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NEUROLOGY, NEUROSURGERY AND THERAPEUTICS

August 23, 2022 | Webinar

Keynote Forum

35 YEARS OF EXCELLENCE IN MEDICAL PUBLISHING

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Received date: 02-08-2022 | Accepted date: 04-08-2022 | Published date: 29-09-2022

From designs for autonomous adaptive agents to clinical disorders: Linking cortically-mediated learning to Alzheimer's disease, autism, amnesia, and sleep

Adaptive Resonance Theory, or ART, is a neural model that explains how normal and abnormal brains may learn to attend, recognize, and predict objects and events in a changing world, and how memories of learned categories avoid catastrophic forgetting. This lecture uses ART to propose and unify the explanation of diverse data about normal and abnormal modulation of learning and memory by acetylcholine (ACh). In ART, vigilance control determines whether learned categories will be general and abstract, or specific and concrete. ART models how vigilance may be regulated by ACh release in layer 5 neocortical cells by influencing afterhyperpolarization currents. This phasic ACh release is mediated by cells in the nucleus basalis of Meynert that are activated by unexpected events. Art also clarifies data about ACh-mediated tonic control of vigilance. ART proposes that there are often dynamic breakdowns of tonic control in mental disorders such as autism, where vigilance remains high, and medial temporal amnesia, where vigilance remains low. Tonic control also occurs during sleep-wake cycles. Properties of Up and Down states during slow wave sleep arise in ACh-modulated laminar cortical ART circuits that carry out processes in awake individuals of contrast normalization, attentional modulation, decision-making, activity-dependent habituation, and mismatch-mediated reset, among other processes. These slow wave sleep circuits interact with circuits that control circadian rhythms and memory consolidation. Tonic control properties also clarify how Alzheimer's disease symptoms follow from a massive structural degeneration that includes undermining vigilance control by ACh in cortical layers 3 and 5. Sleep disruptions before and during Alzheimer's disease, and how they contribute to a vicious cycle of plaque formation in layers 3 and 5, are clarified from this perspective. ART also explains how feature-category resonances support conscious recognition and surface-shroud resonances support conscious seeing. Lesioning the latter causes clinical symptoms of neglect.

Recent Publications:

1. Grossberg, S. (2017). Acetylcholine neuromodulation in normal and abnormal learning and memory: Vigilance control in waking, sleep, autism, amnesia, and Alzheimer's disease. Frontiers in Neural Circuits, November 2, 2017,

2. Grossberg, S. (2017). Towards solving the Hard Problem of Consciousness: The varieties of brain resonances and the conscious experiences that they support. Neural Networks, 87, 38–95.

Biography

Stephen Grossberg is a cognitive scientist, theoretical and computational psychologist, neuroscientist, mathematician, biomedical engineer, and neuromorphic technologist. He is the Wang Professor of Cognitive and Neural Systems and a Professor Emeritus of Mathematics & Statistics, Psychological & Brain Sciences, and Biomedical Engineering at Boston University.

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