Obituary

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BRUCE BRIDGEMAN (1944–2016)

We recently and tragically lost an exemplary scholar and scientist, as well as a treasured spouse, father, and grandfather. Professor Bruce Bridgeman (1944–2016) was in Asia on a speaking tour. The day he was to give his talk at the Medical University of Taiwan, he was hit by a bus while crossing a multilane highway and died instantly on July 10, 2016, at the age of 71. We will miss his colleagueship, intellectual breadth, and quiet good humor.

Bruce was a psychologist and cognitive neuroscientist, fascinated by our ability to perceive and interact with a three-dimensional (3-D) world. His research focused in large part on the interrelationship of perception and behavior. He might say, "What we see depends on how we look and what we are doing." Importantly, Bruce's approach to perception–action systems was highly integrative, generating scholarly contributions that ranged from perception, psychophysics, and behavior to neurobiology, philosophy, and the history of science.

Bruce began his studies of perception as an undergraduate at Cornell, where he learned about the ecological theory of James and Eleanor Gibson, a novel perspective calling for scientists to begin with the perceiver's interactions with the actual environment. This ecological perspective starts with the 3-D "optic array" rather than the two-dimensional retinal image. Bruce went on to earn his PhD at Stanford with eminent brain scientist Karl Pribram. Bruce subsequently received two postdoctoral research fellowships, one from the von Humboldt Foundation to work with Professor O.-J. Grusser at the Free University of Berlin, focusing on interactions of the visual and vestibular (balance) systems, and the other from the National Institutes of Health to work with Professor Larry Stark at the University of California, Berkeley, where he studied eye movements that are essential to visual exploration (Bridgeman, Hendry, & Stark, 1975). In 1973, Bruce joined the Psychology Department at the University of California, Santa Cruz, where he built an international reputation for innovative research on perception and action. In 2012, Bruce was named the Edward A. Dickson Professor of Psychology, having earlier won a University of California, Santa Cruz award for social science research.

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Among his many contributions, Bruce was a leading investigator of the two–visual system hypothesis, which maintains that the brain evolved separate (though interacting) processes: a conscious perceptual process Bruce called the "cognitive" system and a mostly unconscious "motor" system that guides behavior. In several experiments (Bridgeman, Lewis, Heit, & Nagle, 1979), Bruce and his colleagues showed their participants a carefully designed visual target and asked them to report what they saw and also to point toward the target. Their experiments demonstrated that the cognitive and motor visual systems are differentially influenced by context. In a variety of conditions, they found that although participants experienced a "cognitive" illusion, incorrectly perceiving the location or motion of the target, they simultaneously pointed *accurately* toward the target. This was persuasive evidence, substantiated by findings from clinical neurology, that the visual "motor system" enables accurate interaction with the environment despite compelling illusions of conscious perception.

Along with Bruce, we were scholars at Zentrum für interdisziplinäre Forschung in Bielefeld, Germany, when one of us proposed an alternative to the two–visual system interpretation (Massaro, 1990). Bruce was the first to acknowledge Dom's single-system interpretation, and he was quick to inform the other participants about this alternative. This was typical of Bruce's approach to scientific inquiry and life in general. Rather than stand his ground and try to prevail, Bruce was open to alternative ideas, and he always greatly enjoyed the challenge of devising incisive experimental tests.

Bruce also brought vision science to the public arena by analyzing and experimenting with the famous illusions at Santa Cruz's Mystery Spot, where people appear tilted and balls appear to roll uphill. In one of the many visual illusions experienced in this popular tourist attraction, a hanging object appears to be of different weights when pushed from one side or the other. The object is hung in a tilted cabin, and Bruce found that inconsistent impressions of its weight depend on the visual context of viewing and pushing the object toward what appears to be an uphill relative to a downhill position (Bridgeman, 2005). Of course, this explanation might puzzle the typical tourist who is more easily convinced by the mysterious "gravitational vortex" explanation proselytized by the tour guides. Given a few minutes, Bruce would have been delighted to teach the visitors how these "mysteries" arise from normal interactions of the visual and vestibular systems when confronted with highly anomalous conditions.

Bruce believed that evolutionary principles could unite all the diverse areas in psychological inquiry, as described in his engaging textbook on evolutionary psychology, *Psychology & Evolution: The Origins of Mind,* published in 2003. Bruce's moral values were also integral to his pedagogy. For example, Bruce made the persuasive point that because of its recent evolutionary history as part of our psychological makeup, many people have difficulty with the mathematical concept of exponential increases, and this may explain why they are not able to appreciate the dangers of exponential population growth and so behave irrationally.

Early in his career, Bruce studied neural processes in the visual cortex of monkeys. His work, in collaboration with Karl Pribram, Nico Spinelli, and others, helped establish our understanding that development of 3-D stereoscopic vision requires normal binocular visual experience during a critical period early in life, roughly before the age of 5 years in humans. Absent such experience, a person (or monkey or cat) will be "stereoblind" for the rest of their life. The scientific evidence was extensive and compelling, and it is still featured in most textbooks in vision, optometry, and ophthalmology.

One of Bruce's most interesting discoveries came as an astonishing personal experience that violated our understanding of visual development. Bruce was stereoblind because, from early in life, he had a visual problem known as exotropia; that is, his eyes diverged, always looking in different directions (commonly called "walleyed"). By selectively alternating fixation, Bruce could choose to see clearly with either eye, one at a time, but he could not see with both eyes together, and therefore his brain did not develop the ability to see stereoscopic depth.

A few years ago, Bruce and his wife, Diane, went to see Martin Scorsese's film *Hugo* at a theater that provided 3-D (stereoscopic) projection. Bruce rented the polarized 3-D glasses, which are needed to separate the images for the left and right eyes. He paid the fee because he knew the special glasses would

eliminate the fuzziness one sees when one views directly the overlapping images of stereo projection. That made the purchase worthwhile, although Bruce understood that he would not experience enhanced 3-D depth perception because he was stereoblind.

Then came the surprise: Contrary to the vast literature on visual development, Bruce experienced 3-D stereoscopic vision for the first time in his life at age 67. In his own words (Bridgeman, 2014, p. 135),

> To my great surprise, I immediately experienced the film in vivid depth. I was enthralled. . . .
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> When the movie ended, we turned in our polarized glasses and walked out into the street. I was astonished to see a lamppost jump out from the background. Trees, cars, even people appeared in relief more vivid than I had ever experienced. . . .
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> In the next few days, I began experiencing the world in a new light. Riding to work on my bike, I looked into a forest beside the road and saw a riot of depth, every tree standing out from all the others, a 3D feast.

Thus, Bruce became one of a very rare—so far, uncounted—group of individuals who have gained the capacity to see stereoscopic (3-D) depth late in life.

Bruce's experience did not fit the prevailing understanding of visual development, but it was quite consistent with more recent discoveries in neuroscience: The brain's functional capacities are not rigidly fixed by early experience and development. Rather, our brains can be capable of remarkable reorganization, known as neuroplasticity, when one encounters a dramatic change such as loss of vision or hearing, even if that change occurs late in life. In this context, however, Bruce's awakening of stereopsis is unusual and all the more satisfying because it was a thoroughly positive development rather than an adaptation to neuropathology. Moreover, it opens a path to devising more effective clinical treatments for many thousands of people who would otherwise be stereoblind for life.

Bruce established an important area of inquiry in behavioral and neuroscience, without brain dissections and without brain scanning resources. He had a comprehensive and thoughtful perspective about all things psychological and beyond. Later, Bruce turned his attention toward challenging questions about the nature and development of consciousness. This work set the stage for his role as editor in chief of the international journal *Consciousness and Cognition*.

Bruce's intellectual curiosity, leavened by his kind demeanor, was rare, to be treasured all the more as academe becomes increasingly specialized and entrepreneurial. Upon hearing of Bruce's tragic death, Professor Vilayanur Ramachandran of University of California, San Diego, whose lab had been looking forward to a visit from Bruce in fall 2016, wrote, "It's hard to conjure up Bruce's image in my mind without feeling good. His facial expression combines wisdom, a slight mischievous twinkle, and patience. . . . If I was stuck on a desert island with a thousand others, I would probably go to him first for help and advice."

We were very fortunate to have known Bruce, and we will pass on his lessons as best we can.

NOTE

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