



— **Far Future Advances in Neuroscience**

Mad Scientist 2015: Human Dimension 2025 and Beyond
Building Cohesive Teams to Win in a Complex World

—
27 October 2015

Dr. Amy Kruse

VP & CTO Cubic Global Defense

Outline

01. Who Am I?

02. A Tale of Black Boxes

03. The Art of the Possible

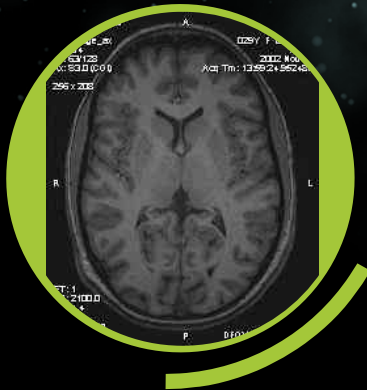
04. What Have We Done?

05. What to Do? Knobs and Gadgets

06. What's Next? Teaming and Connectedness



Who Am I?



Ph.D. in Neuroscience

University of Illinois, Urbana-Champaign

Former DARPA Program Manager

Defense Sciences Office (2005-2010)

Vice President of Innovation

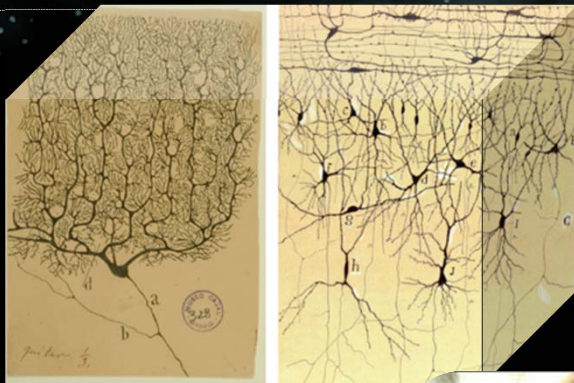
Intific, Inc (2010-Present)

Vice President and Chief Technology Officer

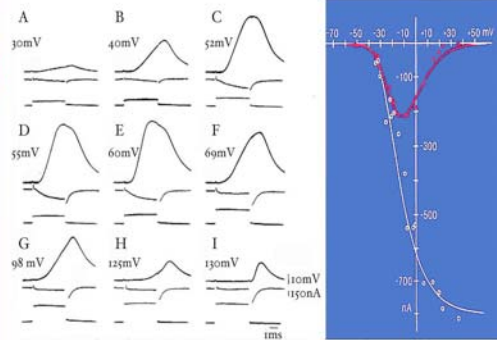
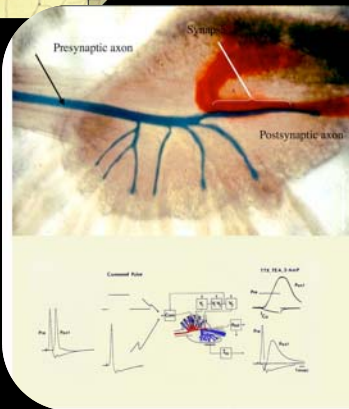
Cubic Global Defense, 2015



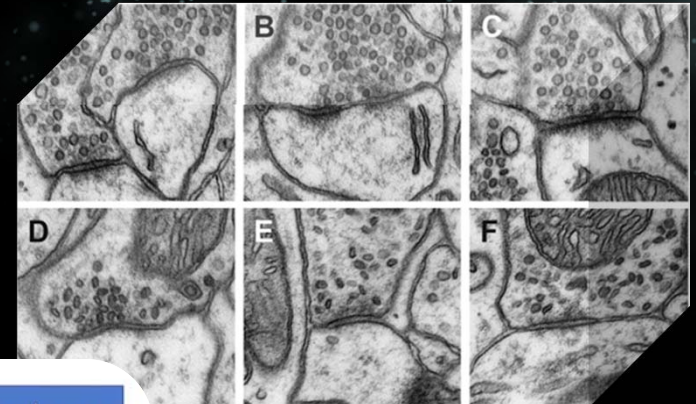
A Tale of Black Boxes



Neuroanatomy



Neurophysiology



Molecular Neuroscience



A Tale of Black Boxes



Electroencephalography
(EEG)

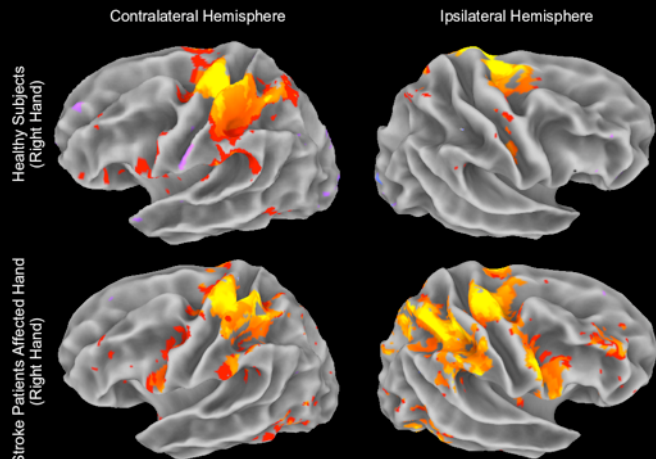
Positron Emission Tomography
(PET)



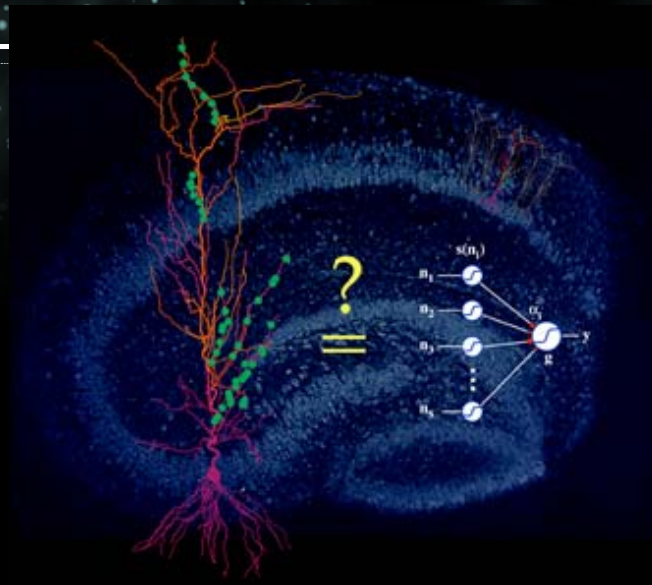
Magnetic Resonance Imaging
(MRI)

A Tale of Black Boxes

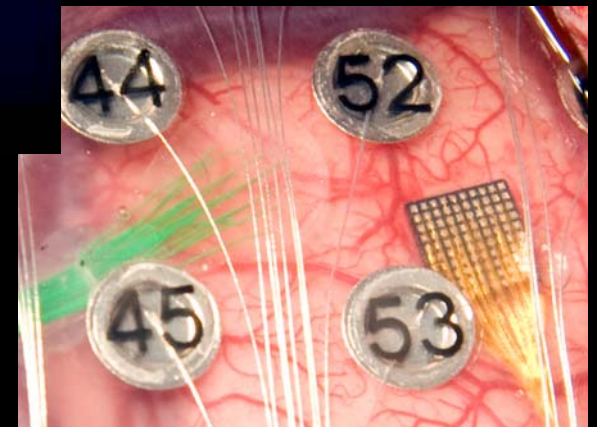
Cortical Activity during Hand Movement



Functional Magnetic Resonance Imaging (fMRI)



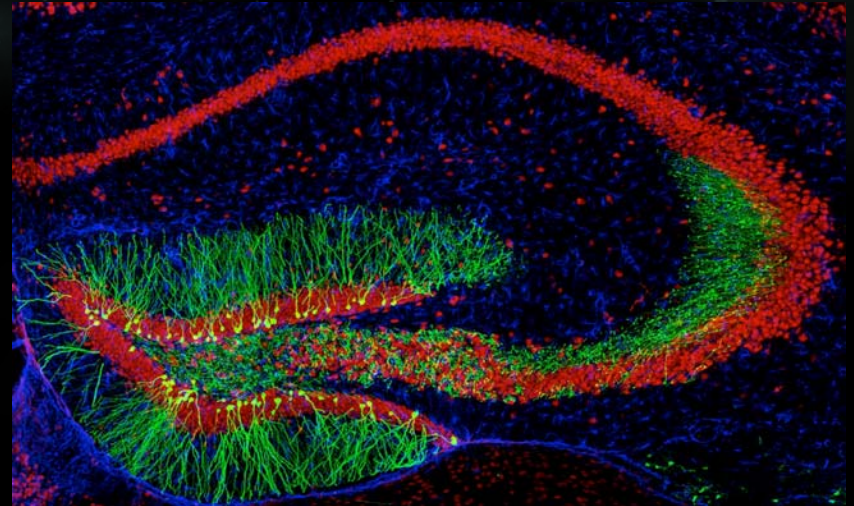
Electrocorticography (eCOG)



The Art of the Possible



From “no new neurons”



To adult neurogenesis!

The Art of the Possible

Neuroplasticity!

The Art of the Possible

Neuroplasticity, also known as brain plasticity, is an umbrella term that encompasses both synaptic plasticity and non-synaptic plasticity. It refers to changes in neural pathways and synapses due to changes in behavior, environment, neural processes, thinking, and emotions – as well as to changes resulting from bodily injury.

The concept of neuroplasticity has replaced the formerly-held position that the brain is a physiologically static organ, and explores how – and in which ways – the brain changes in the course of a lifetime.

Wikipedia

The Art of the Possible



What Have We Done?

WORKSHOP ON INTERACTIVE MEDIA, ATTENTION, AND WELL-BEING

Washington, DC | August 21-22, 2012

SCIENTIFIC ADVISORY PANEL

D. Bavelier, *University of Rochester, USA and University of Geneva, Switzerland*

R.J. Davidson, *University of Wisconsin, Madison*

C.S. Green, *University of Wisconsin, Madison*

L.M. Malamed, *University of Southern California, Los Angeles*

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Contact: C. Steinkuehler-Squire

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Contact: M. Pavel

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In order of appearance

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Jim Shelton

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Daphne Bavelier

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Interactive Media, Attention, and Well-Being

Washington DC, August 21-22nd 2012

A National Science Foundation Report authored by

Daphne Bavelier, *University of Rochester NY, & University of Geneva, CH*

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Richard J. Davidson, *University of Wisconsin, WI*

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www.bcs.rochester.edu/games4good/

What Have We Done?

Social influences on neuroplasticity: stress and interventions to promote well-being

Richard J Davidson¹ & Bruce S McEwen²

Experiential factors shape the neural circuits underlying social and emotional behavior from the prenatal period to the end of life. These factors include both incidental influences, such as early adversity, and intentional influences that can be produced in humans through specific interventions designed to promote prosocial behavior and well-being. Here we review important extant evidence in animal models and humans. Although the precise mechanisms of plasticity are still not fully understood, moderate to severe stress appears to increase the growth of several sectors of the amygdala, whereas the effects in the hippocampus and prefrontal cortex tend to be opposite. Structural and functional changes in the brain have been observed with cognitive therapy and certain forms of meditation and lead to the suggestion that well-being and other prosocial characteristics might be enhanced through training.

**nature
neuroscience**

May, 2012

What Have We Done?

Interventions Shown to Aid Executive Function Development in Children 4 to 12 Years Old

Adele Diamond^{1*} and Kathleen Lee¹

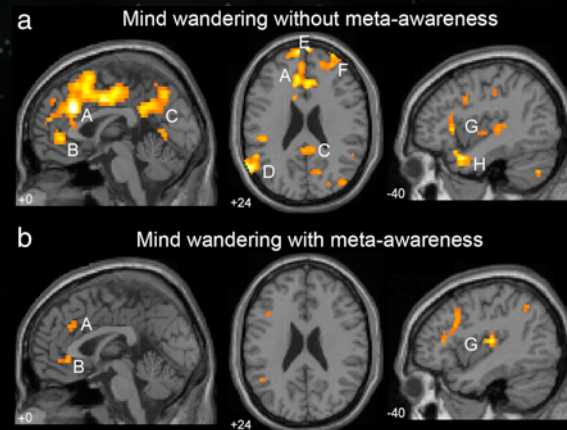
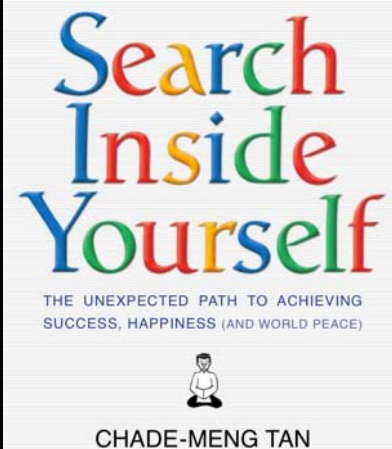
To be successful takes creativity, flexibility, self-control, and discipline. Central to all those are executive functions, including mentally playing with ideas, giving a considered rather than an impulsive response, and staying focused. Diverse activities have been shown to improve children's executive functions: computerized training, noncomputerized games, aerobics, martial arts, yoga, mindfulness, and school curricula. All successful programs involve repeated practice and progressively increase the challenge to executive functions. Children with worse executive functions benefit most from these activities; thus, early executive-function training may avert widening achievement gaps later. To improve executive functions, focusing narrowly on them may not be as effective as also addressing emotional and social development (as do curricula that improve executive functions) and physical development (shown by positive effects of aerobics, martial arts, and yoga).



What to Do?

**IF YOU'RE
WAITING
FOR A SIGN
THIS
IS IT.**

What to Do? ... The Future Now



*“The systematic training of the mind—the cultivation of happiness, the genuine inner transformation by deliberately selecting and focusing on positive mental states and challenging negative mental states—is possible because of the very structure and function of the brain...But the wiring in our brains is not static, not irrevocably fixed. Our brains are also adaptable” (His Holiness the Dalai Lama, *The Art of Happiness*, pp. 44-45).*

What to Do? ... The Future Now



ESCoNS - The Entertainment Software and Cognitive Neurotherapeutics Society

Action video games and neuroplasticity - Daphne Bavelier, Professor of Psychology Université de Genève

Brain training exercises to improve executive function and learning in school children
Bruce Wexler, Professor Emeritus and Senior Research Scientist in Psychiatry
Yale School of Medicine

BrainHQ from Posit Science – clinically validated research for increasing specific cognitive functions

- <http://www.brainhq.com/>

Akili Interactive Labs – Games as Therapeutics

- <http://www.brain.akiliinteractive.com/>



What to Do? ... Cognitive Fitness Level



What to Do? ... Knobs

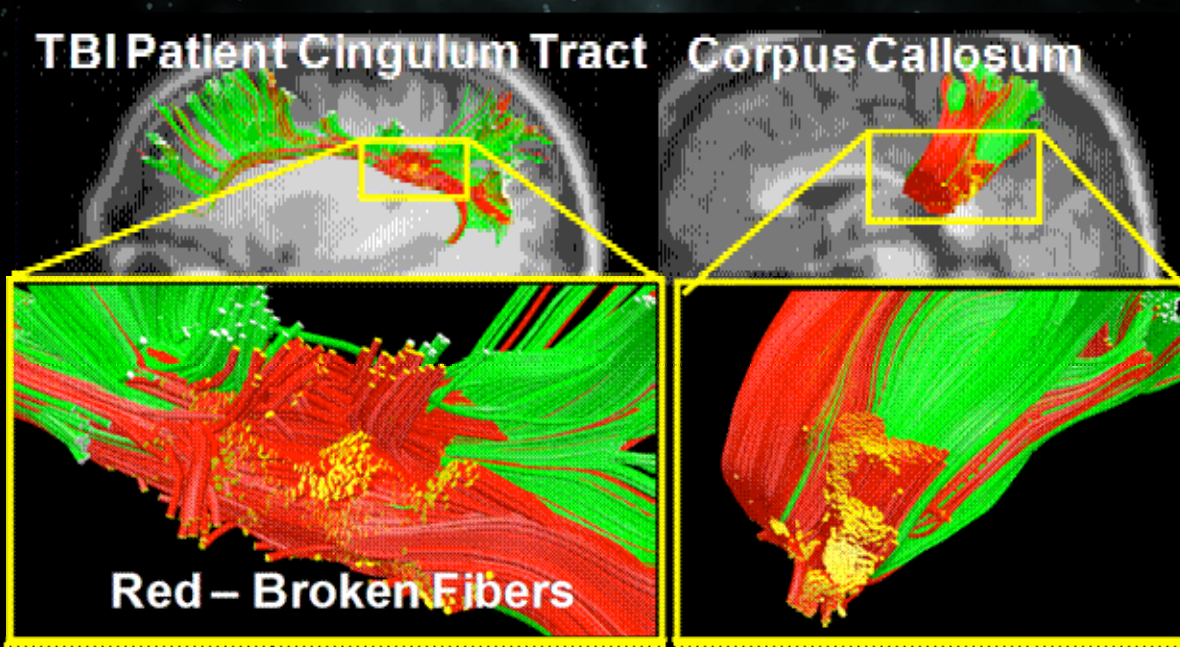


What to Do?

<http://www.lrdc.pitt.edu/hdft/>

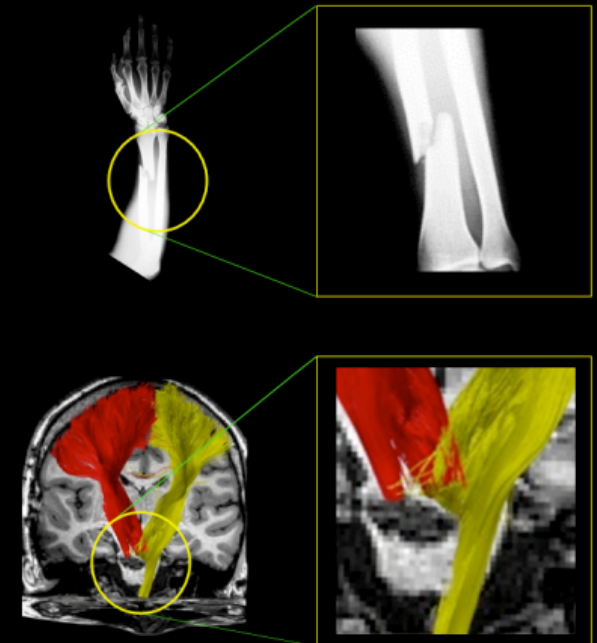
TBI Patient Cingulum Tract

Corpus Callosum



X - Ray

HDFT



Chmura, J., Presson, N., Benso, S., Puccio, A. M., Fissel, K., Hachey, R., Braun, E., Okonkwo, D. O., & Schneider, W. (2015). A high-definition fiber tracking HDFT-brain report for patients with traumatic brain injury and their doctors. *Military Medicine*, 180(3S), 122-134.

What to Do? ... Gadgets



What to Do? ... Gadgets

Subsequent memory effect in intracranial and scalp EEG



Nicole M. Long^a, John F. Burke^b, Michael J. Kahana^{a,b,*}

^a Department of Psychology, University of Pennsylvania, Philadelphia, PA 19104, USA

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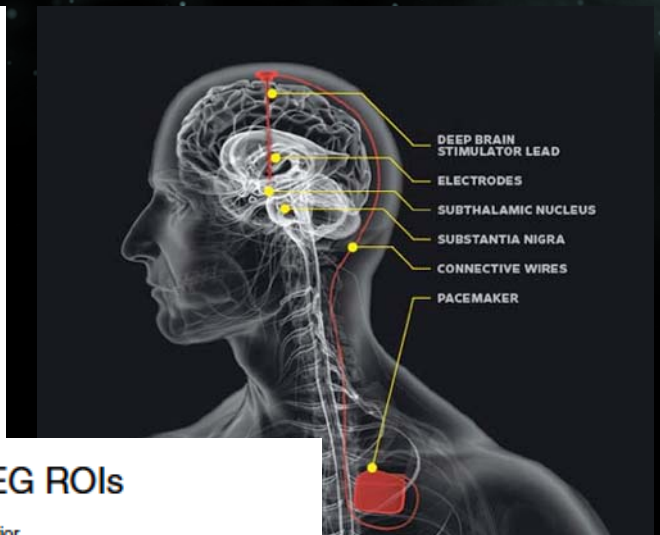
iEEG

Free-recall

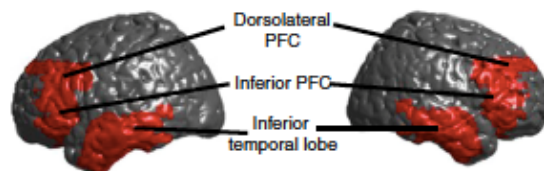
Memory

ABSTRACT

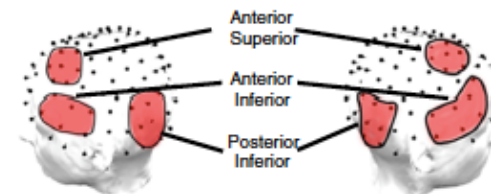
Successful memory encoding is marked by increases in 30–100 Hz gamma-band activity in a broad network of brain regions. Activity in the 3–8 Hz theta band has also been shown to modulate memory encoding, but this effect has been found to vary in direction across studies. Because of the diversity in memory tasks, and in recording and data-analytic methods, our knowledge of the theta frequency modulations remains limited. The difference in the directionality of these theta effects could arise from a distinction between global cortical and deeper subcortical effects. To address this issue, we examined the spectral correlates of successful memory encoding using intracranial EEG recordings in neurosurgical patients and scalp EEG recordings in healthy controls. We found significant theta (3–8 Hz) power modulations (both increases and decreases) and high gamma (44–100 Hz)



iEEG ROIs



Scalp EEG ROIs



Long, N. M., Burke, J. F., and Kahana, M. J. (2014). Subsequent memory effect in intracranial and scalp EEG. *NeuroImage*, **84**, 488–494

What's Next? Teaming and Connectedness



What's Next... Teaming and Connectedness



What's Next... Teaming and Connectedness





Thank you

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