

Obituary: Bosco Tjan 1966–2016



Professor Bosco S. Tjan died on December 2, 2016, as a result of a violent attack. The accused attacker was one of his student advisees. Bosco was at the pinnacle of a flourishing academic career. He was widely respected by his peers worldwide in the vision science community and adored by students, staff, and faculty at his home institution, the University of Southern California (USC). The nature of his death tragically contrasts with the generous spirit he exhibited in sharing his time and expertise with students and research colleagues who sought his advice.

Bosco used psychophysical, brain imaging, and computational methods to study human visual pattern recognition. He contributed important findings to a wide range of topics in vision science including object and face recognition, reading, spatial navigation, properties of peripheral vision, and the functional organization of the visual cortex. He was interested in the applications of his research, especially to the problems faced by people with impaired vision.

In 1987, Bosco received his B.Sci. degree with honors in computer science from the University of Kansas. He then entered the Ph.D. program in computer and

information science at the University of Minnesota where his first peer-reviewed publication described a query language for database access not related to vision science (Tjan et al., 1993). Soon, however, his interests



Bosco Tjan, Gordon Legge, and Wendy Braje at the Ph.D. graduation ceremony, Northrop Auditorium, University of Minnesota. Bosco and Wendy were research collaborators and Gordon Legge was their Ph.D. mentor. (Photo courtesy of Wendy Braje.)

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were engaged by the research on human vision being conducted in the Psychology Department at Minnesota. His Ph.D. thesis (Tjan, 1996), mentored by Gordon Legge, Dan Kersten, and Bill Thompson, dealt with efficiency for three-dimensional (3D) object recognition and letter recognition. After postdoctoral positions at the Max Planck Institute for Biological Cybernetics, Tubingen, Germany (1997–1998), and the NEC Research Institute, Princeton, New Jersey (1998–2000), he joined the faculty of the Psychology Department at USC (2001). His academic career flourished there in the company of cognitive-neuroscience colleagues Zhong-Lin Lu, Irving Biederman, and others. At the time of his death, he was a full professor in psychology at USC.

In his Ph.D. thesis, Bosco used ideal observer analysis to quantify the information available to human vision in an object-recognition task: “An ideal observer for a task is a decision rule that performs the task at the maximally achievable accuracy, given the amount of noise or uncertainties in the input data” (Tjan 1996, chap. 1). By comparing human and ideal performance on various tasks, he was able to quantify how efficiently human subjects used the available visual information. He was influenced by earlier formulations of optimal decision rules by Hecht, Barlow, and others and particularly by the first use of ideal-observer analysis to study 3D object recognition by Liu, Knill, and Kersten (1995). (In later years, Zili Liu and Bosco became close colleagues and collaborated on several research projects.) In one of his thesis projects, Bosco investigated how efficiently human subjects could recognize simple 3D objects—wedge, cone, cylinder, and pyramid—rendered as line drawings, shaded images, or silhouettes and seen from eight randomly chosen viewpoints. He found that human efficiency was only 3% to 8% (Tjan, Braje, Legge, & Kersten, 1995). This low efficiency means that human object recognition fails to use much of the useful visual information available for pattern recognition. Elsewhere in his thesis and in subsequent research, Bosco studied the basis for this inefficiency in human object recognition.

Bosco had a strong interest in the form-processing capabilities of peripheral vision, motivated in part by the challenges of people with central-field loss from macular degeneration. A widely studied characteristic of peripheral vision is crowding, the interfering effects of nearby stimuli on the recognition of eccentrically viewed targets. For a review of crowding, see Levi (2008). Bosco and his first completed Ph.D. student Anirvan Nandy developed an influential model accounting for the neural underpinnings of the key behavioral properties of crowding—especially the radial/tangential asymmetry in the shape of crowding zones (Nandy & Tjan, 2012). The model builds on the idea that neuron responses and connectivity in visual area V1 are influenced by visual experience with the

statistical properties of natural images. Nandy and Tjan showed that the distribution of image statistics at attended locations in peripheral vision are distorted by saccadic eye movements to the attended targets, assuming a refractory period in the neural excitation caused by the spatial spotlight of attention. This model explains the radial/tangential asymmetry of crowding zones and makes several interesting predictions. One of these predictions refers to the case of people with central scotomas who often adopt a retinal location outside the scotoma for fixation, termed the *preferred retinal locus* (PRL). After a period of adaptation over months, eye fixations and saccadic eye movements are referenced to this new retinal site rather than to the fovea. The Nandy and Tjan model predicts that the image statistics at this new reference point would not exhibit the bias leading to the radial/tangential asymmetry of crowding zones. As a result, over time, cortical connections would reorganize so that the asymmetry in the shape of crowding zones would disappear. Chung (2013) tested this prediction by measuring the crowding zones at the PRLs of subjects with macular scotomas. Consistent with the model, she found that the crowding zones were approximately circular and no longer exhibited the asymmetric crowding typically found at the retinal sites tested. It is likely that the Nandy and Tjan model will continue to have a major impact on empirical and theoretical studies of visual crowding and consequently on our understanding of form perception in peripheral vision.

Bosco was interested in the neural plasticity of the adult visual system, especially in the context of visual impairment. For a review of research on brain plasticity and low vision, see Legge and Chung (2016). To study the capabilities of peripheral vision, it would be valuable to have a model of central-field loss amenable to experimental control. Kwon, Nandy, and Tjan (2013) demonstrated that development of PRL-like behavior could be induced in normally sighted subjects. The investigators trained their subjects in a search task with a retinally stabilized artificial central scotoma. Training proceeded for several hours over several days, interspersed with normal foveal vision. These subjects spontaneously learned to bring targets of interest to a specific location near the boundary of the artificial scotoma, qualitatively similar to the formation of a PRL by patients with natural central scotomas from macular degeneration. This valuable finding may provide a basis for more detailed empirical studies of the oculomotor potential of peripheral vision as a “replacement” for central vision. It remains to be determined how this rapid oculomotor learning observed with artificial scotomas relates to the development of PRLs over a longer time course in people with naturally occurring central scotomas (cf. Crossland, Culham, Kabanarou, & Rubin, 2005).

Bosco's interests in PRL formation and other adaptations to visual impairment were motivated and facilitated by a long-lasting collaboration with Susana Chung, a faculty member at UC Berkeley. They first became acquainted when Susana came to Minnesota as a postdoc near the end of Bosco's Ph.D. program there. In the following years, they collaborated on published studies on reading, crowding, and related topics. This fruitful collaboration, and Bosco's ongoing collaborations with other colleagues, have sadly been terminated by his untimely death.

Bosco was a co-director and founding member of the Dana and David Dornsife Cognitive Neuroimaging Center at USC. Soon after arriving at USC, he played a critical role in establishing the technical specifications and obtaining grant funding for the new center. His research contributions using functional brain imaging were both methodological and informative about cortical processing of visual input. In a particularly clever study, Tjan and colleagues were able to estimate the functional dependence of the functional magnetic resonance imaging blood-oxygen level-dependent (BOLD) response on the amplitude of the underlying neural response (Bao, Purington, & Tjan, 2015). In normal human vision, axons from temporal retina project to the ipsilateral hemisphere, while nasal fibers project contralaterally, crossing at the optic chiasm. In rare cases of achiasma, most or all of the nasal axons do not cross but project to the ipsilateral hemisphere (Hoffmann & Dumoulin, 2014). This unusual retino-cortical wiring produces joint representations of the left and right hemifields in the same area of V1. Bao et al. had the opportunity to study a subject with achiasma. They found that the neural representations of the two hemifields in area V1 are spatially overlapping but noninteracting yet share the same vascular supply. By testing the BOLD response to stimuli presented to symmetrical left- and right hemifield locations, either separately or together, they estimated the functional relationship between BOLD response and neuronal response. Data from their subject with achiasma indicated that the amplitude of the BOLD response has a square root dependence on neuronal response.

Bosco's interest in brain imaging included the impact of visual impairment on cortical organization. In one study, Tjan and colleagues examined the functional changes in visual cortex in a group of subjects with late-onset retinitis pigmentosa (Cunningham, Weiland, Bao, Lopez-Jaime, & Tjan, 2014). The retinitis pigmentosa subjects varied in the amount of peripheral field loss. The investigators found a correlation between the extent and amplitude of tactile responses in V1 and the extent of field loss and acuity reduction. Understanding how visual cortex is recruited for tactile processing in such subjects is relevant to the potential for sight restoration from retinal implants. At the time

of his death, Bosco was the principal investigator on a major multi-institutional grant titled "Human Connectomes for Low Vision, Blindness, and Sight Restoration," funded by the National Institutes of Health.

Bosco served the vision science community through numerous invited lectures and his membership on the National Institutes of Health study sections and editorial boards. In addition to presenting his own research at scientific meetings, Bosco frequently commented insightfully on the work of other presenters. His comments contributed to his international reputation as one of the deep, incisive thinkers in cognitive neuroscience. He was a valued member of the editorial board of the *Journal of Vision*, in which the current article is published. According to the Editor-in-Chief Dennis Levi, "Bosco was one of the most dedicated and unselfish contributors to our field, a thoughtful, brilliant scientist, a wonderful, warm person, and a mainstay on the Editorial Board of *Journal of Vision*."

Bosco is survived by his wife Carissa Pang, his nine-year-old son Daniel Tjan, his brother Kokie Tjan, and his mother Thee-Niang Huang. Bosco and Carissa met while they were students at the University of Minnesota, Bosco as a graduate student and Carissa as an undergraduate majoring in chemical engineering. They were married in 1999. Daniel was born in 2007.

Bosco was well known for his expertise with ideal-observer models, but he is better known for being an ideal scientific role model. He excelled as a mentor, teacher, colleague, and researcher. He was smart but never brash, opinionated but never pedantic, generous but never self-serving, humorous but never derisive. He was a highly accomplished interdisciplinary scholar. Vision science and the research community have been enriched by his many personal and professional contributions.



Bosco Tjan, his wife Carissa Pang, and son Daniel Tjan. (Photo courtesy of Carissa Pang.)

A list of Bosco Tjan's research articles can be found on Google Scholar at <https://scholar.google.com/citations?user=UeE29kAAAAAJ>.

Gordon E. Legge
January 2017

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