

## **Introduction: Walter J. Freeman III (January 30, 1927 – April 24, 2016)**

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The Society lost one its most esteemed members last year. The passing of Walter Freeman III is not just a loss for the Society but for the field of neuroscience as a whole. He was a pioneer in the application of mathematical concepts and analysis to the study of neuroscience and the biological basis of psychology, especially ideas from nonlinear dynamics. While we wish to pay tribute to his accomplishments, we also want to make this personal, since we count Walter as not simply a colleague but also as a dear friend.

Walter originally trained in mathematics and physics at Massachusetts Institute of Technology, moving on to philosophy at the University of Chicago, medicine at Yale, internal medicine at Johns Hopkins, and finally neuropsychiatry at UCLA. He moved to U.C. Berkeley, where he worked from 1959 until his death, and he continued to carry out research and publish right up to his death. His remarkably broad background reveals itself in the enormous breadth of his research. He published more than 450 papers and 6 books. His work ranges from detailed experiments in the neurophysiology of sensation and perception through to the history and philosophy of science. He made exemplary contributions to the field of nonlinear science with his seminal papers and books on the role of nonlinear and especially chaotic dynamics in perception and in generating meaning within the brain. His books *Mass Action in the Nervous Systems* (1975), *Societies of Brains* (1995), *Neurodynamics* (2000) and *How Brains Make Up Their Minds* (2001) have profoundly influenced the course of research in neurophysiology over the past 40 years. He was a strong advocate for the use of techniques based in nonlinear dynamical systems theory for analyzing data from neurophysiological experiments.

Walter's work is exemplary, and his volume of collected papers, *Neurodynamics: An Exploration in Mesoscopic Brain Dynamics*, (Freeman, 2000) beautifully illustrates the evolution of a research program, as he painstakingly moves from linear to nonlinear and then to chaotic ideas and methods. The prologue to this volume is well worth reading even if one skips the papers. He shows how research moves from one set of ideas and methodologies to another as the level and experimental tools of observation change. In particular, Walter's work oscillated between neurophysiological measurement and

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mathematical modeling of the experimental situation and back again, enabling a coherence of progress in both domains. This is quite remarkable given the fracturing and balkanization of research programs today. His research shows why it is essential to have a broad range of tools in one's analytical armamentarium, a lesson that needs to be learned by researchers today who seem all too easily seduced by promises of one size fits all methodologies like factor analysis and its descendants.

Both of us, who studied computer models of multi-agent systems, highly appreciate Walter's pioneering studies of mass action in the nervous system. Through painstaking experimental and mathematical studies, he showed how the behaviour of single neurons, which is highly stochastic with little inter-neuronal correlation, contributes to the behaviour of neural networks and ultimately neural populations where correlations, especially with the environment, become more pronounced and stable. He argued that the appropriate level within the brain for the study of psychology was the mesoscopic level. This idea was initially presented in *Mass Action in the Nervous System* (Freeman, 1975), and later elaborated upon in *Neurodynamics* (Freeman, 2000).

Walter also emphasized the nature of the brain as a complex system, in particular the importance of feedback within and between levels of organization in the brain, including the existence of circular causality. He argued that one should search for psychological states, not in the temporal flow of activity, but rather in its spatial organization. He drew extensively on ideas from nonlinear dynamics in building his case. He placed particular emphasis on the presence of chaotic attractors and their role in manifesting psychological states. This was not theoretical speculation. He backed up these ideas with experiments in the dynamics of the olfactory cortex in which he demonstrated the presence of chaotic attractors and their correlations with olfactory stimuli, described in *Neurodynamics* (Freeman, 2000).

Walter followed a very important trend in neurophysiology that emerged as "activity theory" in Russian neuroscience in the mid-1950s and then made its way to the West in the 1970s. Similar to the positions of Bernstein (1935, 1947, 1996; Bongaardt & Meijer, 2000; Whiting, 1984) and Anokhin (1964, 1975), Walter understood cognition and behavioural regulation in general as an active, generative process that is being constructed on the basis of the situational context and the state of the nervous system. In *How Brains Make Up Their Minds* (Freeman, 2001), he provided a popular account of his ideas, suggesting that brains do not form representations of the world but instead generate meaning and intentions upon which they base their interactions with the world. In doing so he departed from the dominant thinking in psychology at the time though this was welcomed by researchers in embodied cognition and collective intelligence.

Remarkably Walter remained an active researcher throughout his retirement. Indeed his last paper was published just a few weeks before his death. For those who believe that scientific success is the purview of the young they should look to the life and career of Walter as a striking counter-example and role

model. Walter was an inspiration to all who knew him, both as a scientific researcher of the first rank, but also as a husband, father and friend.

On a more personal note, one of us, (W.S.) first met Walter in 1993 at the 23<sup>rd</sup> annual meeting of the Society for Neuroscience. He was pleasant, engaging, humble, and clearly enthusiastic about the subject. We quickly became friends as we both shared the view that neurodynamics is a collective mode of highly stochastic populations and not the result of mechanical transfers of well-defined signals from one neuron to another. Together (W.S. and I.T.) we first met Walter in 1996 when the Society for Chaos Theory in Psychology & Life Sciences held its annual meeting at University of California, Berkeley. Those were halcyon days for the Society and we can still recall how the room where Walter gave his talk was overflowing with people eager to hear him speak. We had a stellar group of speakers that year, but Walter was our nova. A special friendship started when his work in understanding meaning attribution (“How brains make up the minds”) converged with Irina’s work on meaning attribution and embodiment. The three of us also held a special appreciation for how variable and distributed neurodynamics is, and Walter’s support of our models of Ensembles with Variable Structures is in large measure what kept us going. We met Walter at several other Society meetings and enjoyed debating ideas at meals and between sessions. He particularly enjoyed discussing serious topics while walking to and from the conference venue. He actively contributed to Society meetings for several years. We made plans several times to visit him in Berkeley but something always put it off.

Walter did not mind adventures, and his age didn’t slow him down. We remember him sending a photo to us picturing him standing near a huge, larger than human sized wasp nest in Australia. He wrote us in 2004, after his retirement, that he was enjoying time with his family, in particular his 16 grandchildren “from Australia to Alaska to Scotland and all in between.”

We invited Walter to be one of the key speakers when we hosted a NATO Advanced Study Institute at the Lomonosov Moscow State University in 2000. Walter’s durability still amazes us. Unlike much younger participants, Walter, at the age of 74, had more patience and stamina needed to survive the bureaucracy of the Russian Ministry of Foreign Affairs, to follow all the senseless procedures and to obtain his visa, and still arrive in Moscow with his nervous system intact. He delivered an excellent, competent speech but continued to be modest and humble outside of the lecture hall. Whenever we took a photo during sight seeing tours, or even in the official photo of the NATO ASI, Walter took off his hat, and pressed it against his chest. It was the position of an honest, hard-working modest scientist who devoted his life to science and did not ask much in return.

Hats off to you, Walter. We love you very much and you will be always in our hearts.

In recognition of and tribute to Walter Freeman’s lifetime of achievement in neuroscience, we have dedicated this special issue of NDPLS. We have gathered a collection of papers that utilize or expand upon Walter’s work, particularly on mesoscopic brain dynamics and its role in psychological

processes. The papers have been grouped according to focus. The first three papers (Alexandrov, Krylov & Arutyunova; Sulis; Trofimova) are primarily theoretical in orientation, and develop ideas within the Functional Constructivism approach in psychology. Precursors to these ideas figure prominently in Walter's book *How Brains Make Up Their Minds* (Freeman, 2001).

The next pair of papers (Combs & Krippner; Berezin & Gridin) are more philosophical in orientation. A rigorous examination of the philosophical foundations of neuroscience formed part of Walter's work. Both of these papers offer interesting speculations into the nature of dreaming and into novel forms of information representation and processing. Berezin and Gridin presents a novel and intriguing hypothesis, in keeping with Walter's own willingness to look beyond current dogma in his quest to understand neural dynamics.

The final trio of papers (Kuhl, Mitina & Koole; Ryan; Derakhshanrad) apply Walter's ideas in clinical settings. The first paper applies nonlinear dynamics to exploring some aspects of mood regulation. The final two papers explore the use of Walter's notion of circular causality in occupational therapy settings.

We hope that you will enjoy them all as much as we have. They serve as evidence that Walter's work will continue long after his passing.

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