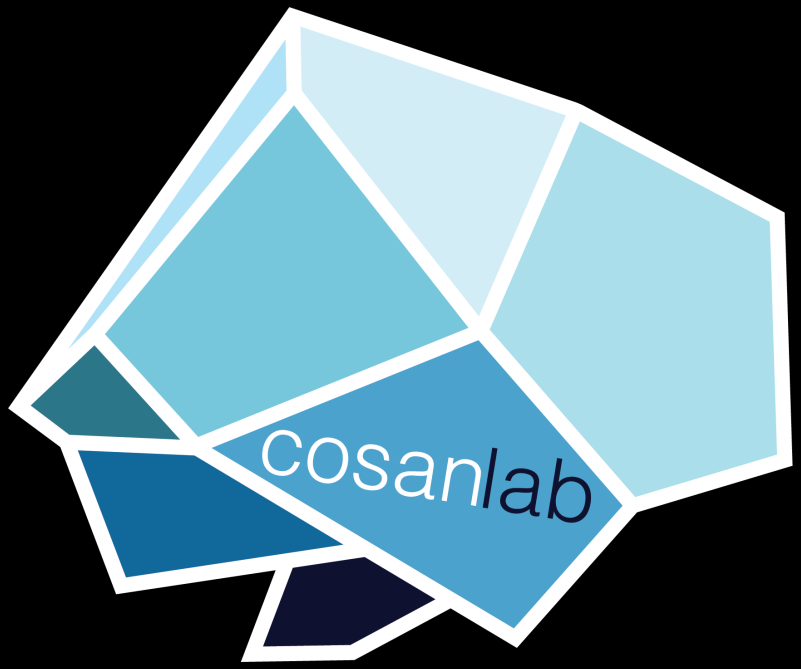


Mapping social spaces

Luke Chang, PhD
Computational Social & Affective Neuroscience Laboratory
Dartmouth College

Goals for Today

- Do people view the world the same way?
- Can we leverage structured social variation in understanding the brain?
- How do people infer social relationships?
- (mostly nonsensical applications of complicated methods)

Social maps

PRINCIPLES OF TOPOLOGICAL PSYCHOLOGY

$B = f(P, E)$

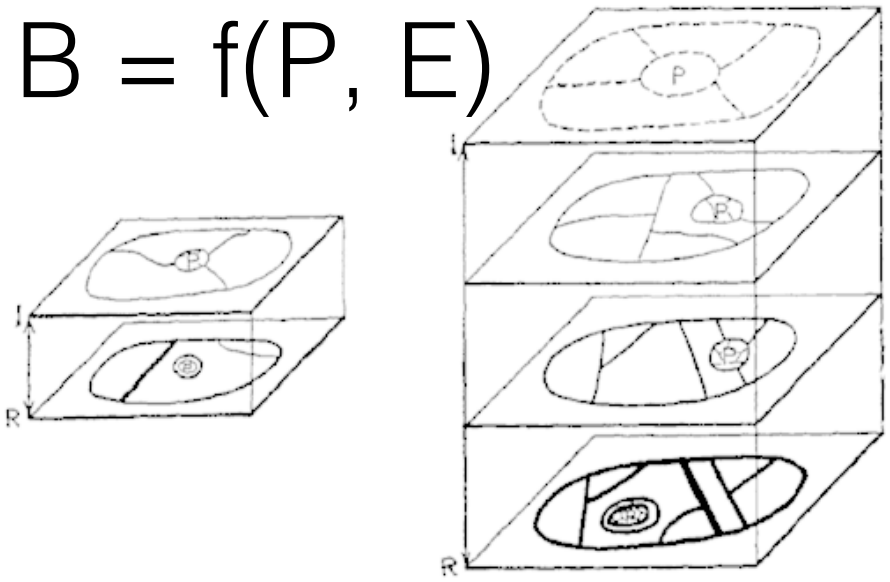
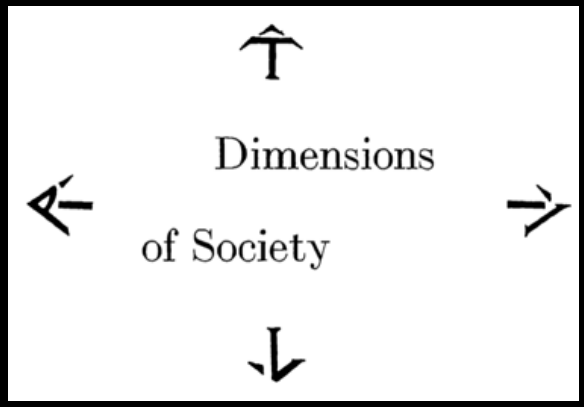


FIG. 48.—Life space of a child (*a*) and of an adult (*b*). The life space of the adult is more highly differentiated in the dimension reality-irreality. The range of reality and irreality layers in the life space of the child corresponds to an intermediate range of layers in the adult's life space.

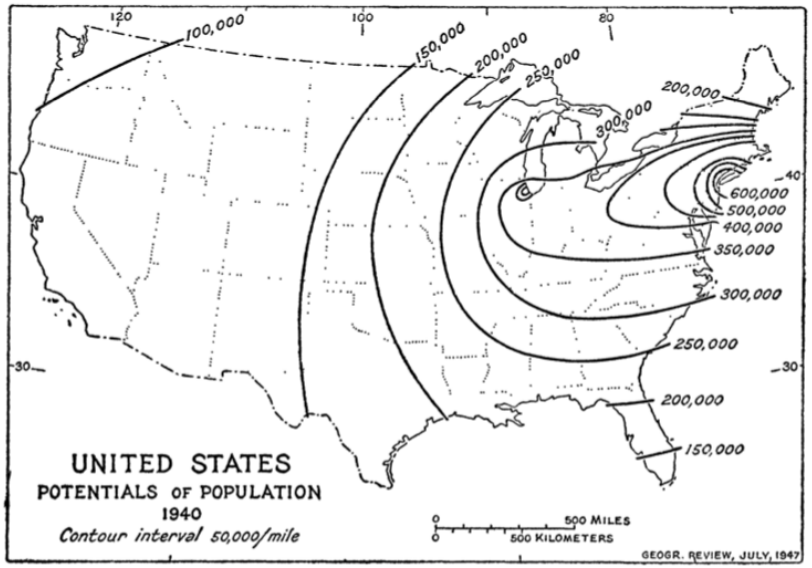
Lewin (1936)



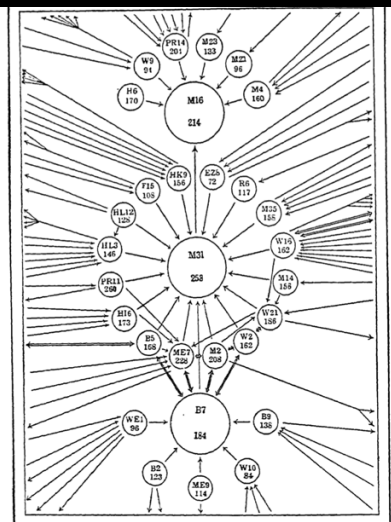
Dodd (1942)

DEMOGRAPHIC GRAVITATION: EVIDENCE AND APPLICATIONS

JOHN Q. STEWART
Princeton University

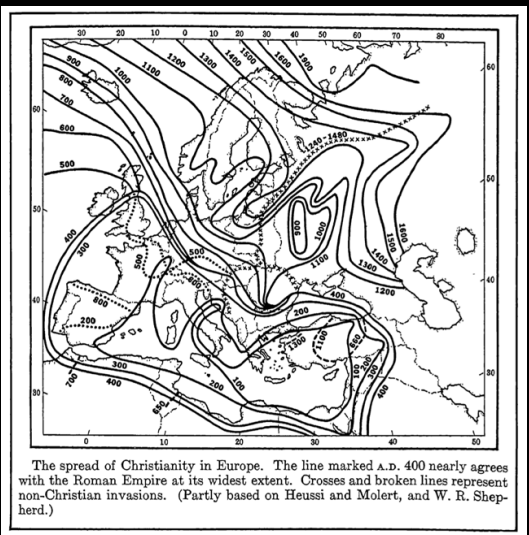


Stewart (1948)



"Friendship" Constellation in a Village. Each person is represented by a circle. The letter and the first number in the circle is the code symbol of the person. The second number is that person's score of socio-economic status on the Chapin scale. Each arrow represents a choice made or received according to the direction of the arrow. Mutual choices are represented by double-headed arrows.

Ref.: Lundberg, George A., and Lawsing, Margaret, "Sociography of some Community Relations," *American* Sociological Review, Vol. II, No. 3, June, 1937, p. 329.



The spread of Christianity in Europe. The line marked A.D. 400 nearly agrees with the Roman Empire at its widest extent. Crosses and broken lines represent non-Christian invasions. (Partly based on Heussi and Molert, and W. R. Shepherd.)

Ref.: Taylor, Griffith, "Environment and Nation," *Amer. Jour. Soc.*, Univ. of Chicago Press, Vol. XL, No. 1, July, 1934, p. 28.

A CRITIQUE OF DODD'S *DIMENSIONS OF SOCIETY*[1]

ETHEL SHANAS

ABSTRACT

The volume, *Dimensions of Society*, by Stuart C. Dodd is critically examined to determine whether Dodd's claims that he has constructed a quantitative science of sociology are justified. Upon investigation his scheme appears to be arbitrary and sterile. There would seem to be no justification for the belief that the *S*-theory makes any major contribution to sociology.

Dimensions of Society by Stuart C. Dodd is a volume of 944 pages which attempts to integrate sociological theory with statistical theory. The purpose of the author is ". . . . to promote the wedding of Mathematics and Sociology" (p. 316). The underlying assumption upon which this work is based is that ". . . . it is possible with our present knowledge to begin constructing a *quantitative systematic science of sociology*" (italics are Dodd's, p. 3).[2]

The author of the *Dimensions of Society* makes a number of sweeping claims for his work. He believes that he has (1) constructed a systematic sociology, (2) presented a method for securing a unified quantitative social science (pp. 59, 70), and (3), through further extension of his method, devised a technique which may serve to unify *all* scientific thought (p. 821).[3] These momentous aims are to be achieved through the application of a mathematical formula devised by Dodd and called by him the *S*-theory. The formula is as follows: $S = \ddot{:}(T; I; L; P)\ddot{:}$ (p. 59). It says in symbols: "People, environment, and their characteristics may change" (p. 25). This formula may serve as a framework for the quantitative formulation of *all* data. This is seen from the following statements of Dodd: ". . . . *Ev-*

Dartmouth Network

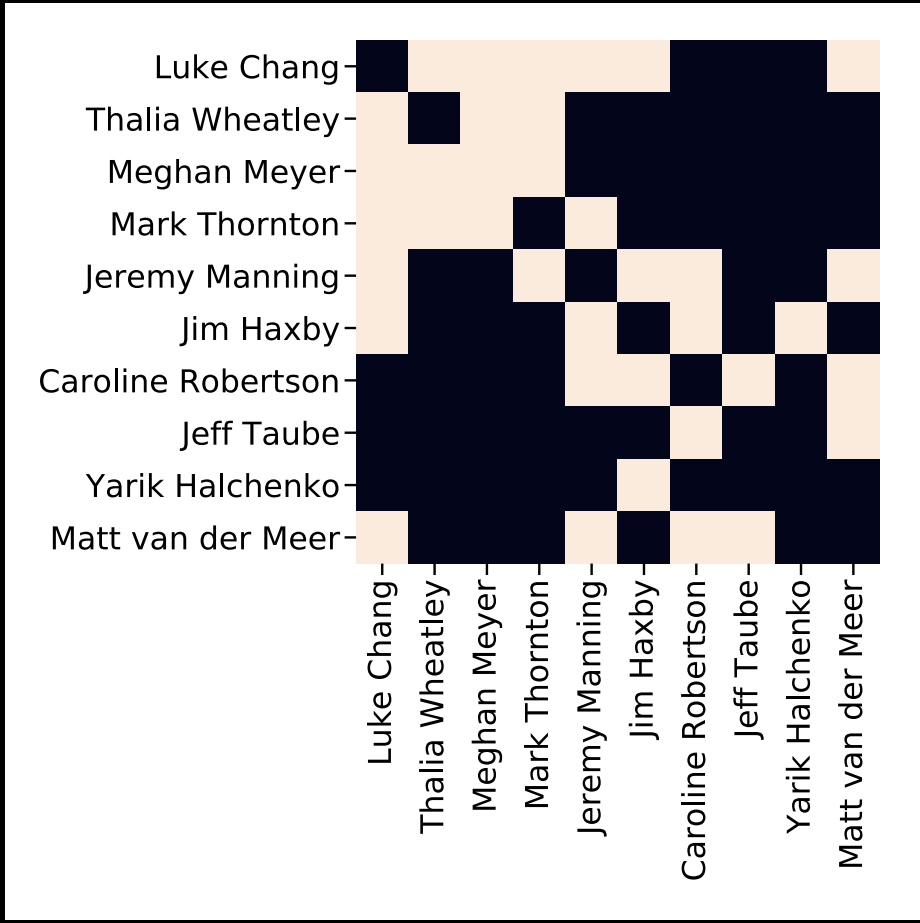


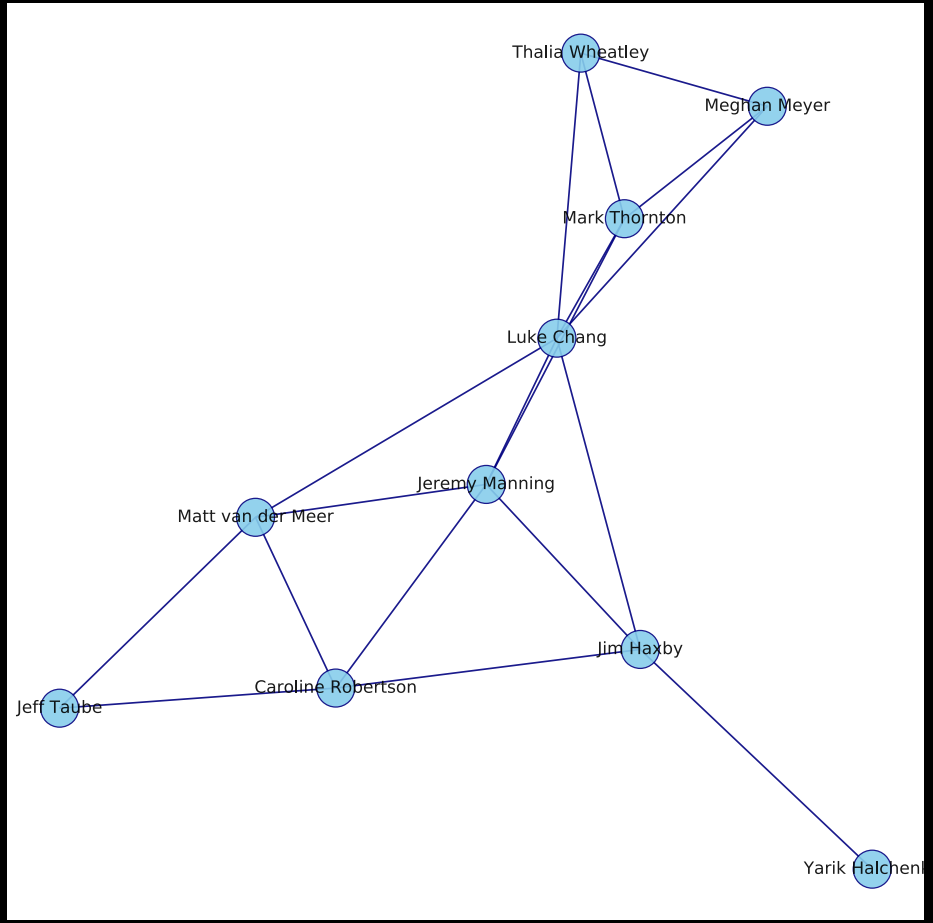







Maps can be represented as graphs





Dartmouth Network










Dartmouth Network

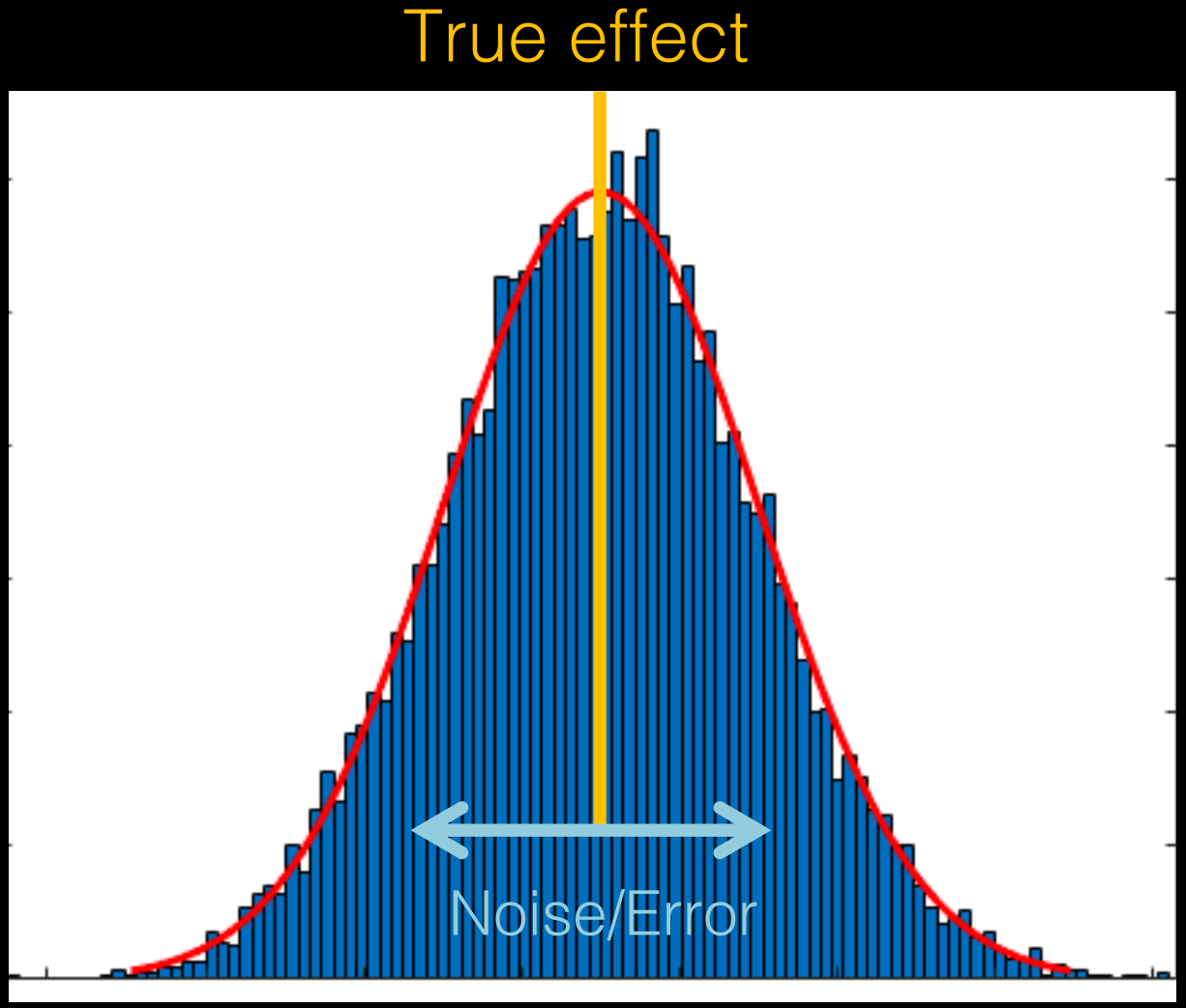
Behavioral

Social

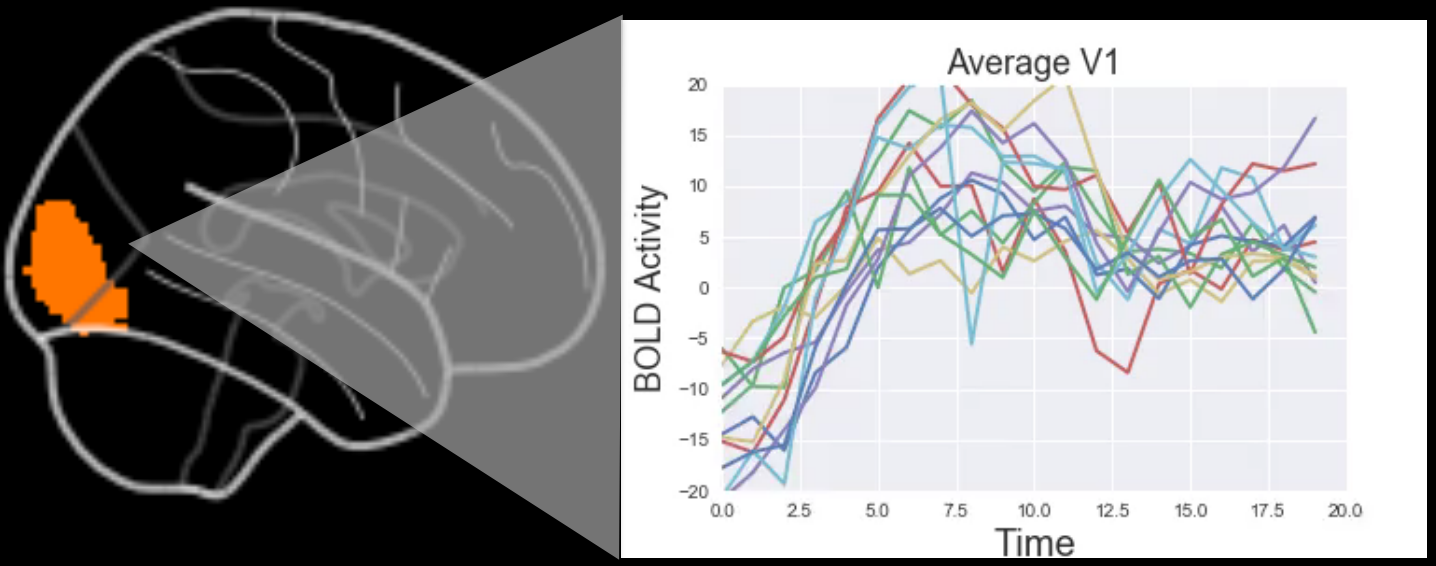
Cognitive

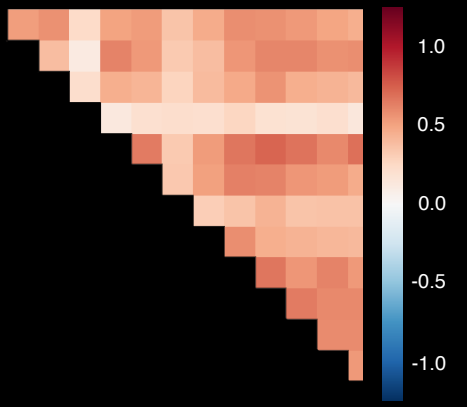
Do different research areas see the world more similarly?

Fundamental assumption of how we make inferences



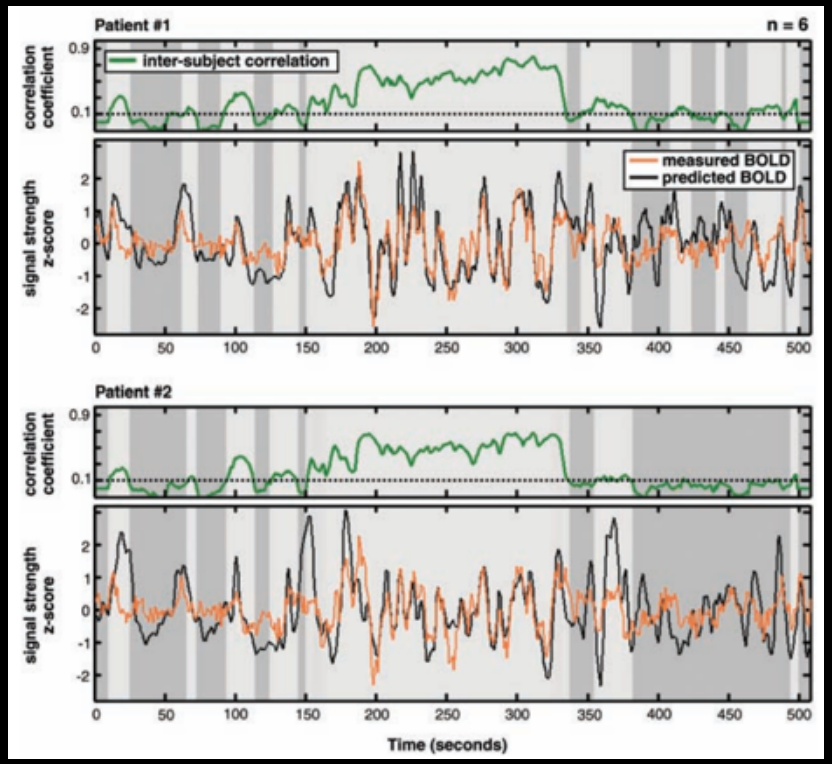
Inter-Subject Correlation (ISC)

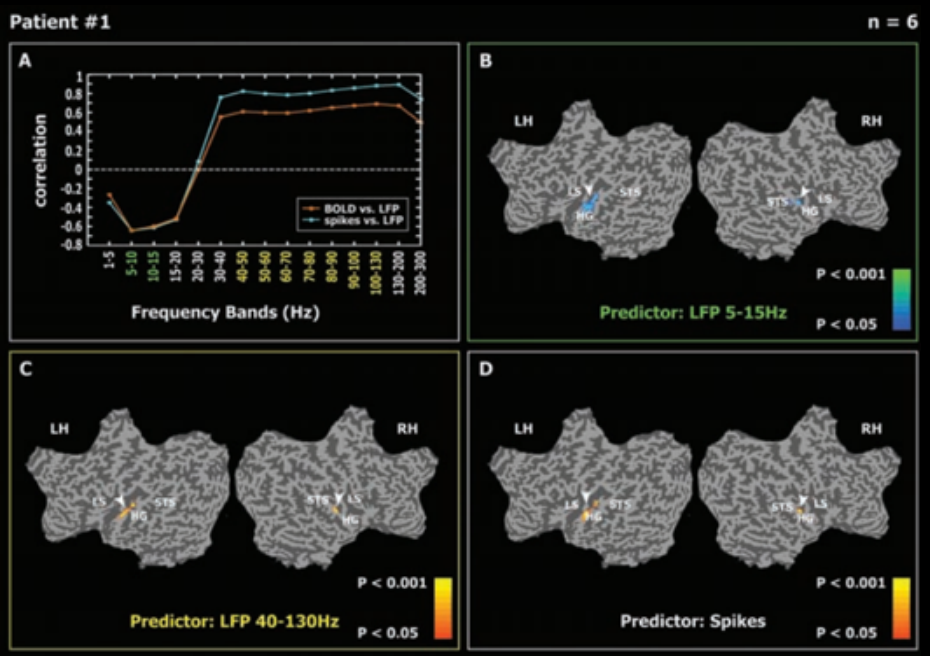




Hasson, Nir, Levy, Furhmann, & Malach (2004) Science
Nastase, Gazzola, Hasson, & Keysers (2019) SCAN

ISC correlates with spike firing rate and broadband gamma

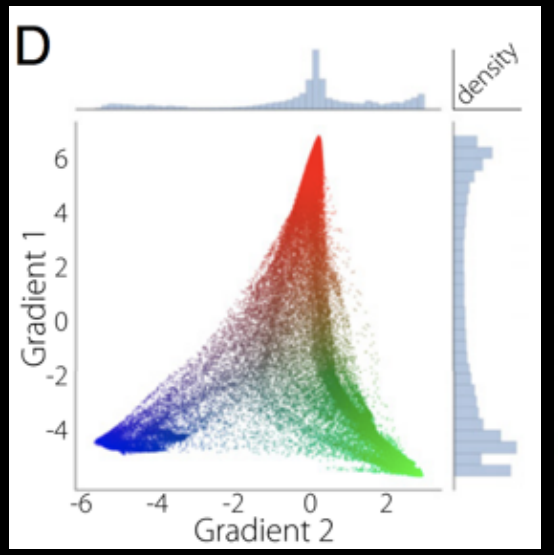


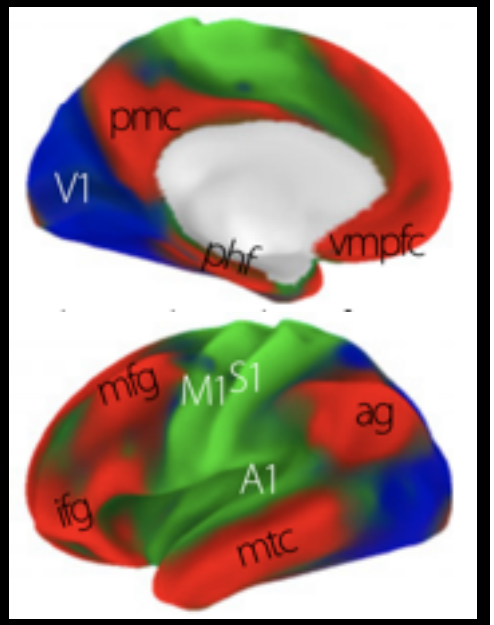


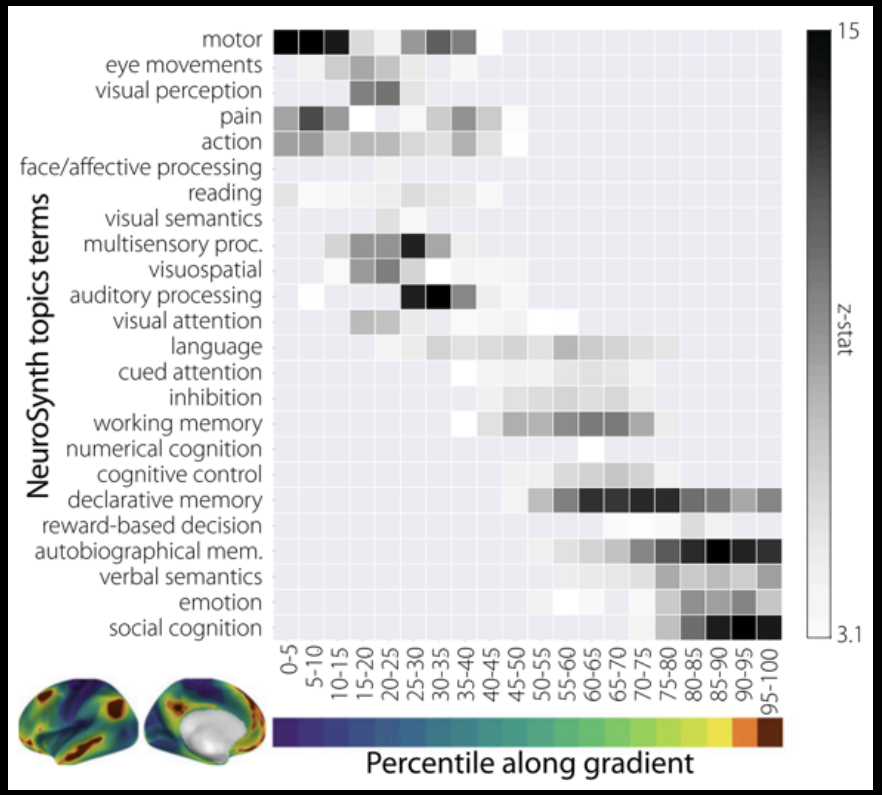
Mukamel et al., 2005 Science

…but are all brain processes really shared across people?

Exogenous to endogenous gradient







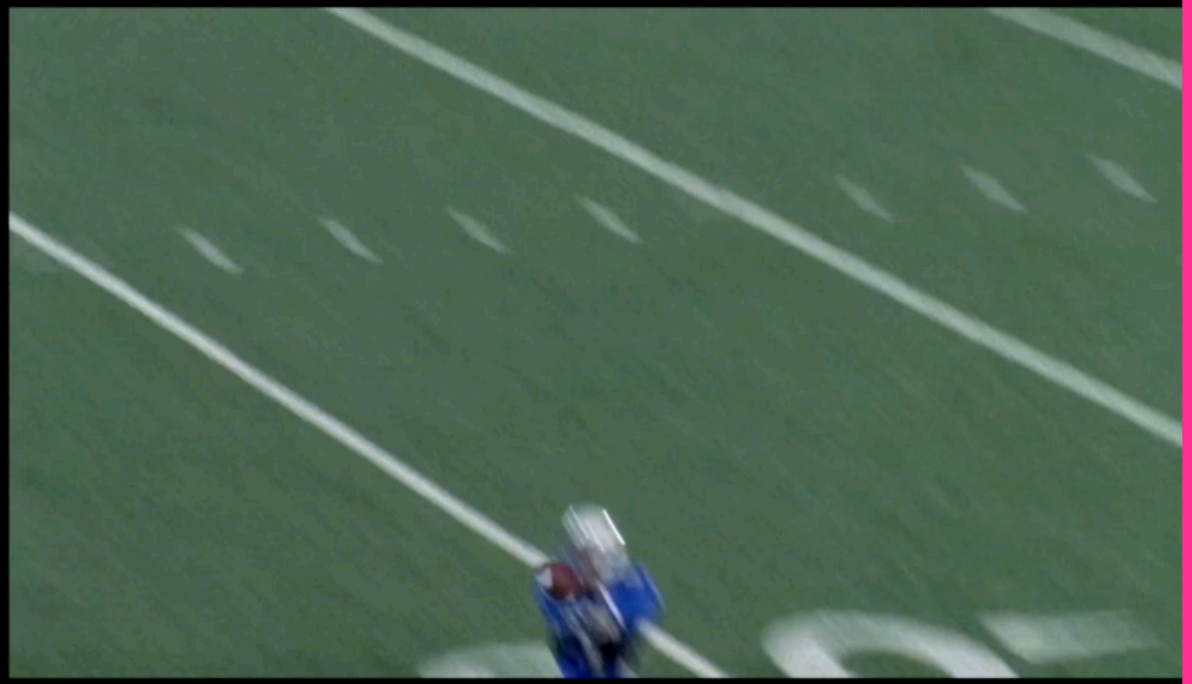
Margulies et al (2016) PNAS

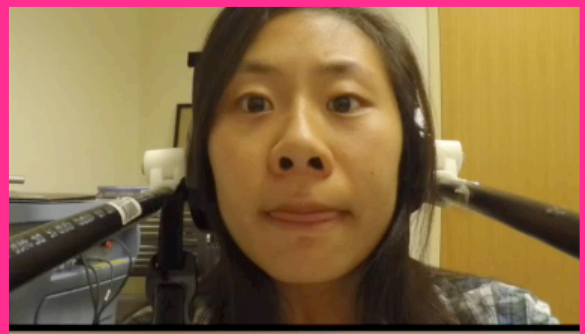
Eshin Jolly

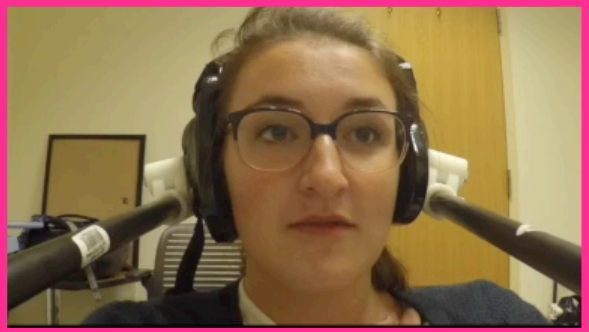
Eliciting emotional experiences

Jeremy Manning

Jin Cheong

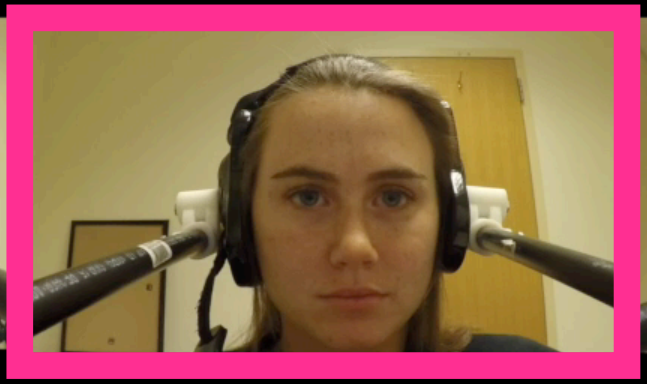




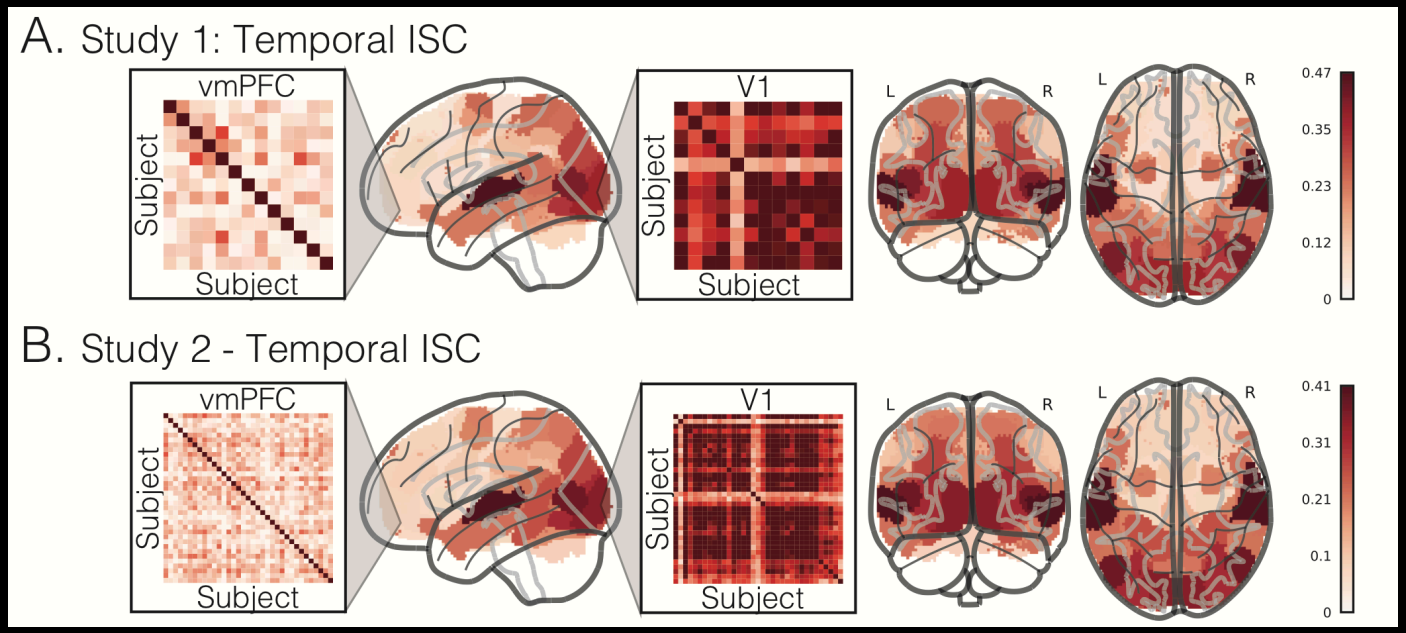








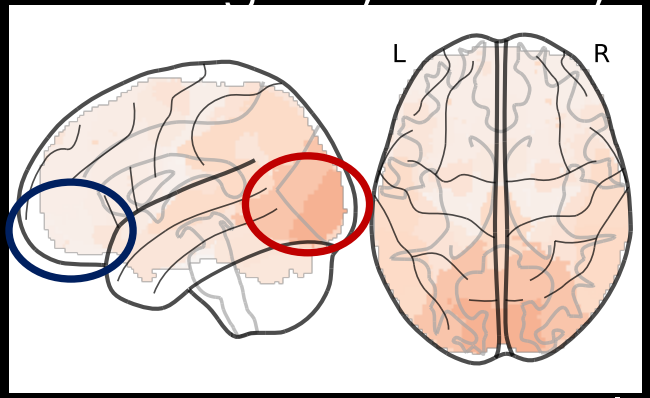

Signals that are consistent across people



Chang, Jolly, Cheong, Rapuano, Chen, & Manning (bioRxiv, 2018)

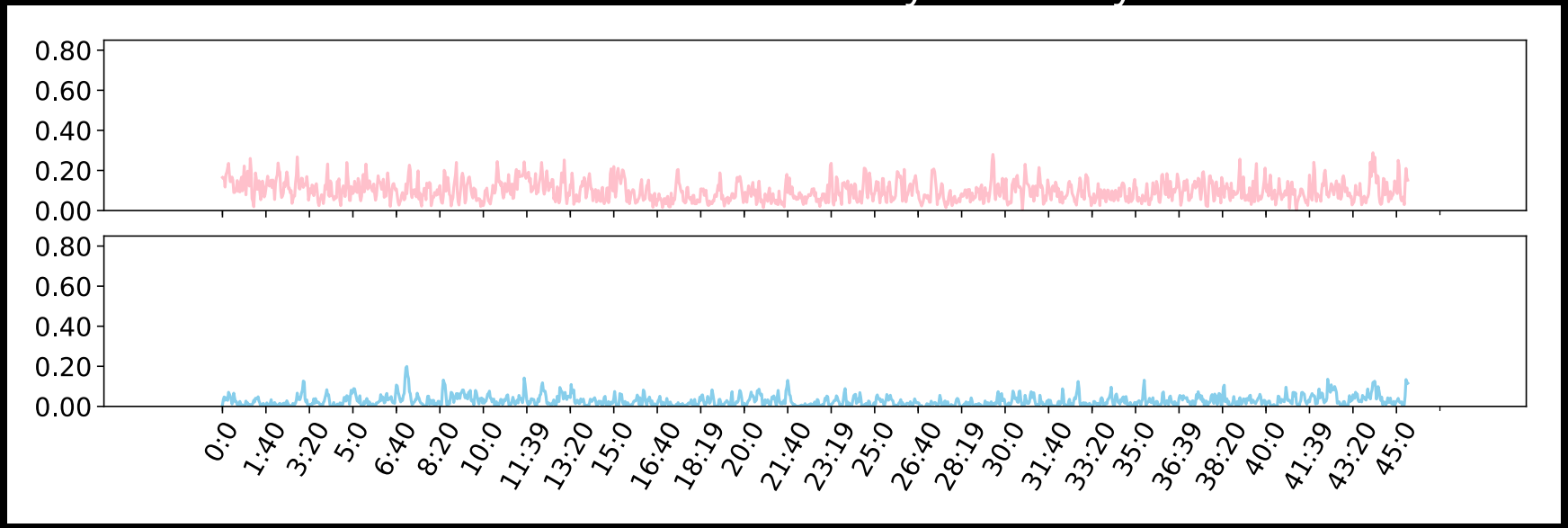
Synchrony Dynamics

Average Synchrony



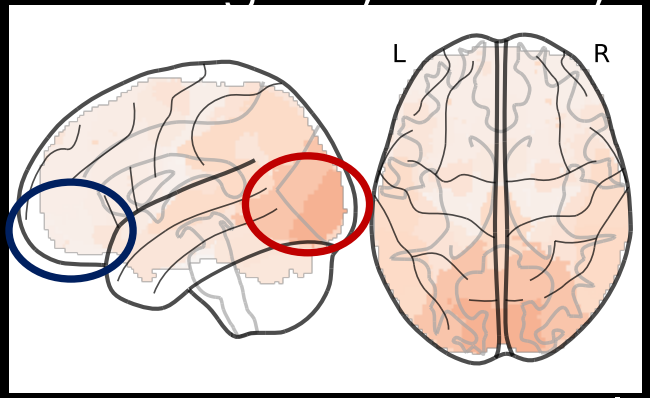
But, what if voxels aren't properly aligned?

Instantaneous Synchrony

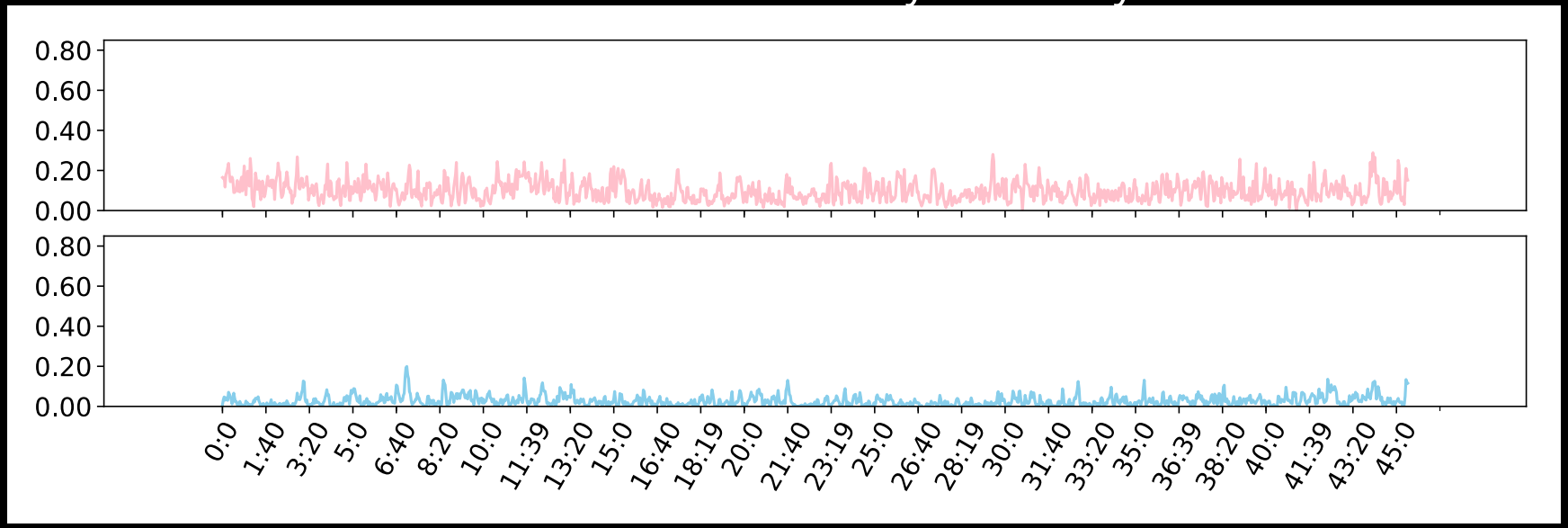


Synchrony Dynamics

Average Synchrony

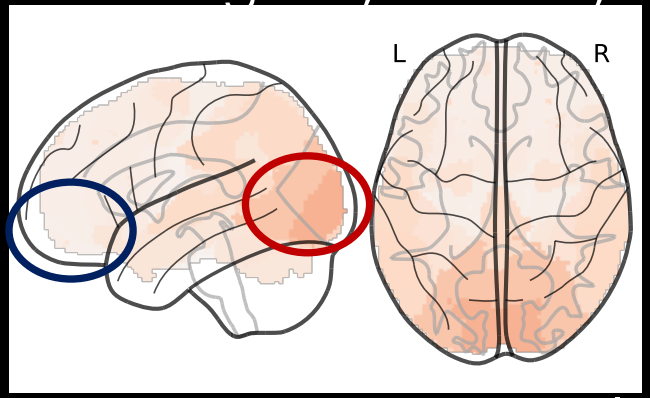


Instantaneous Synchrony

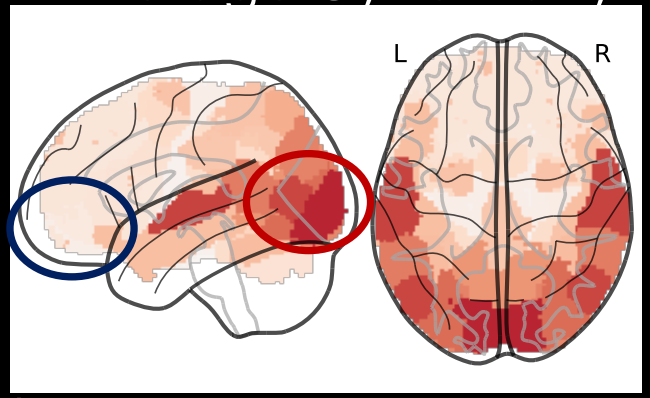


Increasing synchrony with hyperalignment

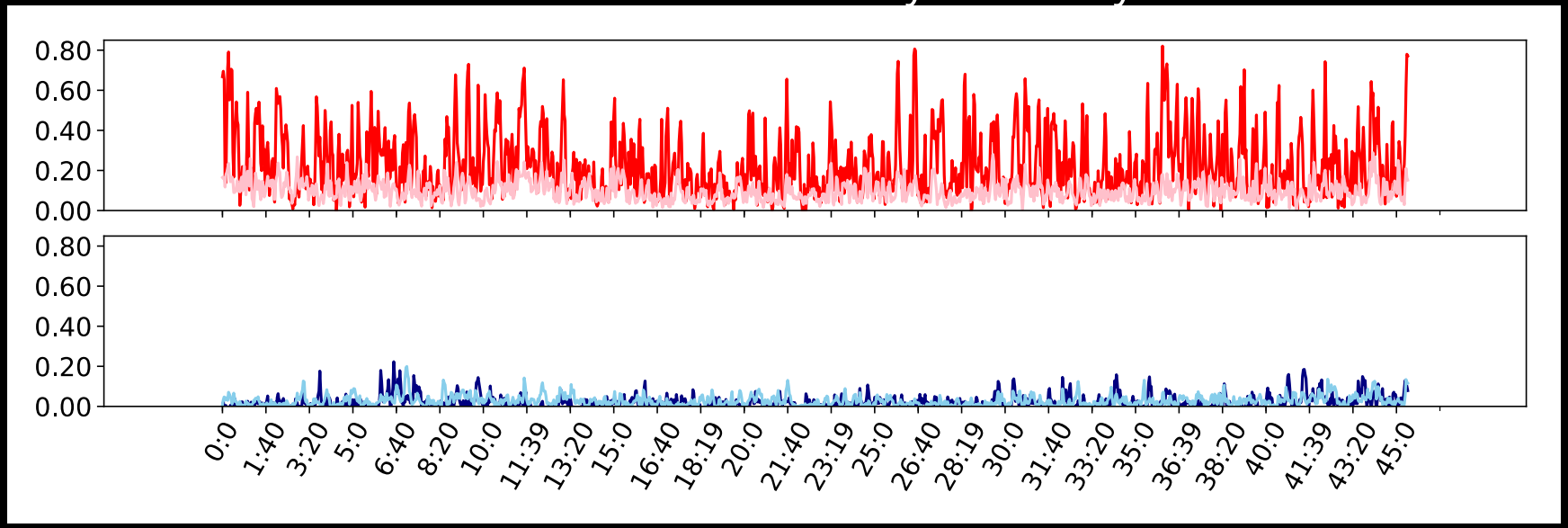
Average Synchrony



Average Synchrony



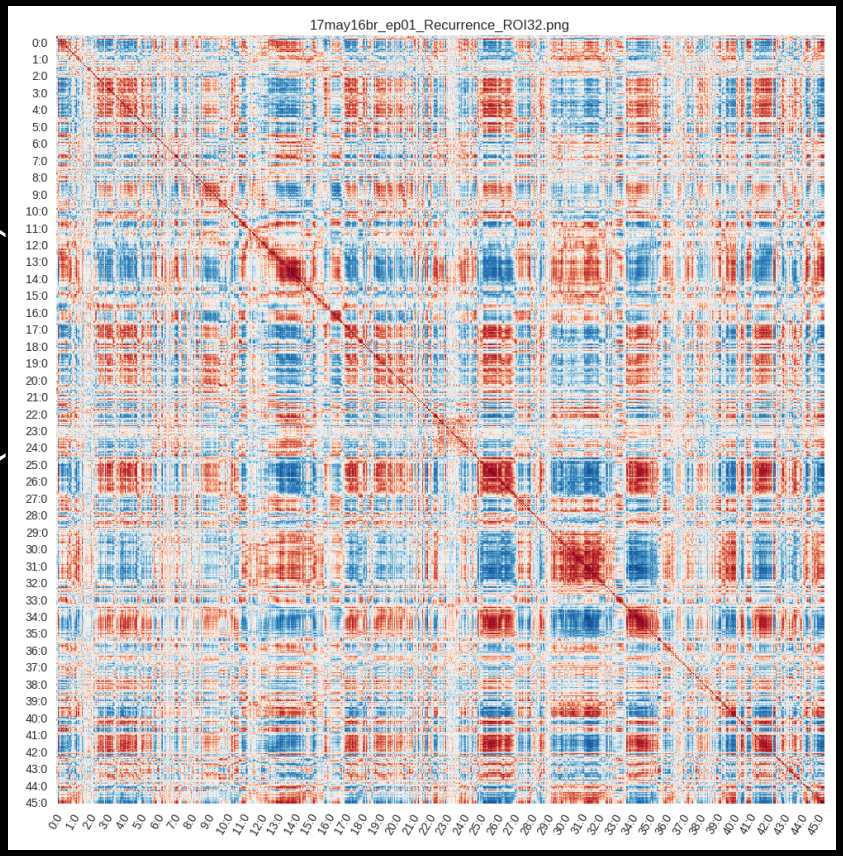
Instantaneous Synchrony



Haxby, et al., 2011 Neuron
Chen, et al., 2015 NIPS

How do patterns change over time?

Single Subject vmPFC
Pattern Recurrence



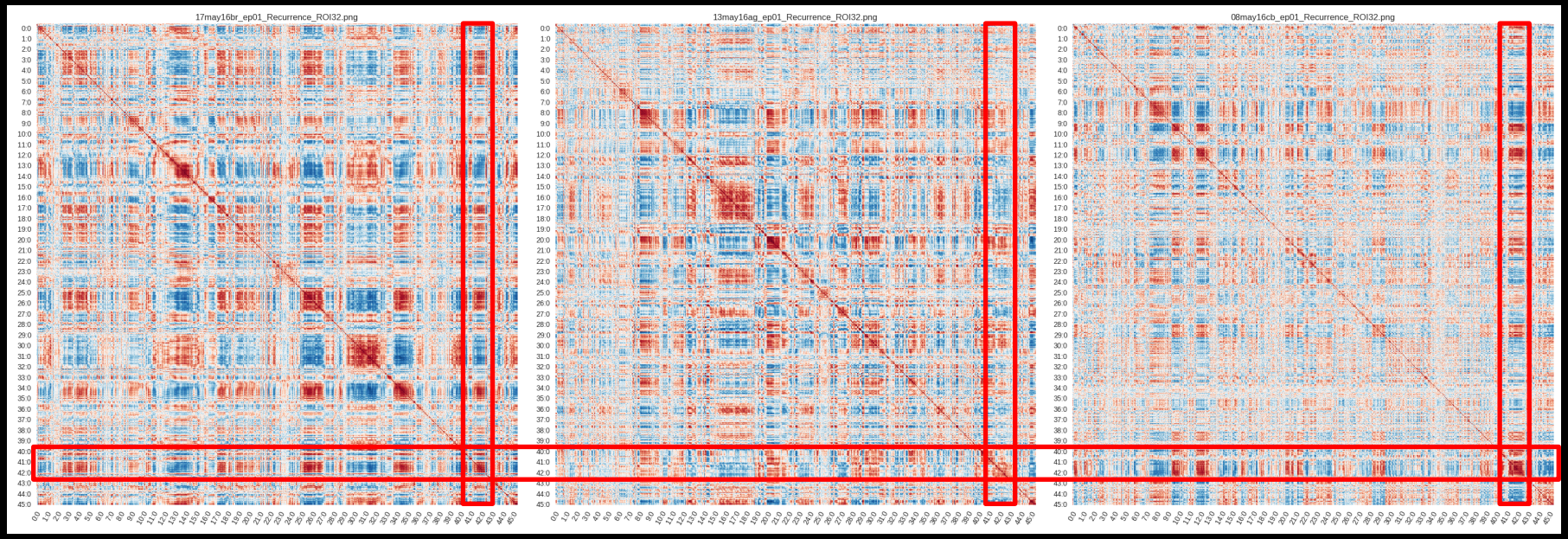
Chang, Jolly, Cheong, Rapuano, Chen, & Manning (bioRxiv, 2018)

All subjects exhibit a distinct spatiotemporal dynamic

Subject 1

Subject 2

Subject 3



Time (min)

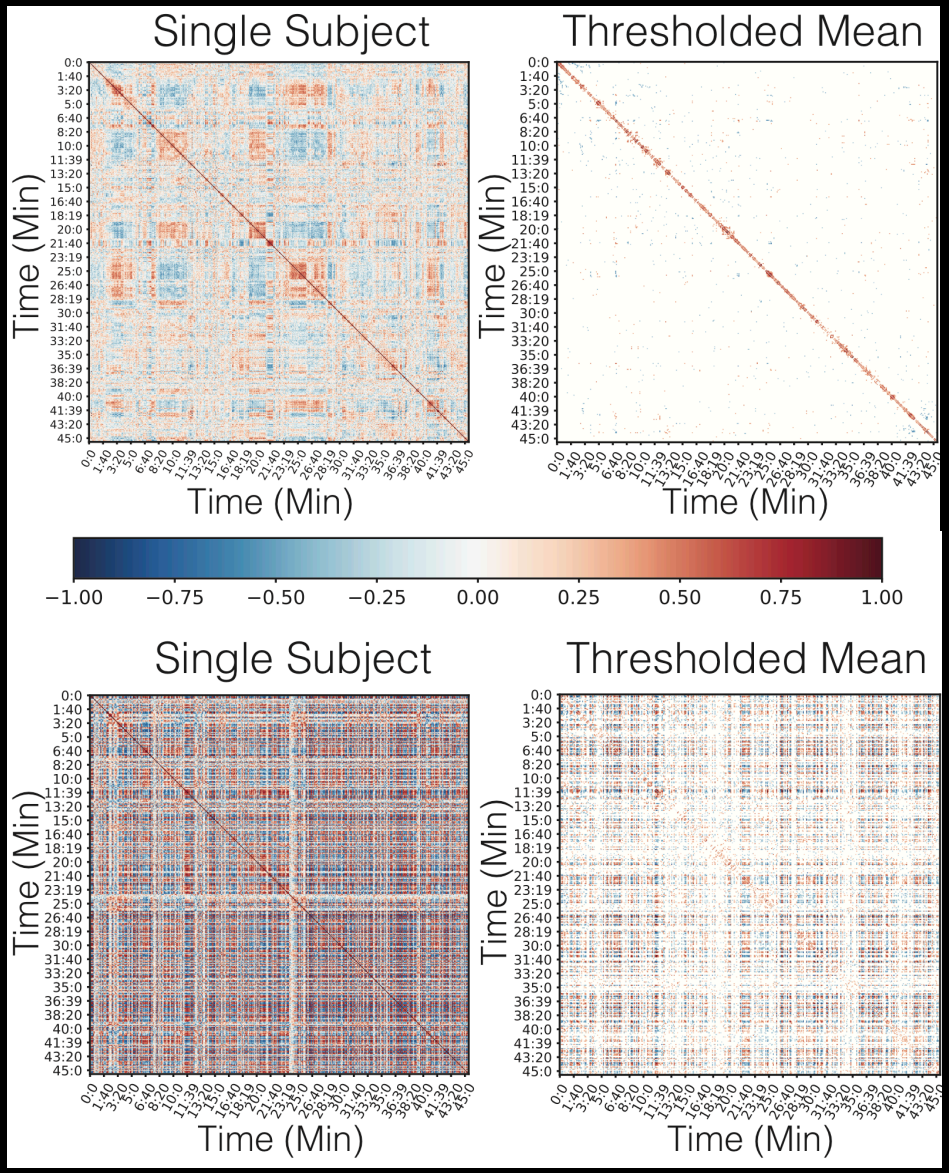
Time (min)

Time (min)

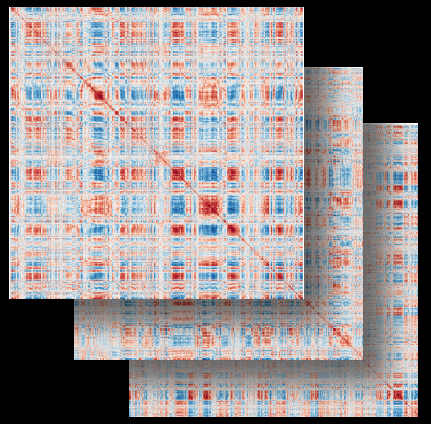
Time (min)

Chang, Jolly, Cheong, Rapuano, Chen, & Manning (bioRxiv, 2018)

Consistency of spatiotemporal dynamics



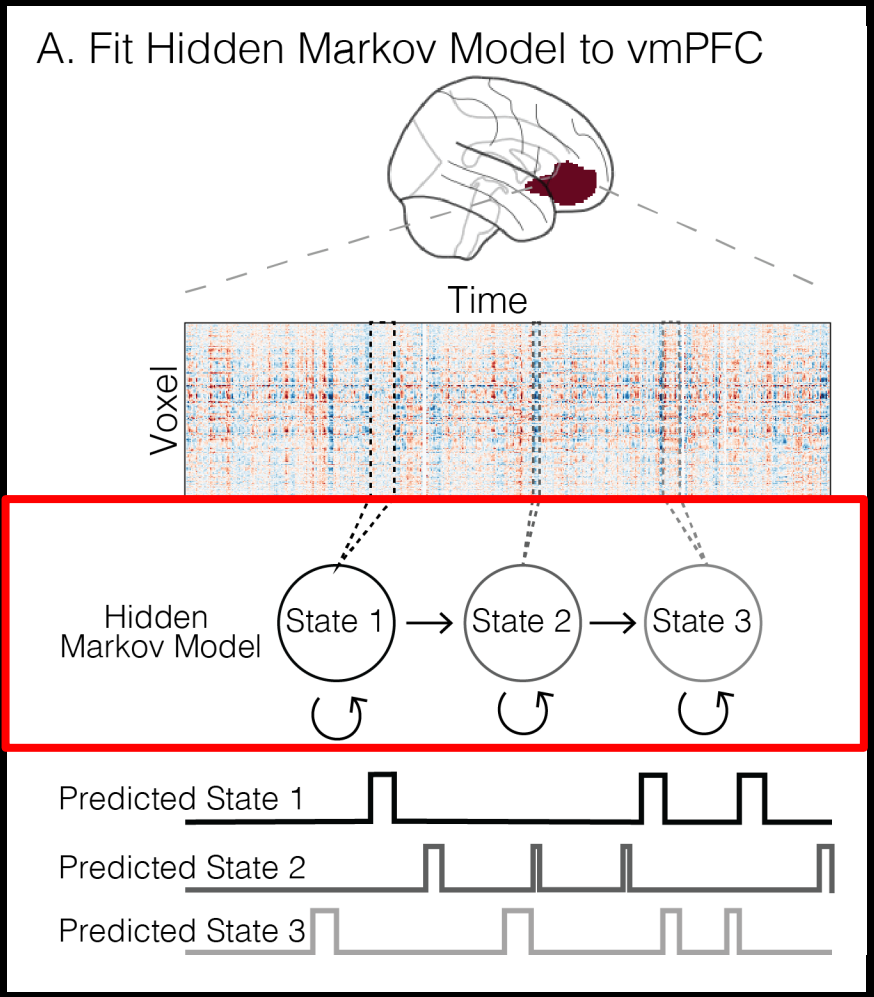
Stack Matrices

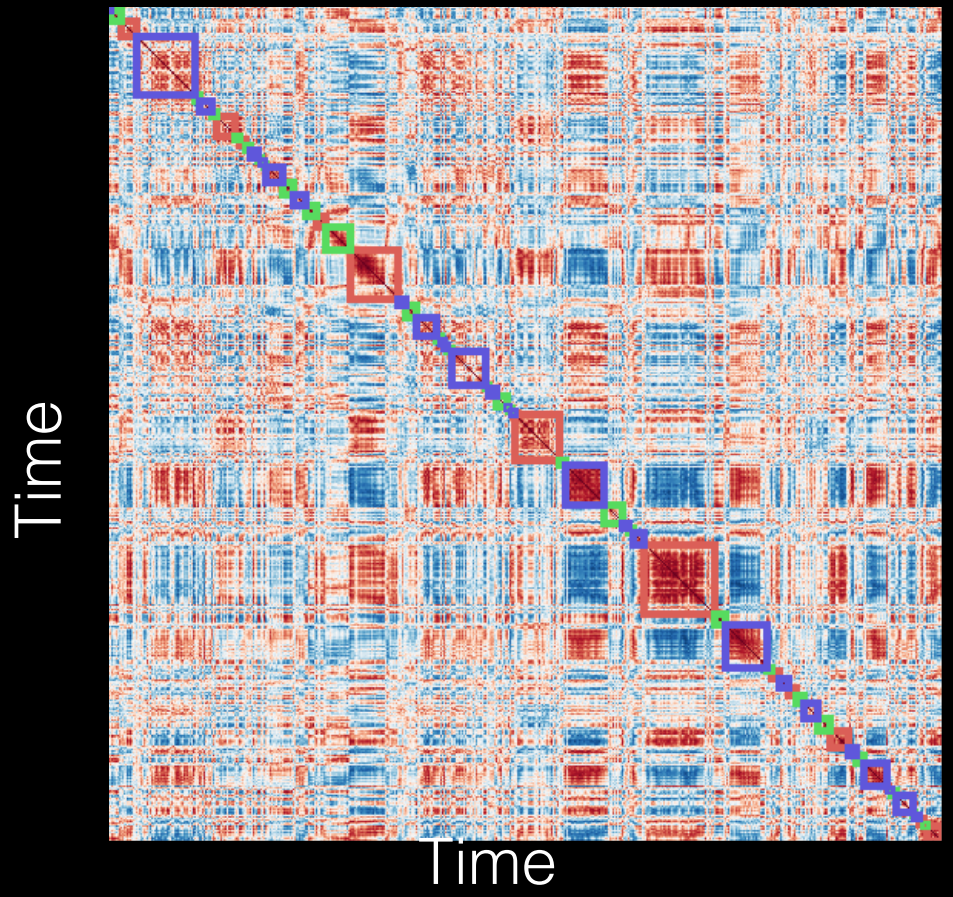


Chang, Jolly, Cheong, Rapuano, Chen, & Manning (bioRxiv, 2018)

What is the spatial and temporal consistency of these vmPFC states across subjects?

Identify latent state changes

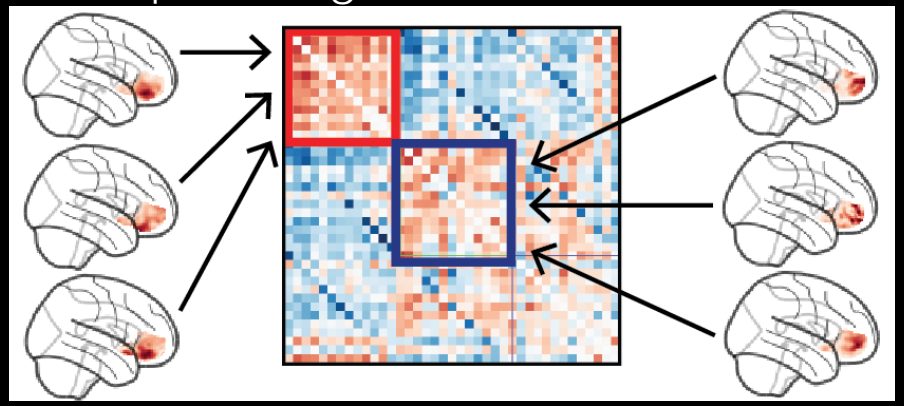




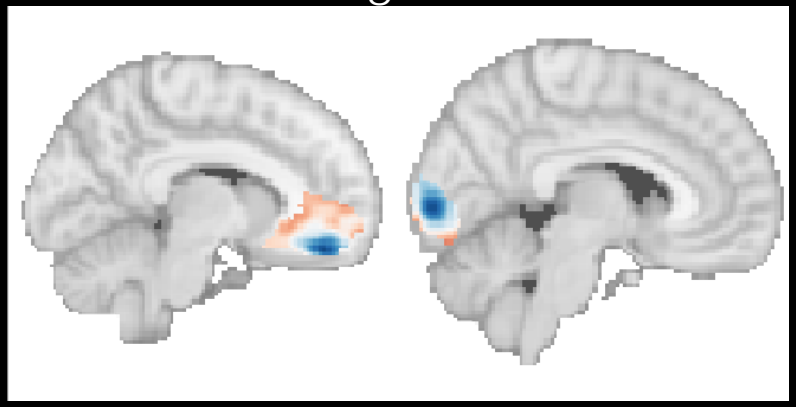
Chang, Jolly, Cheong, Rapuano, Chen, & Manning (bioRxiv, 2018)

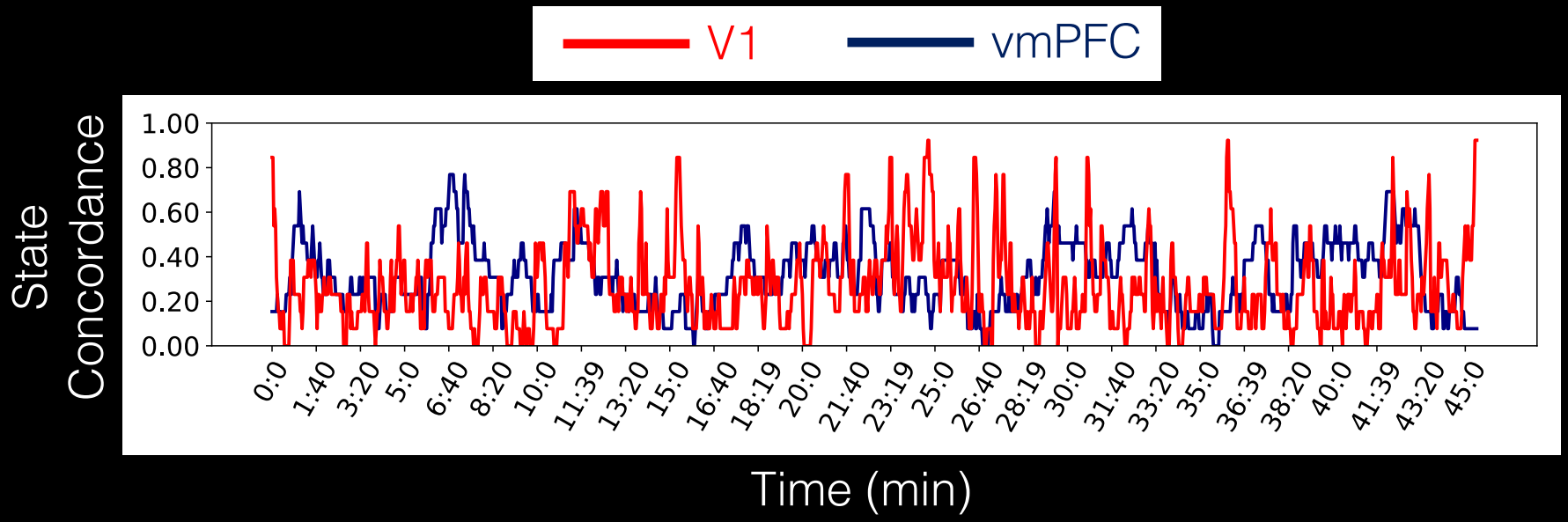
Intersubject Synchrony of Latent States

Spatial alignment of Latent States



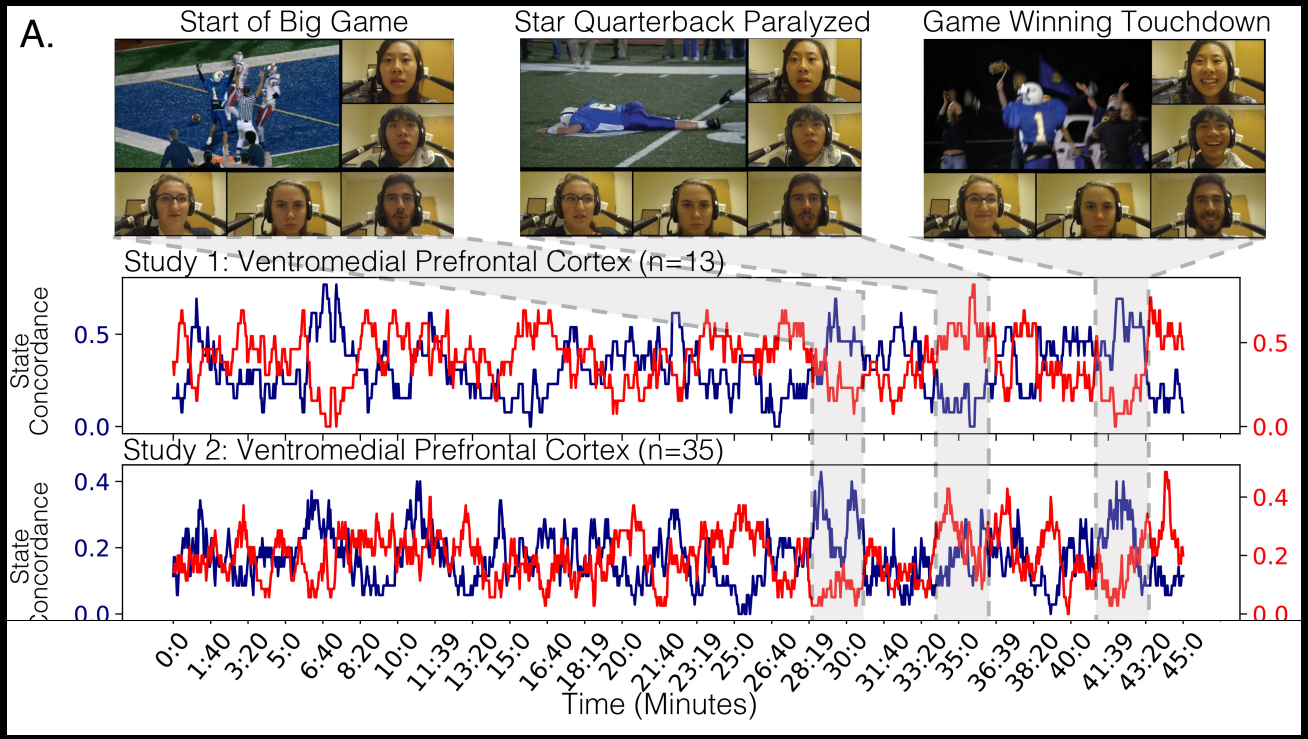
Average Pattern





Chang, Jolly, Cheong, Rapuano, Chen, & Manning (bioRxiv, 2018)

Do people change states at the same time?



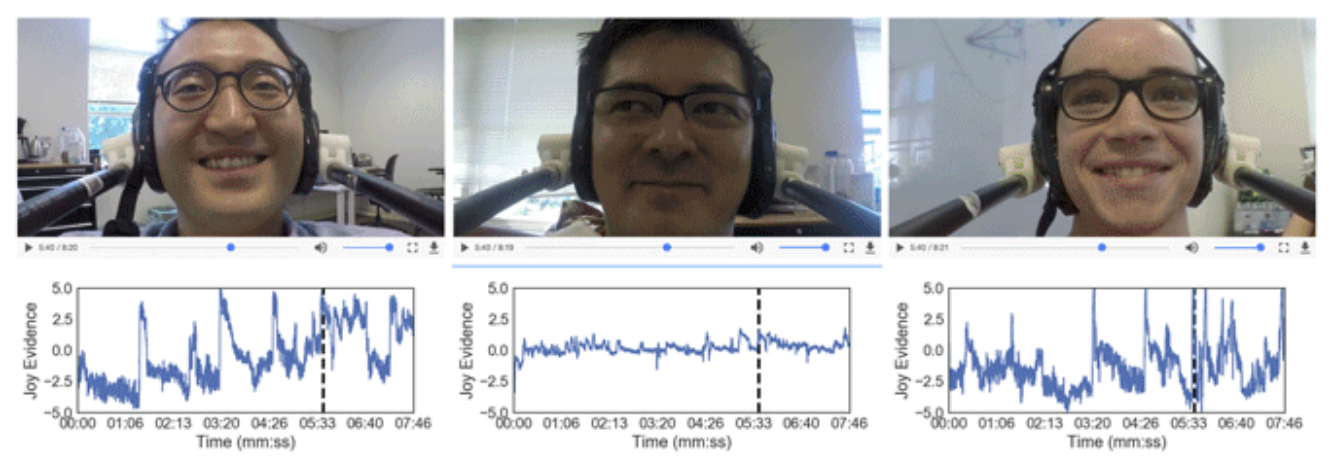
Chang, Jolly, Cheong, Rapuano, Chen, & Manning (bioRxiv, 2018)

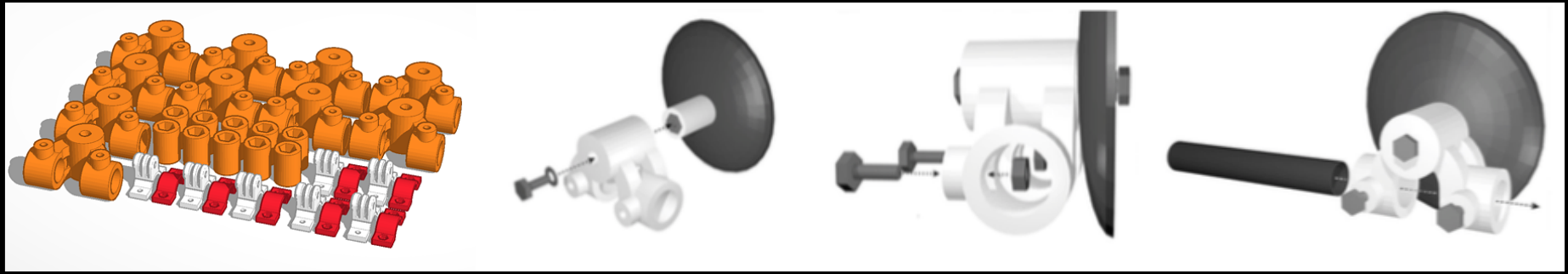
What are these states processing?

Facial Expressions

Jin Cheong
Grad Student

Sawyer Brooks
Undergrad

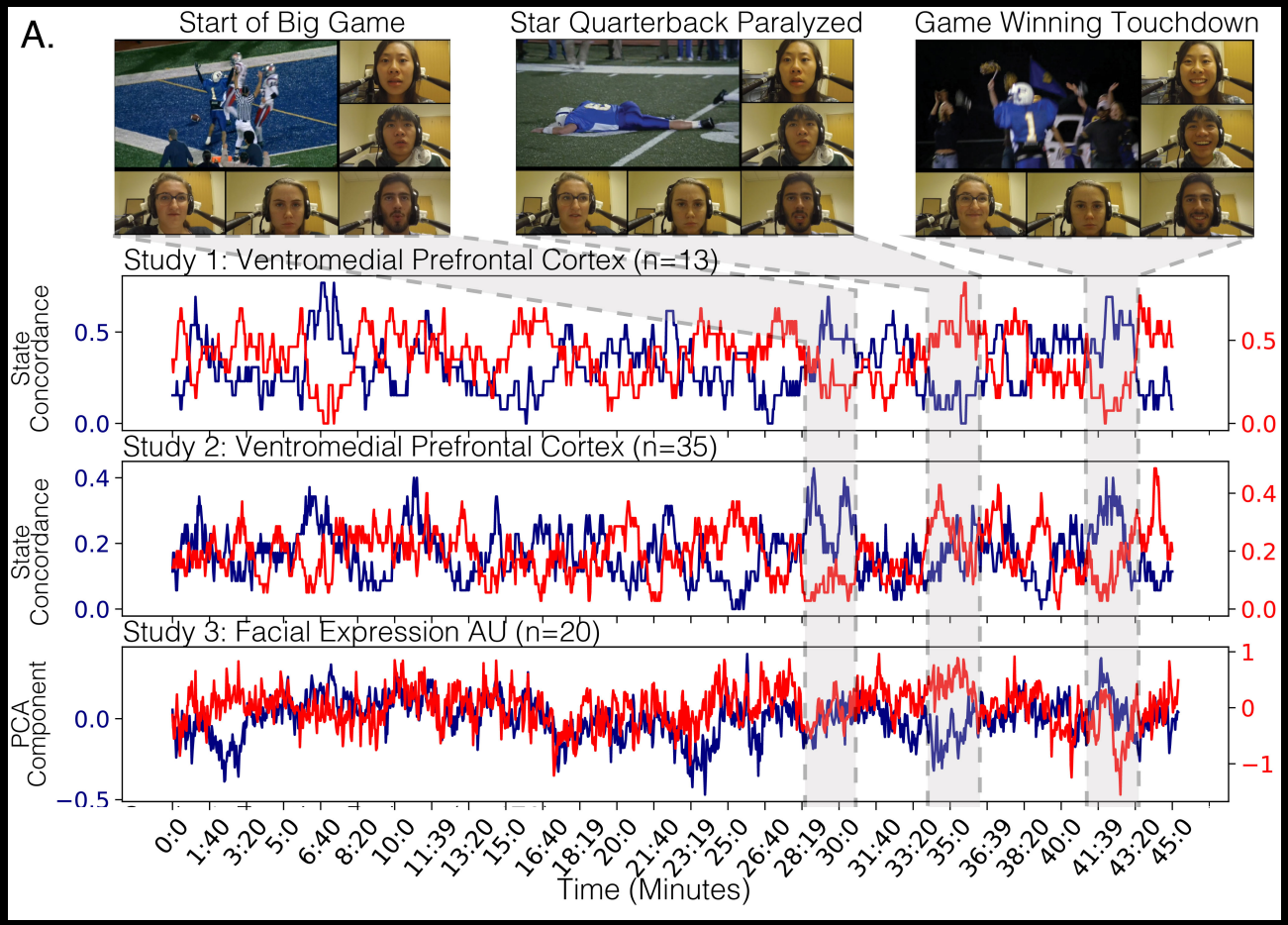


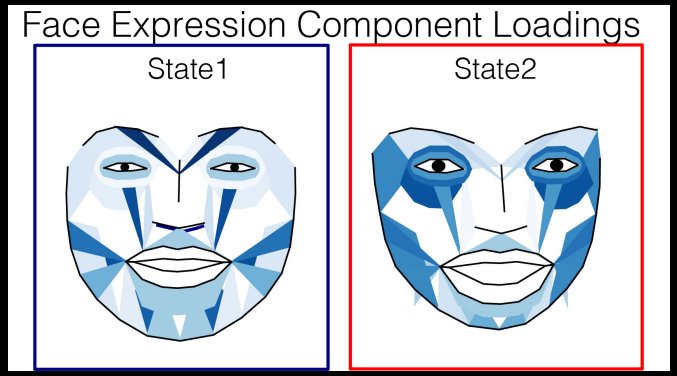


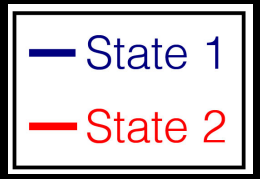
https://github.com/cosanlab/facesync
https://github.com/cosanlab/feat

Cheong, Brooks, & Chang (2019) F1000
Cheong, Byrne, and Chang (In Prep)

Sophie Byrne
Undergrad

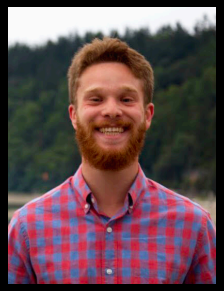






Chang, Jolly, Cheong, Rapuano, Chen, & Manning (bioRxiv, 2018)

How are people feeling?



Nathan Greenstein
Undergrad

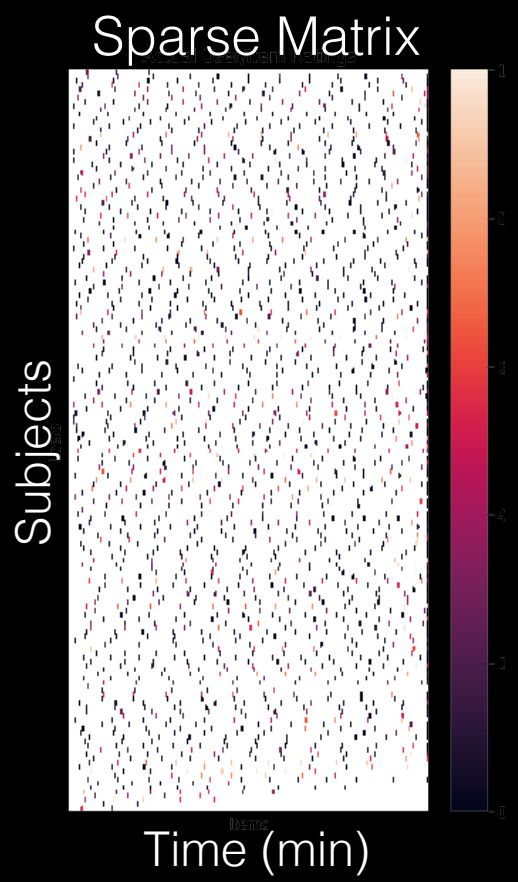
mTurk participants rate subjective feelings

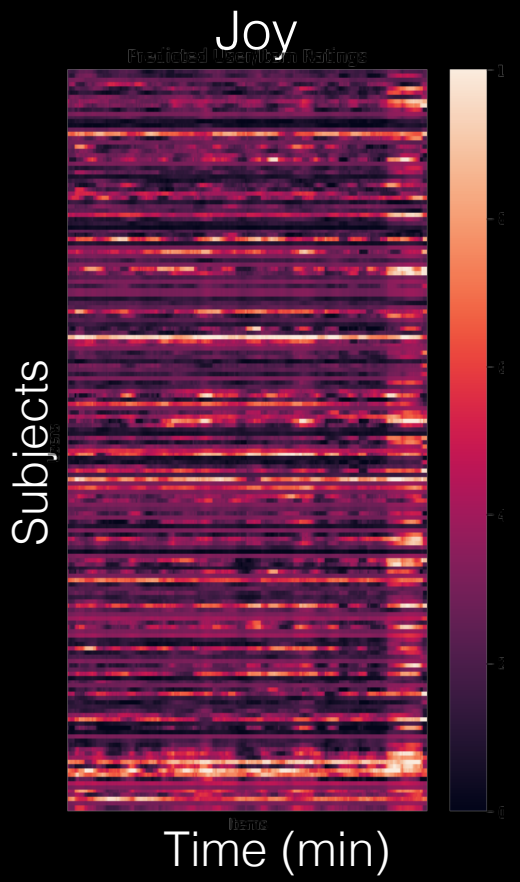
Please rate each of the following emotions:

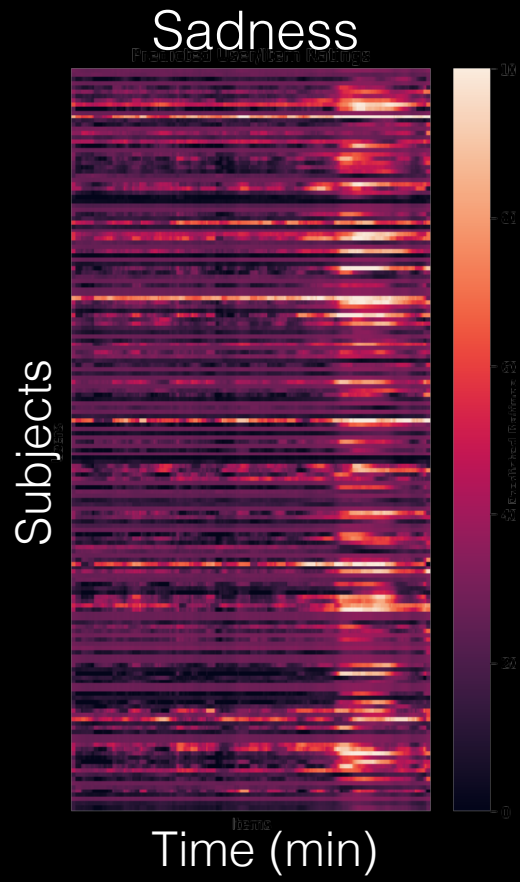
None	Sadness	
None	Joy	
None	Fear	
None	Guilt	
None	Contempt	
None	Envy	
None	Surprise	
None	Elation	
None	Relief	
None	Interest	
None	Pride	
None	Hope	
None	Shame	
None	Satisfaction	
None	Anger	
None	Disgust	

Press 'space' when finished.

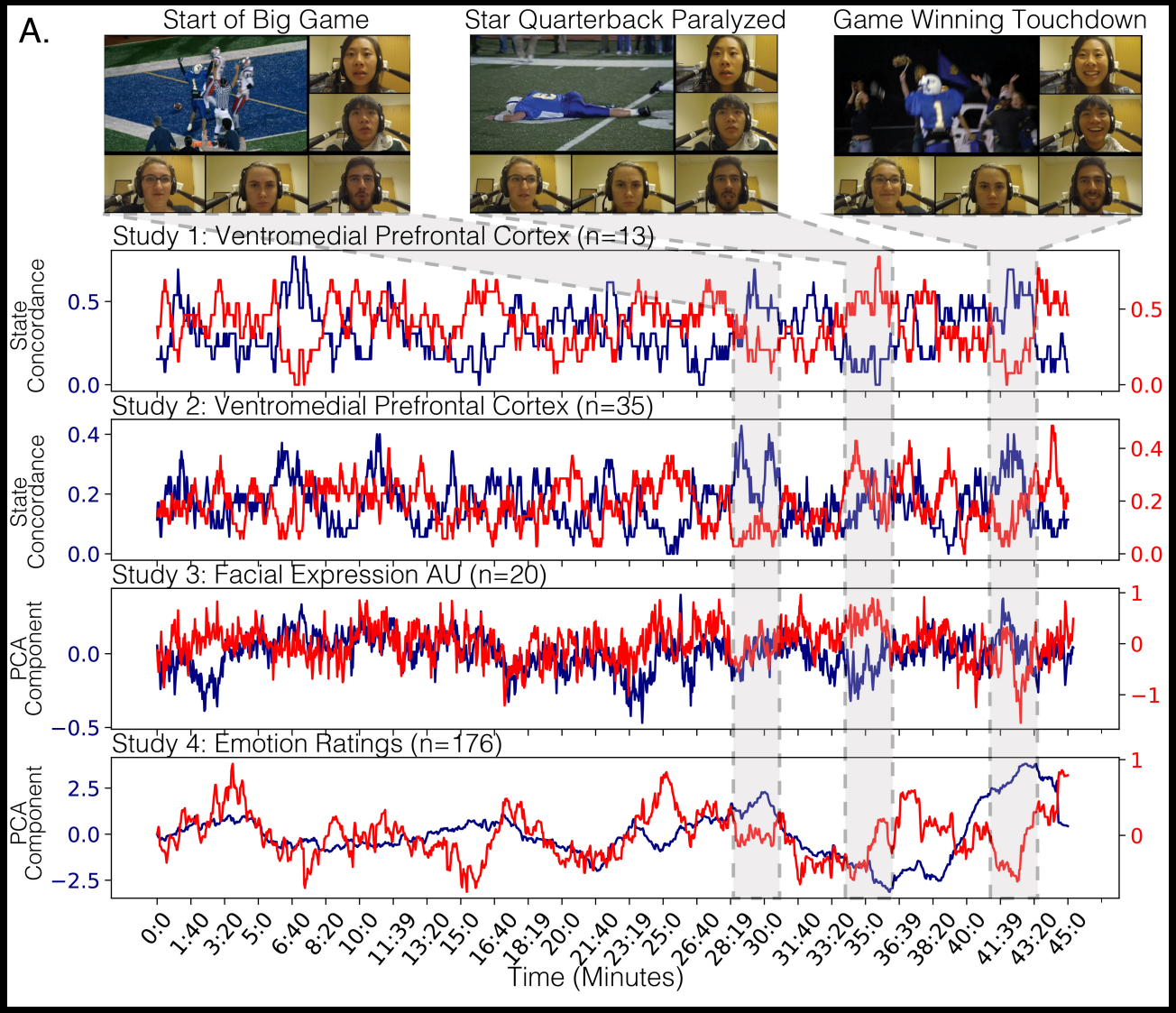
Predicting Individual Emotion Experiences Using Collaborative Filtering

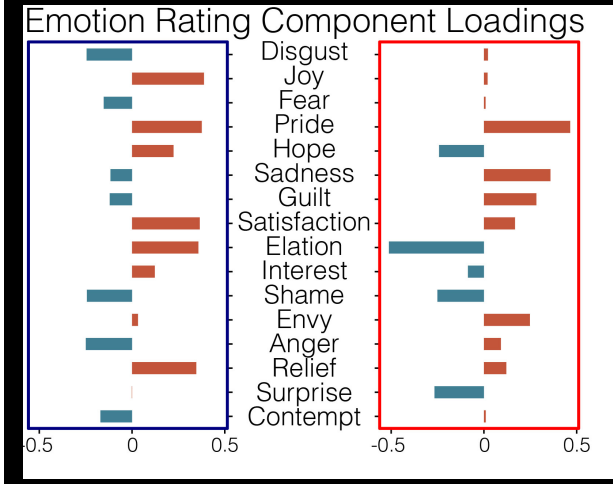


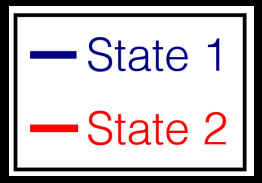




Chang, Greenstein, Eisenbarth, Reddan, Andrews, & Wager, In Prep

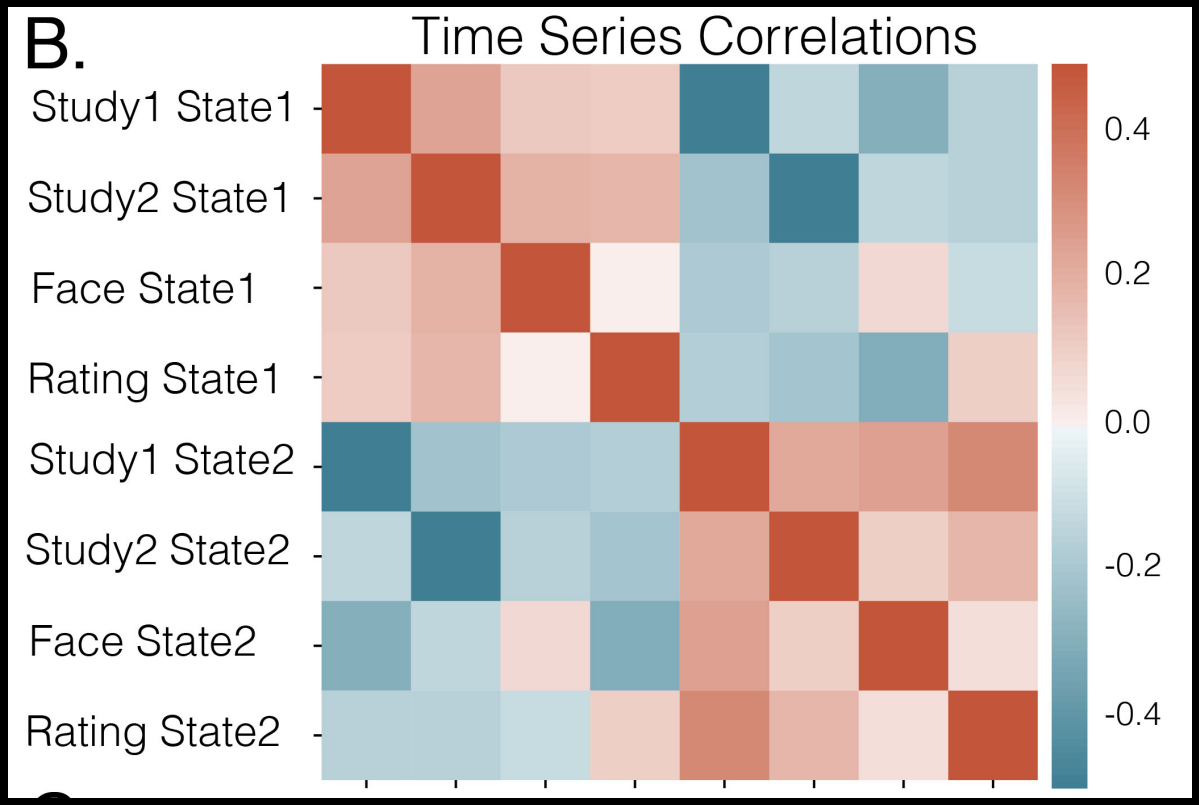






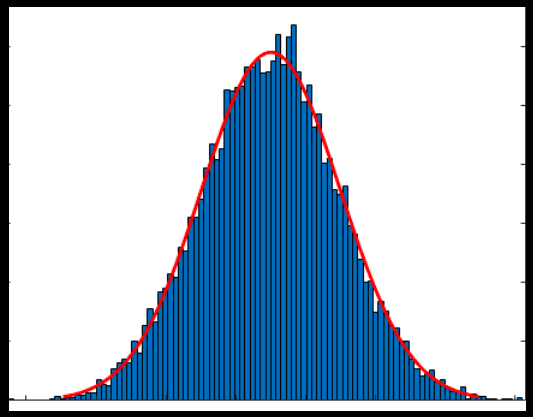
Chang, Jolly, Cheong, Rapuano, Chen, & Manning (bioRxiv, 2018)

vmPFC state concordance tracks affective states

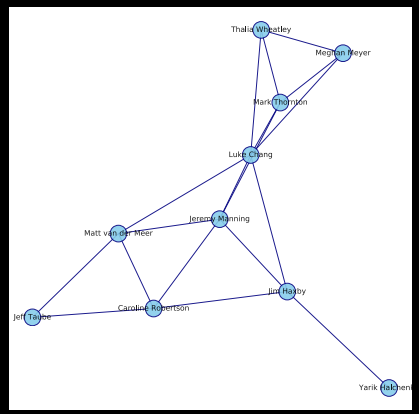


Chang, Jolly, Cheong, Rapuano, Chen, & Manning (bioRxiv, 2018)

What if variation isn't gaussian noise, but has some type of structure?



vs



Social distance as link function

Behavioral

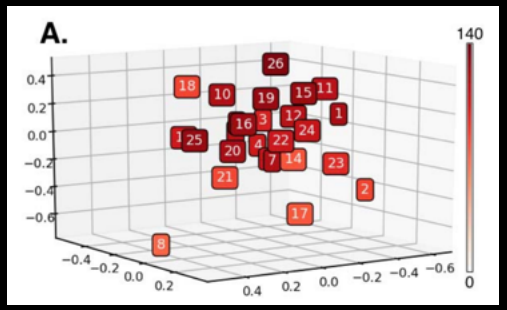
Social

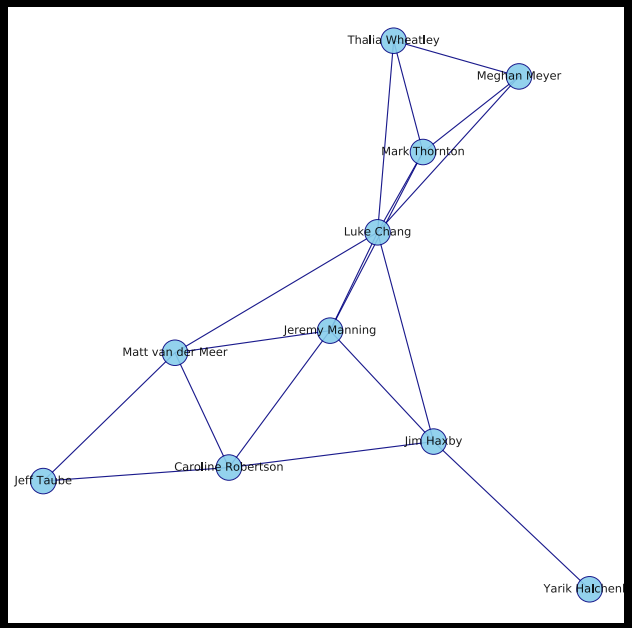
Cognitive

Intersubject representational similarity analysis (IS-RSA)

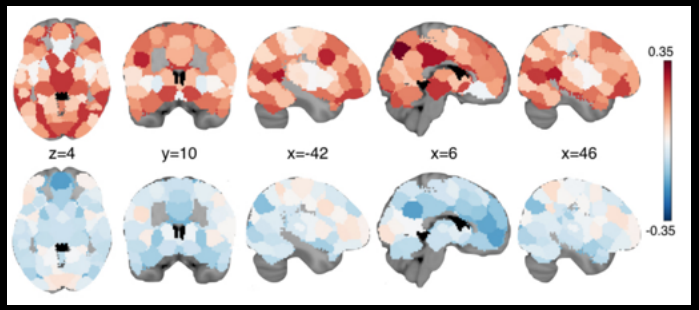
Social distance link function

Similarity in behavior





Similarity in brain patterns



Chen, Jolly, Cheong, & Chang (2019) bioRxiv
van Baar, Chang, & Sanfey (2019) Nature Communications
Cheong*, Jolly*, Chen, & Chang (In Prep)

Trust game with hidden multiplier

Jeroen van Baar
Donders

A

Invests
$10
Believing
multiplier
is 4

B

Alan Sanfey
Donders

2

4

6

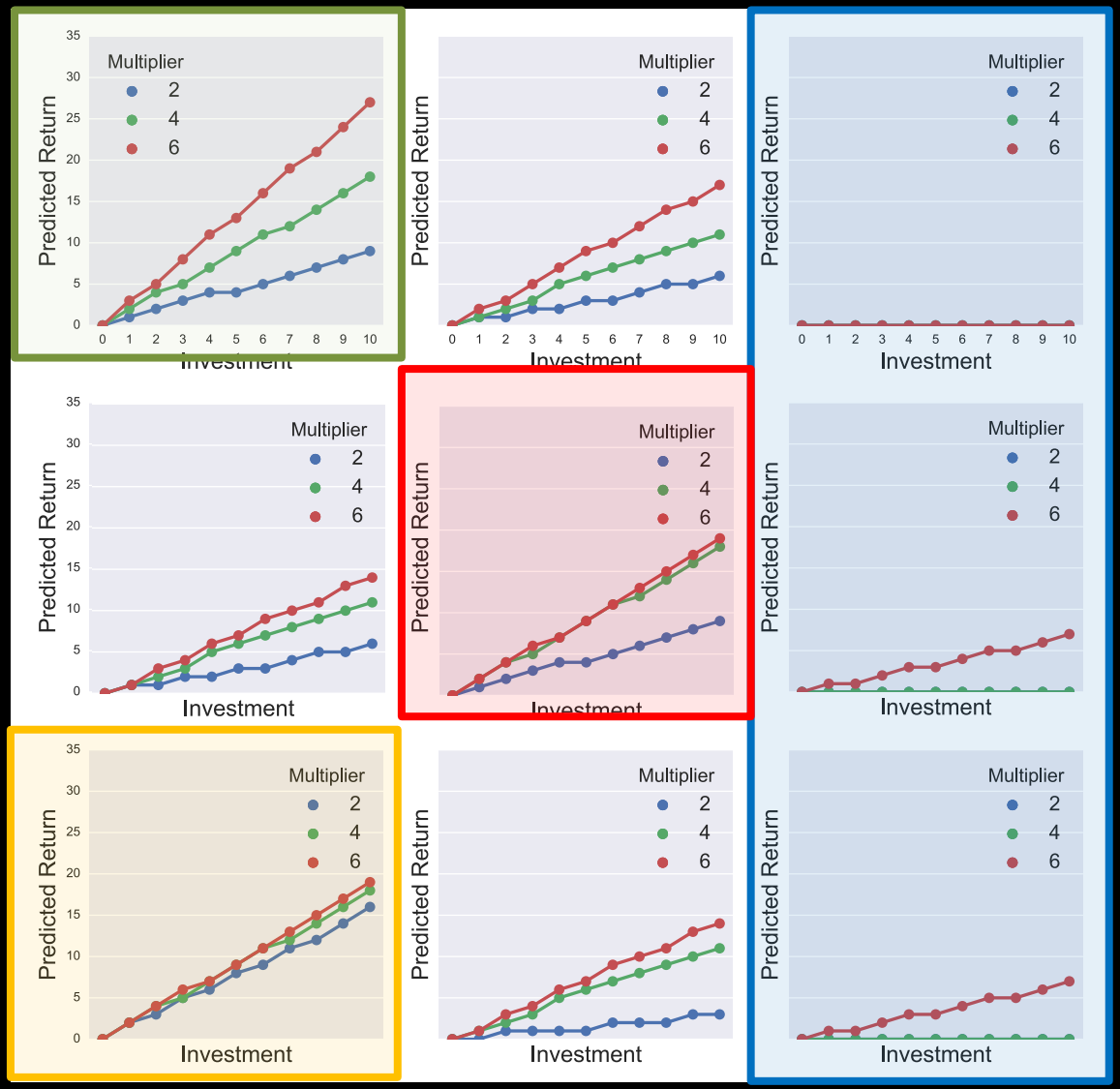
20	10	20	30
0	10	40	30
Guilt-Aversion	Inequity-Aversion	Guilt-Aversion	Inequity-Aversion

$$U = \theta \cdot \pi - (1 - \theta) \cdot \min\left((E_2(E_1(x)) - x)^2 + \phi, (\pi - 0.5)^2 - \phi\right)$$

High

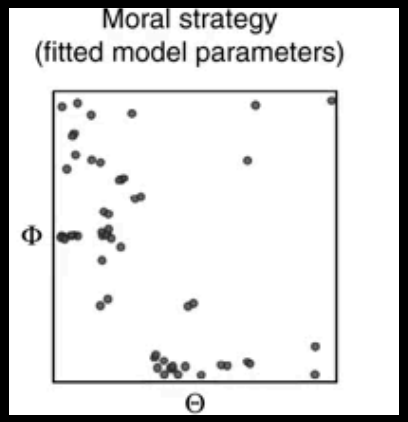
ϕ

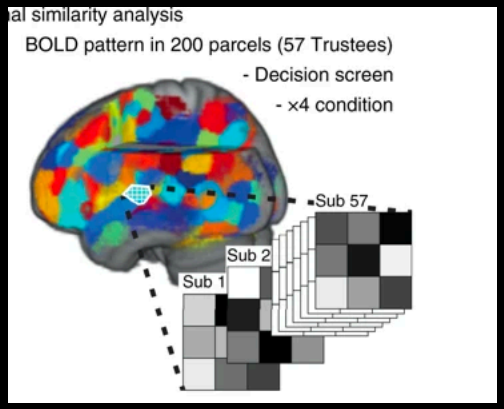
Low

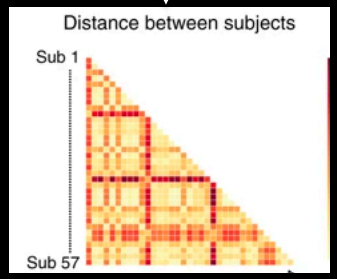


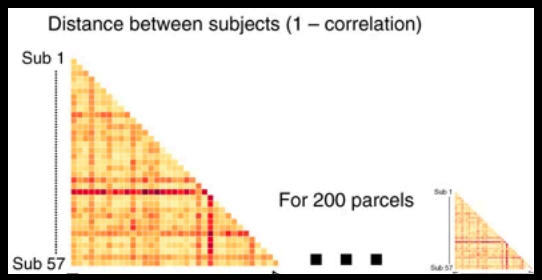
Low ← θ → High

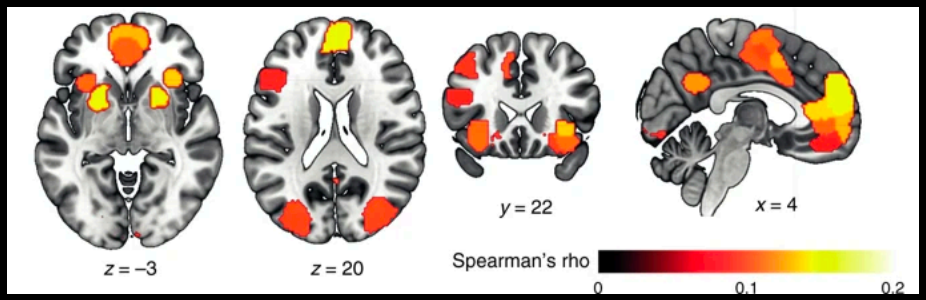
Intersubject RSA











van Baar, Chang, & Sanfey (2019) Nature Communications

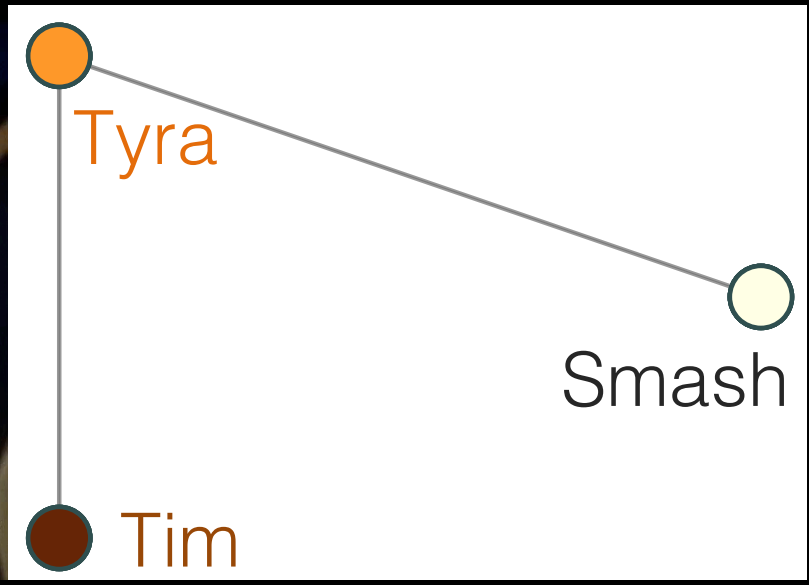
How do we build mental representations of others?

Eshin Jolly
(soon to be postdoc)

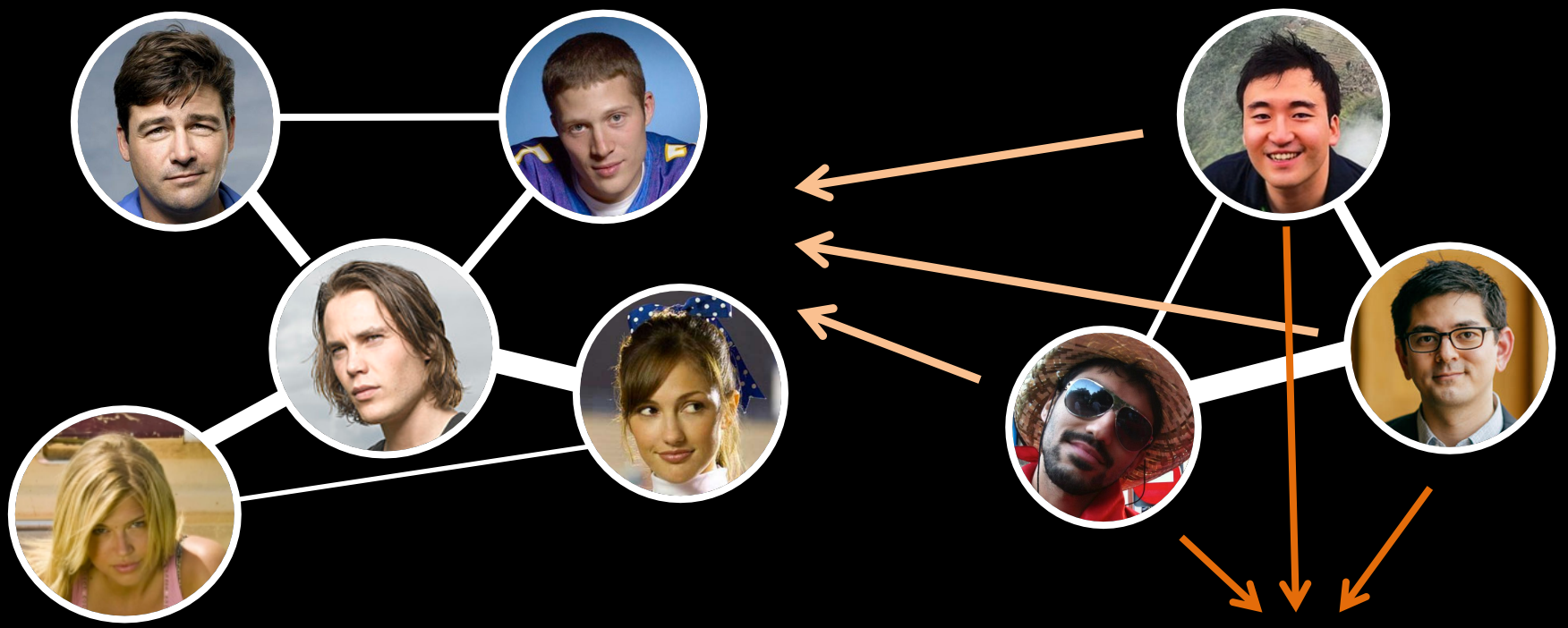
Task

- Watched 4 episodes
- Completed 4 different types of memory tasks
- Rated characters on different dimensions postscan
- Rated character influence networks postscan

How do we learn relationships between people?

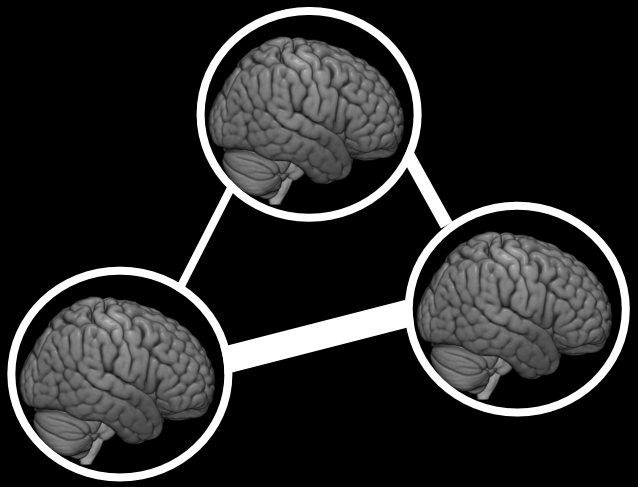


Inter-subject Representational Similarity

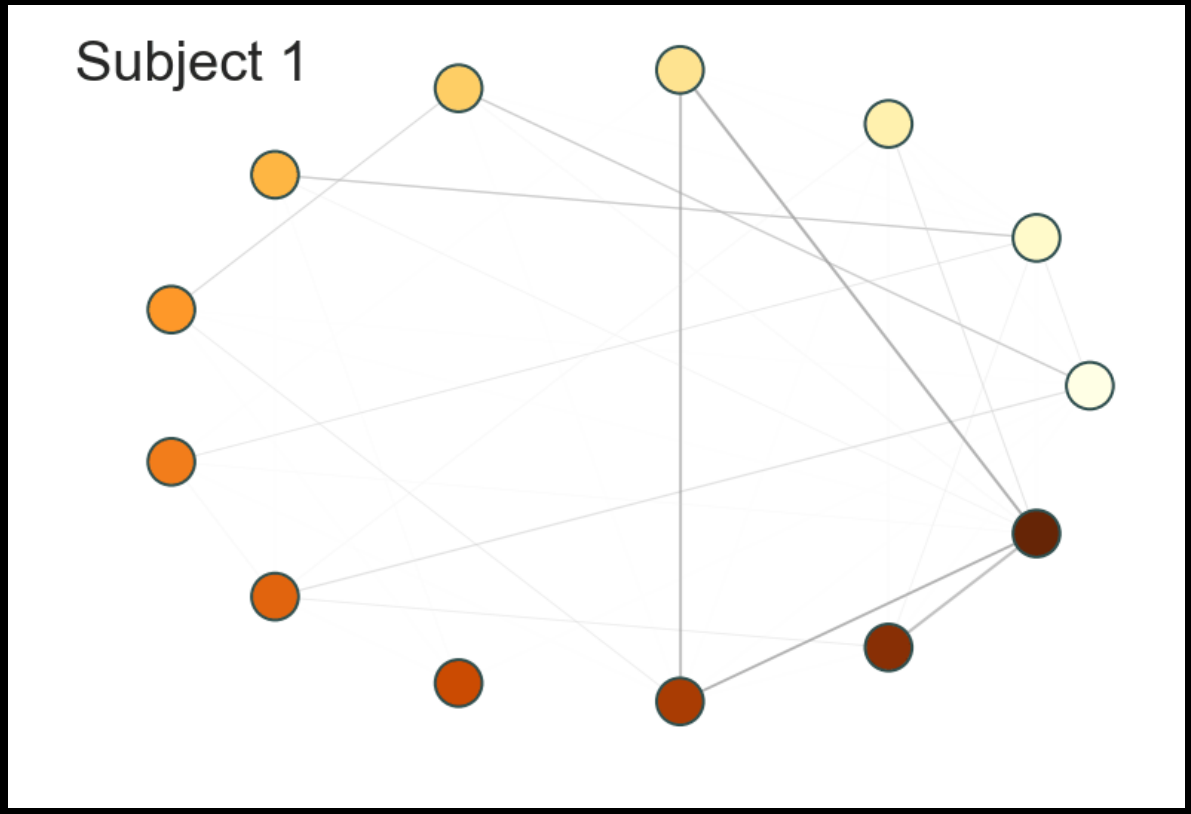


Map perceptions of social relationships to neural processes

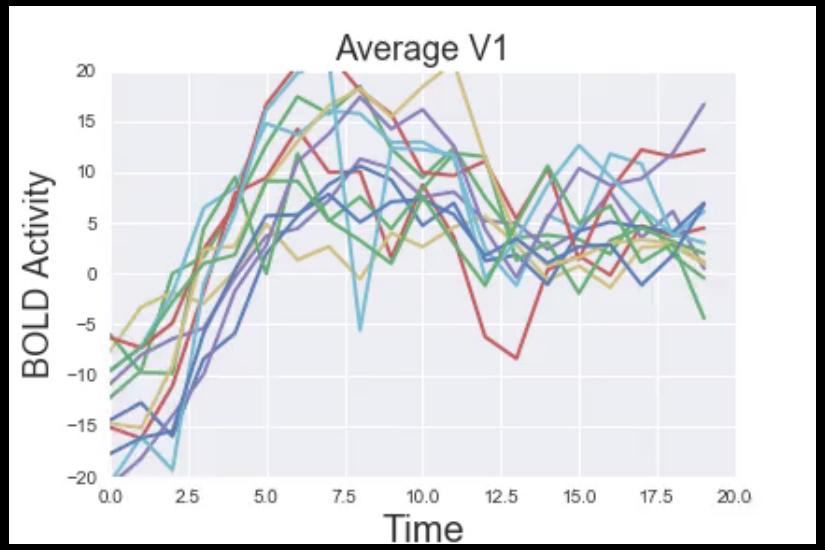
People with similar perceptions should have a similar brain response in regions involved in computation

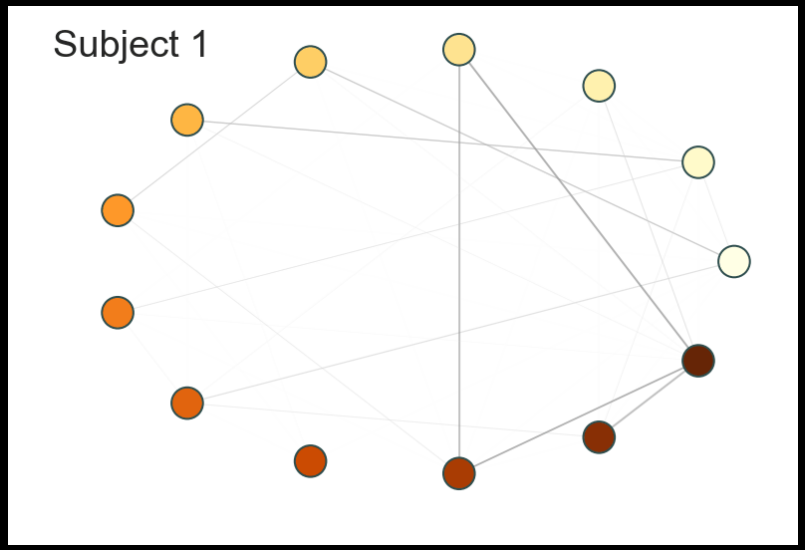


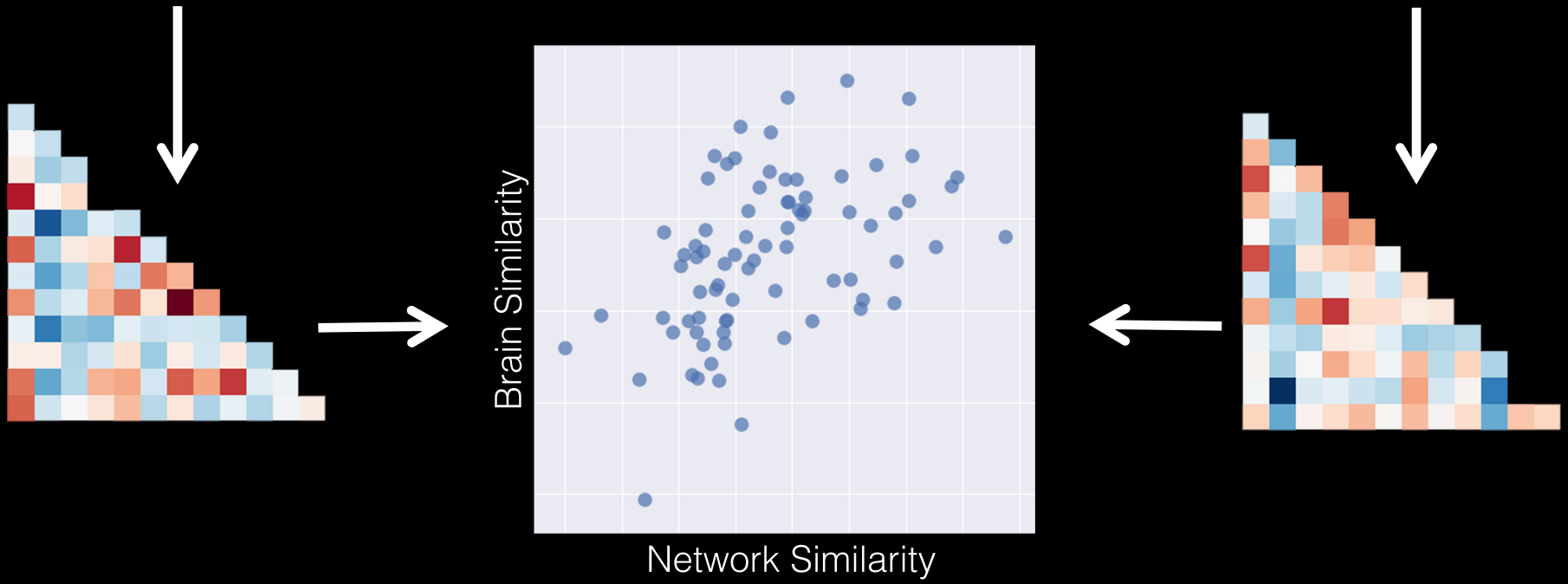
Participants' character liking networks



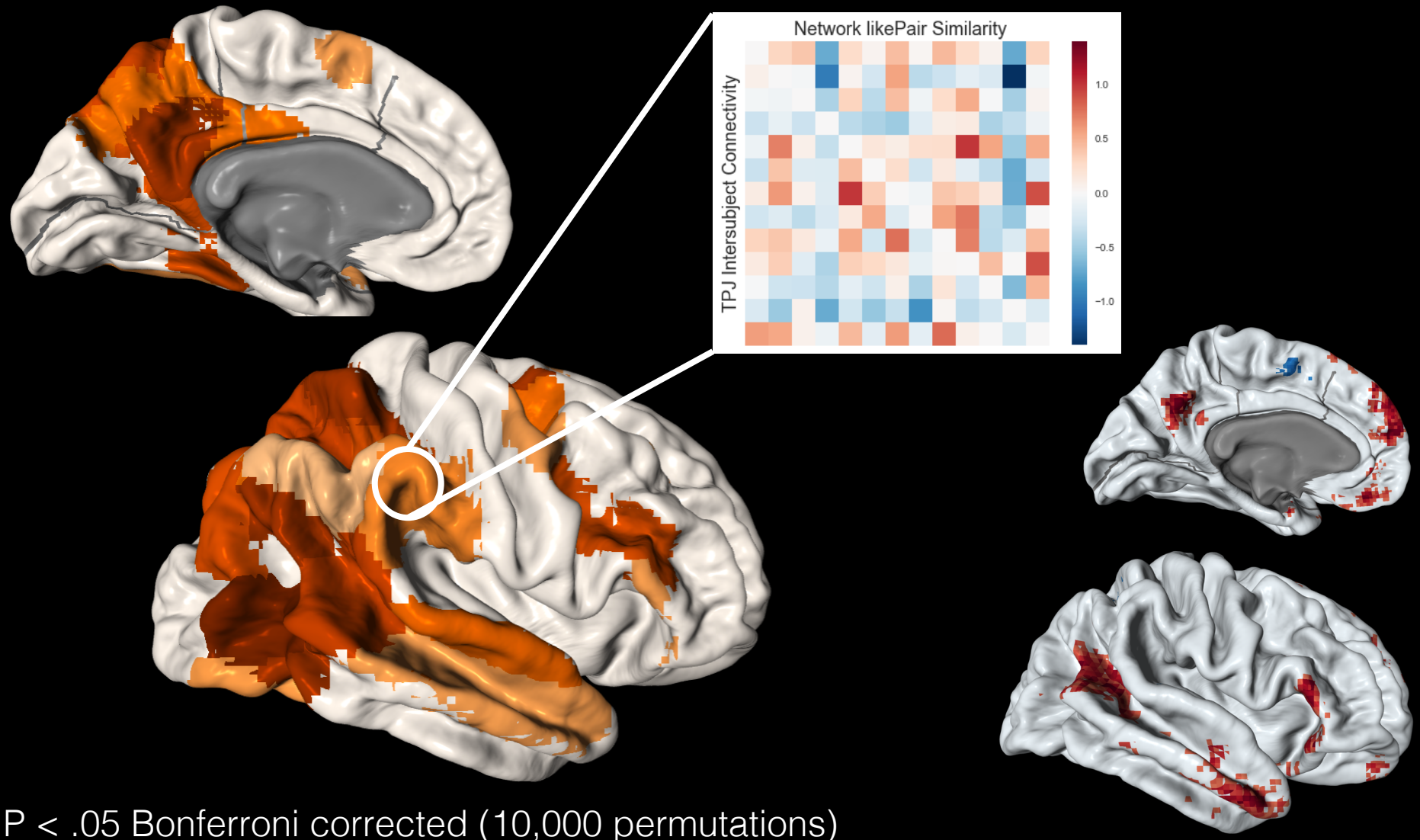
Inter-subject Representational Similarity







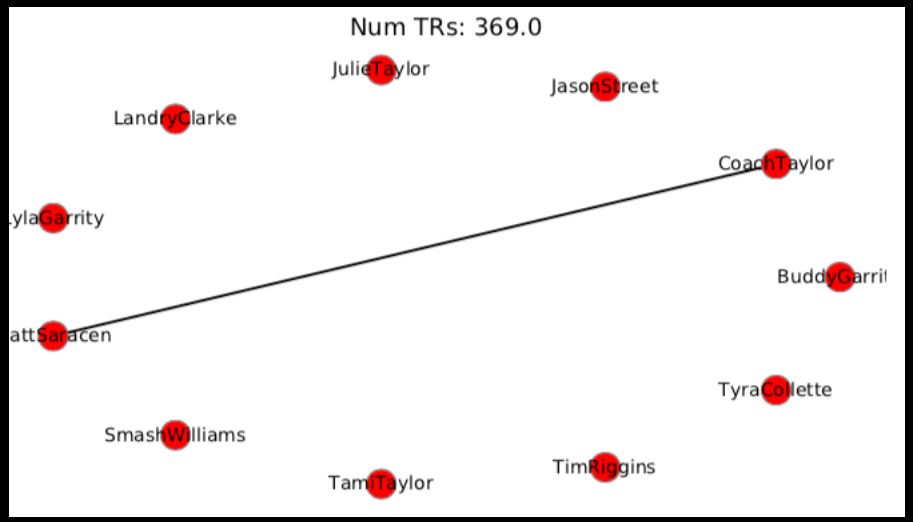
Regions involved in encoding character networks



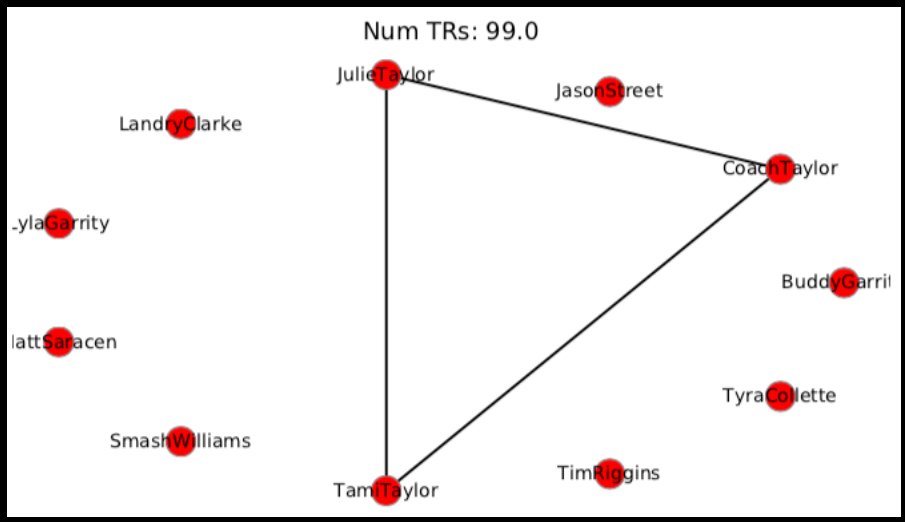
P < .05 Bonferroni corrected (10,000 permutations)

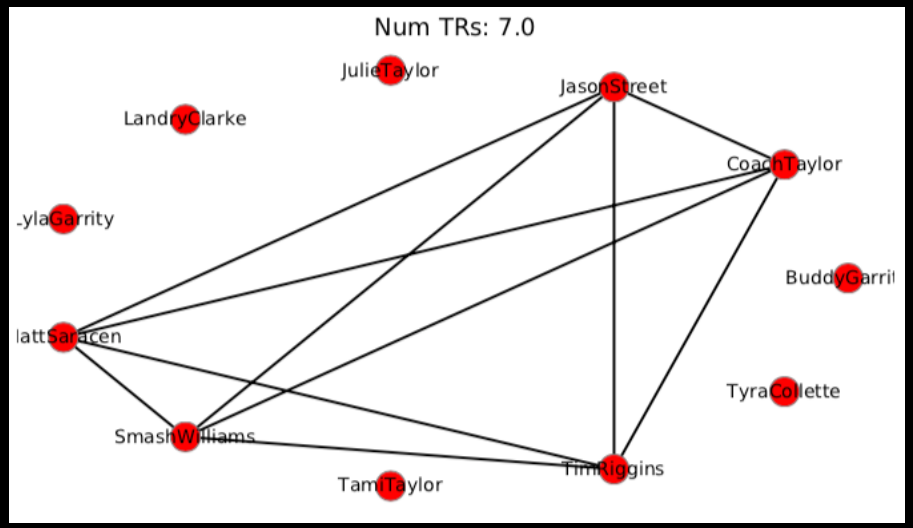
Network Motifs

Mentorship



Family

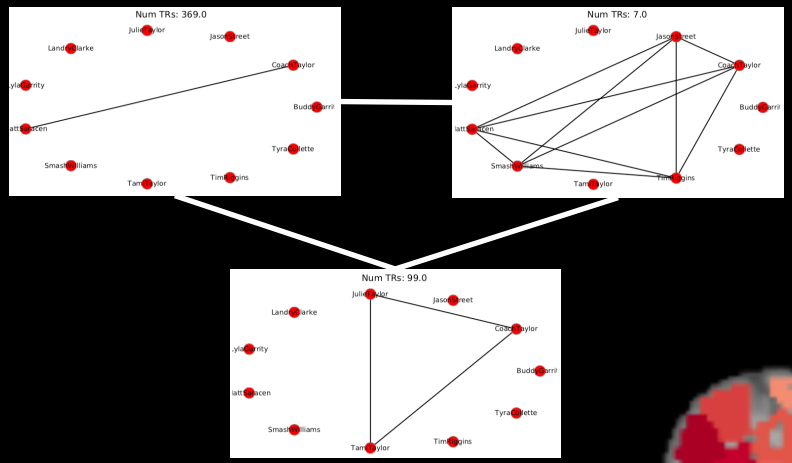


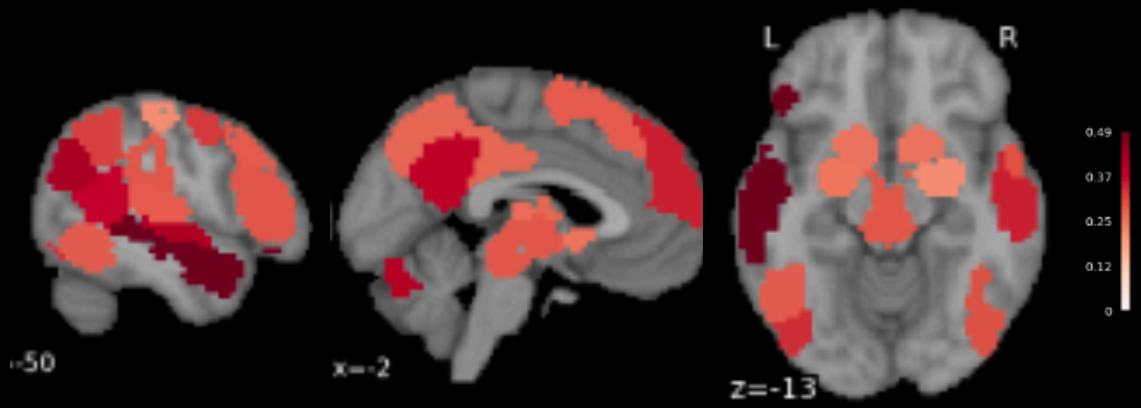


Football Team

Jolly, Cheong, Sadhukha, & Chang (In Prep)

Regions that show a reliable motif similarity structure

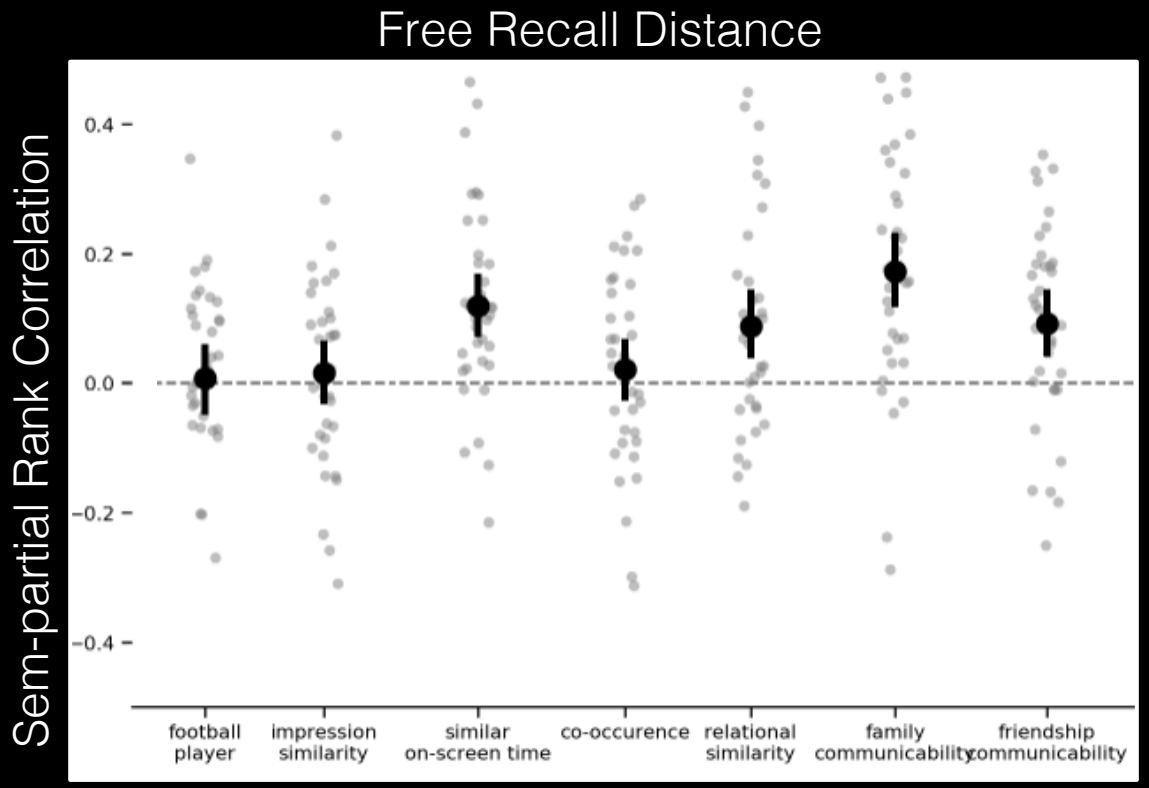




FDR q< 0.05

Jolly, Cheong, Sadhukha, & Chang (In Prep)

How do we remember characters?

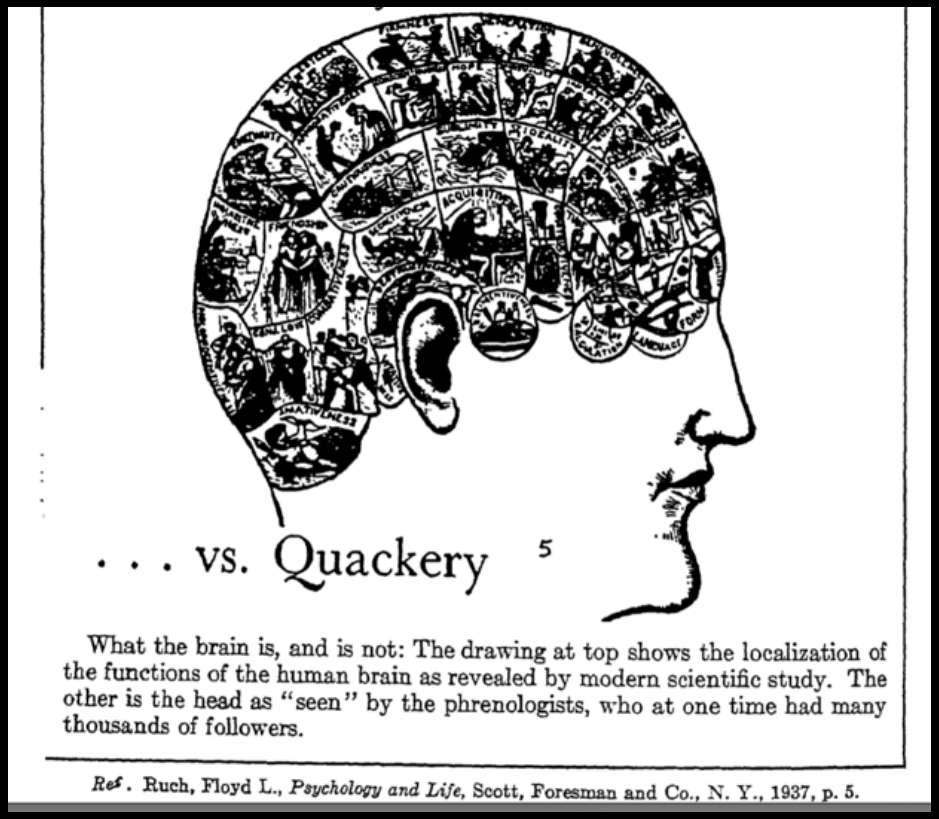


Jolly, Cheong, Sadhukha, & Chang (In Prep)

Too many analyses to cover.

Find Eshin if you're interested in learning more

Take home points



. . . vs. Quackery [5]

What the brain is, and is not: The drawing at top shows the localization of the functions of the human brain as revealed by modern scientific study. The other is the head as "seen" by the phrenologists, who at one time had many thousands of followers.

Ref. Ruch, Floyd L., *Psychology and Life*, Scott, Foresman and Co., N. Y., 1937, p. 5.

We are hiring!

http://cosanlab.com

Lab Members

Andy Chen – Postdoc
Eshin Jolly – Grad Student
Jin Cheong – Grad Student
Emma Templeton – Grad Student
Bryan Gonzalez – Grad Student
Marissa Clark – Grad Student
Daisy Burr – Grad Student
Xiaoxue Gao – Visiting Student

cosanlab

Research Assistants

Amanda Brandt
Maryam Iqbal
Sophie Byrne
Karina Lopez
Samantha Milne
Tucker Brown
Nathan Greenstein
Sushmita Sadhukha
Emma Langfitt
Tricia Yeonas
Taylor Morrell
Ziyi Feng
Hirsh Elhence
Sawyer Brooks

NSF CAREER

neukom

NIH National Institute of Mental Health

R01MH116026
R56MH080716

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