THE POGGENDORFF ILLUSION: THE PRESENCE OF ANOMALOUS FIGURE IN GENERATING THE EFFECT

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Abstract

In the classical version of the Poggendorff illusion the two ends of a straight line segment passing behind an obscuring rectangle appear offset when, in fact, they are aligned. Previous research (Tibber et al., 2008) showed that the illusion persists when the obscuring rectangle is replaced by Kanizsa-like subjective contours. Spoto et al. (2008) show that the illusion is still present when both the obscuring rectangle and transversal segments consist of Pac-Man tokens generating Kanizsa-like subjective contours; in addition, the illusion persists even when the Pac-Man tokens are arranged so that no illusory contours are generated. In the present research the role of Pac-Man tokens in generating the Poggendorff illusion is investigated. Twenty-four participants have been tested using the adjustment method on two conditions including Pac-Man tokens in one condition and not in the other. The response bias in the direction of the classical effect is discussed.

When an oblique line is interrupted by an occluding surface, the two segments which result not covered by the surface appear as misaligned when they are in fact aligned: this is the Poggendorff illusion (Zöllner, 1860). The effect increases when the distance of parallels constituting the surface is smaller (Pressey, 1970), is maximal when the angle of the crossing between oblique and parallel lines is 45° and it disappears when this angle is 90° (Weintraub and Krantz, 1971). As proposed by Gregory (1972), the Poggendorff figures could be generated also by “cognitive” contours, created with Kanizsa-type stimuli. Recently, Tibber, Melmoth and Morgan (2008) compared the illusion strength in a classical Poggendorff figure with that of a figure with Kanizsa-like subjective contours and with the illusion obtained using a control figure, in which Pac-Man tokens are arranged so that no illusory figure is generated (tokens are rotated by 180°). Authors found that, although the classical figure induced the greatest misalignment, the Kanizsa-Poggendorff figure induces a greater misalignment than the control figure.

Starting from this result, Spoto, Bastianelli, Burro and Vidotto (2008) tried to verify whether the Poggendorff illusion persists when both the transversal segment and the rectangle consist of Kanizsa-like subjective contours. Two configurations have been compared. In the first configuration, the oblique line was generated by two black circles dissected by a white segment. The circles were posed one over and one under the occluding surface, so that the two white segments were the extremity of an illusory line (like figure 1a and 1c). In the second configuration, a single transversal line was used in conjunction with a target dot (similarly to Tibber et al, 2008; see figure 1b and 1d). In both configurations the oblique line was oriented at 45° to the parallels. These configurations were tested using the constant stimuli method, in two different conditions: a condition in which the occluding surface consisted in a Kanizsa-like rectangle obtained by four Pac-Mans tokens, and a condition in which the Pac-Mans were arranged so that no illusory rectangle was present. Results confirmed that the presence/absence of the Kanizsa-like rectangle played a crucial role, and showed the presence of the Poggendorff illusion even when both parallel and transversal lines were illusory. However, authors detected a greater effect when the oblique line was defined by a “line-dot” configuration rather than an “illusory line” formed by two Pac-Mans dissected by the white segment. Besides, when the oblique line was illusory, no difference has been found between the presence and the absence of Kanizsa-like contours.

The difference between the condition in which an illusory Kanizsa rectangle is present and the condition in which the rectangle is not present, consists in the fact that the Pac-Mans are rotated at 180°. It’s possible that the mere presence of the Pac-Mans, although not arranged to form a rectangle, influenced subjects’ perception, creating an anchor whereby calibrate the response.

In order to solve this issue, the present research is aimed at analysing the phenomenon using a “Pac-Man free” condition.

Method

Participants

Twenty-four naive participants (12 male and 12 female, mean age 25.58) took part in the experiment on voluntary bases. All had normal or corrected to normal vision.

Apparatus and stimuli

Stimuli were created with the Tkinter module, a graphical user interface widget set for Python language (Grayson, 2000). A monitor 17 in. with a resolution of 1024×768 pixels (where a pixel can be considered as a square of 0.35 mm) and a 100 Hz refresh rate was used.

Stimuli are presented in figure 1a, 1b, 1c and 1d. Configuration 1 and 3 consists of an oblique illusory line generated by two small Pac-Mans dissected by a white segment: then, the transversal line is generated by Kanizsa-like subjective contours (condition named “illusory line”). Configuration 2 and 4 are equal to the configuration “line-dot” presented by Tibber et al. (2008).

Both configurations were presented in two different modality: 1) at the presence of four Pac-Man tokens, generating an illusory rectangle overlapping the oblique line (condition named “Kanizsa-like contours”, figure 1a and 1b); 2) without any other stimulus, so that no Poggendorff illusion should have been generated (condition named “none-contours”, figure 1c and 1d). The horizontal distance between the centres of Pac-Mans was 21.7 cm, and the vertical distance was 8.5 cm. Pac-Man diameters was 4.1 cm; the diameter of tokens generating the illusory line were 2.2 cm.

These four combinations were presented varying the horizontal position of the stimulus at the bottom (the small Pac-Man token in the condition “illusory line” or the dot in the condition “line-dot”): five possible distances from correct point of alignment were selected: -140 pixels, -70 pixels, 0 pixels (the correct point), +70 pixels, +140 pixels. Thus twenty (2×2×5) configurations were presented (number of repetitions: 7).

Procedure

Subjects sat at 60 cm from the screen in a dark room. The experiment was subdivided in two counterbalanced sessions: in one session the Poggendorff configurations displayed in figure 1a and 1c (illusory line) were presented, while in the other session the configurations reported in figure 1b and 1d (line-dot) were presented. Twelve subjects (6 males and 6 females) performed the experimental task in the “illusory line / line-dot” order, while other twelve subjects (6 males and 6 females) carried out the task in the inverse order.

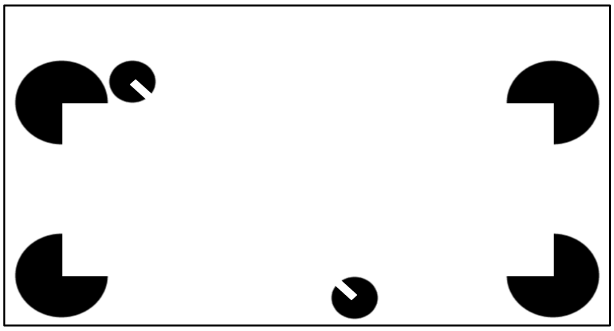

Figure 1a. Configuration 1.

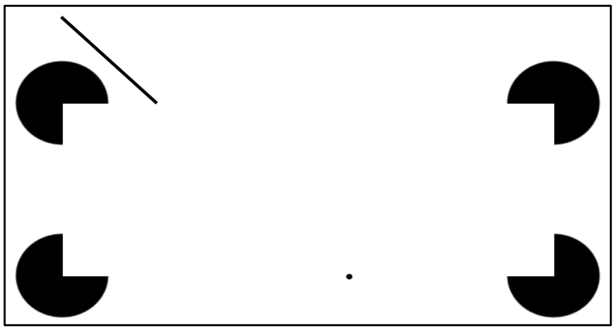

Figure 1b. Configuration 2.

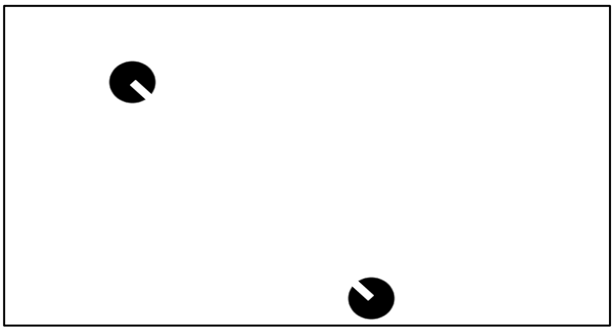

Figure 1c. Configuration 3.

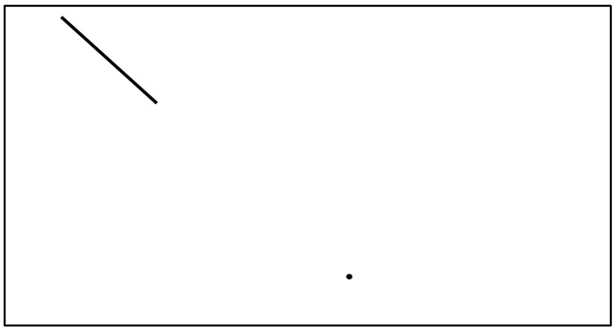

Figure 1d. Configuration 4.

In the illusory line condition, the experimental task consisted in moving with the mouse pointer the token at the bottom of the screen in horizontal direction, adjusting its position until the white lower cutting segment became the ideal prosecution of the white cutting segment of the upper token. Similarly, in the line-dot condition, the experimental task consisted in moving the dot at the bottom of the screen adjusting its position until the dot became the ideal continuation of the segment at the top. Between the presentation of two different stimuli a white screen lasting for 1 second was presented.

Results

For each subject's response, the distance between the response and the correct point was calculated: positive values represent a right shift of the response, negative values a left shift. Clinging the classical Poggendorff effect, we should expect a left shift.

Preliminary analysis highlighted a difference in the distribution trend of errors between the two sexes (figure 2): females (dashed lines) shown a long right tail, while males shown a roughly symmetric distribution centred on the correct point; moreover, standard errors registered for each condition were high. Given this anomalous pattern, we have considered, for each distribution, the scores included between tenth and ninetieth percentile: analysis are performed considering this part of distributions.

Data are analysed using orthogonal contrasts, fitting several mixed-effect models with the *lme4* statistic library (Bates, 2005) implemented for the R software version 2.9.1 (R Development Core Team, 2009). Factor significant evaluation is performed using a model comparisons procedure; selection is based on the calculus of likelihood ratio test, Akaike Information Criterion (AIC; Akaike, 1974) and Bayesian Information Criterion (BIC; Schwartz, 1978). The *p*-values are calculated through Monte-Carlo Markov Chain method, implemented in the *languageR* library for R (Baayen, 2007; Baayen, Davidson & Bates, 2008).

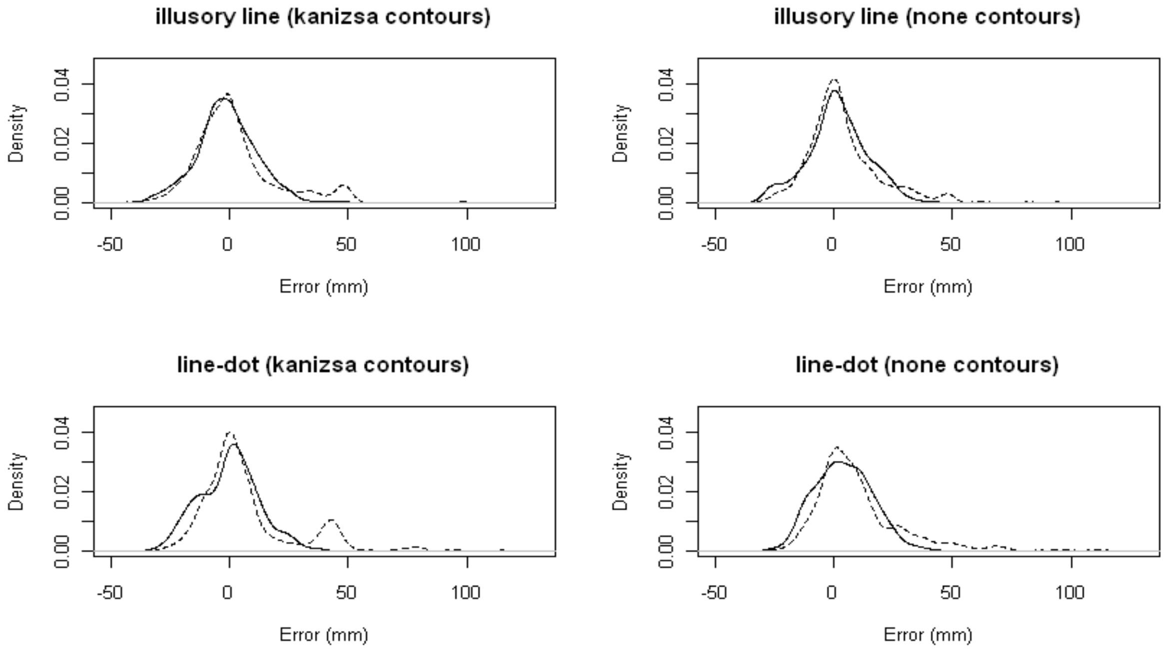

Figure 2. Density plot of subjects' responses for each experimental condition. Male distributions are represented by the continuous lines, and female distributions are represented by the dashed lines.

Starting from the empty model, including "subject" random factor alone, we added the "contours" fixed factor (presence of illusory Kanizsa contours vs. none contours) and the "oblique line type" fixed factor. The additive model shows a better fit than the empty model (ΔAIC=-220.20; ΔBIC=-208.39; χ^2=224.20; *df*=2; p<0.01). The interaction model reveals a fit similar to additive model (χ^2=2.20; *df*=1; p=0.14), with a very slow improvement of AIC index (ΔAIC=-0.20) but a worsening of BIC index (ΔBIC=5.71). Given that *p*-value does not reveal statistic significance too (t=1.47; p=0.13), the interaction are considered not significant. The additive two-way model is better than both the one-way model considering "contours" factor alone (ΔAIC=-121.37; ΔBIC=-115.47; χ^2=123.37; *df*=1; p<0.01) and the one-way model considering the "oblique type" factor alone (ΔAIC=-103.40; ΔBIC=-97.50; χ^2=105.41; *df*=1; p<0.01). Then, both factors show statistic significance, as confirmed by the *p*-values ($t_{contours}$=10.29, p<0.01; $t_{oblique\ type}$=11.15, p<0.01).

The introduction in the model of the "sex" factor and its interaction with "contours" and with "oblique-type" factors improves the model fit (ΔAIC=-40.64; ΔBIC=-22.92; χ^2=46.64; *df*=3; p<0.01). However, this model worsens with the inclusion of the three way interaction (ΔAIC=1.66; ΔBIC=13.47; χ^2=2.34; *df*=2; p=0.31).

By removing from the two-ways interaction model the interaction between "oblique type" and "sex" the fit worsens (ΔAIC=36.79; ΔBIC=30.88; χ^2=38.79; *df*=1; p<0.01), while eliminating the interaction between "contours" and "sex" the model improves (ΔAIC=-0.57; ΔBIC=-6.48); besides, this last model is not statistically different from the one that considers both the two-ways interaction effects (χ^2=1.42; *df*=1; p=0.23). Thus, the model which considers alone the interaction between "oblique type" and "sex" is considered as the best one (this result is confirmed by *p*-value calculus: $t_{\text{oblique type} \times \text{sex}}$ =-6.24, p<0.01).

This result shows that the mean difference between the "illusory line" and "line-dot" condition varies depending on gender: with respect to illusory line condition, in the line-dot condition females present higher error in positive sense than males (mean increment for females: 5.07 mm; mean increment for males: 1.30 mm). This result is clearly displayed by figure 3, showing the mean values for males (black lines) and females (gray lines) for the four experimental conditions. This is a very critical point: the Poggendorff illusion forecasts a left shift in the response, but in this experiment we found a right shift (mean values are positives); this response increased in absence of illusory surface occluding the oblique line (dashed lines). Confidence intervals for average values (table 1) show that the classical Poggendorff effect (a left shift) occurs only for the males when both oblique line and occluding surface are illusory (interval does not include 0).

Discussion

We have found that the "line-dot" configuration generates an effect opposite to the classical Poggendorff figure. Besides, this effect is more extreme when no illusory occluding surface is present. So, we can consider the performance in presence of an illusory surface and a line-dot configuration like a compromise between the classical left-Poggendorff tendency and the right-tendency caused by the line-dot configuration. This pattern is modulated by the sex influence: males seem to present a lower right shift than females. However, we found a high between subject variation in the performance.

Spoto et al. (2008) did not find this effect and probably It is due to the fact that they used the constant stimuli method. Unlike adjustment method, constant stimuli does not require an active participation of the subject: in the adjustment procedure, instead, subject can move the stimulus, and the illusion changes configuration pursuing the subject's action. Subject can actively move the stimulus and the action itself could influence the strength and possibly even the direction of the illusion. This issue should be addressed in a future research.

Another interesting issue for future deepening are gender differences. A similar difference was found by Roig & Cicero (1994), McCourt, Mark, Radonovich, Willison & Freeman (1997) and Jewell & McCourt (2000), in the so-called pseudo-neglect phenomenon: in bisection tasks, males show a slightly greater leftward error than females do.

Sex	*Contours*	*Oblique type*	*Mean*
Females	Kanizsa	Illusory line	-0.10
		Line-dot	4.50
	None	Illusory line	2.26
		Line-dot	7.81
Males	Kanizsa	Illusory line	-1.00
		Line-dot	-0.20
	None	Illusory line	1.91
		Line-dot	3.68

Table 1. Mean errors plotted in figure 3.

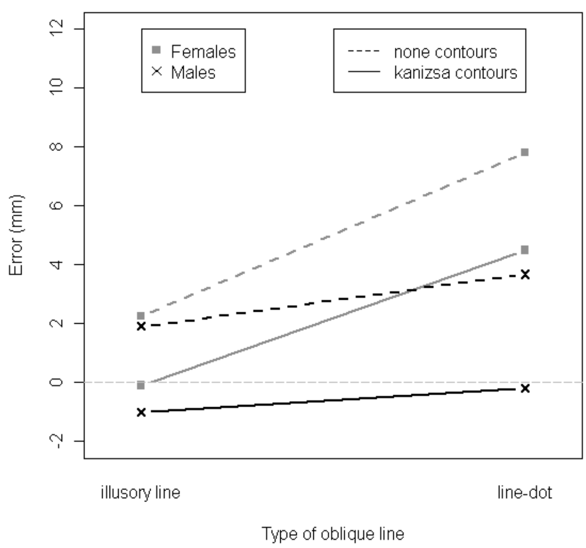

Figure 3. Mean errors for the oblique line conditions plotted with contours conditions. Black lines: males; gray lines: females.

A possible explanation is based on visuo-spatial attention, which is more highly lateralized for males than for females (McCourt et al., 1997; Robinson & Kertzman, 1990). Attention mechanisms might affect participant's performance more actively when the adjustment method is used, which requires an action by the participant and not only a mere judgement, in a way thus similar to the bisection task. We are actually working in repeating both researches with a greater sample, and comparing the present stimuli with the classical Poggendorff configuration. Future research should address the role of different psychophysical method in the strength and direction of the Poggendorff illusion.

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