Notes and Comment

The logic of misperceived distance (or location) theories of the Poggendorff illusion

DANIEL J. WEINTRAUB

University of Michigan, Ann Arbor, Michigan

For the Poggendorff display (transversal interrupted by parallel lines), the typical distance-misperception theory postulates that a particular linear distance extending across the empty space between parallels is underestimated; examples are the intertransversal slant distance defined by the closest ends of the transversal segments (a "wings-in Müller-Lyer like" underestimation) or the perpendicular distance between parallels (parallels "attract"). Distance misperception by itself, however, can neither establish that perceived transversal misalignment exists for a Poggendorff display nor specify the perceived-location condition(s) that will produce perceptual collinearity. The perceptual displacement vector is introduced as a means of specifying fully the perceptual mislocation (displacement) of one transversal segment with respect to the other. Given this vector information (direction as well as distance), the logical soundness of theories postulating distance or location misperception were evaluated, and they were compared on the basis of extant data. Such vector information can be used to evaluate other classes of theories as well.

The classic Poggendorff display consists of a parallel pair of lines, usually vertical, that interrupt a transversal oriented obliquely. The two transversal segments do not appear to be collinear, although they are. An array of explanatory principles have been proposed for this effect. Greist-Bousquet and associates (e.g., Greist-Bousquet & Schiffman, 1981, 1985; Greist-Bousquet, Schiffman, Dorsett, & Davis, 1989a) have been actively promoting a distance-misperception hypothesis grounded on the Müller-Lyer (arrowhead) display, arguing that misperception of the distance between the arrowheads is applicable to the Poggendorff display. They have been challenged by Trueman and Wilson (1989) and Day, Jolly, and Duffy (1987). Some years ago, my decision was to reject a parallels-attract version of the distance-misperception hypothesis (Tong & Weintraub, 1974; Weintraub & Tong, 1974). The time is clearly ripe for a re-evaluation.

As an introduction to the issues and logic underlying misperceived-location (which includes misperceived-

distance) theories, I will review the basic assumptions of Greist-Bousquet et al. (1989a). Next, I will describe an aid in resolving logical problems—a suitable geometry for understanding and evaluating such theories, whose cornerstone is a useful explanatory construct, the perceptual displacement vector. I will conclude with a modest assortment of published evidence (most often dusty but serviceable *Perception & Psychophysics* data from my own laboratory), recast to fit this geometry (a model in the descriptive sense) so that the theories and the data can be compared.

Location-misperception theories form a class. Goals might be to choose among them, or to try to reject the entire set. Predicting Poggendorff collinearity errors from data that reveal the perceived location of the transversal segments has merit. The geometric approach also has general relevance for other classes of Poggendorff theory—for example, for evaluating tracking direction or transversal orientation by means of perceptual vectors.

At issue are two perceptual processes that are related via perceptual plane geometry: the registration of collinearity (alignment) among lines and/or points (in a plane perpendicular to the observer's line of sight), and the registration of the distances between such geometric elements. The appearance of misalignment for truly collinear transversal segments is a manifestation of an underlying process or processes. Nevertheless, the perceptual misalignment may well be caused by misperceived distance rather than by misperceived alignment. Furthermore, a method that can serve to null the perceived misalignment does not thereby establish its cause. For example, moving parallels farther apart can null an error that is actually the result of perceptual mistracking, rather than misperception of the parallels as being too close together, a procedure used by Zanuttini (1976).

Figure 1A depicts the classic Poggendorff display and two variants, the obtuse-angles-only and acute-angles-only versions. Greist-Bousquet et al. (1989a; Greist-Bousquet, Schiffman, Dorsett, & Davis, 1989b) postulated a geometric equivalence between the Poggendorff and Müller-Lyer displays. Note (Figure 1A) that for obtuse-angles-only and acute-angles-only Poggendorff displays, both sets of remaining lines bear a gross resemblance to the *wings-out* Müller-Lyer figure. Furthermore, both sets of remaining lines include the transversal segments, a *sine qua non* for a judgment of transversal collinearity. However, Greist-Bousquet et al. (1989b) argued for the equivalence depicted in Figure 1B, which is carried by two truncated vertical segments from the Poggendorff parallels matched with two similarly oriented wings from the Müller-Lyer display. Their equivalence elements linking the Müller-Lyer display to the Poggendorff display constitute shaft-

Correspondence should be addressed to D. J. Weintraub, Psychology Department, Perry Building, 330 Packard Rd., Ann Arbor, MI 48104-2994.

Figure 1. Structural equivalences between the Poggendorff and Müller-Lyer illusions (panel 1B is based on Greist-Bousquet et al., 1989b).

less Müller-Lyer figures (with two of the four wing segments missing) embedded in the Poggendorff display. None of these equivalence segments is required for judging Poggendorff collinearity.

Logically, distance misperception for the Müller-Lyer display itself must occur along the axis of the shaft between arrowheads. In order for the equivalence to hold, the same should apply to the Poggendorff display; that is, a misperception exists along the extent between transversal segments. As Day and associates (e.g., Day et al., 1987) have emphatically noted, misperceiving this extent cannot itself cause a perceived misalignment of transversal segments (Poggendorff illusion). To highlight for the reader the major logical problem, consider, as in Figure 1C, a pair of collinear transversal segments oriented at 45° from horizontal. Establish two tilted Müller-Lyer wings-in equivalence displays as shown (dotted lines represent imaginary segments) that appear to be similar in most important respects. Imagine that the slant distance between the arrowheads is perceived as too small in each case. Parallels are now inserted in the gap between the original pair of bare transversal segments, vertically in one Poggendorff version, horizontally in the other. The question is, how can perceptual shrinkage along the imaginary slant line between "Müller-Lyer arrowheads"—that is, along the imaginary intertransversal line—cause vertical perceptual displacement (leading to vertical perceptual noncollinearity) with vertical parallels, and horizontal displacement (leading to horizontal noncollinearity) with horizontal parallels?

Problems with Location-Misperception Theories

One aid to understanding location-misperception theories consists of a geometric framework for evaluating their logic and predictions. Stating that the intertransversal Poggendorff distance is perceived as too short will henceforth imply geometrically that the transversal end points

defining this distance have been perceptually displaced closer together. Thus, treating misperceived distance as a consequence of perceptual displacement redirects our focus toward a more precise and geometrically useful construct. The theoretical and experimental goal is to specify the perceptual *location* of the Poggendorff elements on which perceived distance depends.

In the development to follow, when objectively collinear Poggendorff transversals are perceived as noncollinear, the causative factor is assumed to be perceptual displacement (mislocation). *Displacement* means the translation of Poggendorff elements, movement horizontally and/or vertically without rotation. (Transversals are not permitted to be perceptually tilted. Perceptual tracking from one transversal segment to the other is always veridical.) In all cases, the hypothesis is that elements are perceptually misaligned only because they are perceptually displaced.

Since Greist-Bousquet and Schiffman (1981) attributed the Poggendorff illusion to the perceptual shrinkage of the objective intertransversal distance as the result of a wings-in Müller-Lyer effect, Figure 2A represents the assumed perceptual displacement. The two transversals (including the attached vertical lines) are displaced toward each other by an amount v , half of which (i.e., $v/2$) is attributable to the displacement of each side of the display, leaving the shortened perceptual distance, d . Here, lowercase letters will always represent perceptual variables. Thus, in Figure 2A, $v/2 + d + v/2 = D$, the objective intertransversal distance. The reorientation of the Poggendorff parallels in Figure 1C was meant to suggest that the perceptual displacement of two transversal segments is not occurring along the imaginary line connecting objective transversal end points when the perceived distance, d , is less than the objective distance D . In Figure 2A, perceptually displacing transversal end points solely along this imaginary line can lead to no Poggendorff illusion at all, regardless of whether perceived distance, d , is too short or too long. Any perceptual-displacement hypothesis must account for the initial misperception of truly collinear segments, as in Figure 2A.

Explaining the original Poggendorff transversal misalignment without additional explanatory principles is step one. The theory must also explain how perceptual collinearity is achieved by displacing a transversal downward

Figure 2. Distance misperception depicted on the Poggendorff display as perceived distance, d , and its associated perceptual distance error v . The downward displacement of the right transversal necessary to achieve perceived collinearity is labeled E .

a given amount E to cancel the perceptual misalignment as in Figure 2B. The situation is more conveniently depicted (and visualized) if the left half of the Poggendorff display is considered perceptually stationary and the total perceptual displacement, $v/2 + v/2$, as in Figure 2A, is assigned to the transversal intersection point for the right half of the display, as in Figure 2B. The percept can then be visualized by imagining the right transversal intersection (and the lines that constitute it) to be located at the tip of the arrow representing the total perceptual displacement, v_E (subscripted in Figure 2B because the objective intertransversal distance is now shorter, the subject having moved the right transversal downward an amount E). Given that every E leads to a component of underestimation v_E , then how can such a theory predict which E , and its equivalent v_E , will achieve the desired perceptual transversal collinearity?

The lead-in to a formulation of perceptual displacement theories, in general, explores the usefulness of experimentally determining perceived intertransversal slant distance, d . Figure 2C illustrates the possible perceptual circumstances associated with a given value of perceived slant distance, d . Again, consider the left half of the display as perceptually fixed, and the perceptual displacement to be assigned to the right transversal intersection. The circular arc, the locus of equal perceived distances (generally taken to be an underestimate of true slant distance D), can be plotted. But perceived distance underestimation, d (reported by Greist-Bousquet & Schiffman, 1981), is not, by itself, sufficient to establish that a Poggendorff effect exists. When d terminates at Position (1) in Figure 2C (the dashed lines that include this point represent the *perceptual* location of the right half of the Poggendorff display relative to the left half), the right transversal segment is perceived as lying above the imaginary line that is collinear with the left transversal segment, a typical Poggendorff perceptual-misalignment effect. If perceived distance, d , terminates at Position (2), which is equivalent to Figure 2A, then the misperceived distance, d , will

cause no misalignment; if it terminates at Position (3) or (4), the perceptual outcome is an anti-Poggendorff misalignment. Position (3) does not duplicate the conditions of Figure 2B, because, in Figure 2B, the right transversal has actually been adjusted an amount E by the observer to achieve perceptual collinearity.

Because observers make these distinctions, any distance-misjudgment theory must be able to sort *objective* Poggendorff displays into three categories based on the vertical location of their right transversal: transversals that appear perceptually collinear, too high to be perceptually collinear, or too low. To sort, it is necessary to know the location of one perceived transversal intersection relative to the other in both distance and direction.

Perceptual Plane Geometry: The General Case

In all instances, lowercase letters represent perceptual variables. A convenient way to represent perceptual displacement is to use a perceptual displacement vector, the pdv, whose length is v . Let the objective Poggendorff display be drawn in its plane as in Figure 3A. The left half of the display, as usual, is considered to be perceptually fixed, and the total perceptual displacement v is assigned to the right half of the display (consisting of the right parallel and its attached vertical line). The right transversal intersection is the origin of the pdv with v as the pdv length. Thus, v retains its meaning as developed in the discussion concerning Figure 2. However, in Figure 3, the termination point of the perceptual displacement vector is no longer constrained to lie along the imaginary intertransversal line (nor is objective intertransversal distance the sum of perceived distance plus pdv length) as in Greist-Bousquet and Schiffman (1981) and in Figures 2A and 2B of this presentation. Therefore, the tip of the pdv, which represents the perceptual location of the transversal intersection associated with the right half of the display, is not specified in advance. One can visualize how the objective Poggendorff display of Figure 3A will appear perceptually, by imagining the right transversal in-

Figure 3. Specifying perceptual displacement by means of a perceptual displacement vector. The dashed line marked LOCUS in panel 3B is the locus of all such vectors producing the given E . Panel 3C represents a parallel "attract" hypothesis.

tersection (and the lines that constitute it) to be relocated to the tip of the pdv (as indicated in the figure by the heavy dashed lines).

The pdv is not an entity that can be perceived, but it is a way of representing the spatial discrepancies between the percept and the objective display. The pdv specifies the perceptual relocation of the right half of the display relative to the left. In Figure 3A, the observer can be expected to perceive the distance, d , and the direction between transversal intersections represented in the percept. (Remember, theory assumes that the observer does not mistrack.)

Both the direction and length v of the perceptual displacement vector are crucial for specifying a Poggendorff effect. An important reference line in Figure 3A is the true collinearity line extending from the lower left transversal across the space between parallels. Any pdv that terminates on the upper side of the true collinearity line produces a perceived collinearity error typical of Poggendorff displays (right transversal perceived as too high, such as the pdv shown). A pdv terminating on the true collinearity line produces no error. A pdv terminating on the lower side of the line produces an anti-Poggendorff perceptual error (right transversal perceived as too low). Note that perceived distance, d , can be less than, equal to, or even greater than the objective slant distance D while producing a Poggendorff effect. Finally, perceived distance, d , is not to be thought of as a fixed percentage of D , the objective distance. The two are not proportional, but rather can be represented as two sides of a triangle whose third side is the pdv.

The perceptual displacement vector itself can be considered as a sum of horizontal and vertical vector components. If the pdv has a zero vertical component, then parallels "attract" (pdv would point horizontally leftward in Figure 3A) in order to produce a typical Poggendorff effect. If the pdv has a zero horizontal component, then a typical Poggendorff effect requires that transversal intersections be farther apart vertically (pdv would point vertically upward in Figure 3A).

Nulling an error can be effected by translating (without rotation) the right side of the objective display in any manner that puts the tip of the pdv onto the true collinearity line associated with the left transversal. In a typical experiment, the right transversal segment is translated vertically by the subject along the right parallel to achieve perceptual collinearity. Figure 3B represents the objective display after the observer has achieved perceptual collinearity. A useful (but not crucial) assumption is that this transversal translation does not change the length or direction of the pdv. Even if the assumption is true, the error-correcting displacement, E , (Figure 3B) is not a measure of the vertical vector component of a pdv. In Figure 3B, the initial pdv (for the objectively collinear display) is shown as an arrowhead at the end of a dashed line. Consider the set of all pdvs with their origin at the transversal end point that terminate somewhere along the line labeled *locus*. This is the set of pdvs requiring the same error-correcting displacement, E . Obviously E measures

the vertical component of the pdv only when the pdv points vertically upward.

Since Figure 3B represents the objective display after the observer has achieved perceptual collinearity, E is known experimentally. Perceived distance, d_E , for this perceptually collinear display can also be assessed with the method of Greist-Bousquet and Schiffman (1981) for example. Angle A and width W , features of the display as drawn, plus E and d_E determined experimentally, permit the pdv to be specified as shown in Figure 3B. First, draw the objective Poggendorff display after perceptual collinearity is achieved. Then, draw the true collinearity line from the left transversal toward the upper right. Then lay off perceived distance along this line. Insert the pdv (whose length will be v_E) as shown, with the end of the vector at the end of d_E (the *perceived* location of the right transversal intersection) and the origin at the objective intersection of the right transversal (depicted after perceptual collinearity is achieved). The calculations rest on the untested assumption that d_E lies along the true-collinearity line (the observer having achieved perceptual collinearity by moving the right transversal downward to place the end of the pdv onto the true-collinearity line). Although d_E is laid out along the true-collinearity line, it does not correspond to the perceived length of the true-collinearity line (the distance, D , in Figure 3A). Rather, perceptual collinearity having been established, d_E is the perceived length of the objectively noncollinear intertransversal distance D_E of Figure 3B. The objective D_E , which can be computed if one knows E , must not be used as a measure of the perceived distance d in the truly collinear display of Figure 3A. Said one more way—there are two physical distances, each with an associated perceived distance: a true-collinearity D and its associated d ; and a D_E that represents the physical distance between transversals after the subject has achieved perceptual collinearity, and its associated d_E . (The two physical distances, each with an associated perceived distance *must be distinguished*; cf. Trueman & Wilson, 1989).

Greist-Bousquet and Schiffman (1981), Trueman and Wilson (1989), and Weintraub and Tong (1974) have employed a dot-setting task that permits the observer to set the distance and orientation between a pair of free-standing dots to match perceptually the intertransversal slant distance and direction in a Poggendorff display. Wilson and Pressey's (1976) method precludes perceived orientation judgments by requiring all dot settings to be oriented horizontally. (See Greist-Bousquet et al.'s, 1989a, criticism of Wilson & Pressey, 1976, in this regard.)

Greist-Bousquet and Schiffman (1981) constructed variants of the classic Poggendorff display (Figure 1) by selectively deleting line segments (including the transversals). An isolated single dot to the right of the display represented the intersection of the left transversal with its parallel. The subject was "instructed to pencil in a small dot relative to the single dot on the stimulus sheet to reproduce the distance and spatial relationship of the dots in the test figures" (p. 158, small dots having been superimposed over the actual Poggendorff transversal intersections).

Therefore, as in Figures 2C and 3A, the perceived orientation of d as well as the distance, d , itself were obtainable from the dot-setting responses. Since objective collinearity of the transversals was displayed to the observers, Figure 3A presents the situation for determining the perceptual displacement vector. Interdot distance was reported; dot-orientation information was not. Perceived distance was underestimated; that is, $d < D$. No data about the Poggendorff collinearity error, E , were gathered, so the existence of a Poggendorff effect was not established for any of the displays. The conclusions that initiate the discussion (p. 161) cannot be substantiated since a given d that underestimates D may be any of those defined by the locus of equal d in Figure 3A. The statement concerning "apparent elongation of the part of the parallel forming an obtuse angle with the transversal" implies a vertical component for the perceptual displacement vector; d alone does not permit the determination of a unique pdv with that property.

Weintraub and Tong (1974) reported dot-distance and dot-orientation information in conjunction with vertical displacement settings, E , that achieved perceptual collinearity directly on the Poggendorff display. A convenient alteration of the typical Poggendorff display omitted the right transversal segment. Consult the inset at the top of Figure 4 (the thinner lines depicting the six types of required judgments). An observer imagined the perceived collinearity line intercepting the upper region of the right parallel and marked the intersection point using a pencil. A second sample of observers was presented with the same transversal-omitted Poggendorff figure in the same position on the display sheet that, in addition, also contained

a single (isolated) dot in the previously blank right half of the sheet. The single dot represented the intersection of the left transversal with its parallel. The observer inspected the Poggendorff display at the left to imagine where the collinearity point would intercept the right parallel, but marked that intercept position, not on the Poggendorff display, but by placing a dot at the equivalent distance and direction in relation to the isolated dot located to the right (as in the Figure 4 inset). In effect, the imagined collinearity judgment was transferred to a pair of free-standing dots as in Greist-Bousquet and Schiffman (1981). Other free-standing dot measurements (with the isolated dot to the right again representing the intersection of the left transversal with its parallel) included determining the length and orientation of the left transversal, T , the shortest distance between the parallels (width W), and an imaginary line across the parallels erected at the end of and perpendicular to the left transversal (designated by an inverted T). Thus, a pair of free-standing dots was used to measure several orientations (tilts) and lengths perceptually.

Figure 4, reproduced from Weintraub and Tong (1974), depicts the orientation (directional) errors in degrees derived from free-standing dots. Three conditions are of primary interest. The first, labeled T , is the orientation of the left transversal as measured by dots representing the left transversal segment itself. The transversal orientation errors imply that the transversals were misperceived in tilt. (These T errors were not used as controls to correct other data.) Judgments labeled C give the orientation (via the two free-standing dots) of the Poggendorff imaginary perceptual-collinearity line. A mark on the right parallel of the Poggendorff figure itself produced downward displacement errors, E , in millimeters, that are converted in Figure 4 to errors in degrees [C] for comparison with C . It is difficult to argue that dot-orientation data provide biased orientation errors, since the errors for perceived tilt of the left transversal, T , hover around zero. Under distance-misperception theory assumptions, the imaginary perceived-collinearity line, C , should reveal the same directional errors as the perceived transversal tilt, T , because there is no mistracking. Both should be zero. Instead, the C data show somewhat smaller but very similar errors to [C] that were measured on the display.

Figure 5 (which includes the relevant directional errors from Figure 4) transforms the Weintraub and Tong (1974) data into perceptual-displacement terms (the three different transversals oriented at three different A angles plotted in one figure to facilitate comparisons). Figure 3B is the appropriate graphical representation (perceptual collinearity achieved). For example, in Figure 5, the true collinearity line for the most acute angle A (22.5°) is the topmost dashed line traversing the distance between the parallels. The E , mean displacement error judged on the figure itself, was 22.51 mm. Dot-pair settings from other subjects determined d_E (49.01 mm) and the orientation error associated with it (-8.69°). Thus, data were available to establish the pdv (length designated as v_E). The theory of Greist-Bousquet and associates predicts that the data

Figure 4. Mean directional errors in degrees based on the dot-setting procedure. Counterclockwise errors are designated as positive. (From Weintraub & Tong, 1974, Figure 4, Experiment 3.)

Figure 5. Representing dot-setting orientation and distance data by means of a perceptual displacement vector and a transversal displacement setting, E . The orientation errors from Figure 4 are included. Data are from Weintraub and Tong, 1974, Experiment 3.

should appear as in Figure 3B, with d_E lying along the true collinearity line. Only in the case of the smallest Poggendorff effect, an E of 2.24 mm, do the data come close.

Weintraub and Tong (1974) favored a perceptual mistracking hypothesis because, in Figure 5, the free-standing dot settings, unconstrained and context free (the dots do not lie on parallels), might have revealed the termination point of the perceptual displacement vector (pdv) as lying on the true collinearity line. Instead, the pdv tended to fall close to the objective line labeled D_E , and that line represents the track if purely mistracking were taking place. Second, the length and orientation of the pdv might indicate perceptual shrinkage as postulated by Greist-Bousquet and associates, or the fact that free-standing dots themselves are misperceived as too far apart. Since dot settings underestimate all objective distances (including estimates of transversal length itself; see Figure 5, lower left), Weintraub and Tong argued that the dot pairs are perceived as too far apart by a given percent of objective distance, and this percentage should be applied as a correction to distance judgments. Although these data were gathered without the benefit of a coherent geometric framework for theory evaluation, my claim is that they contribute diagnostic data to the perceptual-mislocation debate. (These data incline me toward some version of a mistracking hypothesis.)

Evidence Favoring Perceptual Displacement Theory

Distance-misperception theories of the Poggendorff do not deserve to be dismissed summarily. A logical and simple version is that "parallels attract"; that is, the perceptual displacement vectors point horizontally toward the opposite parallel. How far can such a parallels-attract model be taken? Distance-misperception hypotheses must ultimately provide explanations for independent variables that strongly influence perceptual collinearity. Two such variables are the distance between the parallels and the size of the acute angle A between transversal and parallel. Data from Weintraub and Krantz (1971) are reproduced in Figure 6. Assume that the perceptual displacement vector terminates on the true-collinearity line (after perceptual collinearity is achieved), and that only a horizontally directed pdv is admissible as depicted in Figure 3C. It can be seen that, given angle A , the vertical error correction in millimeters can be converted into v_E , the length of the pdv. Let E be the error correction in millimeters (not degrees). From Weintraub and Krantz (1971), $E = .162 W \cot A$, where W equals the width between the parallels in millimeters. (Unknown to us at the time of publication, Burmester, 1896, had performed much the same experiment, proposed the identical formula, and determined the constant to be .19.)

Thus,

$$E = kW \cot A \text{ (note: } E = 0 \text{ when } A = 90^\circ\text{);}$$

$$\cot A = E/v_E \text{ from Figure 3C, rearranged as}$$

$$v_E \cot A = E.$$

Substituting for E in the original equation, $v_E \cot A = kW \cot A$. And so $v_E = kW$, with k estimated at .18 from the two studies above. Therefore, the assumption that parallels are perceived as too close together by about 18% of objective width accounts for all of the data of Figure 6. Angle A merely determines the appropriate tracking angle across the space between the parallels. Zanuttini (1976) supported the same conclusion empirically, arguing the null hypothesis on the basis of only a few data points. The outcome is compelling enough that a parallels-attract distance-misjudgment hypothesis is worth pursuing even though the evidence is based solely on the vertical transversal correction, E , measured in millimeters. (It is unfortunate that the dot-setting data stand as counterevidence.)

As a topological aside, overall minification of the entire perceptual plane will shrink the perceived distance, d , without disturbing collinearities. (Similarly, a magnifying glass will not disturb collinearities.) Perceptual minification of the space in one dimension (for example, shrinking the entire display perpendicularly to the parallels or obliquely along the intertransversal axis) will not disturb collinearities either.

The reader might infer that the derogation of distance-misperception theories is the goal of this exercise. As reader, researcher, writer, and reviewer of manuscripts on these issues, I conclude that new findings never seem

Figure 6. Poggendorff errors as a function of acute angle A and width W between parallels. Dotted lines are derived from $E = .162W \cot A$. (From Weintraub & Krantz, 1971, Figure 1, Experiment 1.)

to resolve any theoretical issues. In words of few syllables—we aren't getting anywhere. Laying out the logical foundations of theories is a high-priority goal that I hope is shared by others groping for the ultimate Poggendorff explanation(s). Misperceived-location theories must have their underlying logic sharpened and be made specific enough so that critics, at least, can evaluate a position on logical and empirical grounds. The proposed geometric framework is useful beyond the act of choosing among distance-misperception theories. The geometry can represent alternative theories, (e.g., perceptual mistracking or misperceived transversal orientation) and suggest converging experimental operations to distinguish among them.

Reformulations or refutations of the logic presented in this paper are desirable. Ignoring the formulations of everyone else is what most of us do now, which is per-

haps why the literature on illusions (a word I eschew) has always been in such a muddle. Distance-misperception theories of the Poggendorff anomaly do have merit. Because good theories require sound logic, theoretical proponents will do well to burnish them, not to banish them.

REFERENCES

- BURMESTER, E. (1986). Beitrag zur experimentellen Bestimmung geometrisch-optischer Täuschungen. *Zeitschrift für Psychologie*, **12**, 355-394.
- DAY, R. H., JOLLY, W. J., & DUFFY, F. M. (1987). No evidence for apparent extent between parallels as the basis of the Poggendorff effect. *Perception & Psychophysics*, **42**, 561-568.
- GREIST-BOUSQUET, S., & SCHIFFMAN, H. R. (1981). The Poggendorff illusion: An illusion of linear extent? *Perception*, **10**, 155-164.
- GREIST-BOUSQUET, S., & SCHIFFMAN, H. R. (1985). Poggendorff and Müller-Lyer illusions: Common effects? *Perception*, **14**, 427-444.
- GREIST-BOUSQUET, S., SCHIFFMAN, H. R., DORSETT, R., & DAVIS, J.

- (1989a). 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. *Perception & Psychophysics*, **46**, 501-504.
- GREIST-BOUSQUET, S., SCHIFFMAN, H. R., DORSETT, R., & DAVIS, J. (1989b). A relationship between apparent extent and alignment in the Poggendorff illusion. *Bulletin of the Psychonomic Society*, **27**, 556-558.
- TONG, L., & WEINTRAUB, D. J. (1974). Contour displacements and tracking errors: Probing 'twixt Poggendorff parallels. *Perception & Psychophysics*, **15**, 258-268.
- TRUEMAN, M. T., & WILSON, A. E. (1989). Examination of apparent extent as an explanation of the Poggendorff effect. *Perception & Psychophysics*, **45**, 494-500.
- WEINTRAUB, D. J., & KRANTZ, D. H. (1971). The Poggendorff illusion: Amputations, rotations, and other perturbations. *Perception & Psychophysics*, **10**, 257-264.
- WEINTRAUB, D. J., & TONG, L. (1974). Assessing Poggendorff effects via collinearity, perpendicularity, parallelism, and Oppel (distance) experiments. *Perception & Psychophysics*, **16**, 213-221.
- WILSON, A. E., & PRESSEY, A. W. (1976). The role of apparent distance in the Poggendorff illusion. *Perception & Psychophysics*, **20**, 309-316.
- ZANUTTINI, L. (1976). A new explanation for the Poggendorff illusion. *Perception & Psychophysics*, **20**, 29-32.

(Manuscript received January 31, 1992;
revision accepted for publication August 3, 1992.)