Journal of Experimental Psychology: General
1997, Vol. 126, No. 3, 312–314

0096-3445/97/$3.00

COMMENT

Distortions in Visual Memory: Reply to Engebretson and Huttenlocher (1996)

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P. H. Engebretson and J. Huttenlocher (1996) commented on an article by the authors (B. Tversky & D. Schiano, 1989) in which the authors reported that the same lines or curves were distorted in memory differently when interpreted as graph elements than as map elements. In subsequent work (D. Schiano & B. Tversky, 1992), the authors found a different pattern of error for meaningless lines, a pattern consistent with a well-known perceptual effect, the tilt illusion. Engebretson and Huttenlocher's comment was primarily directed at this tilt-illusion account. The comment presented an alternative explanation that was based on a model of J. Huttenlocher, L. V. Hedges, and S. Duncan (1991) and reported 2 experiments on uninterpreted stimuli. The results of those experiments, however, are consistent with established findings in the tilt-illusion and memory-interference literatures.

People's fascination with errors in memory is ancient, certainly earlier than Cicero's apology for a slip of memory (Small, in press). Speculation about the causes of memory errors is equally ancient. Misperception, interference, assimilation to a schema, service to the self, and biased judgment at retrieval are just some of the causes that have been suggested and supported (e.g., Huttenlocher, Hedges, & Duncan, 1991; Johnson, Hashtroudi, & Lindsay, 1993; Ross, 1989; Tversky, 1981, 1996a, 1996b).

A number of years ago, we began investigating systematic errors in memory for maps and graphs, providing evidence that the same visual stimulus is remembered differently, depending on its interpretation. Engebretson and Huttenlocher (1996) have challenged some of that work. In one study, we presented lines of varying slopes embedded in orthogonal axes as parts of either graphs or maps. For graphs, memory for slope was distorted towards the (implicit) 45° diagonal, but not for maps (Tversky & Schiano, 1989). We reasoned that the diagonal where $x = y$ was a meaningful referent for graphs but not for maps, so that lines should be assimilated to the 45° line for graphs, but not for maps. In a follow-up study (Schiano & Tversky, 1992), we showed that yet a different pattern of error arose when the lines were not interpreted as either parts of maps or of graphs. In this case, memory bias was away from both the axes and the 45° line, consistent with a well-known effect in the perception literature, the *tilt illusion*. This distortion peaks at small angles and is maximized if the inducing line is vertical or horizontal (e.g., Blakemore, Carpenter, & Georgeson, 1970; Carpenter & Blakemore, 1973; see also Bouma & Andriessen, 1970; Wenderoth, Parkinson & White, 1979).

In other studies, we showed that people remembered curved lines as more symmetric than they were whether presented as distributions in graphs or as rivers in maps (Tversky & Schiano, 1989). To explain the entire set of findings, we proposed that both perceptual and conceptual factors affect memory for visual stimuli, as revealed in patterns of errors. The factors we called perceptual are those that operate on uninterpreted stimuli, whereas the factors we called conceptual are those that depend on the meaning or interpretation imposed on the stimulus.

Somewhat later, Huttenlocher et al. (1991) found systematic bias in memory for the location of a dot in circle. In particular, participants reproduced dots as closer to the center of mass of the relevant circle quadrant. As Engebretson and Huttenlocher (1996) summarized:

> Huttenlocher et al. argued that this bias is conceptual, arising after encoding. They argued that participants imposed quadrants on the circle by dividing it along the horizontal and vertical axes. They proposed a model of how these imposed regions are used in estimating the location of an item within a bounded form. The model posits that dot location is encoded hierarchically—at fine-grain and category levels. The fine-grain level consists of an inexact but unbiased representation of the dot's location in terms of polar coordinates. The inexactness comes from imprecise encoding or loss of precision in memory. The category level consists of the quadrant of the circle where the dot was located. According to the model, the inexact fine-grain representation is combined with category level information in forming estimates of location. The use of

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This article was written with the help of funds from Interval Research Corporation.

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> spatial categories affects estimates in two ways—weighting with a category prototype and truncation due to category boundaries. . . . The model posits that a fine-grain value is weighted with a category prototype, which biases reports toward a central value within each category. . . . (T)he weight given the prototype, and therefore the degree of adjustment, varies with the inexactness of remembered values in a category. If remembered values are less exact, then greater weight should be given to the prototype, and the extent of bias toward the central value should be increased. Thus, the model predicts an increase in bias when an interference task is given after encoding. (p. 97)

According to Engebretson and Huttenlocher (1996), "(b)oth Schiano and Tversky (1992) and Huttenlocher et al. (1991) predicted that the general pattern of bias in the experiments should be the same" (p. 98). They then reported two experiments on uninterpreted stimuli that are purported to distinguish between their formulation and ours. Before we respond to their empirical work, two items need to be clarified. First, the experiments that Engebretson and Huttenlocher refer to are from Schiano and Tversky (1992) in which we studied distortions in perception and memory of uninterpreted lines in x–y axes (what Engebretson and Huttenlocher called "ell" frames [p. 96]). The model of Huttenlocher et al. (1991) cannot by itself account for the main focus of our work: the large effects of different meanings on the pattern of distortions in memory for line orientation. Second, Engebretson and Huttenlocher used the term *conceptual* to refer to the categorization process they described. We used the term to refer to interpretations of stimuli. This is a semantic issue, not a substantive disagreement. Unfortunately, some of Engebretson and Huttenlocher's objections to our work come from assuming that we used the term as they did.

In Engebretson and Huttenlocher's (1996) first experiment, participants were asked to reproduce lines in either x–y axes (ell frames) or in x–y axes rotated 90° (vee frames). They found bias

> away from the edges of the frame and the implicit line dividing the frame into two halves. . . . However, the extent of bias for the two frame orientations differs. Near the edges of the frame, the bias is greater for the ell frame than for the vee frame. Near the implicit line bisecting the frame, this pattern is reversed—there is less bias in the ell frame than in the vee frame. (p. 99)

They claim that this is inconsistent with the "perceptual explanation adopted by Schiano and Tversky" (p. 99). First, this claim is directed not against any theory of ours but rather against the standard explanations of the tilt illusion. Second, the finding turns out to be not only consistent with those explanations but supported by them (see Blakemore et al., 1970; Carpenter & Blakemore, 1973; Wenderoth, 1977; Wenderoth, O'Connor, & Johnson, 1986, among others). The differences between ell and vee frames are primarily due to the special status of context lines that correspond to the vertical and horizontal, a fact we and others have long emphasized (e.g., Howard, 1982; Schiano & Tversky, 1992; Tversky, 1981; Wenderoth, 1977).

Engebretson and Huttenlocher's (1996) second experiment also failed to provide a critical test between their conceptualization and ours, but for different reasons. According to Engebretson and Huttenlocher, greater bias should be found when an interference task is given after presentation of the line "because more weight is given to the prototype when the inexactness of remembered stimulus values is increased by an interference task" (p. 102). Their second experiment demonstrates just that. As before, we have no argument with these findings, nor would our account make different predictions. The aim of our research was not to develop a complete model to account for all distortions but rather to demonstrate a new phenomenon, differential effects of meaning on patterns of distortion in memory for line orientation, and to present a plausible account of how these patterns may have arisen, on the basis of the adoption of different reference frames.

At some level, there are provocative similarities between the account of the Huttenlocher group and our approach. Their *prototype* seems to function similarly to our *reference frame.* Both serve to assimilate memory of the to-be-remembered stimulus toward them. We discussed conceptual factors determining selection of a reference frame but did not address the case for uninterpreted stimuli, precisely the case that the Huttenlocher group has investigated. Thus, their research is more complementary than conflicting with ours. Distortion, error, and bias in memory occur for myriad stimuli in many situations, with varying consequences for our lives. Their causes may be complex and difficult to isolate empirically. Indeed, like visual illusions (Coren & Girgus, 1978), memory distortions appear to have multiple causes.

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Received March 13, 1996
Revision received August 20, 1996
Accepted December 28, 1996