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Taking into consideration explanations of perception-action interactions that may be "less dramatic, but more reflective of what happens in the real world"☆

Robert W. Proctor*, Aiping Xiong

Purdue University, United States

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ABSTRACT

Bruce Bridgeman and colleagues reported the first experiments providing evidence of two functionally distinct visual-processing systems. We summarize that work and subsequent research that resulted in modifications of this view. Then, we describe studies of stimulus-response correspondence effects that provide evidence for distinct representations of responses. More recently, Bridgeman and colleagues examined whether "action affects perception", concluding that the phenomena can be more accurately construed as "information affects memory". Although unconvinced about claims of action-affects-perception and embodied cognition, Bridgeman and colleagues concluded that processing of visual information in hand-space is facilitated and cited a phenomenon as supporting evidence. We discuss findings indicating that this phenomenon is due to general spatial coding principles. We think that all researchers should proceed in the manner of Bridgeman of developing novel explanations, devising critical tests between them and alternative possible explanations, and accepting the explanation that best conforms to the results, even if that explanation is a "less dramatic" option.

1. Introduction

In the words of Wolfgang Prinz, the noted perception-action researcher, Bruce Bridgeman was "on a worldwide scale, one of the most prominent scholars of relationships between perception and action in the spatial domain" (cited in University of California News Center, 2016). Three of Bridgeman's most cited articles in the Web of Science directly address perception-action relations (Bridgeman, Kirch, & Sperling, 1981; Bridgeman, Lewis, Heit, & Nagle, 1979; Bridgeman, Peery, & Anand, 1997). In them, Bridgeman and colleagues developed a two-visual-systems account of differences between verbal reports of perceptual experience and influences of the same stimuli on manual responses. In the first half of the present paper, we provide a brief review of those articles and subsequent work related to them by Bridgeman and colleagues. We then link their findings to studies of stimulus-response correspondence effects for relevant and irrelevant spatial information, obtained with wheel-rotation responses, that have been explained in terms of two types of response representations but not linked previously to Bridgeman's work. In the latter half of the article, we review some of Bridgeman's later research on action-affects-perception and embodied cognition, and relate it to experiments on irrelevant flanker-compatibility effects that have been taken to provide evidence that visual information processing in hand space is unique. As the title of our tribute to Bruce Bridgeman is intended to convey, he had an admirable willingness to subject his theoretical views and those of others to stringent tests, and to allow the results of those tests to determine which views were "more reflective of

☆ The quote is the final statement by S. Blaesi & B. Bridgeman, 2015, in their article "Perceived Difficulty of a Motor Task Affects Memory but not Action".

* Corresponding author at: Department of Psychological Sciences, Purdue University, 703 Third Street, West Lafayette, IN 47907, United States.
E-mail address: rproctor@purdue.edu (R.W. Proctor).

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the real world", even if they were the less dramatic accounts.

2. Two systems for visual position perception

Bridgeman et al.'s (1979) study was extremely influential in the study of perception-action relations because it provided the first evidence in normal human participants for a functional distinction between "cognitive and motor-oriented systems of visual position perception" (p. 692; see his mention of this in Bridgeman, 2016). In that study, three participants made saccadic eye movements between the left and right edges of a large random dot pattern at a rate of one per second. The participants were also to make a detection response whenever a target stimulus was displaced from a position slightly to the left of the center to one slightly to the right of center, or vice versa. Periodically, the experimenter stopped the saccade detection sequence and asked the participant to use an unseen pointer to point to the location of a center spot on the target stimulus. Participants often did not detect displacements that occurred near the time of a saccade (saccadic suppression; Bridgeman, Hendry, & Stark, 1975), and the result of interest was that accuracy of pointing to the target location was independent of whether the displacement had been detected. This result was obtained both when the image information was visible (Experiment 1) during pointing and when it was removed (Experiment 2). Bridgeman et al. (1979) interpreted their results as showing "a functional difference in the information available to a subject for spatial and nonspatial tasks" (p. 699) and suggested that this distinction might be the same as the anatomical distinction between "ambient" and "focal" systems (Trevarthen, 1968).

The two other widely cited articles examined implications of the two-visual-systems concept. Bridgeman et al. (1981) used a method in which the target remained stationary but was perceived as being displaced due to step motion (Experiment 1) or sinusoidal motion (Experiment 2) of a background random dot pattern. A condition was also included in which this apparent displacement was canceled by actually displacing the target in the opposite direction. With both types of background motion, the pointing results did not show the full effect of the illusion but they also were not to the location that would be expected if the illusion had no influence. The authors summarized the results as, "In general, the illusions affected pointing less than they affected perceptual experience" (p. 339). Their conclusion was similarly couched in relative rather than absolute terms: "The motor system uses more veridical spatial information and is less affected by relative changes in two retinal systems than is the cognitive system" (p. 336).

Bridgeman et al. (1997) induced a target inside an off-center frame to be perceived as located in the direction opposite that of the side to which a frame was shifted (the induced Roelofs effect; see Fig. 1). In one condition, participants made cognitive responses to perceived target location by pressing one of five keys corresponding to possible target positions. In another condition, the participants were to point at the target location with an unseen pointer. When responding immediately at target offset, all participants showed a perceived displacement of the target in the direction opposite the frame displacement, but only half of the participants showed an effect of the illusion on the pointing task. Bridgeman et al. (1997) concluded that the difference between participants who did not and did show the illusion on pointing responses was due to different strategies: "some responded in a motor mode, whereas others switched almost immediately to a cognitive mode, which brought the illusion along with it" (p. 467). After a 4-s delay, the effect of the illusion on perceived location was still strong, and now all participants showed an effect on their pointing responses. When, in another experiment, participants pointed to the target and judged its location on each trial, both measures showed the induced illusion on immediate responses. Bridgeman et al. (1997) interpreted their entire results in terms of the two visual systems but ended their article by concluding "that the evidence for two distinct functional representations of visual space in humans is strong, but that

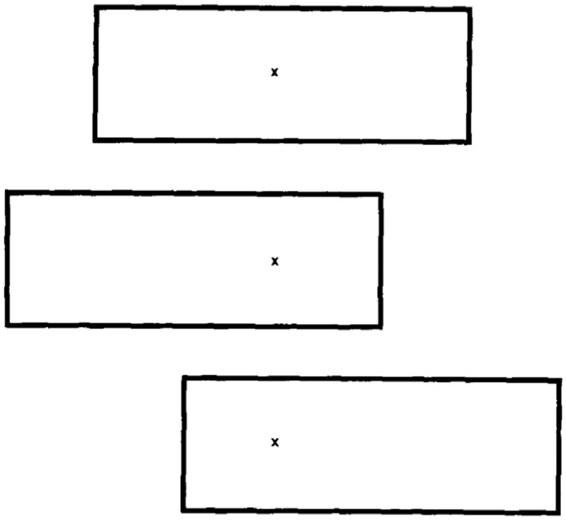

Fig. 1. Stimulus array used in Experiments 1 and 2 of Bridgeman et al. (1997). The frame was centered (top row), offset left (middle row), or offset right (bottom row). The figure shows a target presented at the center position among five positions separated from each other by 2°. Only a single target and frame were shown on a given trial.