**The relation between apparent extent and alignment in the Poggendorff illusion:
A response to "No evidence for apparent extent between parallels as the basis of the Poggendorff effect," by Day, Jolly, and Duffy**

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In the classic Poggendorff illusion (Figure 1A), the two collinear oblique lines or transversals appear to be non-collinear or misaligned. Several investigators (e.g., Pressey, 1971; Quina-Holland, 1977; Zanuttini, 1976) have suggested that this misalignment illusion is due to an underestimation of the distance between the parallels. Figure 1 illustrates how underestimation of interior extent may promote a misalignment effect. Following much earlier work (Judd, 1899), Greist-Bousquet and Schiffman (1981a) verified the intertransversal underestimation empirically, and they suggested that the underestimation is due to the influence of an amputated form of the wings-in Müller-Lyer figure contained within the Poggendorff parallels (Figure 2B). Although an analogous wings-out figure is also present (Figure 2C), previous research on the Müller-Lyer illusion (e.g., Greist-Bousquet & Schiffman, 1981b; Warren & Bashford, 1977) indicates that this amputated variation produces little overestimation.

In addition to a Müller-Lyer effect caused by the parallels, another Müller-Lyer effect that may partially contribute to Poggendorff misalignment is a displacement of the transversals away from each other. This transversal-displacement effect is caused by an elongation of the parts of the parallels that form obtuse angles with the transversals (Figure 3A), due to a minimal Müller-Lyer wings-out effect. The transversal-displacement effect causes a reduction in the magnitude of intertransversal underestimation because the transversals are displaced away from each other (Figure 3A vs. Figure 3B), and this has been verified (Greist-Bousquet & Schiffman, 1981a). However, previous research (Day & Dickinson, 1976; Greist-Bousquet & Schiffman, 1981a; Hotopf & Ollerearnshaw, 1972; Judd, 1899) has shown that the transversal-

displacement effect plays a minor role in the Poggendorff illusion.

Day, Jolly, and Duffy (1987) make three criticisms of the proposal that underestimation and misalignment are related effects within the Poggendorff illusion. The first criticism has to do with the assumption that Poggendorff underestimation determines apparent misalignment. Day et al. (1987) suggest that Morinaga's paradox (Figure 4A) seriously calls this assumption into question, since distortions of the horizontal extents correspond to the Müller-Lyer illusion but are in a direction *opposite* to the apparent vertical misalignment of the apexes of the angles. Although the figure is paradoxical, examinations of variations of the Morinaga figure (Day, Bellamy, & Norman, 1983; Restle, 1976) have shown that misalignment occurs for a *single* vertical array of angles (Figure 4B) in which there are no Müller-Lyer effects; that is, Morinaga misalignment is an effect independent of the Müller-Lyer illusion. This finding suggests an independence of illusion effects within the complete Morinaga figure. (Indeed, explanations of Morinaga's paradox propose different mechanisms for the two effects. Restle [1976] argues that alignment and extent errors are caused by different

Figure 1. The classic Poggendorff illusion (A) may be attributable to an underestimation of the distance between the parallels. Moving the right parallel laterally, the increase in interior extent produces the impression of subjective collinearity (B), whereas a decrease in interior extent accentuates the misalignment effect (C).

Figure 2. The Poggendorff figure (A) contains an amputated version of the wings-in Müller-Lyer illusion (B), and an amputated version of the wings-out Müller-Lyer illusion (C). (The complete Müller-Lyer figure is shown above B and C.)

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Figure 3. Misalignment in the Poggendorff illusion may be enhanced by a transversal-displacement effect, caused by an elongation of the parts of the parallels that form obtuse angles with the transversals (A). The transversal-displacement effect reduces intertransversal underestimation; removing the transversals (in B) causes underestimation of the same extent to be more pronounced.

Figure 4. Morinaga's paradox (A) in which distortion of the horizontal extents corresponds to that in the Müller-Lyer illusion but is in a direction opposite to the apparent vertical misalignment of the apexes of the angles. Misalignment also occurs for a single vertical array of angles (B).

figure-ground organizations of the entire figure, and Day et al. [1983] examine explanations that encompass only the misalignment effect.) Thus, Morinaga's paradox is not relevant to Greist-Bousquet and Schiffman's (1981a; 1985) explanation of the Poggendorff illusion.

A second criticism made by Day et al. (1987) is aimed at the assumption that oblique extent is reduced in the manner illustrated in Figure 1. Day et al. cite previous findings of overestimation of oblique extent within the Poggendorff figure (Finlay & Caelli, 1975; Wilson & Pressey, 1976). Although we have previously questioned

these results (Greist-Bousquet & Schiffman, 1981a), since the stimulus judgment and the required response differ in these studies, a more detailed discussion is offered here.

In their Experiment 3, Wilson and Pressey (1976) asked subjects to estimate the oblique distance between the transversal and a dot in a Poggendorff figure by producing a horizontal extent equivalent to the oblique extent on a subsequently presented response sheet. The problems posed by this method are obvious. Not only must a subject remember the oblique extent, the subject must then translate it to an "equivalent" horizontal extent. Finlay and Caelli (1975) used two equally obscure methods: (1) Subjects had to mark off on the left vertical parallel line their estimate of the inner oblique distance between two transversals, and (2) subjects had to indicate on a lower right transversal line their estimate of the inner oblique extent. Both methods used by Finlay and Caelli require the subject to judge an unfilled extent and transfer it onto a filled extent; the first method has the additional step of translating an oblique estimate to a vertical extent.

Thus, these findings of overestimation are questionable. Furthermore, other investigators have found underestimation of inner oblique extent when subjects produce (Greist-Bousquet & Schiffman, 1981a; Weintraub & Tong, 1974), adjust (Judd, 1899), or compare (Quina-Holland, 1977) stimuli that are equivalent in content and orientation (i.e., an unfilled oblique extent). Day et al. (1987) extend these findings of underestimation to diagonally oriented versions of the Poggendorff illusion (e.g., see Figure 5A).

Another aspect of Day et al.'s (1987) second criticism is that oblique underestimation does not necessarily signify horizontal underestimation within the Poggendorff figure. Day et al. examined the relationship between judgments of the extent between transversals (or identically located dots) and judgments of the right-angle extent between the parallels. In their two experiments, they report

Figure 5. Diagonally oriented Poggendorff and control figures. In Day et al.'s (1987) study, subjects recreated the intertransversal extent in A and the extents identified by dots in B, C, and D.

opposite results for the two extents: underestimation of intertransversal (or identical interdot) extent and overestimation of right-angle interparallel extent. However, a number of issues raised by their methods and results require exploration.

Specifically, in Day et al.'s (1987) Experiment 3, the subjects recreated the extents identified by dots in Figures 5B and 5C. Judgments on control figures (without the parallels) were not made in this experiment, since the two-dot vertical control figure (Figure 5D) was judged veridically in their Experiment 1 ($M = -0.06$). Yet in Experiment 5 of Day et al. (1987), the *same* control figure induced a significant underestimation ($M = -0.99$). Furthermore, Day et al. did not collect right-angle control data in their Experiment 3 or in their preceding experiments. The importance of control data cannot be overemphasized, particularly in light of the large individual differences that occur in judgments of illusory figures. Indeed, the control data collected by Day et al. in Experiments 1 and 5 reflect these wide variations. Since no right-angle control data were collected, the results from their Experiment 3 are inconclusive.

Experiment 4 of Day et al. (1987) resulted in underestimation of oblique intertransversal extent and overestimation of right-angle interparallel extent in conventionally oriented Poggendorff figures. Oblique and right-angle control data were collected in this experiment. Control judgments were subtracted from oblique extent judgments since judgments on the control were significantly different from 0 ($M = -0.67$). Right-angle control data were not significantly different from 0 ($M = -0.26$) and therefore not subtracted from right-angle estimates for the Poggendorff figure. When the mean for the right-angle control figure is subtracted from the mean of Poggendorff right-angle extent judgments, the values no longer are overestimations but rather become underestimates of right-angle extent. However, none of the means in this experiment were significantly different from 0.

Day et al.'s (1987) nonsignificant results in Experiment 4 for oblique estimates are inconsistent with their own results of a comparable extent in some diagonally oriented versions of the Poggendorff figure, as well as with previous results for conventional Poggendorff figures. Day et al. suggest that the presence of the transversals serves as an additional illusory effect. Specifically, they argue that reduced underestimation of the intertransversal extent may be due to the transversals present in the figure, perhaps due to a limiting case of the Müller-Lyer illusion in which the segments that ordinarily form the wings-out arrows are coincident (i.e., reduced to one line) and are collinear with an interior judged extent. Interestingly, their explanation would predict results identical to the transversal-displacement account offered by Greist-Bousquet and Schiffman (1981a). In fact, Day et al.'s (1987) findings of enhanced underestimation in figures without transversals are consistent with both accounts.

While noteworthy, these particular concerns about the methods and results of Day et al. (1987) are less important than a remaining issue regarding the assessment of right-angle extent. We argue that the intertransversal underestimation is caused by wings-in Müller-Lyer components contained within the parallels of the Poggendorff illusion. However, if subjects are asked to judge the extent in a figure that does *not* contain wings-in parallel components (as in Figure 5C), then underestimation should not be obtained. Previous research (Restle & Decker, 1977) on the Müller-Lyer illusion has shown that when the central shaft of a Müller-Lyer figure meets perpendicular wings, overestimation is obtained. This is precisely what Day et al. (1987) observed in Experiment 3 with an analogous (but shaftless) Poggendorff figure. Similarly, if the subjects' task does not require that they evaluate the intertransversal extent between wings-in parallel components, then underestimation should not occur. (Of course, evaluation of the intertransversal extent occurs when subjects must estimate alignment or the extent itself within the conventional figure.) Perhaps the subjects accurately estimated right-angle extent in Day et al.'s Experiment 4 because they did not need to attend to the critical intertransversal extent and the wings-in parallel components within the Poggendorff figure.

Finally, Day et al. (1987) present a third criticism of Greist-Bousquet and Schiffman's explanation: Judgments of oblique extent and alignment in the same Poggendorff figure have not been compared. In fact, we have found a significant correlation between alignment and extent estimates when subjects align the transversals and recreate the intertransversal extent in the variation of the Poggendorff illusion shown in Figure 5A (Greist-Bousquet, Schiffman, Dorsett, & Davis, 1989).

Historically, the Poggendorff and Müller-Lyer illusions have been considered separately, each with its own distortion-producing mechanism. We have not argued that the two illusions produce identical distortion effects. In the classic presentation of the Müller-Lyer illusion, there is an obvious distortion of linear extent when one compares wings-in and wings-out figures. In contrast, the less obvious distortion of intertransversal extent in the Poggendorff figure promotes the apparent noncollinearity of the transversals. Since controversy and confusion continue in explorations of visual illusions, it is important to identify the commonalities among illusion effects. Accordingly, our suggestion that the Poggendorff and Müller-Lyer illusions share a common basis is an attempt to reduce the confusion, not add to it.

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Announcement

13th European Conference on Visual Perception—ECVP 90 Paris, France September 4–7, 1990

The ECVP 90 will be held at La Cité des Sciences et de l'Industrie in Paris, France, September 4–7, 1990. It will cover, as usual, most of the fields of visual research in psychophysics and neurophysiology. There will be two parallel sessions of free communications and posters covering such topics as the spatiotemporal aspects of visual coding, color vision, clinical aspects, motion, stereopsis, modeling of lower and higher visual processing stages, etc. The ECVP 90 will also include a few invited symposia on multiple scaling and neural networks, eye movements and vision, and parallel visual pathways.

The deadline for the submission of abstracts is February 28, 1990. Mail should be addressed to A. Gorea, Lab. Psychol. Exp., 28 rue Serpente, 75006 Paris, France (E-mail: UPEC010@FRORS31.EARN).