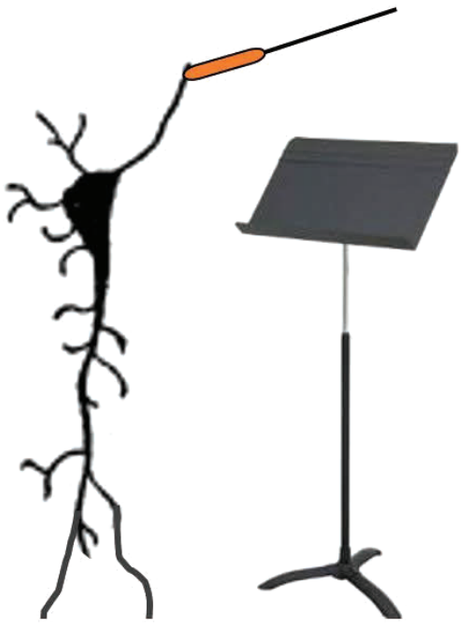
NEUROSCIENCE OF CREATIVITY 2016



9:05 am – Daniel Schacter
Imagination and Creativity:
Functions of Episodic Simulation and Retrieval
Harvard University

9:45 am – Kalina Christoff
Mind wandering as spontaneous thought: A dynamic framework
University of British Columbia

10:25 am –BREAK

10:40 am – Indre Viskontas
The brain basis of musical creativity:
from composition to performance
University of San Francisco, San Francisco Conservatory of Music

11:20-12:50 ABSTRACT PRESENTATIONS DATA BLITZ

12:50-1 pm – Closing Remarks and Future Plans

Friday, November 11, 2016

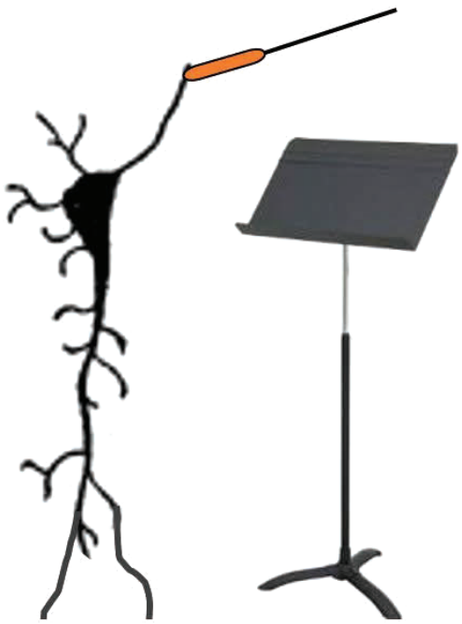
9 am – 1 pm

Manchester Grand Hyatt San Diego
1 Market Place
San Diego, CA 92101
Hilcrest AB

Satellite conference to Society for Neuroscience, 2016

Visit us at: http://tsfnc.org/

NEUROSCIENCE OF CREATIVITY 2016



9:05 am – Daniel Schacter
Imagination and Creativity:
Functions of Episodic Simulation and Retrieval
Harvard University

9:45 am – Kalina Christoff
Mind wandering as spontaneous thought: A dynamic framework
University of British Columbia

10:25 am –BREAK

10:40 am – Indre Viskontas
The brain basis of musical creativity:
from composition to performance
University of San Francisco, San Francisco Conservatory of Music

11:20-12:50 ABSTRACT PRESENTATIONS DATA BLITZ (5 min each)

12:50-1 pm – Closing Remarks and Future Plans

Friday, November 11, 2016

9 am – 1 pm

Manchester Grand Hyatt San Diego
1 Market Place
San Diego, CA 92101
Hilcrest AB

Satellite conference to Society for Neuroscience, 2016

Visit us at: http://tsfnc.org/

KEYNOTES

Imagination and Creativity: Functions of Episodic Simulation and Retrieval

Daniel L. Schacter
William R. Kenan, Jr. Professor of Psychology
Department of Psychology, Harvard University, Cambridge, MA

Abstract

Episodic memory was initially defined as the ability to recollect past personal experiences. However, recent research points toward a role for episodic retrieval in imagining future experiences and divergent creative thinking. This talk will consider both cognitive and neuroimaging studies that attempt to characterize this role, including evidence regarding the role of the default network, how specificity inductions may help to identify underlying processes, and functional contributions of episodic processes. Implications for research on mind wandering will also be considered.

Mind wandering as spontaneous thought: A dynamic framework

Kalina Christoff
Professor of Psychology
University of British Columbia, Vancouver, BC, Canada

Abstract

Mind-wandering has recently come to occupy a central position in cognitive psychology and neuroscience. Most theories and research so far have examined it in terms task-unrelated or stimulus-independent mental contents that occur at particular moments of time. A defining feature of mind-wandering, however, are its dynamics: how thought moves over time. In this talk, I will introduce a dynamic framework for understanding mind-wandering and its neural basis. I propose that mind-wandering is best understood as a member of a larger family of spontaneous thought processes – a family that also includes creative thought and dreaming. I will distinguish between two types of constraints on thought – deliberate and automatic – that can reduce thought's spontaneous movement. Within this framework, fluctuations between spontaneous, automatic, and deliberate modes of thinking correspond to changing interactions among large-scale brain networks. Finally, the framework situates spontaneous thought within a broader conceptual space that allows its comparison to goal-directed thought, as well as to

clinical disorders that make thought excessively constrained – such as in rumination and anxiety, or excessively variable – such as in ADHD.

The brain basis of musical creativity: from composition to performance

Indrė Viskontas
Professor of Humanities and Sciences, San Francisco Conservatory of Music
Adjunct Professor of Psychology, University of San Francisco, San Francisco, CA

Abstract

Musical creativity comes in many forms and its neural basis is a reflection, of course, of this variability. There are a few general principles, however, which will be outlined in this talk, along with an overview of the state-of-the-art of research on the topic and suggestions for future directions. A special emphasis will be placed on the training of creativity in music performance, including observations and insights gained while teaching musicians at the San Francisco Conservatory of Music.

ABSTRACT PRESENTATION DATA BLITZ

1

Dreaming As Intensified Mind-Wandering Enabled By An Augmented Portion Of The Default Network

G. William Domhoff
Department of Psychology, University of California, Santa Cruz

Numerous blind quantitative studies of dream content, including individual dream journals containing thousands of dream reports, demonstrate that dreams contain a wide range of personal concerns, which are then verified by the dreamer and friends of the dreamer. Longitudinal and cross-sectional studies of young children awakened in sleep laboratories reveal that dreaming begins around ages 5-6, reaches an adult level in frequency and complexity at ages 9-11, and only starts to include personal concerns and negative emotions at ages 11-13. A combination of neuroimaging studies and neurological lesion studies suggests that dreaming is based in an augmented portion of the DN, which becomes highly activated and creative when the CEN, the DAN, and the SN are at low levels of activation. It is noteworthy and deserving of further study that the DN develops gradually and only begins to appear adultlike in terms of functional connectivity and integration with the CEN at ages 9-11, about the same time as dreaming becomes more frequent and complex. Based on these findings, it is hypothesized that dreaming is an intensified form of mind-wandering that makes use of embodied simulation and is based in an augmented portion of the DN. Dreaming occurs whenever there is (1) a mature DN; (2) an adequate level of cortical activation; (3) an occlusion of external stimuli; (4) a cognitively mature imagination system; and (5) the loss of conscious self-control due to the deactivation of the CEN and the decoupling of the DAN from the anterior portions of the DN.

2

Thinking cap plus thinking zap: tDCS of frontopolar cortex improves creative analogical reasoning and facilitates conscious augmentation of state creativity

Adam Green
Department of Psychology, Georgetown University
Adam Weinberger
Department of Psychology, Georgetown University
Evan Giangrande
Clinical and Translational Neuroscience Branch, National Institute of Mental Health
Katherine Spiegel
School of Medicine, University of Connecticut
Peter Turkeltaub
Department of Neurology, Georgetown University & Research Division, MedStar National Rehabilitation Hospital

Recent evidence points to neural mechanisms that support acute improvements in creative performance (i.e., augmented state creativity). Neuroimaging of cognitive interventions (e.g., creativity cues) indicates mechanisms by which individuals succeed at consciously augmenting state creativity. Neural interventions via transcranial direct current stimulation (tDCS) indicate encouraging potential for modulating neuronal function during creative performance. Extant evidence leads to new questions. If cognitive and neural interventions are separately effective, can they be used in combination? Does state creativity augmentation represent "real" creativity, or do interventions simply yield divergence by diminishing constraints on meaningfulness/appropriateness? A key question is whether state creativity interventions can bolster creative intelligence, including creative reasoning by analogy that is frequently the basis for innovation. Here, we used tDCS in combination with a creativity cue. tDCS was targeted to potentiate activity in a frontopolar region where activity has recently been shown to predict improvement in creative performance during cued augmentation of creative state. In a novel Analogy Finding Task, participants sought valid analogical connections in a matrix of word-pairs. tDCS elicited formation of substantially more creative analogical connections (creativity was measured quantitatively via latent semantic analysis). Critically, increased analogical creativity was not due to diminished accuracy in discerning valid analogies, indicating "real" creativity rather than inappropriate divergence. A simpler relational creativity paradigm (modified verb-generation) revealed an interaction whereby tDCS facilitated the effect of cuing on creative production. The data support augmentation of creative reasoning via neurostimulation and suggest that tDCS can make it easier to make one's self more creative.

Support:
National Science Foundation (DRL-1420481), The John Templeton Foundation (#51971), and Pymetrics to A.G.; and the NIH/NCATS via the Georgetown Howard Universities Center for Clinical and Translational Science (KL2 TR000102) to P.T.

3

The Flexible Brain: Openness to Experience and Dynamic Brain States

Roger Beaty
Harvard University
Qunlin Chen
Southwest University
Alexander Christensen
University of North Carolina at Greensboro
Paul Silvia
University of North Carolina at Greensboro
Jiang Qiu
Southwest University

Openness to Experience is a personality trait marked by a tendency to engage in imaginative, creative, and abstract cognitive processes. Openness consistently predicts outcomes of central importance to creativity, including high-level creative achievement, everyday creative behavior, and creative cognitive ability. Related neuroimaging evidence suggests that creative cognition and behavior involves flexible and dynamic interactions between large-scale brain networks, particularly those involved in self-generated thought (i.e., default) and cognitive control (i.e., frontoparietal, salience, and dorsal attention). The present research explored the extent to which

Openness to Experience is characterized by functional connectivity among these brain systems. To this end, we obtained personality and resting-state fMRI data from two samples of healthy young adults recruited from the United States (n = 130) and China (n = 256). Dynamic functional network connectivity (dFNC) was used to identify several "brain states" (recurring patterns of brain network correlation) via a sliding window approach, and structural equation models estimated the effects of Openness on the proportion of time that participants spent in these brain states (i.e., "dwell time"). Across both samples, Openness predicted increased dwell time in a brain state characterized by positive correlation among core cognitive brain networks: default, frontoparietal, salience, and dorsal attention. Other personality traits were unrelated to time spent in this brain state, and the effect of Openness remained robust in a model including age, gender, and fluid intelligence. The findings provide cross-cultural evidence for a biological basis of Openness to Experience, and suggest that increased brain network synchrony may account for the enhanced imaginative and creative cognitive abilities of people high in Openness.
Support:
John Templeton Foundation; National Science Foundation of China

4
Using Transcranial Direct Current Stimulation over Prefrontal and Occipital Cortex to Enhance Creativity

Evangelia G. Chrysikou
University of Kansas
Hannah M. Morrow
University of Connecticut
Austin Flohrschutz
University of Kansas
Lauryn Denney
University of Kansas Medical Center

Recent evidence from cognitive neuroscience has shown that inhibitory transcranial direct current stimulation (tDCS) over left prefrontal cortex (PFC), relative to excitatory or sham stimulation, can improve performance on creative thinking tasks; studies have also suggested that such tasks may benefit from excitation of right frontotemporal cortex. Further, functional neuroimaging investigations have reported increased activity in occipitotemporal cortex during flexible object knowledge retrieval. Here, we examined whether altering activity in PFC and occipital cortex regions using tDCS would facilitate performance on an open-ended task. We showed participants images of everyday objects and asked them to report aloud either the common or an uncommon use for them while undergoing tDCS. A forward digit span was also used as a negative control task. In a series of experiments, participants received different montages of excitatory and inhibitory tDCS over right or left PFC, excitatory tDCS over right or left occipital cortex, bilateral stimulation of these regions, or sham stimulation. Cathodal stimulation of the left, but not right, PFC elicited shorter reaction times and fewer omissions on the uses task, but had no effects on the control tasks. Concurrent bilateral stimulation of the PFC regardless of polarity, and excitatory stimulation of the occipital cortex did not alter performance on either task. These results contribute to our understanding of the role of left PFC in creative

object use and elucidate the precise involvement of this region for flexible object knowledge retrieval.

5

Anodal tDCS to right dorsolateral prefrontal cortex facilitates performance for novice jazz improvisers but hinders experts

David S. Rosen
Drexel University
Brian Erickson
Drexel University
Roy H. Hamilton
University of Pennsylvania
Daniel Mirman
University of Alabama
John Kounios
Drexel University

Research on creative cognition reveals a fundamental disagreement about the nature of creative thought, specifically, whether it is primarily based on automatic, associative (Type-1) or executive, controlled (Type-2) processes. We posit that Type-1 and Type-2 processes make differential contributions to creative production dependent upon domain expertise. We tested this hypothesis with jazz pianists who, through experience and training, amass deeply ingrained musical patterns and implement various strategies to improvise novel melodic phrases and rhythms. fMRI studies of music improvisation report that domain expertise is characterized by deactivation of the right-dorsolateral prefrontal cortex (r-DLPFC), which is accompanied by a network of increased functional connectivity including bilateral DLPFC, dorsal premotor cortices (PMD), and pre-supplementary motor areas (p-SMA). Thus, we use right-lateralized non-invasive, transcranial direct-current stimulation (tDCS) localized over r-DLPFC (F4) with the reference electrode on the contralateral mastoid (1.5mA, 15 min.) to modulate jazz pianists' choices, behaviors, and ultimately, their creative processes while improvising. Pianists improvised to an array of chord changes with drum and bass accompaniment in sham, cathodal and anodal conditions. Jazz experts rated each improvisation for creativity, aesthetic appeal, and technical proficiency. Neither anodal nor cathodal stimulation increased ratings compared to sham; however, a significant interaction between anodal tDCS and expertise emerged, such that stimulation benefitted musicians with less experience but hindered those with more experience. We interpret these results as evidence for dual process theories of creativity, in which novices and experts differentially engage DLPFC in pursuit of creativity.

Support:
ExCITe Center Seed Grant

6

Measuring Creativity Accurately and Appropriately in Neuroscientific Investigations

Mark A. Runco
University of Georgia

This five minute presentation will open with a very brief review of four studies, from 2015-2016, each of which suggests that creativity can, under the right circumstances, be assessed in a reliable fashion, and the results of creativity tests do have moderate and acceptable predictive validities. Importantly, predictive validity was determined using criteria from the natural environment (i.e., real world creative performances). The second part of this short presentation will point to the requirements for measuring creativity in a reliable fashion, such that test scores have validity. These requirements are very difficult to satisfy in highly controlled settings, including those often used in neuroscientific research on creativity. As a matter of fact it appears that, just as the field of psychology as a whole has been faced with a trade-off of internal validity vs. external validity, so too is much of the neuroscientific research on creativity opting for rigorous internal validity (i.e., experimental control) but as a direct result may be sacrificing externally valid results. The key message from this brief presentation is that creativity testing has certain requirements, and if these are overlooked (or precluded by rigor and experimental control), it is not really creativity that is being measured. The requirements will be covered very briefly (bullet pointed). The data presented in the first section of this presentation are from various 2015-2016 investigations of (a) literal divergent thinking, (b) comparisons of curricular and extracurricular creative performances, (b) comparisons of different tests of divergent thinking, and (d) computer analyses of ideational flexibility and originality.

7

Musical evolution in the lab: Rhythmic universals emerge in a cultural transmission experiment

Andrea Ravignani
Artificial Intelligence Lab, Vrije Universiteit Brussel
Tania Delgado
Department of Cognitive Science, University of California, San Diego
Simon Kirby
Centre for Language Evolution, School of Philosophy, Psychology and Language Sciences, University of Edinburgh

Many human behaviours, like music, show structural regularities, some shared across all cultures and traditions. Why these musical universals exist has been object of theoretical speculation but received little empirical attention. Here, by focusing on rhythm, we test for the first time the mechanisms underlying musical universals. Human participants are asked to imitate sets of randomly generated drumming sequences, after which their attempts at reproduction become the training set for the next participants in a transmission chain. The structure of drumming patterns, transmitted in independent chains of participants across cultural generations, evolves adapting to human biology and cognition. Drumming patterns transmitted within cultures develop into rhythms which are easier to learn, distinctive for each experimental cultural tradition and characterized by all six statistical universals found among world music. Rhythmic structure

emerges from repeated enhancement of features that adapt to be easily perceived, imitated and transmitted within a culture.

Support:
European Research Council grants 283435 ABACUS (to Bart de Boer) and 230604 SOMACCA (to W. Tecumseh Fitch)

8

Hemispheric Asymmetry of Functional Brain Networks and Divergent Thinking Ability

Qunlin Chen
School of Psychology, Southwest University; Key Laboratory of Cognition and Personality, Ministry of Education, Chongqing
Jiangzhou Sun
School of Psychology, Southwest University; Key Laboratory of Cognition and Personality, Ministry of Education, Chongqing
Hui Haung
School of Psychology, Southwest University; Key Laboratory of Cognition and Personality, Ministry of Education, Chongqing
Jiang Qiu
School of Psychology, Southwest University; Key Laboratory of Cognition and Personality, Ministry of Education, Chongqing

BACKGROUND: A critical component of creativity is divergent thinking, which relies on the activity and functional connectivity within distributed brain regions. However, it remains unknown whether creativity is related to the overall efficiency of functional network architecture during rest-state, and whether hemispheric asymmetry of functional network architecture contributes to individual creative thinking ability. METHODS: Resting-state functional MRI was employed to investigate inter-hemispheric differences in the topological organization of brain functional networks and its relationships with composite creativity index (CCI) in 185 (109 female) healthy and right-handed college students. RESULTS: The overall and hemispheric networks exhibit small-world attributes (short paths and high clustering), and right hemisphere has higher local network efficiency than left hemisphere using graph analysis. The results show a strong positive association between the characteristic path length of the whole brain network and CCI. Moreover, a significant positive association was found between CCI and clustering coefficient C and characteristic path length L in the right hemisphere, but not in left. Further analysis shows that more rightward asymmetry in local network efficiency associated with higher CCI. At the nodal level, individual with higher CCI exhibited more rightward asymmetry of nodal efficiency mainly around the middle and medial temporal cortex, DLPFC and posterior occipital cortex, as well as exhibited less rightward asymmetry of nodal efficiency mainly around the language-related cortexes. CONCLUSIONS: These findings challenge the popular view that novelty ideas relied on efficiently integrates information in large-scale brain regions, and highlight the importance of efficient local information processing of functional architecture within both special regions and hemisphere responsible for creative thinking.

Support:
National Natural Science Foundation of China (31271087; 31470981; 31571137; 31500885)

9

Associations between finger tapping and self-reported creative attributes and behaviors

Brad J. Ferguson
Interdisciplinary Neuroscience Program, University of Missouri
Paul S. Foster
Department of Psychology, Middle Tennessee State University
David Q. Beversdorf
University of Missouri Departments of Radiology, Neurology, and Psychological Sciences, Thompson Center for Autism & Neurodevelopmental Disorders, Interdisciplinary Neuroscience Program

The research literature supports a relationship between the dopamine system and creativity. For example, one investigation found an inverted U-shaped relationship between spontaneous eye-blink rate, which is associated with central dopaminergic functioning, and flexibility scores on the alternate uses task, an indicator of divergent thinking that is a key component of creativity. Another investigation found differences in blood levels of dopamine in creative versus non-creative individuals. Thus, there appears to be a link between the dopamine system and creative thinking. The neurotransmitter dopamine also plays a significant role in motor movements. On a finger tapping test, decreases in finger oscillations are associated with reductions in dopamine as well as striatal dopamine D2 receptor density. Given the association between dopaminergic functioning and creative thinking, it is possible that a relationship exists between motor indices of dopaminergic functioning in the brain and self-reported behaviors and attributes associated with creativity. This investigation sought to examine the relationship between finger tapping scores and self-reported attributes and behaviors associated with creativity. A total of 36 individuals complete a finger tapping task and surveys related to creativity, current mood, and handedness. Non-linear analyses indicated an inverted U-shaped relationship between creative attributes and behaviors and finger tapping scores. These findings provide support for a relationship between self-reported attributes and behaviors associated with creativity and finger tapping, which may be associated with dopaminergic functioning in the brain.

10

Comparing “sticky” and “non-sticky" mind-wandering with computational modeling

Marieke van Vugt
University of Groningen

While distraction is commonplace in modern-day society, and neuroscientific research into mind-wandering is expanding, there are few formal computational models of this process. My computational model of this process can describe both objective behavioral and subjective introspective data from two different mind-wandering experiments. The model is based on the idea that there is a continuous competition between a task goal and a distraction ``goal'', which reflect other goals and experiment participant may have. As the task goal decays over time, the distraction goal can take over, and when that happens, a mind-wandering process is put into action. The characteristics of this mind-wandering process determine what the effects are on performance of the main task. This model can accurately predict performance on a mind-wandering task, including introspective judgments. With an explicit process model of mind-

wandering, it becomes possible to examine how processes like rumination differ from more casual mind-wandering, for which I will also show some experimental data. Moreover, I will explore how we could inform that model with data from experience sampling studies of depressed patients and healthy controls.

11
Temporal variability of default mode network correlates with creativity

Jiangzhou Sun
Faculty of Psychology, Southwest University
Zhaowen Liu
Centre for Computational Systems Biology, Fudan University
Qunlin Chen
Faculty of Psychology, Southwest University
Jiang Qiu
Faculty of Psychology, Southwest University

Creativity is commonly defined as the ability to produce something both novel and useful. Creative people are thought to be more capable of shifting between abstract, analytical thinking and dreaming, reverie thinking. Most previous studies just explored the functional connectivity of brain regions in a given time period and neglect the variability across the time. We correlate the temporal variability of the resting-state functional brain networks at three different scales (regional level, network level: within networks and between networks and the whole brain level) to TTCT verbal score, to identify the neural basis for creative thinking. We found that the temporal variability of 5 brain regions such as medial prefrontal cortex, posterior cingulate cortex, Precuneus within the default mode network (DMN) correlated significantly with TTCT sore. This is complemented by the findings that both within-network variability and between network variability of DMN are also correlated with creativity. Unlike previous static functional connectivity, for the first time, our study supplement previous notion about the role of DMN and provide support for the notion that creative thought involves dynamic cooperation between spontaneous and deliberate processes by reflected dynamic coupling between brain networks associated with spontaneous thought and cognitive control, attention or others cognitions.

12
Interaction between DRD2 genotype and parental authoritarianism in predicting creativity: evidence for gene-parenting interactions

Jinghuan Zhang
Shangdong Normal University
Si Si
Shangdong Normal University

This study examined whether DRD2 rs1799732 (–141C Ins/Del) genotype interacts with parental authoritarianism in predicting creativity and whether gender acts as a moderator on the relation between the interaction term (DRD2×parental authoritarianism) and creativity. Participants were

427 college students selected from a molecular genetics association study of creativity. All of them were Han Chinese descendants and provided informed consent at the beginning of the study. The creativity test used here were three verbal tasks selected from Runco Creativity Assessment Battery (rCAB). The data analysis revealed that there was an interaction between DRD2 and parental authoritarianism when predicting creativity such that parental authoritarianism (both for father and mother) was associated with lower levels of fluency and flexibility when individuals carried at least one minor allele (Del allele) at DRD2 rs1799732 in both genders. And the results of the present study also demonstrated that only father authoritarianism was associated with lower levels of originality which is the key of creativity (Runco, 2010) in individuals for both genders with at least one DRD2 rs1799732 Del allele. These data suggested that carrying minor allele at DRD2 rs1799732 would confer risk for creativity in individuals with adverse rearing experiences and father authoritarianism had more detrimental consequences to originality. This study is a preliminary research on G×E model (specifically diathesis-stress model) in the field of creativity as well as the first to show that the relationship between authoritarian parenting and creativity might be dependent on genetic make-up.

Support:
National Natural Science Foundation of China (31470999); Science and Technology Projects of Shandong, China (ZR2014CQ017)

13

Finding the neural correlates of middle childhood "slump" in creativity using functional near-infrared spectroscopy

Manish Saggar
Psychiatry and Behavioral Sciences, Stanford University School of Medicine
Atanas Stankov
Psychiatry and Behavioral Sciences, Stanford University School of Medicine
Meredith Schreier
Psychiatry and Behavioral Sciences, Stanford University School of Medicine
Allan Reiss
Psychiatry and Behavioral Sciences, Stanford University School of Medicine

Little is known about the underlying neurodevelopmental processes that contribute to a child's creative capacity. Of particular interest is the decline in creativity during middle childhood. Longitudinal neuroimaging studies are required to understand whether a decline in creativity is due to the burden of social norms, educational training, or typical brain development. Here, we present preliminary results from a cohort-sequential semi-longitudinal study using functional Near-infrared Spectroscopy (fNIRS). A total of 56 children (n=24 3rd-graders and n=32 4th-graders) were assessed longitudinally at two time-points. Creativity was evaluated using the standardized Torrance Test of Creative Thinking (TTCT). The fNIRS data from bilateral prefrontal cortices were collected while children engaged in the TTCT and a control drawing-task. As expected, 3rd-graders scored higher on TTCT during the end of their grade, while 4th-graders had a decline in TTCT scores towards the end of their grade. Based on previous work, we hypothesized that the 4th-grade decline in creativity could be associated with a greater need for "conformity" from classroom expectations and peer pressure. We operationalized conformity

in terms of variability in task-related functional connectivity (FC). Thus, less FC variability would imply greater conformity. Significant grade by time interaction was observed for both TTCT and control conditions (ps<.05), such that 4th-graders had reduced variability in fc towards the end of their grade, whereas no changes were observed for 3rd-graders. taken together, our data suggest longitudinal neuroimaging studies could provide insights into neural basis 4th-grade decline creativity.

Support:
Child Health and Research Initiative Postdoctoral Fellowship, Stanford University School of Medicine.

14

From the lab to the real-world: Ecologically valid neuroimaging of dyadic creative design thinking using portable functional near infrared spectroscopy (fNIRS)

Naama Mayseless
Center for Interdisciplinary Brain Sciences Research, Department of Psychiatry and Behavioral Sciences, Stanford University School of Medicine
Manish Saggar
Center for Interdisciplinary Brain Sciences Research, Department of Psychiatry and Behavioral Sciences, Stanford University School of Medicine
Grace Hawthorne
Hasso Plattner Institute of Design at Stanford
Lindsay Chromik
Center for Interdisciplinary Brain Sciences Research, Department of Psychiatry and Behavioral Sciences, Stanford University School of Medicine
Allan Reiss
Center for Interdisciplinary Brain Sciences Research, Department of Psychiatry and Behavioral Sciences, Stanford University School of Medicine

One of the challenges of neuroscience is developing neuro-scientific methodologies that can measure real-life behavior in laboratory settings. Specifically to creativity, one way to do this is to adapt real-life creativity to the lab setting in a way that can be measured using neuroimaging methodologies. The limitation of this is that creative abilities that manifest in naturalistic environments might not be best captured in lab settings. Here we sought to take neuroimaging to the “real-world” of creative collaborative design. Functional near-infrared spectroscopy (fNIRS) is a non-invasive optical imaging method that measures concentration changes in hemoglobin. fNIRS has the advantage of being portable, low cost and less reactive to movements than other imaging methods. Furthermore, fNIRS allows us to measure brain activity in more ecologically valid environments. We employed a naturalistic experimental design to directly assess the brain basis of collaboration and team-creativity while designers interact in real-time. We used ultra portable fNIRS to simultaneously measure brain activity in two people while they were engaged in collaborative creative design thinking in an ecologically valid design space. Preliminary analysis employed inter-brain synchronization to identify regions that act in synchrony between dyads. Identification of inter-brain synchrony during creative collaborative design can advance our understanding of team creativity.

Support:
Hasso Plattner Design Thinking Research Program

15
The Big C Project: Overview and Neurocognitive Profiles

Robert Bilder
UCLA Semel Institute for Neuroscience & Human Behavior
Kendra Knudsen
UCLA Semel Institute for Neuroscience & Human Behavior
Kevin Japardi
UCLA Semel Institute for Neuroscience & Human Behavior
Susan Bookheimer
UCLA Semel Institute for Neuroscience & Human Behavior

Few studies of individual differences in creativity have focused on samples selected for exceptional achievement, leaving open questions about whether "Big C" creativity is associated with unique brain and behavioral characteristics. The "Big C Project" at UCLA enrolled more than 30 people in each of three groups: (1) Visual Artists (VA); (2) Scientists (SCI); and (3) a "Smart Control Group" (SCG) matched to VA and SCI on demographic characteristics and IQ estimates. Participants completed: (1) Interview; (2) Neurocognitive assessments; (3) Personality assessments, rating scales and structured interviews for psychopathology; and (4) MRI scanning including structural, diffusion tensor imaging, rest state functional, and two cognitive-activation functional (fMRI) studies of divergent and convergent thinking. VA, SCI and SCG groups were well matched on age, sex, race, ethnicity, hand preference, parental education, and estimated WAIS-IV IQ. Big C groups had higher income, and markedly higher Creative Achievement Questionnaire scores in their respective domains. VA had higher fluency and originality scores on the Unusual Uses test, but tended to make more intrusions and repetitions during list-learning. SCI had highest scores on several working memory indices and tended to do better on design fluency and Ravens Progressive Matrices. There were no group differences on multiple other tests of divergent/convergent thinking, working memory or response inhibition, including latent inhibition. The results validate the ascertainment processes used to identify "Big C" participants and reveal relatively subtle group differences with VA excelling on selected divergent thinking and SCI excelling on selected convergent thinking and WM tasks.
Support:
John Templeton Foundation, Michael E. Tennenbaum Family Endowment for Creativity Research

16
The Big C Project: Structural MRI and DTI Findings

Robert Bilder
UCLA Semel Institute for Neuroscience & Human Behavior
Kevin Japardi
UCLA Semel Institute for Neuroscience & Human Behavior
Kendra Knudsen
UCLA Semel Institute for Neuroscience & Human Behavior
Susan Bookheimer
UCLA Semel Institute for Neuroscience & Human Behavior

The UCLA Big C Project recruited more than 30 exceptionally creative people comprising: (1) Visual Artists; (2) Scientists; and (3) a Smart Control Group (matched to Big C participants on age, sex, race/ethnicity, parental education, and current IQ estimates). In addition to interviews, neurocognitive, personality, and functional MRI assessments, each individual had structural MRI (sMRI) and diffusion tensor imaging (DTI) exams. The sMRI acquisition was a high-resolution T1-weighted image with 1 mm isometric voxels; DTI scans used 64-directions with 2 mm isometric voxels. Structural analysis used Freesurfer to segment cortical and subcortical regions and compute thickness, area, and volumetric measurements within cortical parcellation units. DTI connectivity matrices were analyzed using graph theory metrics. There were no differences between groups in total cortical gray, white, or CSF volumes, nor in the sizes of any subcortical or limbic parcellation units. Visual artists had larger volumes and areas of left superior parietal cortex, right supramarginal gyrus, and right precuneus, with effect sizes in the range eta-squared = 0.1 to 0.13 ($p<.01$ to $<.002$). there were no significant differences on dti graph measures. the findings are striking in revealing larger cortical territories regions putatively subserving complex visuospatial functioning and serving as core components of default mode network, selectively among visual artists. results prompt questions about degree which these may be subject experience-dependent plasticity exceptional artists, individuals have been predisposed intensive engagement art.

Support:
John Templeton Foundation, Michael E. Tennenbaum Family Endowment for Creativity Research

17
The Big C Project: Functional MRI Findings

Kevin Japardi
UCLA Semel Institute for Neuroscience & Human Behavior
Susan Bookheimer
UCLA Semel Institute for Neuroscience & Human Behavior
Kendra Knudsen
UCLA Semel Institute for Neuroscience & Human Behavior
Robert Bilder
UCLA Semel Institute for Neuroscience & Human Behavior

The UCLA Big C Project recruited over 60 exceptionally creative visual artists and scientists, and a control group matched on age, sex, race/ethnicity, parental education, and current IQ estimates. In addition to structural MRI scans, participants completed two task-based fMRI scans and a 6-minute resting state scan. An Alternate Uses Task (AUT) and a Remote Associates Task (RAT) aimed to engage divergent and convergent thinking, respectively. During the AUT, participants generated as many unusual uses (UU) or typical qualities (TQ) for everyday objects as possible. During the RAT, participants thought of an associative word that linked three words, selected two synonyms within a group of words, or selected the initial character from sets of randomized characters. Functional scans were collected using an EPI sequence at 3T with 3mm isotropic voxels. During the resting state participants relaxed with eyes open, viewing a black screen. We investigated between-group differences for both task conditions, and used graph theory metrics to evaluate the strength of resting state networks. Scientists showed lower frontal

and parietal activation than controls during UU, while visual artists showed lower frontal activation than scientists and controls during TQ. The RAT showed no significant between-group differences. In the resting state, scientists showed lower clustering and small worldness relative to controls. The results confirm substantial overlap in functional activations across "Big C" and controls, but suggest that exceptionally creative individuals may depend less on task positive networks during divergent thinking, and that exceptional scientists may be characterized by more random network architectures.

Support:
John Templeton Foundation, Michael E. Tennenbaum Family Endowment for Creativity Research

18

The Big C Project: Personality and Psychopathology Profiles

Kendra Knudsen
UCLA Semel Institute for Neuroscience & Human Behavior
Kevin Japardi
UCLA Semel Institute for Neuroscience & Human Behavior
Susan Bookheimer
UCLA Semel Institute for Neuroscience & Human Behavior
Robert Bilder
UCLA Semel Institute for Neuroscience & Human Behavior

As part of a broad investigation of brain and behavior, the UCLA 'Big C' Project investigated the association of exceptional creativity with personality and psychopathology. We examined more than 30 individuals each in three groups: Big C Visual Artists (VA), Big C Scientists (SCI) and a Smart Comparison Group (SCG) matched on age, sex, race/ethnicity, parental education, and IQ estimates. We measured schizotypal traits with the Schizotypal Personality Questionnaire (SPQ), autistic features with the Social Responsiveness Scale (SRS), personality with the International Personality Item Pool Representation of the NEO PI-R (IPIP-NEO). VA had significantly higher scores than SCI (and nominally greater scores than SCG) on Cognitive/Perception and Disorganization SPQ factors. Specifically, VA showed higher levels of odd beliefs, ideas of reference, unusual perceptions and odd speech. VA also reported significantly higher scores in SRS subscales of social communication, social motivation, and restricted interests and repetitive behaviors, when compared to SCG. We also saw a linearity effect of openness across participants (VA>SCI>SCG), with significantly greater levels in VA compared to SCG. These results complement and extend past findings of high openness and magical ideation associated with creative achievement in healthy individuals. These results support the hypothesis that "subclinical" levels of schizotypal and autistic characteristics are associated with higher levels of creativity, especially in artists, and suggest that high openness personality traits may mediate this effect.

Support:
John Templeton Foundation, Michael E. Tennenbaum Family Endowment for Creativity Research

19

Neural Dynamics of Spontaneous Thought: An EEG Study

Manesh Girn
Cognitive Neuroscience of Thought Lab, University of British Columbia
Eric Laycock
The Psychophysics and Cognitive Neuroscience Laboratory, University of British Columbia
Melissa Ellamil
Max Planck Institute for Human Cognitive and Brain Sciences
Cognitive Neuroscience of Thought Lab, University of British Columbia
Lawrence Ward
The Psychophysics and Cognitive Neuroscience Laboratory, University of British Columbia
Kalina Christoff
Cognitive Neuroscience of Thought Lab, University of British Columbia

Spontaneous thinking constitutes a ubiquitous aspect of our mental life and has increasingly become a hot topic of research in cognitive neuroscience. To date, functional neuroimaging studies of spontaneous thought have revealed general brain recruitment centered on a combination of default mode network and executive regions. The precise temporal relationship between the regions recruited, however, has yet to be fully elucidated. A previous study by our group employed fMRI to this end (Ellamil et al., Neuroimage, 2016), and characterized regional recruitment in blocks of 2 seconds prior to, during, and after the spontaneous arising of thought. A primary finding was the recruitment of medial temporal lobe structures 2 seconds prior to thought onset, suggesting hippocampal generation of spontaneous thoughts. The limited temporal resolution of fMRI, however, strongly constrained the precision of our analyses. The present study seeks to expand our previous findings by employing EEG in a more fine-grained analysis of the temporal dynamics of brain activity underlying spontaneously arising thoughts. To do this, we performed independent component analysis (ICA) on high-density EEG recorded using our previously used paradigm. On ICA-based localization of EEG recordings recovered multiple sources of electrical brain activity previously identified by our fMRI study. Additionally, as expected, it enabled a more fine-grained analysis of the dynamics of information flow between the regions involved. Results suggest a signal that originates in the posterior cingulate, and subsequently evolves in a general posterior-anterior gradient in the generation, appraisal, and elaboration of spontaneous thoughts.

20

Why Does the Mind Move? Explaining the Dynamics of Mind-Wandering Through Experience-Sampling

Dylan D. Stan
Cognitive Neuroscience of Thought Lab, University of British Columbia
Quentin Raffaelli
Cognitive Neuroscience of Thought Lab, University of British Columbia
Kalina Christoff
Cognitive Neuroscience of Thought Lab, University of British Columbia

The bulk of the mind-wandering literature has primarily operationalized spontaneous thought as a function of being on- versus off-task, with rates of stimulus-independent or task-unrelated thoughts accounting for 30 -50% of daily life (e.g., Killingsworth & Gilbert, 2010). This task-centric perspective has thus predominately shaped the way in which researchers have attempted to capture spontaneous mental activity, and has in turn neglected the dynamic property of mind-wandering, namely the tendency of the mind to move in a relatively unconstrained fashion within a broad conceptual scope of ideas from one moment to the next (e.g., Christoff et al.,2016). The present study capitalized on experience-sampling methodology and developed novel probe items that aimed at empirically measuring thoughts' dynamic qualities outside of the lab, where thoughts are expected to be subject to a host of potentially concurrent and ongoing tasks and at the mercy of contextual influences. Participants responded to thought probes at randomized times over the course of multiple days, being asked to rate their thoughts on a number of different dimensions (7-point Likert scales), including the felt spontaneity of thoughts movement as well as their thoughts' relatedness to the current activity (*on- vs. off-task*). Results suggest the felt spontaneity of thoughts movement and task relatedness were separable dimensions of thoughts. It is thus possible that freedom of thoughts movement captures something about the wandering mind that task relatedness does not.

21
Neural Dynamics of Spontaneous Thought: An EEG Study

Quentin Raffaelli
Cognitive Neuroscience of Thought Lab, University of British Columbia
Dylan D. Stan
Cognitive Neuroscience of Thought Lab, University of British Columbia
Kalina Christoff
Cognitive Neuroscience of Thought Lab, University of British Columbia

A prominent view of mind wandering defines it is a "*shift in the contents of thoughts away from an ongoing task and/or from events in the external environment to self-generated thoughts and feelings*" (Smallwood & Schooler, 2016, p488). However, this definition fails to capture the most important phenomenological characteristic of a wandering mind: its dynamic quality, including the tendency of the wandering mind to move in unconstrained fashion (free unfolding) with the potential to cover ideas within a broad conceptual range (conceptual variability). Here we developed novel experience sampling items aiming to capture this so far neglected aspect of mind wandering. All sampling items were rated on a 7-point Likert scales. Participants answered 10 thoughts probes sent at random time within regular time intervals for 5 days. We were specifically interested in how freedom of thought's movement relates to the extent to which thoughts are perceptually coupled with the environment. Preliminary results suggest that a hallmark characteristic of the prominent view of mind wandering, namely being decoupled from (or unaware of) the external environment, was only weakly predictive of the felt spontaneity of thoughts movement. In addition, the degree of perceptual coupling with the environment appears relatively independent of the felt spontaneity of thought's movement, suggesting that freedom of movement captures something about the wandering mind that perceptual decoupling does not.

Conference supported by:
University of Missouri Mizzou Advantage Fund (DB)
University of British Columbia (KC)
John Templeton Foundation (AG)

Steering committee:

David Beversdorf
Adam Green
Lila Chrysikou
Kalina Christoff
Mark Beeman
Rex Jung
David Kraemer

NOTES:

REGISTRANTS (AS OF 10/31/16)

Name	Affiliation	Email
Kevin Japardi	UCLA	KJapardi@mednet.ucla.edu
Andrea Ravignani	Vrije Universiteit Brussel	andrea.ravignani@gmail.com
David Beversdorf	U of Missouri Depts of Radiology, Neurology, and Psychol Sciences	beversdorfd@health.missouri.edu
David S. Rosen	Drexel University	Drosen@drexel.edu
Indre Viskontas	University of San Francisco and San Francisco Conservatory of Music	indre.viskontas@gmail.com
Kendra Knudsen	UCLA	KKNUDSEN@MEDNET.UCLA.EDU
Manish Saggar	Stanford University	saggar@stanford.edu
Allison Halt	University of Missouri	akh8c8@mail.missouri.edu
Evangelia G. Chrysikou	University of Kansas, Department of Psychology	lilachrysikou@ku.edu
Naama Mayseless	Stanford University	nmay@stanford.edu
Brad Ferguson	University of Missouri Interdisciplinary Neuroscience Program	fergusonbj@health.missouri.edu
Marieke van Vugt	University of Groningen	m.k.van.vugt@rug.nl
Robert Bilder	UCLA Semel Institute	rbilder@mednet.ucla.edu
G. William Domhoff	Department of Psychology, University of California, Santa Cruz	domhoff@ucsc.edu
Savannah Lokey	National Institute of Mental Health	lokey.savannah@nih.gov
Sara Ahmed	NIMH	ahmeds10@nih.gov
Jiangzhou Sun	Southwest University, China	sjzny_good@126.com
Jinghuan Zhang	Shandong Normal University	zhangjinghuan@sdnu.edu.cn
Robyn Oliver	Qualcomm Technologies, Inc.	roliver@qti.qualcomm.com
Joel Bernarte	Qualcomm Technologies, Inc.	joelb@qti.qualcomm.com
Gini Keating	Qualcomm Technologies, Inc.	gkeating@qti.qualcomm.com
Ying Choon Wu	Swartz Center for Computational Neuroscience, UC San Diego	yingchoon@gmail.com
Rex Jung	University of New Mexico, Department of Neurosurgery	rex.jung@runbox.com
Ekaterina Kazimirova	Kaspersky Lab	Ekaterina.Kazimirova@kaspersky.com
Bernard Cox	writer	bernard.m.cox@gmail.com
Dylan Stan	University of British Columbia	dylanstan@gmail.com
Quentin Raffaelli	University of British Columbia, Vancouver	quentinraffaelli@psych.ubc.ca
Alexandrea Russell	Georgetown University	alexandrea.russell@gmail.com
Kalina Christoff	University of British Columbia	kchristoff@psych.ubc.ca
Manesh Girn	University of British Columbia, Vancouver	maneshg94@gmail.com
Adam Green	Georgetown University	aeg58@georgetown.edu
Mark Beeman	Northwestern University	mbeeman@northwestern.edu
Daniel L. Schacter	Harvard University	dls@wjh.harvard.edu

ANNOUNCEMENT:

MARK YOUR CALENDARS

3rd Annual Neuroscience of Creativity Meeting
Friday, March 24, 2016
San Francisco, California

(The day before the Cognitive Neuroscience Society meeting)