

## **Advances in Brain Sciences 2019: Glimpses of the Future**

***Avital Adler, NYU*** – Plasticity and Stability of Pyramidal Neurons in Learning and Sleep

**Abstract:**

The mammalian cortex has an enormous capacity for learning new information, while maintaining previously acquired memories intact. What are the mechanisms that underlie experience-dependent plasticity in the cortex? How changes of synaptic connections induced by new learning do not interfere with old memory? I will present results demonstrating the roles of cortical inhibitory interneurons and sleep in regulating plasticity and stability of pyramidal neurons in response to motor skill learning. I will show that somatostatin-expressing inhibitory interneurons and CaMKII-dependent synaptic plasticity control the establishment of sequential activity during initial motor training and prevent the interference from new learning. Additionally, by investigating structural re-wiring of pyramidal neurons, namely the formation of post-synaptic spines after motor skill learning, I will show that motor training-induced new spines are not uniformly added along dendritic segments and that post-training sleep governs new spine locations. Together, these results reveal cortical plasticity mechanisms occurring on-line during motor learning and off-line during sleep for information encoding and storage. Finally, I will briefly discuss my future research plans to investigate how sub-cortical neuromodulation orchestrates inhibition and sleep to regulate learning and memory.

***Yoav Livneh, Harvard University*** – Cortical estimation of current and future bodily states

**Abstract:**

Physiological needs bias perception and attention to relevant sensory cues. This process is 'hijacked' by drug addiction, causing cue-induced cravings and relapse. Similarly, its dysregulation contributes to failed diets, obesity, and eating disorders. Human neuroimaging studies implicate insular cortex in these phenomena. However, it remains unclear how 'cognitive' cortical representations of motivationally-relevant cues are biased by subcortical circuits driving specific motivational states. In my postdoctoral work, I approached this question by focusing on both aspects, and how they interact: insular cortex on one end, and hypothalamic neurons driving specific motivational states on the other end (e.g., hunger and thirst). I developed a microprism-based cellular imaging approach to monitor insular cortex activity in behaving mice across different physiological need states. I then combined this imaging approach with circuit-mapping, cell type-specific and circuit-specific manipulation approaches. I will present data from my postdoctoral work using this combined approach to interrogate how InsCtx represents both current and anticipated future bodily states to guide adaptive behavior.

***Shachar Maidenbaum, Columbia University*** – Representations of space and directions in the human brain

Abstract:

Spatial navigation and memory are critical activities for humans. To perform these processes, the human brain represents spatial features of the surrounding environment (e.g. place, head direction, goal location) and of spatial activity within it (e.g. movement, speed, distance, grid). These representations can be seen on many different levels - ranging from micro signals in single cell recordings, through oscillation in local field potentials (recorded via intracranial electroencephalography, iEEG) to macro signals in fMRI and EEG. In this talk I will focus on several directional signals found in human subjects while they performed virtual spatial memory tasks. I will present the existing signals and then focus on two signals we recently found for grid-like representations, hexadirectional modulation of oscillatory power in the theta band (5-8Hz), which is linked to spatial memory and a global heading direction signal. I will present these signals' anatomical prevalence, theories for their underlying basis and their relation to other levels of neural representation, and the way these signals are modulated by external perceptual input (e.g. navigating virtually with different levels of fog) and by internal idiothetic input (e.g. navigating in the real world with Augmented Reality). I will conclude with discussing how directional signals change across different levels of neural representations, their relation to human behavior, and the potential of spatial representations in general as a mechanistic basis for novel biomarkers and therapeutic targets for diseases causing spatial disorientation or memory impairments.

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Wednesday, October 2<sup>nd</sup>

**Assaf Breska, UC Berkeley** – Cognitive and neural mechanisms of temporal anticipation

Abstract:

A key principle of brain function is predicting the future state of the world, and proactively allocating resources to optimize interaction. Recent evidence indicates that this is not confined to anticipating the location (“where”) and content (“what”), but also the timing of future events. I will present a series of studies in healthy and neurological populations, in which I investigated the cognitive architecture and neural basis of temporal anticipation. In the first part of my talk, I will demonstrate that distinct mechanisms support temporal predictions when based on interval representation or on rhythmic streams. Moreover, I will show that prediction in these two contexts causally depends on the cerebellum and basal ganglia, respectively. In the second part, I will present evidence that the cerebellum controls multiple aspects of the neural dynamics of interval-based, but not rhythm-based, temporal prediction. I will also show that a cerebellar representation of isolated intervals is shared across timing domains. Altogether, these findings establish the role of subcortical structures in temporal anticipation, challenging the dominant cortico-centric view.

**Yulia Oganian, UCSF** – The neural code that maps sensory inputs onto linguistic representations

Abstract:

The human ability to understand language relies on a neurocomputational architecture that maps sensory inputs, such as speech and letter sequences, onto linguistic representations. To study this transformation, I combine neuroimaging methods with explicit models linking neural responses to sensory and linguistic content of the signal. I will present two examples of this general approach. First, using intracranial electrocorticography (ECoG) recordings from speech cortex on the superior temporal gyrus (STG) and magnetoencephalography, we discovered the neural code for speech temporal structure: Populations in middle STG represent acoustic onset edges, a marker of syllables in speech. This encoding principle provides a novel alternative to the dominant theory of speech perception based on oscillatory entrainment. Second, we find that language experience shapes processing in speakers of different languages and in bilinguals: Converging evidence from behavior, fMRI and ECoG shows that in visual and auditory cortex shared neural substrates underlie processing of different languages, in line with previous research. However, neural populations also encode language-specific patterns, suggesting that language experience shapes processing throughout the sensory pathways.