IBS CNIR-KSMRM Joint Symposium: Human fMRI

SY17-1

An fMRI connectivity-based signature for pain

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Recent advances in functional neuroimaging, such as functional magnetic resonance imaging (fMRI), has opened up a unique opportunity to measure pain objectively based on brain features without relying on self-report. However, the brain-based marker development efforts have been limited to modeling acute pain with fMRI activation patterns, though their potential for clinical translation is unclear. Here we developed an fMRI signature of tonic pain using machine learning approach to identify multivariate functional connectivity patterns sensitive and specific to tonic pain intensity. The signature showed high sensitivity in predicting within-individual tonic pain ratings across three different studies involving a total of 110 participants (Studies 1-3). In addition, the signature demonstrated high specificity in discriminating tonic pain from other aversive conditions including bitter taste and aversive odor. Furthermore, the tonic pain signature explained between-patients variability of pain scores and predicted placebo-induced analgesia for clinical pain treatment (Studies 4-6, N = 185). This study provides a promising brain-based biomarker for tonic pain that holds high potential for clinical translation.

Keywords : Tonic pain, Functional connectivity, FMRI, Biomarker

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Nonlinear system identification for unraveling neural mechanisms of natural cognition

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An intricate hierarchy of brain areas orchestrates complex cognitive abilities by processing an endless stream of information from the external world. There is a longstanding effort to locate different levels of the hierarchy in the brain, and to reveal the information processing implemented at each level. However, traditional experiments that use artificial laboratory settings have proven to be of limited utility in the study of natural cognition. To surmount this problem, we are pursuing a novel approach that enables the study of brain function during natural behavior. Our approach starts by recording a substantive amount of brain activity during daily-life behavior, noninvasively with functional magnetic resonance imaging (fMRI). The next step is to utilize powerful statistical models to mine interesting patterns in the recorded data. Leveraging this framework, we have recently demonstrated predictions of human brain activity during natural vision with unprecedented accuracy. In addition to advancing our understanding of the visual system, this framework also enables mind reading, i.e. inferring the contents of conscious visual perception merely from brain activity. These powerful models have a broad range of applications from brain-machine interfaces and aids for sensory impairments, to communication with locked-in patients and dream decoding.

Keywords : FMRI, Computational neuroscience, Encoding and decoding models, Machine learning, Natural cognition

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SY17-3

MR Physics Demands of High-Resolution fMRI

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High-Resolution fMRI studies must overcome the limitations imposed by the T2* decay of the signal during acquisition. Reducing the voxel size inherently leads to a reduction in signal strength and thus SNR, which can be partially compensated for by going to higher fields. But decreasing the voxel size also leads to long echo trains in Echo-Planar Imaging (EPI) which is the primary pulse sequence used to acquire data in fMRI studies. Long echo trains result in increased blurring in the phase-encode dimension due to the T2* decay of the signal and this effect is exacerbated at higher fields since T2* is shorter. With the use of higher magnetic fields, the echo time for the optimum BOLD response is also shorter, which will likely necessitate a Partial Fourier acquisition even if in-plane acceleration methods are used. A number of high-resolution fMRI studies dealt with these competing demands by employing multi-shot EPI, however this results in significant loss in either temporal resolution or spatial coverage, or both. Alternate approaches have been developed in an attempt to reconcile these competing demands in order to successfully resolve fine functional structures in the brain. In this talk I will explore the limitations these competing demands put on high-resolution fMRI studies and discuss the pros and cons of various approaches to dealing with those demands.

Keywords : High-Resolution fMRI, Multi-Shot EPI, T2* blurring