed that the Poggendorff alignment is carried out as a two stage process: the first process estimated the origin of the virtual line and second process compares the orientation of the virtual line to the orientation of the target lines. They suggested that the endpoints are mislocated into acute angles of the figure as a consequence of spatial blurring by second stage filters. Consequently, an illusory misalignment between the orientation of the virtual line and that of the visible obliques is observed.

A wide body of research has studied the Poggendorff illusion when parallels are defined by subjective contours (Goldstein & Weintraub, 1972; Beckett, 1989; Westheimer & Wehrhahn, 1997). These studies reported that the effect is observed only when the salience of the contours was reinforced by the addition of luminance defined by hemi-circles along their lengths. In a recent work, Tibber, Melmoth and Morgan (2007) studied whether Kaniza-like subjective contours are capable of driving the Poggendorff illusion. Comparing the observers' judgment made on the classical Poggendorff figure, the Poggendorff figure with Kaniza-like subjective contours and the control figure (in which PacMan tokens are rotated 180°), the authors found that, although the classical figure induced a grater misalignment, the subjective contours figure induces a greater misalignment than the control figure. According to Tibber et al. (2007) the inclusion of a control image suggests that the effect is driven, by the presence of subjective contours rather than as a result of the Pac-man tokens. Further, given that the precision of observers' performance did not differ between judgements made on the classical Poggendorff figure and the Poggendorff figure with Kaniza-like subjective contours, the authors suggested that the luminance-defined and subjective contours are encoded at a similar level in the visual system, probably processed early in the visual pathways.

The aim of the present research is to verify whether the Poggendorff illusion persists when both the transversal segment and the parallels consist of Kanizsa-like subjective contours. To reach this goal four different stimuli have been used in order both to study the threshold value and to verify if the presence/absence of the illusory parallel influences the size of the Poggendorff illusion.

Method

Participants.
Eight participants, 4 females and 4 males, aged between 22 and 30 years (mean age = 26.12, sd = 3.18) volunteered for the experiment. All had normal or corrected-to-normal vision.

Apparatus and stimuli.
The stimuli were presented on a PC Pentium 4- based computer equipment connected to a 17 in. monitor with a resolution of 1024 x768 pixels (where a pixel can be considered as a square of 0.25 mm) and a refresh rate of 100 Hz.

In Figures 1a, 1b, 2a, 2b the four stimuli used for the experiment are presented. For each of the four configurations 7 different variations were presented to participants. Two Kanizsa like parallel subjective contours compose configurations 1 and 3, while in configurations 2 and 4 the four PacMan tokens do not generate an illusory figure. The dimensions of the rectangle (i.e. the distances between the centres of the four PacMan tokens) were respectively 21.6 cm and 8.4 cm, the PacMan tokens had a diameter of 4.1 cm. The distance between the centres of the transversal PacMan tokens of configurations 1 and 2 was 20.8 cm. The transversal line formed a 45° angle with the parallel lines.

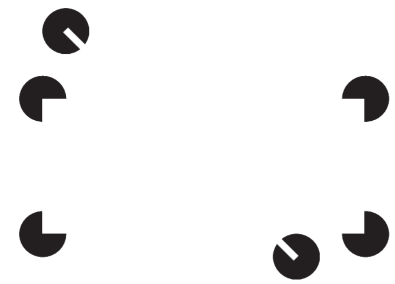

Fig. 1a : Configuration 1

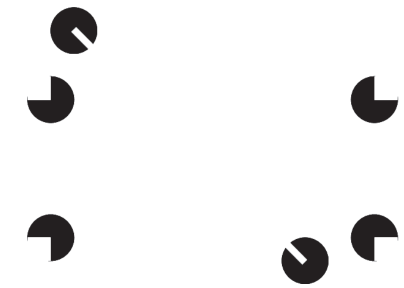

Fig. 1b : Configuration 2

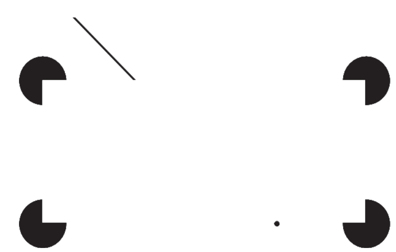

Fig. 2a : Configuration 3

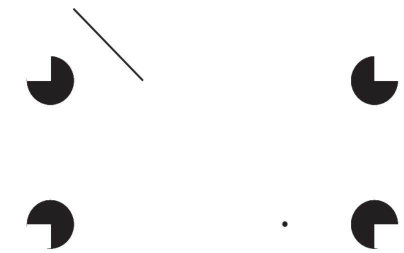

Fig. 2b : Configuration 4

In configurations 3 and 4 the length of the visible transversal segment was 6 cm, and the same distance was constructed in configurations 1 and 2 between the upper side of the Kanizsa like rectangle and the centre of the upper transversal PacMan token. The transversal segment in configurations 1 and 2 had a 2 mm width. The seven variations of configurations 1 and 2 consisted in the shift of the lower transversal PacMan token of 1, 2 or 3 mm on the left or on the right of the actual alignment. The seven variations of configurations 3 and 4 consisted in the shift of the dot of 1, 2 or 3 mm on the left or on the right of the actual alignment.

Procedure.
Participants sat at a 60 cm from the screen in a dark room. The experiment was subdivided into two counterbalanced sessions. The method of constant stimuli was used. During the first one, the seven variations of stimuli 1 and 2 were randomly presented to participants. For each stimulus the participant had to evaluate if the transversal PacMan token on the bottom of the rectangle was on the left or on the right side of the ideal continuance of the illusory transversal line. Participants were asked to respond by pressing the "A" button in the first case or the "L" button in the second one. In the second session the seven variations of stimuli 3 and 4 were randomly presented to participants. The task was the same as in the previous session except for the fact that participants had to evaluate the position of the dot on the bottom of the figure. In both sessions each stimulus was followed by a blank interval of 2000 ms.

The completely within-subjects experimental design included two factors: Configuration (4 levels) × Position (7 levels) for a total of 28 stimuli. The set of stimuli presented comprised seven replications, for a total of 296 trials. The whole experimental session lasted approximately 20 minutes.

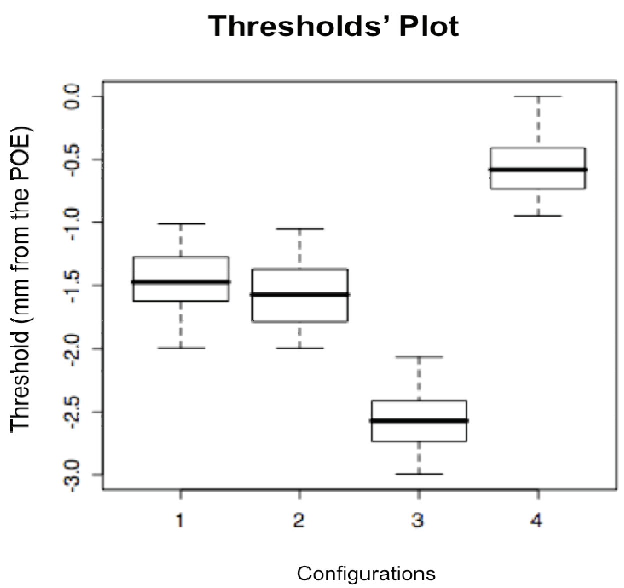

Fig. 3 : Mean threshold values of the bootstrapped samples in the four configurations.

Method

Analysis were performed using the software R version 2.6.0 (R Development Core Team, 2007). In the first part of the analysis the threshold values for the four configurations were estimated. Using the Bootstrap technique a number of 1000 samples were re-sampled from the observed one via a uniform distribution with substitution allowed. Applying the following formula (1) to each value obtained from the bootstrap, a vector containing the same number of thresholds (AT) as the number of bootstrapped samples were obtained.

$$AT = R_l + \frac{(R_u - R_l)(.50 - p_l)}{(p_u - p_l)} \qquad (1)$$

In the formula (1), AT indicates the Absolute Threshold, R_l is the value of the last stimulus below the threshold, R_u indicates the value of the first stimulus that is above the threshold while p_l and p_u indicate the probability of affirmative responses to R_l and R_u respectively. Calculating the average value of the thresholds vector obtained for each configuration, four thresholds values were obtained. All the four configurations present threshold values significantly different from the Point of Objective Equality (POE). The mean calculated thresholds were -1.45 mm, -1.59 mm, -2.56 mm and -0.57 mm for configuration 1, 2 , 3 and 4 respectively. The 95% confidence intervals of the four thresholds distributions were all different from 0. In Fig. 3 the four confidence intervals of the threshold values are presented.

Having the vectors of the threshold values some comparisons have been performed. More specifically, it has been found that the values observed for configurations 1 and 2 did not differ in a significant way since that the confidence interval of the differences vector includes the 0. On the opposite, significant differences were found comparing the configuration 1 and 3 (the threshold value is significantly lower for 3 than for 1), comparing the configuration 3 and 4 (the value observed for 3 is significantly lower than for 2), and comparing the configuration 2 and 4 (the threshold of 2 is lower than the one of 4).

The repeated measures ANOVA performed on the two factors Position (7 levels) and Configuration (4 levels) showed the significant main effect of the Position factor ($F_{(6,42)} = 24.12$; $p < 0.05$), whereas, no effect has been found neither for the Configuration factor nor for the interaction between the two factors.

From the analysis of the results of the repeated contrasts for the Position factor emerges that a significant difference is present between the levels 2 and 3 ($F_{(1,7)} = 37.80$; $p < 0.05$) , i.e. between the stimuli in which the target is 2 mm and 1 mm on the left of the POE. It is interesting to note that between these values it can be identified the threshold value of configurations 1 and 2.

The results of the deviation contrasts performed on the factor Configuration show that the only configuration that significantly differs from the mean of the other ones is configuration 3 ($F_{(1,7)} = 8.59$; $p < 0.05$). As well in this case, the threshold of this configuration was significantly the lower one.

Discussion

The results show the presence of the Poggendorff illusion even when both parallel and transversal lines are illusory.

However, our findings presented some interesting aspects of the stimuli presented. In Tibber, Melmoth and Morgan's work (2008) in fact, a crucial role was played by the presence/absence of the Kanizsa-like rectangle. In the present study the same effect as Tibber et al. (2008) was found for stimuli 3 and 4 (the same as those used by these authors), while the effect for stimuli 1 (where both parallel and trasversal lines where illusory) is significantly lower when compared to stimuli 3. This suggests that when all the lines presented in the display are illusory the Poggendorff effect is still present, albeit with a smaller magnitude. However, the absence of a significant difference between the stimuli 1 and 2 needs to be further investigated.

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IS SELF-ESTIMATED LINEAR LENGTH LINEAR?

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Abstract

There is wide evidence that magnitude estimates of apparent length are essentially linearly related to physical length, but it is yet unknown whether these self-estimates are linear, that is, whether they are linearly related to apparent length. Gage in 1934 and Pfanzagl in 1959 devised two tests that would help resolve this problem. In the study presented here, these tests were used to select subjects producing equidifferent apparent lengths. Mean magnitude estimates and mean ratings of equidifferent apparent lengths were found to be linearly related to these same lengths, thus showing that self-estimates of apparent length were linear.

In this paper we consider the length of lines presented frontally, hereafter called length. Absolute magnitude estimates of apparent length are related to physical length almost linearly, with exponents ranging from 0.95 to 0.98 (Verrillo, 1982, 1983). The exponents obtained by conventional magnitude estimation are similar in size although they depend on the standard and modulus (Pitz, 1965; Wong, 1963). As shown hereinafter, in spite of the well-established relation between magnitude estimates of apparent length and physical length, the relation of magnitude estimates of apparent length to apparent length is indeterminate.

Attneave (1962) had distinguished among the ordinary psychophysical function with exponent n (relating magnitude estimates of apparent length to physical length), the sensory function with exponent k (relating apparent length to physical length), and the response function with exponent m (relating magnitude estimates of apparent length to apparent length). These functions imply that

$$n = k \cdot m \qquad (1)$$

(Curtis, Attneave, & Harrington, 1968).

Baird, Kreindler, & Jones (1971) have shown that the way subjects select numbers in magnitude estimation affects n indirectly by affecting m. They used lines with length varying from 2 to 64 cm as stimuli. Eight groups of subjects magnitude-estimated the apparent length of these lines in two sessions. In the first session, the shortest line was used as the standard with modulus 1. The resulting mean ns of the eight groups ranged narrowly from 0.86 to 1.01. In the second session the standard and modulus were the same as before but now the same eight groups were additionally told which number to use as a magnitude estimate for the longest line. This prescribed number differed for each group. Depending on the prescribed number, the resultant mean ns of the groups ranged widely from 0.31 to 2.55. Since the stimulus lines were the same for all groups in both sessions, k was the same in each group and session. Consequently, the prescribed number determined a change in n because it determined a change in m and not in k. Since it is virtually impossible to know beforehand how the subjects select their numbers in magnitude estimation, Baird et al.'s (1971) results show that it is indeterminate whether $m = 1$, that it, whether the response function is linear.