

THE POGGENDORFF ILLUSION WITH ANOMALOUS SURFACES: MANAGING PAC-MANS, PARALLELS LENGTH AND TYPE OF TRANSVERSAL.

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Abstract

In the classical Poggendorff illusion, a rectangular surface partially occludes an oblique line, and it lead to perceive as misaligned the two ends of the line segment, when, in fact, they are aligned. The illusion persists when the obscuring rectangle is replaced by Kanizsa-like subjective contours (Tibber et al. 2008) and when both the rectangle and oblique segments consist of Pac-Man tokens, generating Kanizsa-like subjective contours (Spoto et al., 2008). Nevertheless, previous research did not completely clarify the role of the presence of Pac-Man tokens in generating the effect. In the present research, using the adjustment method, the role of the mere presence of the Pac-Mans is further investigated, comparing three kinds of configurations: Pac-Mans generating surface, rotated Pac-Mans and no Pac-Mans, with two surface sizes and two types of oblique segment (classical line-dot and illusory line). Main results show that an overall effect of the mere presence of Pac-Man induces a sort of anchor in the perceived effect; moreover, we found an illusory effect even in the “No Pac-Man” condition, opening a new issue to be addressed by research in this field.

When an oblique line is interrupted by an occluding surface, the two segments not covered by the surface appear to be misaligned even if they are actually aligned: this is the Poggendorff illusion (Zöllner, 1860). Research showed the illusion to be more evident when the distance of parallels constituting the surface is smaller (Pressey, 1970), presents a maximum effect when the angle between oblique and parallel lines is 45° and it disappears when parallels and oblique are perpendicular (Weintraub and Krantz, 1971). Gregory (1972) suggested that Poggendorff figures could be obtained through “cognitive” contours, generated by Kanizsa-type stimuli. Recently, (Tibber, Melmoth and Morgan, 2008; Spoto, Bastianelli, Burro and Vidotto, 2008; Massidda, Spoto, Bastianelli, Actis Grosso and Vidotto, 2009) proposed a number of studies involving the illusion strength in a classical Poggendorff figure, in 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°). All these authors found interesting and somehow controversial results.

More specifically, Spoto et al. (2008) found that the Poggendorff illusion persists even when both parallel and transversal lines were illusory (see figure 1 for an example). This effect was found also by Massidda et al. (2009) but in the opposite direction; authors conclude that subjects’ performance in presence of an illusory surface is a compromise between a natural tendency to right shift (probably due to an attention bias) and the classical left-Poggendorff tendency.

An open question is the role of the Pac-Man tokens in generating the illusory effect. Massidda et al. (2009) explained that the mere presence of Pac-Mans, although not arranged to form a rectangle, could affect the subjects’ perception, creating an anchor whereby

calibrate the response. In this paper we deepen this issue, comparing a condition in which the Pac-Mans horizontal distance are equal to Massidda et al. (2009) and a condition in which the Pac-Mans distance are greater: in the latter condition, the oblique line is farther to Pac-Mans, and these should have less impact in the perception.

Method

Participants

Twelve participants (6 males and 6 females, mean age: 26.9 years with st. dev.: 2.6) 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 for Python (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 displayed in Figure 1. Configurations from 1 to 3 present a “line-dot” oblique (i.e. they composed the “line-dot” condition), similarly to the ones presented by Tibber et al. (2008); differently, configurations from 4 to 6 include an oblique illusory line made by two small Pac-Man tokens dissected by a white segment, generating Kanizsa-like subjective contours in the transversal line (these configurations composed the “illusory line” condition). In both conditions the oblique line was oriented at 45° to the parallels; for details see Spoto et al. (2008) and Massidda et al. (2009).

These conditions (“line-dot” and “illusory line”) were tested: i) with an occluding surface consisting of a Kanizsa-like rectangle obtained through four Pac-Man tokens (figure 1a and 1d); ii) with the Pac-Mans arranged so that no illusory rectangle was generated (figure 1b and 1e); iii) with no Pac-Man tokens, i.e. no occluding surface (figure 1c and 1f). Two different horizontal distances between Pac-Mans were selected: 21.6 cm (small surfaces) and 28.6 cm (large surfaces).

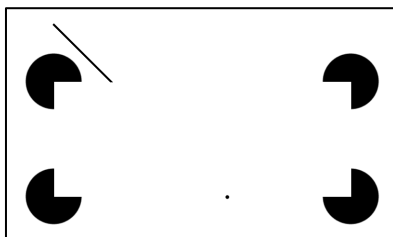


Fig. 1a. Configuration 1

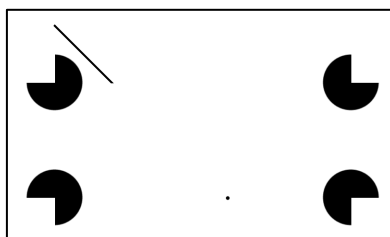


Fig. 1b. Configuration 2

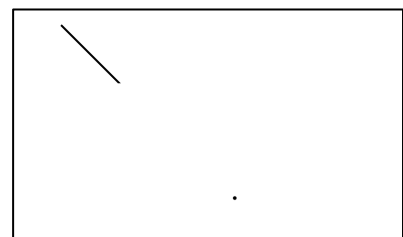


Fig. 1c. Configuration 3



Fig. 1d. Configuration 4

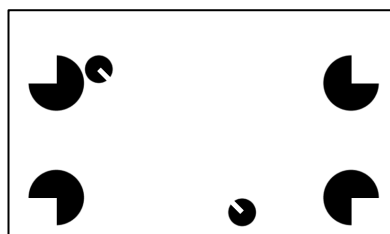


Fig. 1e. Configuration 5

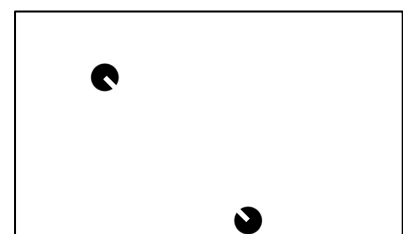


Fig. 1f. Configuration 6

Configurations were presented varying the horizontal position of the bottom stimulus (either the Pac-Man token or the black dot). Two possible starting point were selected: -2.45 cm and

+2.45 cm (where a negative value represents a left shift and a positive value represents a right shift); the “correct point” is the ideal continuation of the segment starting from the top and interrupted by the parallels.

Procedure

Participants sat at 60 cm from the screen in a dark room. The experiment was subdivided in two counterbalanced sessions: in one session the “line-dot” configurations were presented, while in the other session the “illusory line” configurations were presented. Session order was balanced for number of subjects and sex.

The experimental task consisted in moving with the mouse pointer either the black dot or the small Pac-Man token at the bottom in horizontal direction, adjusting its position until this moving stimulus became the ideal continuation of the segment at the top. Subjects evaluated each configuration for 7 times.

Results

Analysis was performed with the software R version 2.11.1 (R Development Core Team, 2010) using the following ANOVA design: Type of contours (Pac-Mans, rotated Pac-Mans, no Pac-mans) × Surface width (small, large) × Oblique Type (line-dot, illusory line); multiple comparison was performed by orthogonal contrasts.

For each subject’s response, the distance between the response and the correct point was calculated: positive values represented a right shift of the response, negative values a left shift. Three-way ANOVA shows a significant difference between the illusory-line and line-dot ($F_{(1,11)} = 5.97, p < 0.05$); this difference is highlighted in Figure 2: the error in the line-dot condition is always greater than in the illusory-line condition.

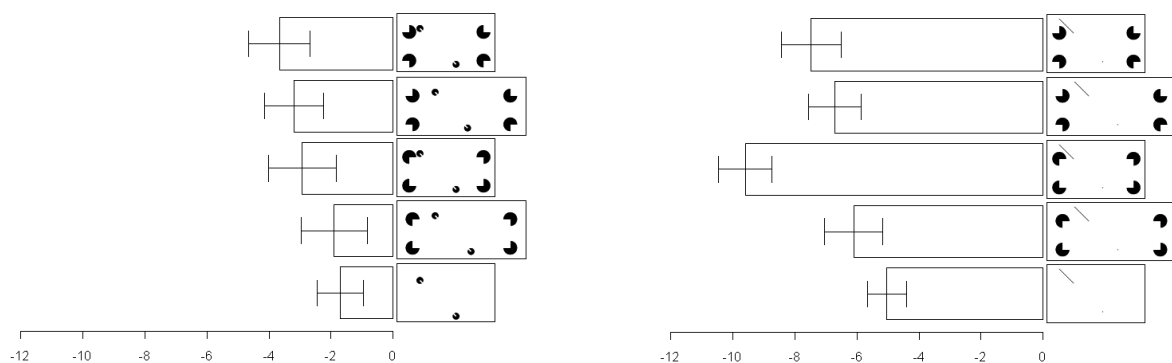


Figure 2. Mean values (in millimetres) of distance from the correct point for each configuration. Left panel: illusory line condition; right panel: line-dot condition.

The difference between the rotation of Pac-Mans (mean: -5.26, st. dev.: 12.31) and their absence (mean: -3.36, st. dev.: 12.70) is significant ($F_{(1,11)} = 35.53, p < 0.001$), but no difference was found ($F_{(1,11)} = 1.16, p = 0.303$) between the presence of occluding surface (“Pac-Mans” condition) and the absence of surface (“Rotated Pac-Mans and “No Pac-Mans” taken together). Besides, ANOVA shows a difference between the large and the small horizontal distance between the Pac-Mans ($F_{(1,11)} = 22.83, p < 0.001$), but this difference varies depending on the presence or absence of the illusory surface ($F_{(1,11)} = 12.87, p < 0.01$). Figure 3 shows the interaction between the surface width and the type of contours: when the

horizontal distance between the Pac-Mans is large, the difference between the presence of the illusory surface and their absence is negligible; differently, when the width of generated surface is small, this difference is more consistent, and the error is greater when the Pac-Mans are rotated or absent.

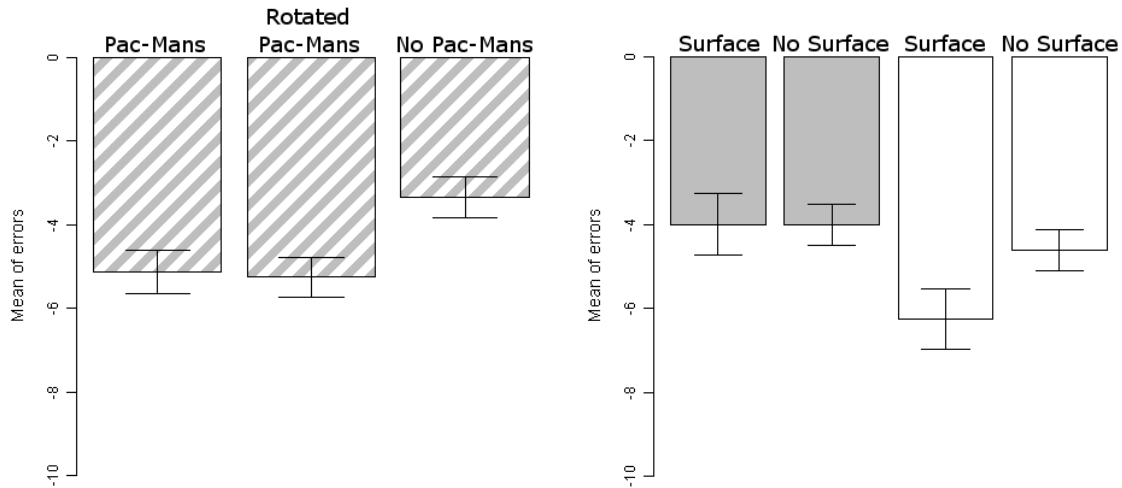


Figure 3. Right panel: mean of shift from the correct point (in millimetres) for the levels of Contours factor: “Pac-Mans”, “Rotated Pac-Mans” and “No Pac-Mans” conditions. Left panel: interaction between the *surface width* (horizontal distance between the Pac-Mans) and the *type of contours*: when the illusory surface is large (gray bars) the difference between the presence of a surface and their absence is negligible; differently, when the width of generated surface is small (white bars), this difference is more consistent.

Discussion

The first interesting result comes out from the fact that the two contrasts aimed at testing the effect of the contours in the participants’ responses display different outcomes. It is worth to note how these opposite results seem to converge to a unique potential explanation. In fact, the absence of significant differences when comparing the “Pac-Man” condition with the “Rotated Pac-Man” and the “No Pac-Man” conditions together may be due to the fact that the “Rotated Pac-Man” condition is close to the first one. In other words it seems reasonable that an overall effect of the presence of some kind of Pac-Man (either rotated or not) induces a sort of anchor effect for the respondent. This interpretation is confirmed both by the fact that threshold values of “Pac-Man” and “Rotated Pac-Man” conditions are closer to each other than to the ones of “No Pac-Man” condition and by the second contrast. In fact the difference between the “Rotated Pac-Man” and the “No Pac-Man” conditions turned out to be significant. This result confirms our hypothesis regarding the fact that the presence of some sort of anchor does influence the response by either generating an illusory surface (even when Pac-Mans are rotated) or giving to participants a sort of reference point to calibrate their responses.

Another relevant result is that the difference between the presence and the absence of the illusory surface appears only whenever the surface is small: in fact, when the surface is large, the illusory effect does not vary. It is possible that the horizontal distance between Pac-Mans equal to 28.6 cm is too large, and does not generate any occluding surface. This result on the one hand seems to confirm the effective generation of illusory contours, on the other

hand fixes a boundary for the generation of the illusion. This boundary is the distance between the Pac-Man tokens. Whenever this distance is too wide, the effect does not occur. Furthermore, this result could lead to some further investigations about the threshold of the anomalous surface generation.

It has to be stressed that the threshold is significantly different from zero even in the “No Pac-Man” condition. This result is very interesting. In fact, it seems to confirm that even in front of a white surface, respondents tend to interpret the gap between the two parts of the diagonal (i.e. the segment and the dot in one case and the two Pac-Mans in the other case) as the interference of an occluding surface. Thus, they perceive the spatial mislocation typical of the Poggendorff illusion. This result does not support what reported by Massidda et al. (2009). In fact, in similar conditions they found a right instead of a left shift. Furthermore, this result seems to be coherent with Spoto et al. (2008) who reported a left shift (even if they used the constant stimuli method). This finding seems to be quite puzzling and needs actually to be further investigated.

From the descriptive point of view a difference between males and females was found. This difference is not statistically significant, but it is interesting to note that it appears to be in the same direction of what reported by Massidda et al. (2009). In fact, in both cases females seem to be less subject to the illusion by providing a lower left shift than their male counterparts. It has to be stressed that the difference between males and females could be another interesting topic to be investigated through further experiments.

In the present research we used the psychophysical method of adjustment. It is worth to remind that the methodology used to investigate a phenomenon could influence the results. In our opinion it would be very useful and interesting to perform a comparison among different psychophysical methodologies in order to understand how each one of them could introduce biases. In fact, some of the observed differences between the present results and the past ones could be due to this element. Massidda et al. (2009) used the adjustment method, Spoto et al. (2008) used the constant stimuli method, and in the present research we used again the adjustment method. In this last, an observer can actively move the stimuli and the illusion changes configuration pursuing the subject’s action; on the contrary, constant stimuli method does not require an active participation, and this could lead to different results.

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