Movies in the Magnet: Emerging themes from naturalistic viewing studies in fMRI

Tuesday, Jun 19: 2:45 PM - 4:00 PM 2204
Symposium
Tuesday - Symposia PM

In addition to an ongoing interest in driving the brain in complex, dynamic ways, the need to decrease head motion and to increase scan duration is currently combining with a burgeoning interest in detecting individual differences in the brain to further propel the use of naturalistic paradigms in neuroimaging. The learning outcomes for this symposium provide foundational background information about this emerging subfield (e.g., test- retest reliability, head motion statistics), orient researchers to resources applicable to a broad range of research interests, and set the stage for the next wave of studies by describing novel analytic approaches.

Objectives:
1. Discuss how naturalistic paradigms can target complex cognitive processes in unique ways.
2. Describe how novel analytic approaches leverage the variability and duration of BOLD-signal changes evoked during movie watching.
3. List publicly available databases, paradigms, and analytic tools that have been designed to further the use of naturalistic viewing as an MRI acquisition state.

Target Audience
Because naturalistic viewing paradigms are used across modalities (e.g., fMRI, MEG, EEG), we expect the audience to be fairly diverse, especially including researchers who work with difficult-to-study populations. Additionally, researchers interested in probing high-order cognitive processes using complex paradigms, studying temporal dynamics, individual differences, and more methodological work targeting novel analytic approaches, would find the symposium useful. Finally, we think that the open-science aspect of the symposium will further increase the diversity of the target audience.

Co Organizers
Christine Guo, QIMR Berghofer
Tamara Vanderwal, Yale University

Datablitz Format: This symposium is piloting a new datablitz format at OHBM, with 7 presenters speaking for 8 minutes each. Questions will take place after all 7 presentations are concluded. Speakers for Theme Three were asked to present novel analyses using the same database (Healthy Brain Network Biobank).

Theme One: Advantages of movie paradigms		
1	Christine Cong Guo	Hippocampal connectivity during natural memory retrieval predicts recall confidence
2	Tamara Vanderwal	Individual differences in FC during movie-watching
Theme Two: Using movies with difficult-to-scan populations		
3	Fengji Geng	Memory and hippocampal FC during early childhood
4	Michael Milham	Bringing naturalistic viewing to scale in human and nonhuman populations
Theme Three: Novel movie-based analyses		
5	Simon Eickhoff	Predictability of individual traits across brain states and networks
6	Emily Finn	Linking variation in movie-evoked brain activity to behavioral phenotypes across subjects
7	Alejandro de la Vega	Neuroscout: A turnkey solution for the flexible (re)analysis of naturalistic fMRI data

Presentations

1. Anterior hippocampal connectivity during natural memory retrieval predicts recall confidence.
Presenter: Christine Cong Guo, QIMR Berghofer Medical Research Institute, Australia
Our interactions with the world are constantly influenced by memories of recent life events. This influence, often triggered by perceptual cues, occurs naturally without conscious effort and is essential to our adaptive functioning. Prior research into the neural mechanisms of episodic retrieval has been largely dedicated to voluntary retrieval with deliberate purpose and conscious search effort. Here, we investigated the neural processes underlying spontaneous, involuntary memory using a novel naturalistic paradigm. Healthy participants viewed news clips that were either a continuation of recently viewed clips – hence containing cues relating to recent memory - or naïve clips. Viewing the continuation clips evoked greater bilateral activation in anterior hippocampus, precuneus, and angular gyrus. While these regions manifest reciprocal connectivity across both viewing conditions, continuation viewing specifically modulated the effective connectivity from the anterior hippocampus to precuneus. Intriguingly, this modulation of hippocampus-precuneus connectivity predicts participants' confidence in voluntary recall of news details subsequent to the scan.

2. Individual differences in functional connectivity during movie watching.
Presenter: Tamara Vanderwal, Yale Child Study Center, Connecticut, USA
Previous work has shown that during movie-watching, hemodynamic changes are synchronized across subjects and involve large areas of the cortex (Hasson 2004). Functional connectivity (FC) across subjects is also more strongly correlated during movies than during task-free rest (Vanderwal 2017). It is unclear whether individual differences in functional connectivity are enhanced or diminished under such conditions. Here, we present data from healthy adults scanned during two distinct movie conditions and eyes-open rest. We found that an unsupervised test-retest matching algorithm that identifies individual subjects from within a group based only on FC patterns produced accuracies between 61 and 100%. Overall, pairings involving movies outperformed rest, and the social, faster-paced movie attained 100% accuracy. We also show that movies evoke inter-individual variability in FC with spatial patterns similar to those observed during rest, but that variability in the frontoparietal network is increased during naturalistic viewing. These data suggest that using complex, dynamic stimuli such as movies enhances the detection of FC patterns that are unique at the individual level.

3. Memory and hippocampal functional connectivity during early childhood.
Presenter: Fengji Geng, University of Maryland
Resting-state functional connectivity MRI (rs-fcMRI) maps show robust connectivity between BOLD signal in the hippocampus and multiple cortical regions. Previous studies show that rsfcMRI maps relate to episodic memory in adults (Wang et al., 2010) and children (e.g., Riggins et al., 2016). The present study used the Inscapes movie paradigm (Vanderwal et al., 2015) to examine age-related differences in the relation between hippocampal function connectivity and memory performance in two hundred 4- to 8-year-old children (M=6.2 years, SD=1.5). Results from the final sample of 137 children indicated age-related differences in relations between hippocampal functional connectivity and episodic memory in left lingual gyrus, especially between 5-7 years. The findings are consistent with previous behavioral findings indicating that episodic memory develops rapidly during this developmental period (Riggins, 2014) and illustrate the power of using the Inscapes movie paradigm to acquire rs-fcMRI data from very young children. Fengji Geng will be presenting this work, which was done in collaboration with Tracy Riggins and Elizabeth Redcay.

4. Bringing naturalistic viewing to scale in human and nonhuman populations.

Presenter: Michael Milham, Child Mind Institute, New York, USA

Naturalistic viewing paradigms are gaining increased attention in imaging studies due to their ability to improve scanner tolerability for difficult-to-scan populations (Vanderwal et al., 2015), and due to the range of novel analyses for which they are uniquely suited (Simony et al., 2016). Here, we report on the use of movie-watching in the ongoing large-scale Healthy Brain Network, which is collecting multimodal imaging data from 10,000 children (ages 5-21 years). We will present results from the first 600 participants demonstrating head motion advantages for naturalistic fMRI over resting fMRI in younger children (Alexander et al., in press). We will also discuss comparisons of motion profiles for resting state and naturalistic viewing fMRI in awake, nonhuman primate imaging studies, again demonstrating an advantage for naturalistic viewing (Xu et al., 2018). For both human and nonhuman populations, we present data demonstrating high reliability for the detection of inter-individual differences between states. Finally, we highlight the value of Predictive Eye Estimate Regression as a means of monitoring behavioral compliance during naturalistic viewing.

5. Predicability of individual traits across brain states and networks.

Presenter: Simon B.Eickhoff, Institute of Neuroscience and Medicine, Brain & Behaviour (INM-7), Research Centre Jülich, Germany

It has repeatedly been demonstrated that individual cognitive or socio-affective traits can be predicted from resting-state functional connectivity (FC) data. Such an approach faces three challenges. First, the dimensionality of the connectome is substantially larger than the usually available number of subjects, leading to potential overfitting. Second, if whole-connectome data is used for prediction, selected edges may be hard to interpret, limiting insight into the neurobiology of individual traits. We recently addressed both concerns by showing that robust a priori definitions of functional networks can be derived from coordinate based meta-analyses. FC within these networks then provide features that enable accurate predictions and good interpretability (Pläschke et al., 2017, Nostro et al., 2018). Here we extend this approach to naturalistic viewing data, addressing the third challenge of resting-state data, namely the mixture of trait and (random) state related processes. We predicted individual traits from FC within a priori defined networks during movie-watching using machine learning. These analyses revealed that out-of- sample predictability is dependent on both brain states and networks. Our analyses showed generally higher prediction accuracy using movie stimulation, but also shifts of predictive power for socio-affective traits from interoceptive to exteroceptive networks. The current results open up ideas for the construction of functional assays allowing the probe of network dynamics and the robust prediction of individual traits.

6. Linking variation in movie-evoked brain activity to behavioral phenotypes across subjects.

Presenter: Emily Finn, National Institute of Mental Health, Washington DC, USA

Traditionally, naturalistic tasks have been used to study patterns of brain activity that are shared across the population, but movies also yield brain responses that vary meaningfully across individuals. How can we best pull out shared variance between movie-evoked brain activity and a behavioral phenotype of interest? Using HBN data, I will present results from an extension of the inter-subject correlation (ISC) approach that can identify brain regions that are more synchronized among some pairs of participants than others, and relate similarity of brain activity to similarity on a phenotypic measurement (e.g., the Social Responsiveness Scale, which measures social ability/autistic tendencies). I will show that this technique outperforms other approaches, including traditional regressor-based analyses and functional connectivity, in terms of identifying differences that scale with phenotype. Ultimately, this line of work may help us develop a movie-based brain “stress test” to predict present and future phenotypes in novel individuals.

7. Neuroscout: a turnkey solution for the flexible (re) analysis of naturalistic fMRI data.

Presenter: Alejandro de la Vega, University of Texas Austin, Austin, Texas, USA

The intrinsically high dimensional nature of naturalistic tasks makes them well-suited for exploring a wide-range of novel scientific hypotheses. However, their potential utility is constrained by the resource-intensive nature of fMRI, which is compounded by the high cost of manually annotating psychologically relevant features in these complex stimuli. Here, we present a prototype of a new platform called *Neuroscout*, which enables researchers to rapidly test novel hypotheses by harnessing state-of-the-art feature extraction tools, such as deep learning APIs (Application Programming Interfaces). *Neuroscout* extracts hundreds of novel predictors from publicly available datasets, and allows users to create self-contained executable analyses through a web application. We demonstrate the utility of this approach by fitting a variety of statistical models using automatically extracted predictors on three publicly accessible movie-watching datasets. Across the three datasets, results generally converged with those obtained using conventional experimental approaches, and showed a moderate amount of reliability across datasets, despite using highly distinct movies. These results demonstrate the viability of studying perceptual mechanisms not only under highly controlled experimental conditions, but also under ecologically valid conditions involving complex scene statistics. Furthermore, these results highlight the re-usability potential of rich, naturalistic paradigms that can be tapped in to by leveraging rapidly advancing data mining techniques.