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FAST MOVING FRONTS - 2008

November 2008

PDF

Nikos K. Logothetis & Brian A. Wandell talk with *ScienceWatch.com* and answer a few questions about this month's Fast Moving Front in the field of Neuroscience & Behavior.

Article: Interpreting the BOLD signal
Authors: Logothetis, NK;Wandell, BA
Journal: ANNU REV PHYSIOL, 66: 735-769 2004
Addresses: Max Planck Inst Biol Cybernet, D-72076 Tubingen, Germany.
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SW: Why do you think your paper is highly cited?

Functional magnetic resonance imaging (fMRI) and behavior are the principal ways we learn about human brain activity. The vast majority of our understanding about the brain, however, is derived from electrical measurements of activity in animal brains. fMRI does not measure precisely the same electrical responses—either action potentials or local field potentials—that are measured in most animal experiments. Rather, fMRI measures a blood oxygen level dependent (BOLD) signal.

Our understanding of the brain can be advanced greatly if we learn how to combine the information acquired through these different methods. The *Annual Review* paper we wrote was one of the first papers to summarize our current understanding of the relationship between BOLD fMRI and electrical measurements of neural activity. The review was written to be a resource of references for advanced investigators; it also includes sections that we hope are used by students to learn about the basic principles of these different signal types.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

The paper describes both a number of seminal studies that made fMRI possible and the new physiological/MRI studies that address the nature of the BOLD fMRI signal. We tried to describe various measurement methods and synthesize our understanding of the similarities and differences between these methods.

SW: Would you summarize the significance of your paper in layman's terms?

fMRI is the mainstay of neuroimaging in cognitive neuroscience. The results from fMRI are being applied to a variety of topics that span

clinical applications (pain management), legal applications (lie detection), and education (how children learn to read).

Despite the rush to apply fMRI to important problems, scientists remain unsure about the connection between the fMRI signal and the signals in the fundamental computational elements of the brain (neurons). The review describes what we do and do not know about the fMRI signal. The review aims to show where the fMRI signal can be used to advantage, but also its limitations.

Coauthor
Brian A. Wandell

SW: How did you become involved in this research and were there any particular problems encountered along the way?

NL: I was trained as a neurophysiologist and spent years recording the activity of single units in monkeys trained to perform a variety of perceptual or cognitive tasks. Single-unit recordings also have limitations, as they report the physiological properties of isolated neurons rather than the properties of the networks that underlie any cognitive capacity.

Over the years it became clear to us that a global view of activity, in particular a view that reports feedforward and feedback as well as modulatory effects, would be utterly necessary to ensure correct interpretation and evaluation of electrophysiological results. The development of invasive MRI methods was definitely challenging but also rewarding.

"Functional magnetic resonance imaging (fMRI) and behavior are the principal ways we learn about human brain activity."

BW: Understanding how we see has always been an inter-disciplinary field, spanning behavior, computation, and neuroscience. I was trained to make behavioral measurements and work on computational models. With the invention of fMRI, I was fortunate to be at an institution with colleagues who could help me learn how to measure fMRI signals and study the visual cortex of the human brain.

From the beginning, we recognized that data about the human brain function and structure are precious; but we were always eager to connect human measurements to the neural signals measured in macaque by electrophysiologists. The opportunity to collaborate with Nikos, including on this review, opened up a new range of possibilities for understanding how to combine our work with other types of brain measurements.

SW: Where do you see your research leading in the future?

To a better understanding of the important relationship between brain and behavior.

SW: Do you foresee any social or political implications for your research?

Work in fMRI has been used in many ways which are of broad interest. There is a provocative claim that fMRI of the human brain can provide an objective measure of a person's sensory experience and thoughts. Some propose that fMRI be used to determine whether a person is telling the truth, and this type of evidence has been admitted in courts in India. Others use the method to measure "unconscious evaluation of Black and White social groups," a code for evaluating racism.

Economists and marketing experts want to measure the brain to determine how much a person values a product, while clinicians seek to use biofeedback to help patients control their thoughts and feelings. There has been vigorous criticism, both among scientists and the public, about some of these applications. In our view, powerful applications that benefit society will flow from a better theory of brain and mind. Many current proposals for applications seem premature; but we have noted that historically entrepreneurs are not shy.

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Keywords: functional magnetic resonance imaging, neuroimaging in cognitive neuroscience, electrical measurements of neural activity, blood oxygen level dependent signal, pain management, lie detection.

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