MEMORY, COGNITION AND IN BETWEEN

Tel Aviv University, Jaglom Auditorium, Senate Building

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Prof. Noam Sobel, Weizmann Institute of Science

Human olfaction: a constant state of change-blindness

Paradoxically, although humans have a superb sense of smell, they don't trust their nose. Furthermore, although human odorant detection thresholds are very low, only unusually high odorant concentrations spontaneously shift our attention to olfaction. Here we suggest that this lack of olfactory awareness reflects the nature of olfactory attention that is shaped by the spatial and temporal envelopes of olfaction. Regarding the spatial envelope, selective attention is allocated in space. Humans direct an attentional spotlight within spatial coordinates in both vision and audition. Human olfactory spatial abilities are minimal. Thus, with no olfactory space, there is no arena for olfactory selective attention. Regarding the temporal envelope, whereas vision and audition consist of nearly continuous input, olfactory input is discreet, made of sniffs widely separated in time. If similar temporal breaks are artificially introduced to vision and audition, they induce "change blindness", a loss of attentional capture that results in a lack of awareness to change. Whereas "change blindness" is an aberration of vision and audition, the long inter-sniff-interval renders "change anosmia" the norm in human olfaction. Therefore, attentional capture in olfaction is minimal, as is human olfactory awareness. Not all this, however, diminishes the role of olfaction through sub-attentive mechanisms allowing subliminal smells a profound influence on human behavior and perception.

Dr. Yaara Yeshurun-Dishon, Tel-Aviv University

Deeper than you think: partisan-dependent brain response

Recent political polarization has highlighted the extent to which individuals with opposing views experience ongoing events in markedly different ways. In this talk I'll will describe a project aiming to explore the neural mechanisms underpinning this phenomenon. We conducted functional magnetic resonance image (fMRI), scanning right- and left-wing participants watching political videos just before the 2019 elections in Israel. As expected, behavioral results demonstrated significant differences between left- and right-wing participants in their interpretation of the videos' content. Surprisingly, neuroimaging results revealed partisanship-dependent differences in activation and synchronization already in early sensory, motor and somato-sensory regions. These results suggest that political polarization is not limited to higher-order processes as previously thought, and that individuals are seeing and hearing different things not just metaphorically, but also literally.

Prof. Gabriel Kreiman, Harvard University & Boston Children's Hospital

Towards real-world episodic memory formation: behavior, neurophysiology and computation

Our brains are continuously bombarded with both external sensory information and internal processing. A small fraction of those external and internal signals end up being consolidated in the form of episodic memories as a result of complex cognitive processes that filter and interpret incoming inputs. Our understanding of encoding processes in memory formation are mostly derived from laboratory conditions typically involving lists of words or pictures devoid of the fundamental emotional, narrative, and temporal aspects of episodic memory. Here I will describe our efforts towards combining behavioral measurements, neurophysiological recordings, and computational models to shed light on memory formation in continuous real-life scenarios. We used movies as a coarse proxy to examine dynamic formation of memories with rich stimuli. The systematic quantitative metrics for memory formation show that subjects showed consistent and high memorability for short movie events, even single frames, at temporal scales of minutes up to one-year post-encoding, and low memorability for real-life events. I will also describe neuronal recordings from the medial temporal lobe of human epilepsy patients that are beginning to shed light on the biological mechanisms that lead to consolidation of real-world memory events. We developed a machine learning approach that can make accurate predictions about which events people will and will not remember. The computational predictions were almost as accurate as self-predictions or majority-based human predictions, even for single trials and individual subjects. The behavioral, physiological, and computational models provide initial steps towards elucidating the fundamental steps that decide which events are to be remembered.

Prof. Rafael Malach, Weizmann Institute of Science

A neuronal mechanism underlying free behaviors in the human brain

The ability to behave freely - i.e., without being fully controlled by external stimuli - constitutes a fundamental aspect of human nature, underlying a rich space of spontaneous and creative behaviors. However, the neuronal mechanism that enables free behaviors is unknown. In my presentation, I will present the hypothesis that free human behavior is driven by the Ultra-slow spontaneous (also termed resting-state) fluctuations in neuronal-network activity that have been observed across the entire human cerebral cortex. I will present experimental findings derived from two types of free behaviors: free visual recall on the one hand and verbal fluency and creativity on the other. Results from BOLD-fMRI and intra-cranial recordings of single neurons, neuronal groups and the massive synchronous hippocampal events termed Sharp Wave Ripples will be compared. Intriguingly, all these neuronal signals share a common signature of an ultra-slow anticipatory buildup prior to the emergence of a free behavior. Crucially, I will show that the dynamics of this buildup can be predicted by the nature of resting-state fluctuations across individuals.

Prof. Josef Parvizi, Stanford University

Exploring the human mind with intracranial EEG recordings and electrical brain stimulation

Studies of the human brain with intracranial EEG recordings combined with direct electrical stimulation of the cerebral cortex is blossoming in various fields of neuroscience. While some have unrealistic expectations, others remain skeptical or want to learn more about it. How can human intracranial EEG complement other methods of neuroscience beyond simply replicating what is already known, or can be known, from non-invasive lines of research such as fMRI or scalp EEG and how does it differ from single-unit recordings in humans or other mammalian brains? How can we translate our discoveries to the benefit of patients who so graciously donate their time and brains for our research endeavors? How can we ensure that the current reporting of data is optimized and the practice of human intracranial EEG remains ethical? And how can our field incorporate new breakthroughs from material and computer sciences?

Prof. Itzhak Fried, UCLA (USA) and Tel-Aviv University

Epilepsy surgery as a window to brain mechanisms

Epilepsy surgery provides unique intraoperative and extra-operative opportunities to study brain mechanisms of cognition in patients who can declare their percepts, memories, intentions, and emotions. I will discuss how human memory is studied and modulated using recordings of iEEG, LFPs and single-neuron activity, and electrical stimulation. Single neuron recordings in the epilepsy monitoring unit and iEEG recordings in ambulatory patients with chronically implanted responsive neurostimulators show that humans share with rodents hippocampal-entorhinal mechanisms of spatial memory including place cells, grid-like cells, theta rhythm and phase precession. Nonspatial cellular mechanisms of memory in humans include concept cells and a neural code that is highly specific yet invariant, sparse, and associative. Time is represented by various cellular mechanisms operating during tasks and delay periods. Electrical stimulation of entorhinal white matter during encoding enhances retrieval of spatial and nonspatial information and closed-loop electrical stimulation guided by hippocampal slow waves during sleep enhances consolidation and cortico-hippocampal dialogue. These findings may provide a platform for development of neuro-prosthetic devices to assist patient with memory disorders.

Dr. Michal Andelman-Gur, Weizmann Institute of Science

Between dream and reality: perceptual alterations induced by electrical brain stimulation

Electrical brain stimulation is part of the presurgical evaluation in patients with drug-resistant epilepsy. In rare cases, the stimulation may induce experiential phenomena, i.e. vivid experiences created in one’s mind. The most common are complex hallucinations that are percepts appearing without real stimuli, and illusions that are perceptual distortions of sensory stimuli. However, the exact brain regions and neural networks involved in the production of these fascinating responses remain unclear.

In my presentation, I will present experimental findings showing asymmetry in dispersion of visual complex hallucinations induced by brain stimulation, suggesting the existence of a high-level visual neural network, more widespread in the right hemisphere than the left one. In addition, I will discuss a case study of exceptional value, where electrical stimulation of the left superior frontal gyrus produced negative and positive changes in the subjective feeling of volition. This intriguing case study leads to the challenging question of whether volition and its inhibition may coexist, as will be addressed in the talk.

Prof. Michael Kahana, University of Pennsylvania (Upenn)

The recursive mind: implications for memory, mood, and decision making

Learning and memory play a central role in emotional disorders, particularly in depression and posttraumatic stress disorder, and in value-based choice. Here I will present our recent theoretical work applying computational memory models to problems related to mood and choice. The modeling framework - retrieved-context theory - proposes that memories form associations with the contexts in which they are encoded, including emotional valence and value. Later, encountering contextual cues retrieves their associated memories, which in turn reactivate the context that was present during encoding. I will first illustrate how these models account for laboratory studies of emotion and memory. Then I will show how one can extend this approach to account for real-world phenomena including persistent negative mood after chronic stressors, intrusive memories of painful events, the efficacy of cognitive-behavioral therapies, and (even) financial crises. In each case, the key predictions follow from the recursive nature of memory.

Prof. Marla Hamberger, Columbia University

Moving words from unconscious semantic memory to fluid speech

Our knowledge of words and how to use them is a uniquely human form of memory, which, generally, remains outside of consciousness. When this system is intact, speech is fluent and effortless; one word follows the next without hesitation. However, word production is comprised of a multiple, complex, unconscious cognitive processes, and therefore, it is vulnerable to disruption due to damage at any point along this pathway. Hence, the integrity of word production can serve as a sensitive barometer of neurological function. Accordingly, difficulty producing words at will or on command, known clinically as “naming” impairment, can be an early sign of various neurological disorders such as brain tumor, epilepsy, vascular anomaly, or an age-related degenerative process. Additionally, because naming encompasses multiple language processes, object naming is the primary task used with neurosurgical patients to identify and then spare brain regions critical for language with the goal of protecting postoperative language functioning.
Historically, visual object naming has been the most widely used task, both to assess naming ability behaviorally, and to map language areas in neurosurgical patients. However, research has shown that, visual object naming does not reliably identify clinical naming deficits and has failed to consistently identify brain areas that are critical for word production. Considering the auditory-based context when naming difficulty typically occurs, we developed an auditory, more conceptually based naming measure, which has both, identified naming deficits in otherwise undiagnosed patients, and revealed a neuroanatomical distinction between brain areas that

support auditory versus visual object naming. This more detailed understanding of temporal lobe mediation of word retrieval has assisted with lateralization and localization of brain pathology, and has enhanced our ability to identify and protect critical language areas in neurosurgical patients. Our current work moves in several directions - academically, further probing the neurofunctional underpinnings of word retrieval, and clinically, developing techniques to further enhance assessment and protection of naming ability throughout the age span.