Journal of Illusion

PHENOMENAL REPORT

Three-dot misalignment illusion and related new illusions: a rediscovery of Bouma and Andriessen's (1968) oblique effect as a strong illusion

Kentaro Usui[1]* and Akiyoshi Kitaoka[2]

[1]Graduate School of Human Sciences, Ritsumeikan University, Ibaraki, Osaka, Japan; [2]College of Comprehensive Psychology, Ritsumeikan University, Ibaraki, Osaka, Japan

Abstract

We describe a misalignment illusion observed in the spatial arrangement of three collinear dots, where two dots are proximally positioned while the third is distally located. The illusion manifests when the dots are oriented obliquely, creating a perceived deviation from linear alignment. In a near-vertical configuration with slight clockwise orientation, the extrapolated line connecting the proximal dots appears to pass laterally left of the superior distal dot. Conversely, in a near-horizontal arrangement with counterclockwise orientation, the perceived line trajectory falls inferior to the rightward distal dot. The illusion's magnitude exhibits distance-dependency: it is absent when all three dots are equidistant but intensifies as the distance between the pair of dots and the remaining dot increases. While we independently discovered this perceptual phenomenon, subsequent literature review revealed its correspondence with the findings reported by Bouma and Andriessen (1968). Although historically categorized as tilt normalization or an oblique effect, we propose reconceptualizing this Bouma–Andriessen phenomenon as a distinct and robust misalignment illusion. Furthermore, we demonstrate that this illusion emerges even with abstract geometric features, such as circle centres or rectangle corners.

Keywords: *geometrical illusion*; *oblique effect*; *tilt normalization*; *misalignment illusion*; *Watanabe illusion*

Edited by:
Yuki Yamada, Kyushu University, Japan

Reviewed by:
Dejan Todorović, University of Belgrade, Serbia

Shuichiro Taya, Keio University, Japan

Received: 24 July 2024; Revised: 15 August 2025; Accepted: 15 August 2025; Published: 30 December 2025

Usui and Kitaoka (2023) documented a novel misalignment illusion in celestial constellations, specifically in the spatial relationship between Polaris and the Big Dipper constellation. The traditional celestial navigation method for locating Polaris involves extrapolating an imaginary line from the α and β stars of the Big Dipper toward the zenith (Dyches, 2021). Polaris is situated along this projected line at approximately five times the α–β stellar separation distance from the α star (Rey, 1976).

Figure 1 shows a pattern of eight dots, with seven dots representing the Big Dipper constellation and one dot representing Polaris (the rightmost dot). Polaris is positioned along the extended line of the α–β alignment, where star α is the second dot from the right and star β is the third dot from the right. Despite the physical collinearity of these three points (α star, β star, and Polaris), observers perceive a systematic misalignment where Polaris appears to be displaced rightward relative to the projected α–β vector.

The left image of Fig. 2 presents a simplified configuration abstracted from Fig. 1, retaining only the three critical points. The perceptual misalignment persists with equivalent phenomenological characteristics in this reduced display. When the dot array's orientation is manipulated to approximate horizontal alignment as shown in the right image of Fig. 2, an inverse perceptual displacement manifests: the terminal dot appears displaced superior relative to the extrapolated trajectory defined by

*Correspondence: Kentaro Usui. Email: cp0004xr@ed.ritsumei.ac.jp

Journal of Illusion 2025. © 2025 Kentaro Usui and Akiyoshi Kitaoka. This is an Open Access article distributed under the terms of the Creative Commons CC-BY-NC-ND 4.0 license (https://creativecommons.org/licenses/by-nc-nd/4.0/), allowing third parties to copy and redistribute the material in any medium or format and to remix, transform, and build upon the material for any purpose, even commercially, provided the original work is properly cited and states its license.
Citation: Journal of Illusion 2025, **5**: 10908 - https://doi.org/10.47691/joi.v5.10908

Fig. 1. Polaris and the Big Dipper Illusion. When we designate the rightmost point as Polaris, the second point from the right as star α, and the third point as star β, although these three points are collinear, Polaris appears to be positioned right of the line extending from stars α and β.

the two proximal points. The directional specificity of this misalignment illusion exhibits systematic dependence on the array's principal orientation, with qualitatively distinct effects emerging as the configuration approaches either vertical or horizontal axes.

A phenomenologically related perceptual effect is the Watanabe misalignment illusion (Watanabe, 2018), illustrated in Fig. 3. When observers are tasked with identifying the point on the vertical array that corresponds to the perceived 'gaze direction' of the circular elements, they typically indicate the third or fourth point from the superior terminus. However, a line drawn from the centre of the large circle through the centre of the black circle aligns with the uppermost point. A critical distinction between this phenomenon and the three-dot misalignment illusion lies in the nature of the reference points: while the three-dot illusion utilizes explicit point stimuli, the Watanabe illusion incorporates a virtual point defined by the geometric centre of one circular element, introducing an additional perceptual component to the alignment judgment.

The dot that the two 'eyes' are looking at is the uppermost dot arranged along the right vertical line; however, it appears to be one of the lower dots.

A rediscovery of Bouma and Andriessen (1968) from an illusion research perspective

During the peer review process of this paper, we discovered that Bouma and Andriessen (1968) had already reported the same phenomenon. They demonstrated that when the orientation of a line segment approaches vertical or horizontal, there is a systematic bias in its perceived orientation. Specifically, line segments near vertical appeared to tilt more vertically, while those near horizontal appeared to tilt more horizontally. To investigate these tilt illusions, they employed a methodology using a dot positioned away from the line segment, systematically varying its position to determine the point of perceived collinearity. They also found that the magnitude of the illusion was inversely related to the length of the line segment for lengths shorter than 60 min of arc, while no illusion was observed for lengths exceeding 60 min. Furthermore, Bouma and Andriessen (1968) extended their investigation beyond line segments to arrays of two dots, obtaining similar results.

The phenomenon in which a line segment's apparent orientation tends to be biased toward either the vertical or horizontal axis was termed 'tilt normalization' by Howard (1982), who cited Bouma and Andriessen's (1968) study as a demonstration of this effect. Tilt normalization was defined as 'occurring towards the normally vertical or horizontal retinal meridia or towards the gravitationally defined vertical and horizontal' (Howard, 1982). Appelle (1972) incorporated Bouma and Andriessen's (1968) findings into the broader framework of the 'oblique effect', a well-documented phenomenon wherein visual performance systematically declines when stimuli are presented at oblique orientations relative to when they are aligned with vertical or horizontal axes. Chiang (1975) developed a mathematical model of the Poggendorff illusion that incorporated multiple perceptual factors, including the orientation effect documented by Bouma and Andriessen (1968). Although Wenderoth et al. (1978) cited Bouma and Andriessen's (1968) effect in their introduction, characterizing it as an illusion, their experimental investigation focused exclusively on the acute-angle expansion illusion without incorporating the Bouma and Andriessen effect as an experimental variable.

Although Bouma and Andriessen's (1968) findings using line segments have been extensively cited in the aforementioned studies, their parallel observations using dot patterns have received remarkably little attention in the subsequent literature. In Bouma and Andriessen's (1968) original paper, the dot condition stimulus was presented only as a marginal illustration in the upper right corner of their results graph. This minimal documentation may explain why their findings have not been recognized within the context of misalignment illusions. The present study aims to highlight the significance of their dot condition findings by demonstrating that they represent a robust misalignment illusion (hereafter referred to as the Bouma–Andriessen dot illusion).

The illusion exhibits systematic dependencies on stimulus parameters. No perceptual distortion is observed when

Citation: Journal of Illusion 2025 5: 10908 - https://doi.org/10.47691/joi.v5.10908

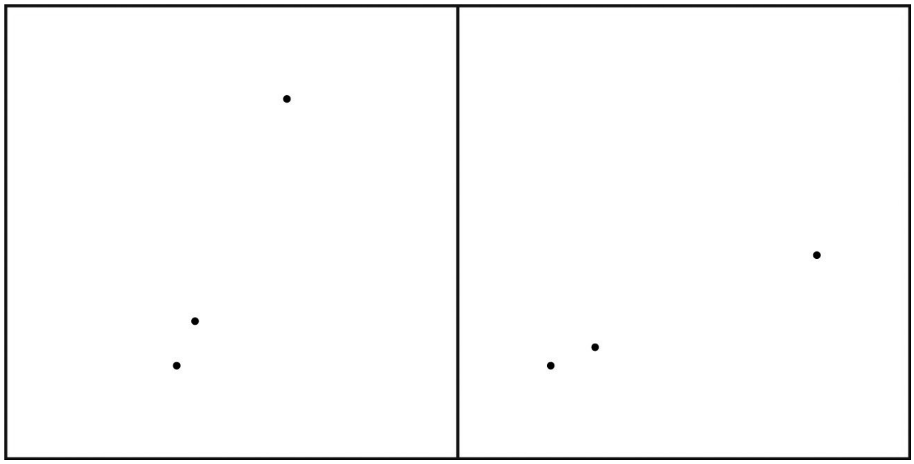

Fig. 2. Three-dot misalignment illusion. Left: Although three dots are collinear, the uppermost dot appears to be positioned right of the line extending from the lower two dots. Right: Although three dots are collinear, the rightmost dot appears to be positioned above the line extending from the left two dots.

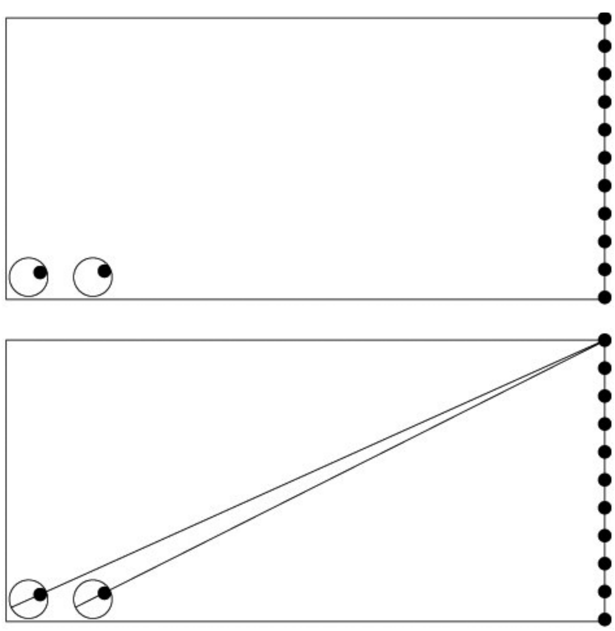

Fig. 3. Watanabe misalignment illusion (reproduced with permission from Watanabe).

the three dots are aligned vertically (Fig. 4a), horizontally (Fig. 4c), or at ±45°diagonal orientations (Fig. 4b). Similarly, the illusion is absent when the three dots are equidistant (Fig. 5a). As the distance between the pair of dots and the isolated dot increases, the magnitude of the effect increases (Fig. 5b, c). These parametric dependencies replicate the original findings of Bouma and Andriessen (1968). Furthermore, the illusion demonstrates relative invariance to changes in stimulus visual angle (Fig. 6). In the original study by Bouma and Andriessen (1968), three dots were presented in a stimulus arrangement where the dots were aligned in a downward rightward direction, as shown in Fig. 7g and h. However, this illusion persists with comparable strength when presented in other arrangements (Fig. 7a–f).

The illusory misalignment generalizes to four-dot configurations, where two dot pairs replace the original three-dot arrangement (Fig. 8). This illusion is analogous to the three-dot configuration (Figs. 2 and 4). The perceptual distortion is observed when the dot alignment deviates from cardinal axes (Fig. 8b, d), while no illusion occurs at vertical (Fig. 8a), horizontal (Fig. 8e), or ±45° orientations (Fig. 8c).

Systematic perceptual bias occurs in near-cardinal orientations. When dot pairs deviate slightly clockwise from vertical (b), the upper pair appears displaced rightward relative to the lower pair. Conversely, in counterclockwise-deviated arrangements (d), the upper pair appears displaced upward. No illusory misalignment is perceived in cardinal (a: vertical, e: horizontal) and oblique (45°) orientations (c).

Watanabe's misalignment illusion represents a structural variant of the three-dot misalignment illusion (Bouma–Andriessen dot illusion), wherein the central dot is substituted by a circle's centre point. The illusion exhibits distinct orientation-dependent characteristics, with the direction of perceived misalignment reversing based on the proximity to cardinal axes (Fig. 9a, b). Notably, the illusion disappears entirely when two dots and the circle's centre point are precisely aligned along vertical (Fig. 9c), horizontal (Fig. 9e), or ±45° diagonal orientations (Fig. 9d). While Watanabe (2010) termed this phenomenon the 'visual direction illusion' and proposed that its eye-like appearance might be functionally significant, Fig. 10 has revealed that this configurational resemblance to the eye is not essential for the illusion's occurrence. Specifically, the perceptual effect persists in

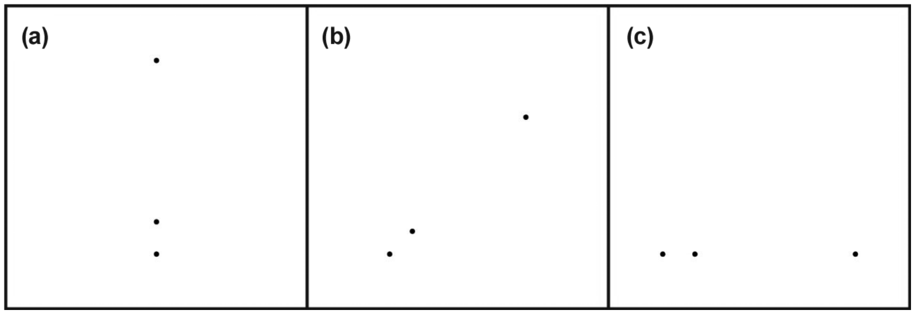

Fig. 4. Three configurations of dot arrays that do not elicit illusory misalignment.

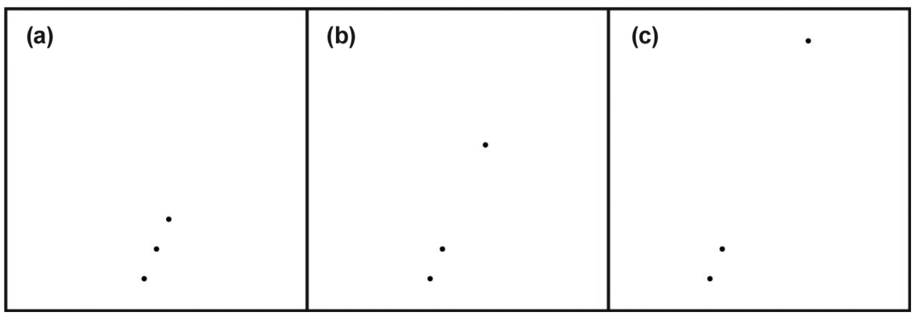

Fig. 5. Effect of the position of the isolated dot. Magnitude of illusory misalignment increases with increased distance between the lower-left dot pair and the isolated dot.

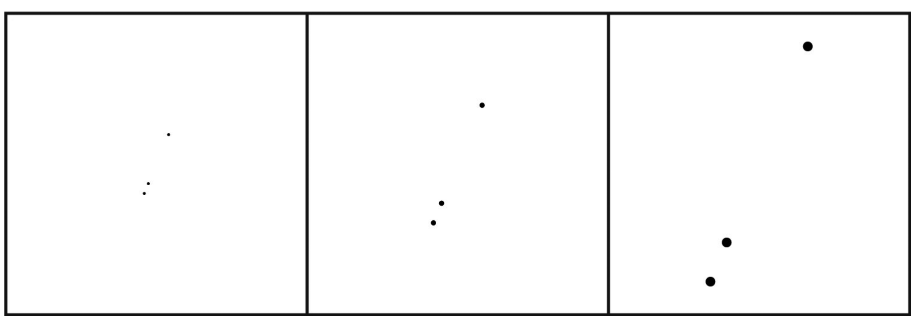

Fig. 6. Scale invariance of the illusion. Perceptual misalignment persists across variations in stimulus visual angle.

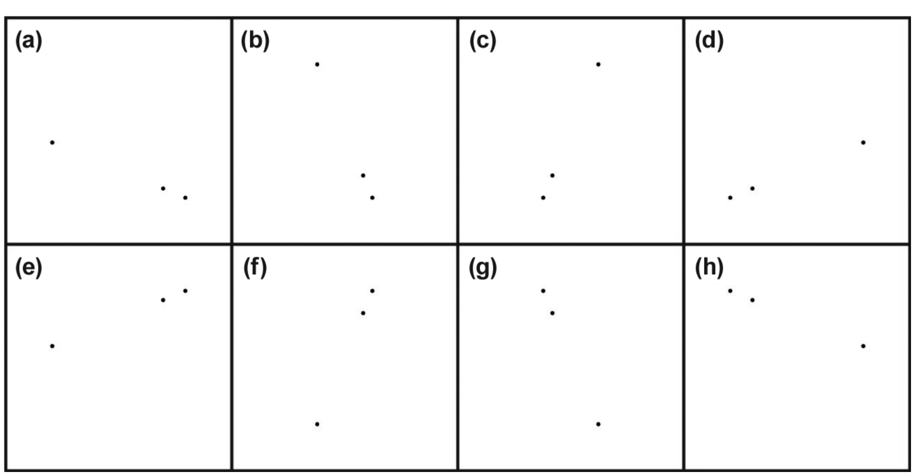

Fig. 7. Orientation invariance. Illusory misalignment persists across all eight cardinal and oblique stimulus configurations.

Citation: Journal of Illusion 2025 **5**: 10908 - https://doi.org/10.47691/joi.v5.10908

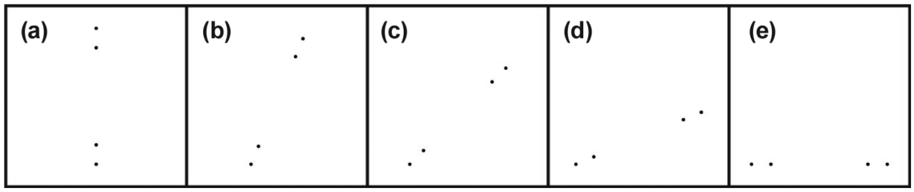

Fig. 8. Orientation-dependent illusory misalignment in four-dot configurations.

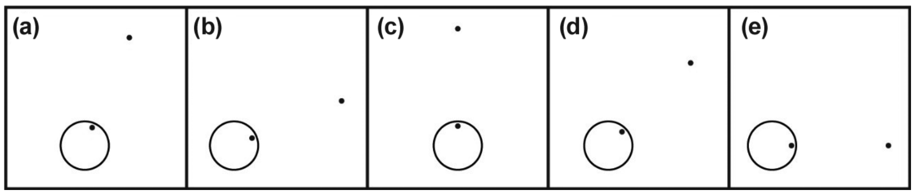

Fig. 9. Demonstration of systematic orientation-dependent perceptual biases of the Watanabe misalignment illusion. (a) The upper dot appears displaced rightward from the alignment of the circle's centre and internal dot. (b) The right dot appears displaced upward from the alignment. No misalignment is perceived in the remaining configurations where elements are arranged at vertical (c), horizontal (e), or ±45° angles (d).

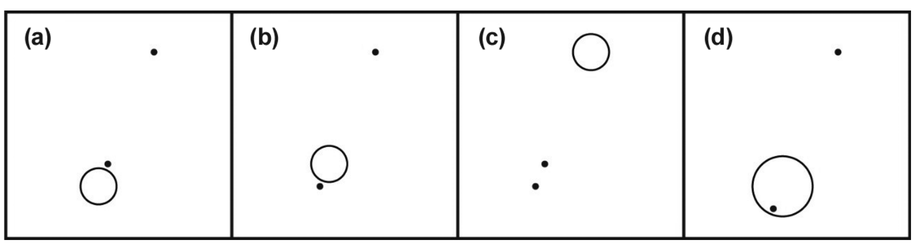

Fig. 10. Variants of the Watanabe misalignment illusion. (a, b) The upper dot appears shifted rightward from the alignment between the circle's centre and the proximal dot. (c) The circle's centre appears displaced rightward from the line connecting the two external dots. (d) The upper dot appears shifted rightward from the alignment of the circle's centre and its internal dot.

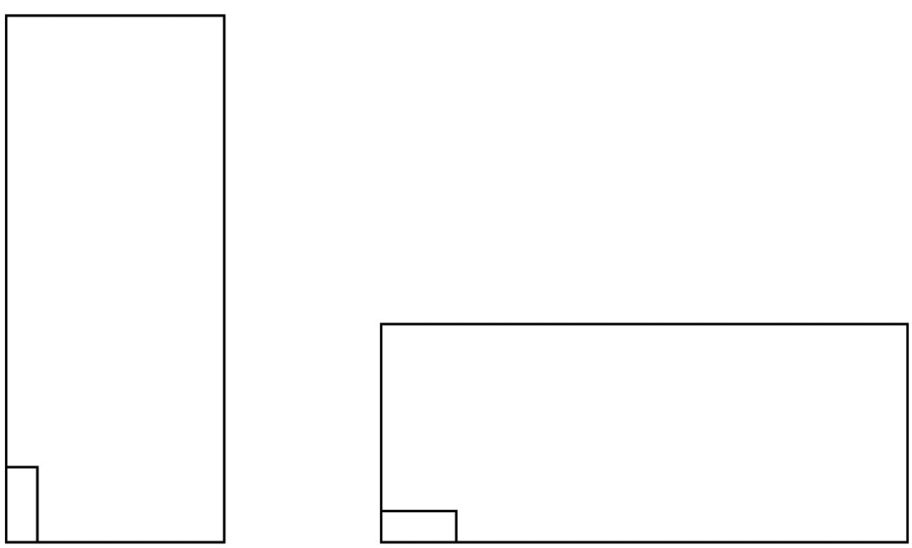

Fig. 11. A novel misalignment illusion emerges when two geometrically similar rectangles are arranged in specific orientations in the same way as the three-dot misalignment illusion.

modified arrangements where the dot inside the circle is moved outside (Fig. 10a–c) or the circle contains a dot positioned on the opposite side relative to the external dot (Fig. 10d). These variants maintain the fundamental illusory effect, demonstrating that the phenomenon's underlying mechanism operates independently of eye-like appearance while preserving the core geometric properties and orientation-dependent characteristics of the original three-dot paradigm.

Figure 11 demonstrates a novel variant of the illusion using two similar rectangles. In the left image, the upper-right vertex of the larger rectangle appears displaced rightward from the line connecting the vertices of the smaller rectangle. This misalignment is illusory, as the rectangles maintain geometric similarity. In contrast, the right image shows an apparent upward displacement of the larger rectangle's upper-right vertex from the alignment of the smaller rectangle's vertices.

Discussion

In this paper, we demonstrate an illusion in which three physically collinear points appear to deviate from collinearity. Although this phenomenon was mentioned by Bouma and Andriessen (1968), it has not been treated as an illusory figure. We focus on this phenomenon as an illusory figure, illustrating its characteristics with a wealth of demonstrative diagrams. Furthermore, we show that similar misalignment illusions occur not only when the three points are defined explicitly but also when they are defined by other geometric features, such as the centre of a circle or rectangle's corners. In all cases, the direction of the misalignment illusion is consistently opposite when the slope of the three obliquely arranged points is near vertical compared to when it is near horizontal.

This paper does not provide an explanation for the mechanisms underlying this phenomenon. However, this misalignment illusion suggests that, in addition to the vertical and horizontal axes, the diagonal axes at ±45° also play a significant role in visual perception.

Among the most famous illusions of misalignment involving oblique arrangements is the Poggendorff illusion, where line segments aligned along a diagonal appear misaligned across parallel lines. Like the illusions illustrated in this paper, the Poggendorff illusion also exhibits directional dependence relative to its principal axis. Leibowitz and Toffey (1966) and Weintraub and Krantz (1971) documented systematic variations in the Poggendorff illusion's magnitude as a function of figure orientation, demonstrating that the illusory effect diminished to near-zero when the collinear line segments were aligned horizontally or vertically. Interestingly, the illusory effect remained evident when the line segments were oriented at ±45°, which contrasts with the present illusion, where no such effect is observed at this orientation. This persistence of the illusion at 45° has also been reported by Day (1973), who found similarly strong effects at this angle. Day (1973) investigated the illusory effects that persist when the parallel lines are eliminated from the classical Poggendorff figure, specifically examining stimuli consisting of only two collinear line segments. The arrangement described by Day (1973) corresponds to Fig. 8 in this paper where the endpoints of the two line segments are replaced with dots. Day (1973) reported that the misalignment illusion was most pronounced at 45°, with notable effects at 60° and 75°, while no illusory effect was detected at 0°, 15°, 30°, or 90°. The absence of illusory effects when dots are aligned vertically or horizontally, a characteristic observed throughout the present study, corresponds to previous Poggendorff illusion research showing diminished effects with vertical or horizontal orientations. However, the three-dot misalignment illusion exhibits no illusory effect at a 45° orientation as well. Thus, we conclude that the current illusion and the Poggendorff illusion represent related but distinct perceptual phenomena.

Conflict of interest and funding

This study was supported by JSPS KAKENHI Grant Number 22KJ3034.

References

Appelle, S. (1972). Perception and discrimination as a function of stimulus orientation: The 'oblique effect' in man and animals. *Psychological Bulletin*, *78*, 266–278. doi: 10.1037/h0033117

Bouma, H., & Andriessen, J.J. (1968). Perceived orientation of isolated line segments. *Vision Research*, *8*(5), 493–507. doi: 10.1016/0042-6989(68)90091-6

Chiang, C. (1975). A theory of Poggendorff illusion. *Japanese Psychological Research*, *17*(3), 111–118. doi: 10.4992/psycholres1954.17.111

Day, R.H. (1973). The oblique line illusion: The Poggendorff effect without parallels. *Quarterly Journal of Experimental Psychology, 25*(4), 535–541. doi: 10.1080/14640747308400375

Dyches, P. (2021, July 28). *What is the north star and how do you find it?*. NASA. Retrieved from https://science.nasa.gov/solar-system/what-is-the-north-star-and-how-do-you-find-it/

Howard, I.P. (1982). *Human visual orientation.* New York: Wiley.

Leibowitz, H., & Toffey, S. (1966). The effect of rotation and tilt on the magnitude of the Poggendorf illusion. *Vision Research*, *6*(1–2), 101–103. doi: 10.1016/0042-6989(66)90018-6

Rey, H.A. (1976). *Find the constellations (revised edition)*. Boston, MA: Houghton Mifflin Company.

Usui, K., & Kitaoka, A. (2023). *Polaris & the plough illusion* [Demo & Illusion Night]. The 45th European Conference on Visual Perception, Aliathon Resort, Paphos, Cyprus.

Watanabe, E. (2010, April 2). *Watanabe illusion 2010 – Illusion of direction of line of sight*. Neurophysiology Laboratory @NIBB. Retrieved from https://eijwat.blogspot.com/2010/12/blog-post.html

Watanabe, E. (2018). *Watanabe Illusion 2010 (Version 3)*. figshare. doi: 10.6084/m9.figshare.5838606

Weintraub, D.J., & Krantz, D.H. (1971). The Poggendorff illusion: Amputations, rotations, and other perturbations. *Perception & Psychophysics*, *10*, 257–264. doi: 10.3758/BF03212818

Wenderoth, P., Beh, H., & White, D. (1978). Alignment errors to both ends of acute- and obtuse-angle arms. *Perception & Psychophysics*, *23*(6), 475–482. doi: 10.3758/bf03199522

***Kentaro Usui**
Graduate School of Human Science
Ritsumeikan University
2-150, Iwakura-cho
Ibaraki
Osaka
567-8570 Japan.
Email: kentaro.usui731@gmail.com