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Reflections on Bruce Bridgeman's insights into the Evolution of Consciousness and Cognition

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ABSTRACT

This tribute to Bruce Bridgeman has three parts, which were selected to illustrate his diverse approaches for linking consciousness and cognition. In Part 1 Bridgeman's research on eye movements is used to show how the visual system is functionally divided into two very different streams: the temporal pathway is available for cognitive aspects available to consciousness and the parietal pathway is available to the motor system and is largely unconscious. Part 2 provides links to his *Psycoloquy* article that connects language and consciousness. The *Psycoloquy* format has other scholars write a response and then the author responds to each one. Part 3 covers Bruce Bridgeman's book *Psychology and Evolution*, which is special because it covers many areas with examples not typically treated in introductory psychology textbooks. I decided to quote directly from Bridgeman's writings throughout this essay. I can't think of a better way to pay tribute to him and to inspire others to read his publications.

1. Introduction

I am deeply pleased to write this tribute to Bruce Bridgeman, the third editor-in-chief of *Consciousness and Cognition*. I'll begin by giving my history of how all three editors-in-chief, William Banks, Bernard Baars and Bruce Bridgeman have deeply influenced me. Professor Banks probably had the greatest influence on me. He inspired me to switch from my PhD field of particle physics to his field of vision research during our 12 years of overlap at the Claremont Colleges (1969–1981). It was because of that switch in research fields that I was able to get my position at UC Berkeley starting in 1987. Then starting in 1988, I had many interactions with Bernard Baars who was on the faculty of the Wright Institute, a few blocks from my office. It was just a few years later, in 1992, that Banks and Baars created the journal *Consciousness and Cognition*. And shortly after that, with the help of several of us from UC Berkeley, they created the Association for the Scientific Study of Consciousness (ASSC) with the first meeting in Claremont in 1994. There is no question that the two of them had a powerful impact on my deep interest and involvement in consciousness studies. I am delighted now to discuss Bruce Bridgeman, who has lately had at least as strong an impact on me as the two previous editors of this journal.

This essay for *Consciousness and Cognition* is my attempt to give a glimpse of how Bruce Bridgeman has also strongly influenced me through my recent reading his works. I'll focus on just three of his writings: The first is his paper "Conscious and Unconscious Processes" that is about the dramatic differences between temporal and parietal cortical regions of visual processing. I'm unable to stop wondering and worrying about why just the temporal region is so heavily connected to consciousness. The second part focuses on his paper "On the Origin of Consciousness and Language" (1992) published in the journal *Psycoloquy*. I loved this article largely because of the unusual format of the journal, whereby following Bridgeman's initial article, other scholars write a response and then the author responds to each one. That format not only provided deeper analyses of critical issues, but it also gives a flavor of

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Bridgeman's personality as he responds to 14 scholars many of whom are leaders in the field. However, it was reading Bruce's book *Psychology and Evolution*, which is the focus of the final section of this article that deeply connected me to Bruce the person. I found the book to be one of the most interesting and moving books I've read in ages. It covers many areas with examples not typically treated in introductory psychology courses. Given Bridgeman's enviable knack for writing, the present paper will have many quotations directly from his written work. I think that it is the best way I can pay tribute to him.

2. Two visual systems as a window to consciousness vs. unconsciousness

I found Bridgeman's article "Conscious vs Unconscious Processes" (1992) to be one of the most interesting and provocative essays on consciousness that I've come across. It focuses on the use of eye movements to gain insights into consciousness. I'll begin with his abstract and the first few sentences of the text:

> "***ABSTRACT****. Several lines of empirical research show a contrast between conscious and unconscious functions in humans. Dyslexics show eye movement patterns that concentrate on correct solutions to language problems, even if the patients fail to solve the problems, showing a decoupling of observable behavior from conscious awareness and integrating ability. Vision is represented by many topographic maps in the brain, and these maps can be separated into two streams of visual processing. Only one is available to consciousness; the other controls visually guided behavior. In the laboratory, different spatial values can be stored simultaneously in cognitive and sensorimotor visual systems respectively, and seemingly contradictory spatial behavior can originate from each. Taken together, the empirical studies show important unconscious aspects of mental activity, and a very restricted role for consciousness.*" (p. 73)
>
> ***First few sentences of text:***
>
> "*At one time the study of consciousness was the exclusive domain of the philosopher. In the last few decades, however, empirical work in psychology and neurophysiology has begun to inform efforts at understanding consciousness. This paper reviews some of those efforts, from both my laboratory and others. The first set of examples takes advantage of eye movements as 'windows on the mind'; a second set reviews evidence for two parallel visual systems, one conscious and the other not, that use different aspects of the visual world to carry out different functions.*" (p. 73)

The first sentence of the section titled "Eye Movements and Consciousness" is "*Eye movements present a golden opportunity of psychologists, who are in the business of explaining behavior, for most human behaviors are eye movements".* Those last 6 words are surprising and capture one's attention. Bridgeman clarifies that claim by pointing out that the eyes make finely tuned, one might even say "clever," saccadic jumps about three times per second; that is more than 172,000 jumps in a 16 h day, a number that far exceeds all other movements. Although he didn't use the word "clever," much of his paper is devoted to the awesome topic of how different aspects of eye movements are controlled by two very different parts of the brain. The first paragraph of the section ends with: *"The fact that we are blissfully unaware of them, so much so that they were discovered only relatively recently, speaks to the minor role that consciousness plays in both governing and monitoring behavior."*

The next section of the paper, entitled "Conscious and Unconscious Vision," is the main and largest section of the paper, and it goes into fine details of the two very different visual systems operating simultaneously in our brains. All cortical vision starts in occipital cortex but then branches into two separate pathways. The parietal pathway that is closely linked to a mid-brain structure called the superior colliculus is linked to the motor system. The temporal pathway is the home of the "face" and "place" neurons and is linked to the cognitive system. Bridgeman is careful to point out that one must not take that claim in a totally black and white manner. It is well known that the temporal pathway has an emphasis on the foveal region with high spatial frequencies and for the parietal pathway the fovea is less important. The aspect that was refreshingly novel was that conscious awareness of what we see occurs mainly in temporal cortex. But Bridgeman makes the point that, even with that general awareness, we are blissfully unaware of all the saccadic jumps. That unawareness is not only blissful, it is also one of the great unexplained mysteries associated with neural processing. Learning how brains enable the visual world to appear stable despite so many eye movements will be a major discovery for future neuroscience. The good news is that the brains of macaque monkeys have pretty much the same subdivisions as the human brain, so much has been learned by studying them. So for the topics of consciousness, doing experiments on monkeys may enable one to learn about our neural correlates of consciousness. It is mainly the emergence of language where humans are special as will be mentioned in Section 3.

Bridgeman describes a number of psychophysical experiments that he and colleagues carried out to reveal interesting distinctions between the two visual systems. I was especially interested in his very clever double dissociation paradigm (Bridgeman, Kirch, & Sperling, 1981) where different visual information was used by the motor and cognitive systems. To clarify the setup, I'll first explain what is meant by induced motion. The classic illusion of induced motion occurs when a stationary object is *induced* to appear as moving when its background or surroundings are actually moving. This is sometimes seen when the (stationary) moon appears to "sail" when wind-blown clouds pass in front of it. To send motion signals only to the cognitive system, Bridgeman et al. used stroboscopic induced visual perception judgment. The purely motor stimulus was obtained by using an unseen hand to point to the target. They found that although the illusion is perceptually powerful, one can still point accurately with their unseen hand. Thus, he discovered that the hand (actually, the visual control of pointing) is not affected by conscious experience of the induced motion illusion.

In another set of experiments, Bridgeman and colleagues use the "Roelof's effect" whereby a stationary object appears to jump to the left if the surrounding frame is jumped to the right (Bridgeman, Peery, & Anand, 1997; Dassonville, Bridgeman, Bala, Thiem, and Sampanes, 2004). This experiment discovered strong differences depending on whether the subject responded by pointing or by giving a symbolic number to describe their perception of motion. Using different time delays, they found significant differences in the