ISMRM 27TH ANNUAL MEETING & EXHIBITION
Palais des congrès de Montréal · Montréal, QC, Canada · 11–16 May 2019

Periods of discernible cognition contribute to dynamic functional connectivity during rest

Javier Gonzalez-Castillo[1], César Caballero-Gaudes[3], Natasha Topolski[1], Francisco Pereira[2], Daniel A. Handwerker[1], Peter A. Bandettini[1,2]

[1]Section on Functional Imaging Methods, National Institute of Mental Health, NIH, USA
[2]Machine Learning Team, National Institute of Mental Health, NIH, USA
[3]Basque Center on Cognition, Brain and Language, Spain

FIM

NIH National Institute of Mental Health

Gonzalez-Castillo et al., 2019 BioRxiv

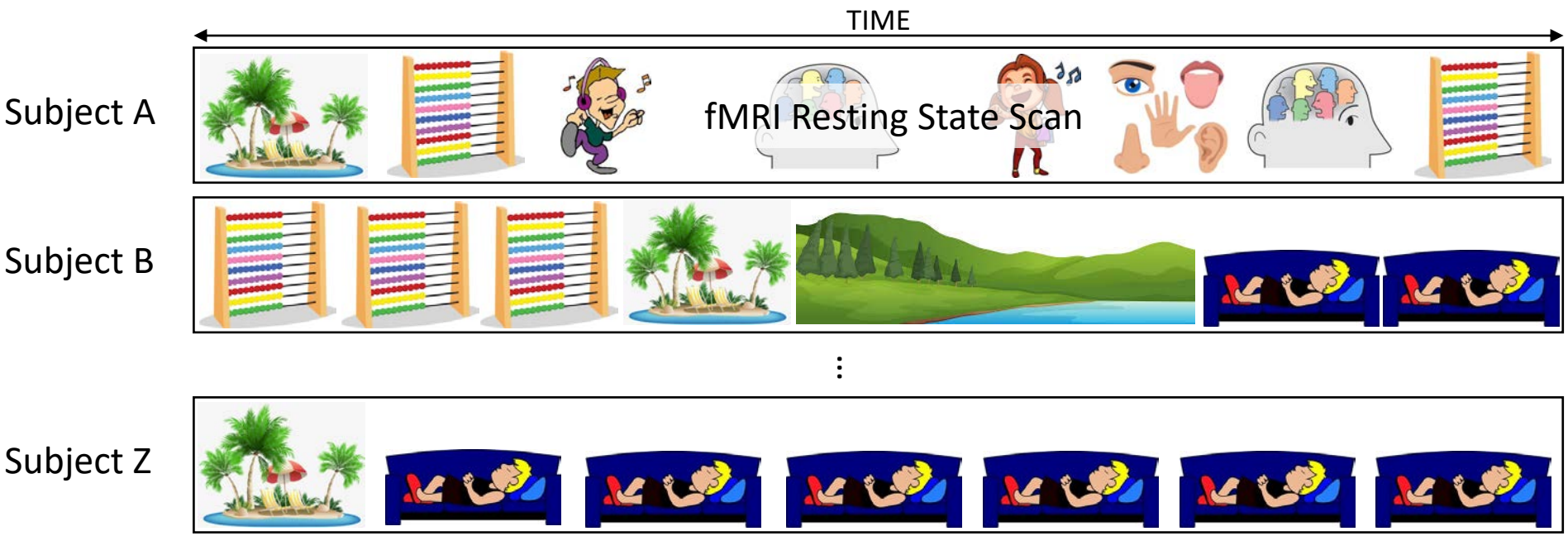
bcbl BASQUE CENTER ON COGNITION, BRAIN AND LANGUAGE

Declaration of Financial Interests or Relationships

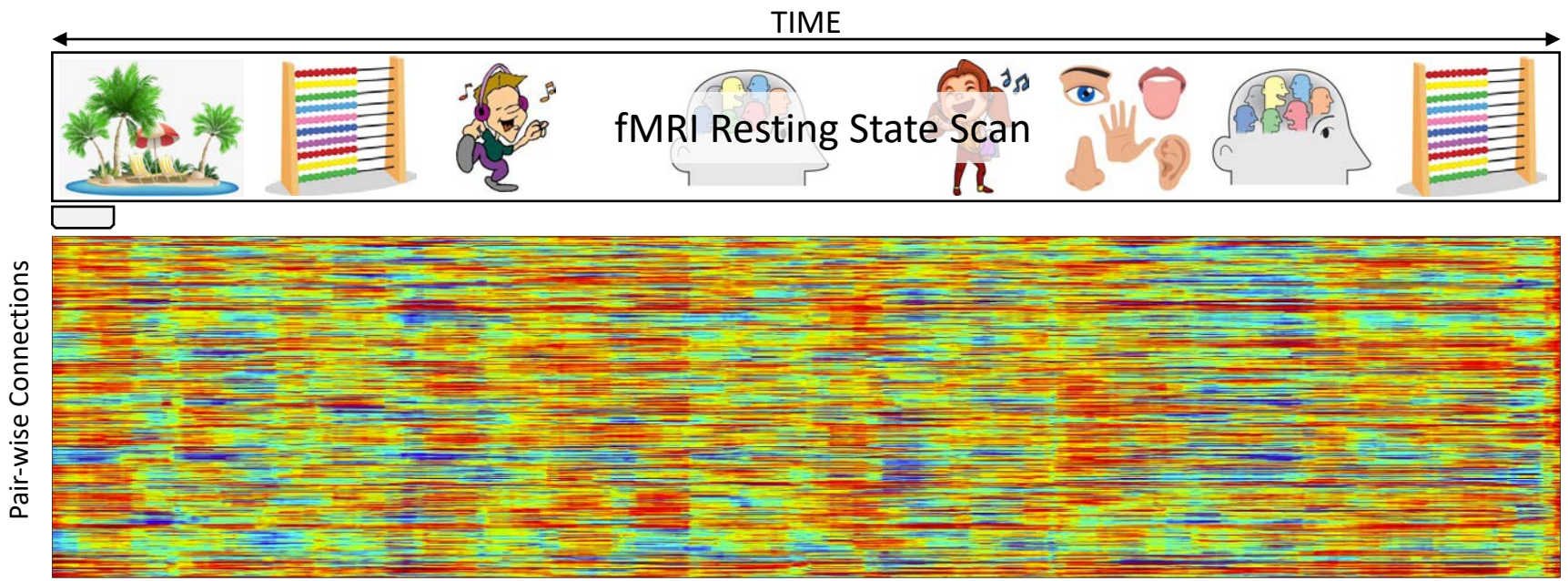
Speaker Name: Javier Gonzalez-Castillo

I have no financial interests or relationships to disclose with regard to the subject matter of this presentation.

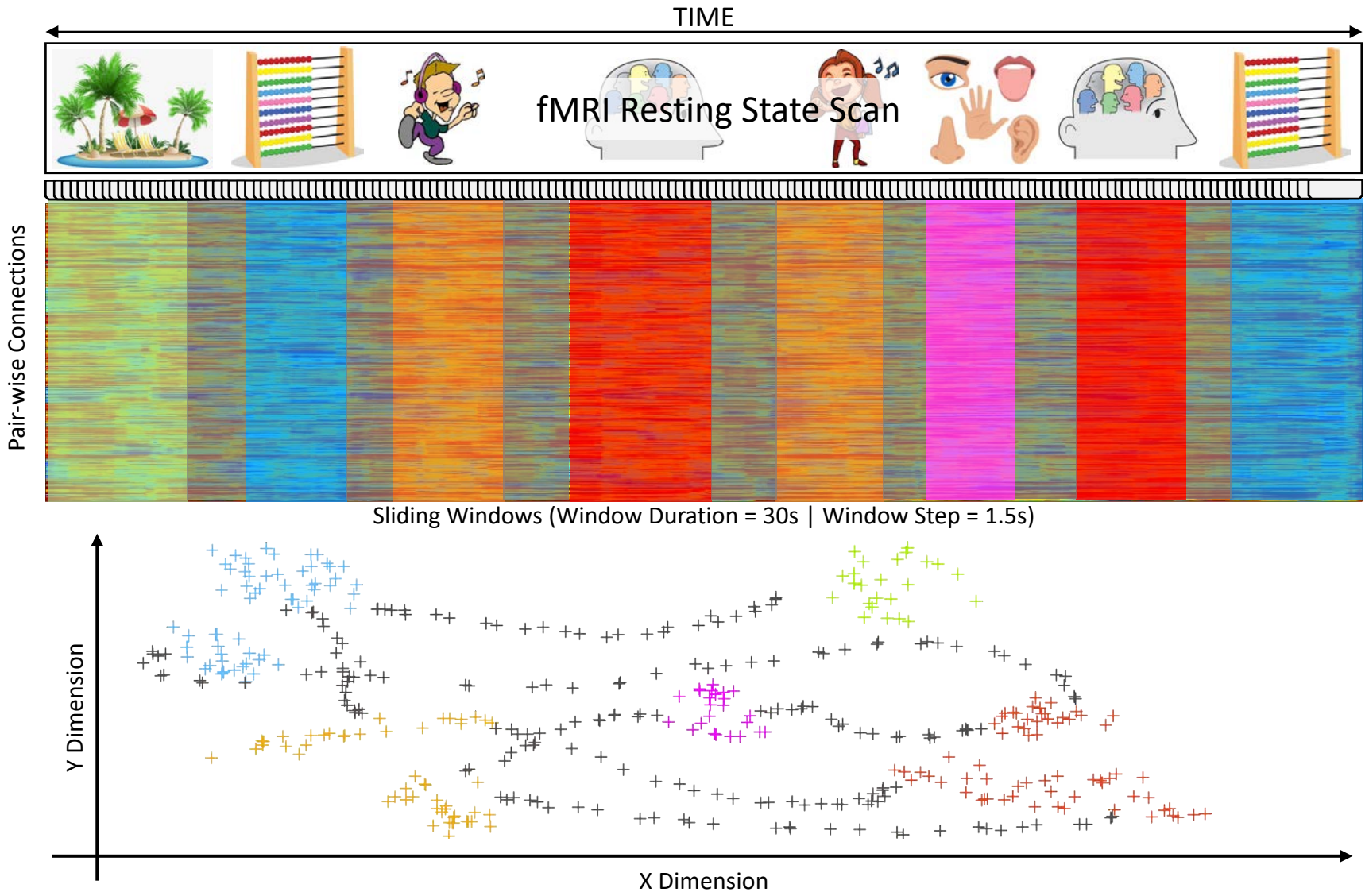
Working Hypothesis



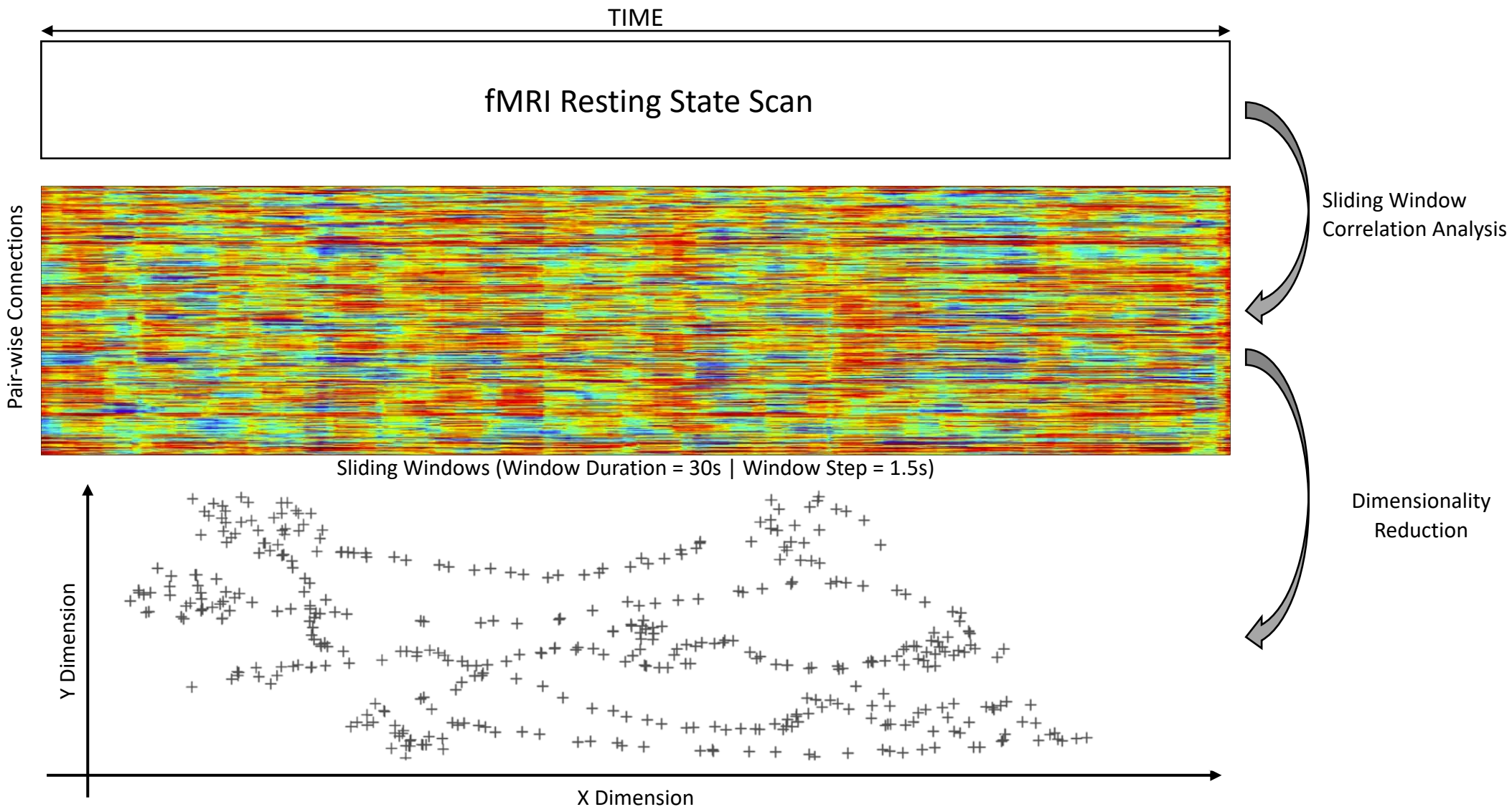
Working Hypothesis



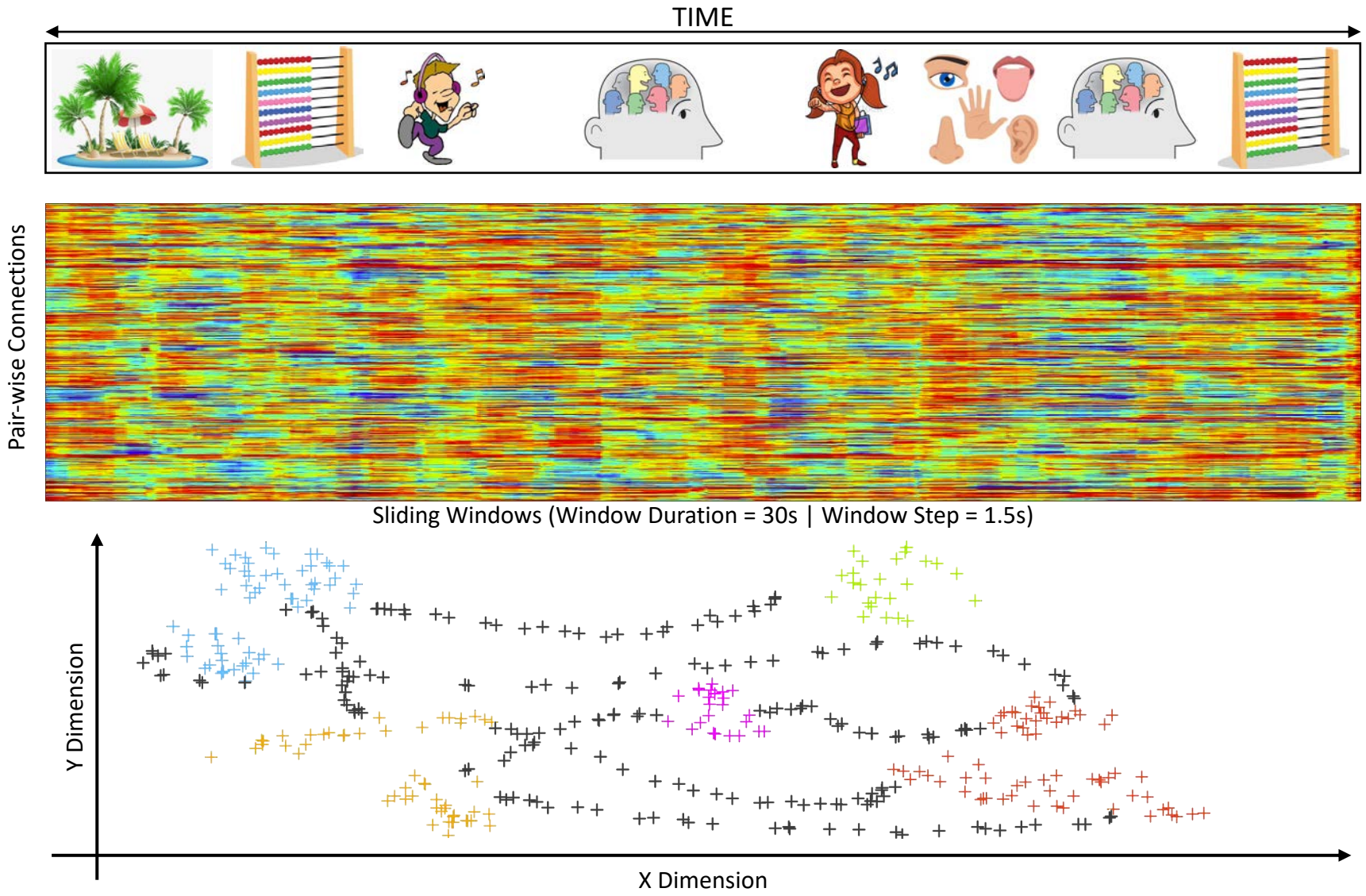
Working Hypothesis



Working Hypothesis

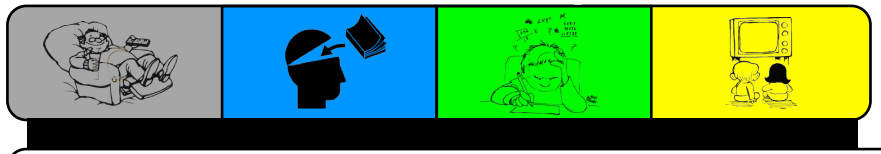


Working Hypothesis

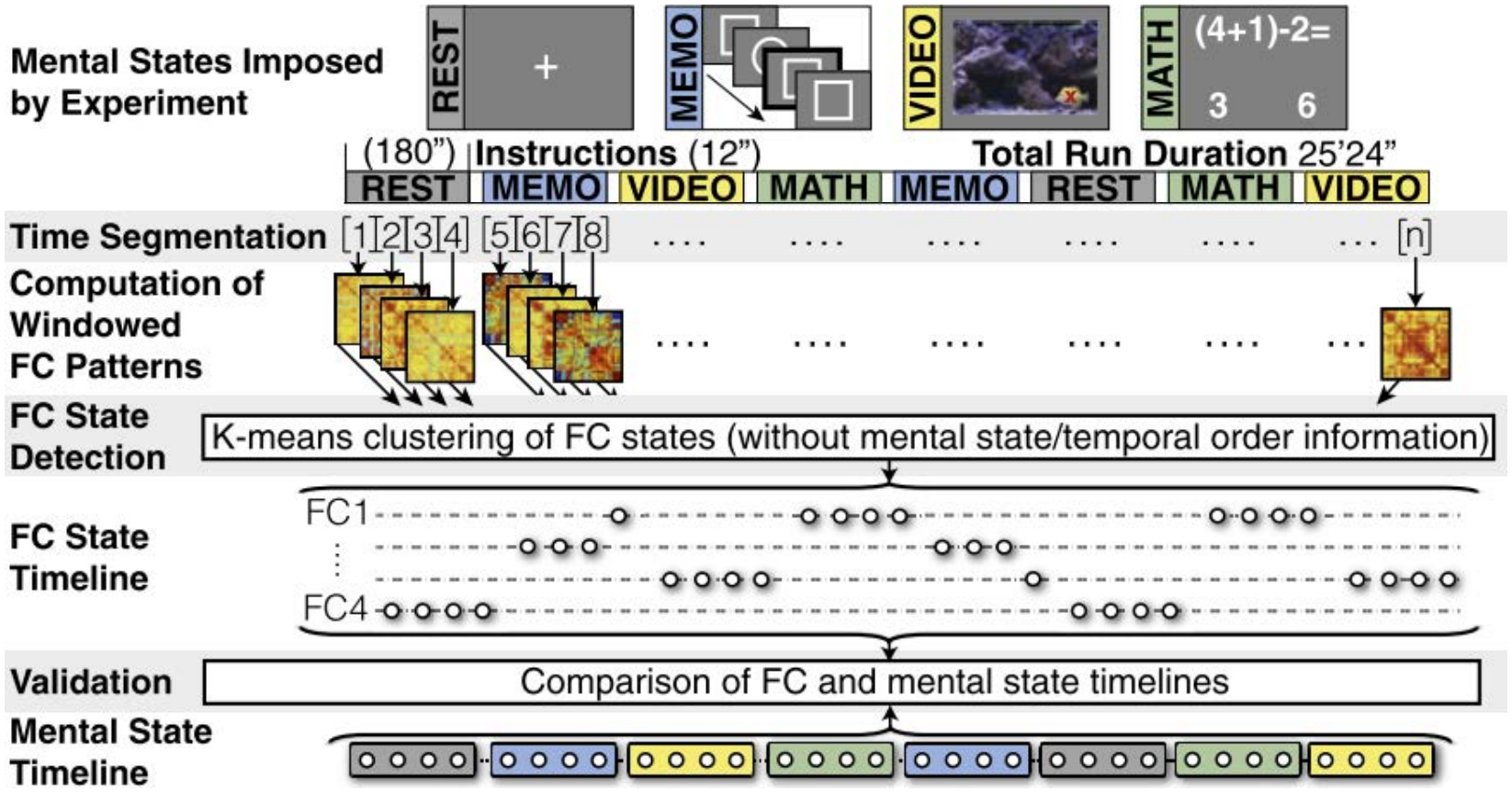


Experiments / Methods

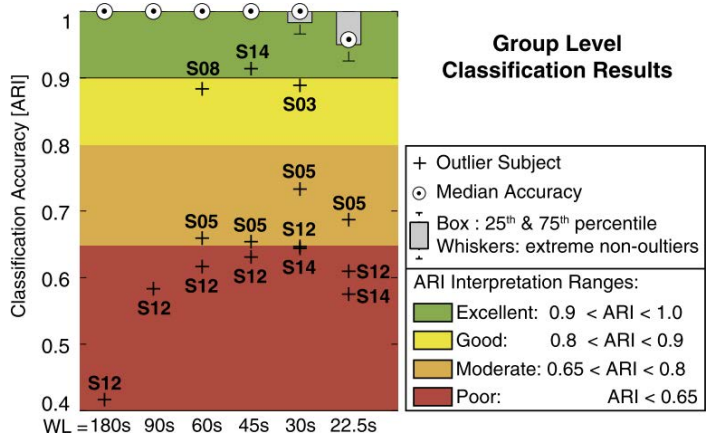
Multi-Task Dataset | Testing



Continuous Rest Dataset | Application



- 20 Subjects | 7T | 2mm³ | TR = 1.5s
- Task timing known to experimenter
- Dynamic FC helped segment scans into FC homogenous segments that align with cognitive tasks.



- Lacks ability to determine the cognitive nature of those segments.

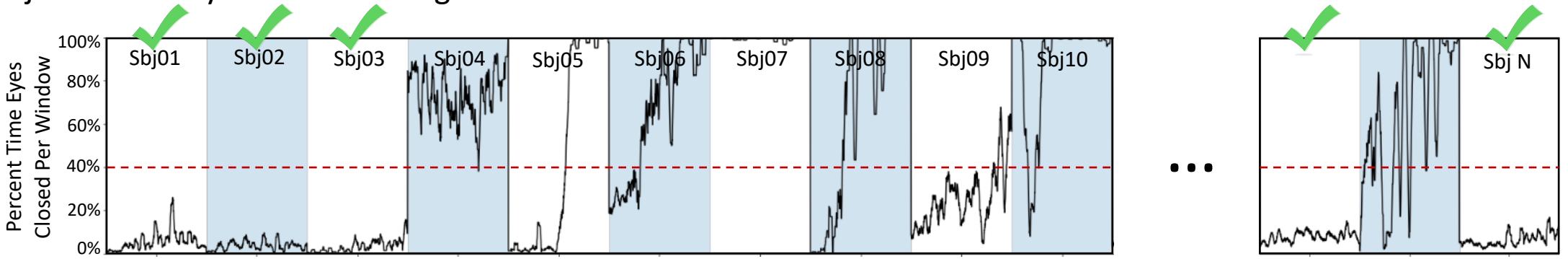
Gonzalez-Castillo et al. PNAS 2015

Experimental Datasets / Methods

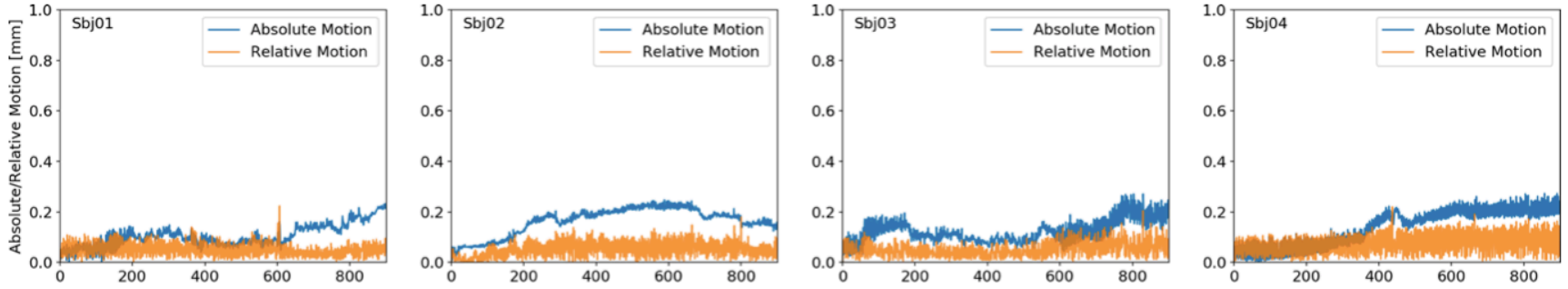
Multi-Task Dataset | Testing

Continuous Rest Dataset | Application

- 7T HCP Release: 15-min long eyes-open resting state scans with concurrent eye tracking recordings.
- Subjects that stayed awake during the whole rest scan.



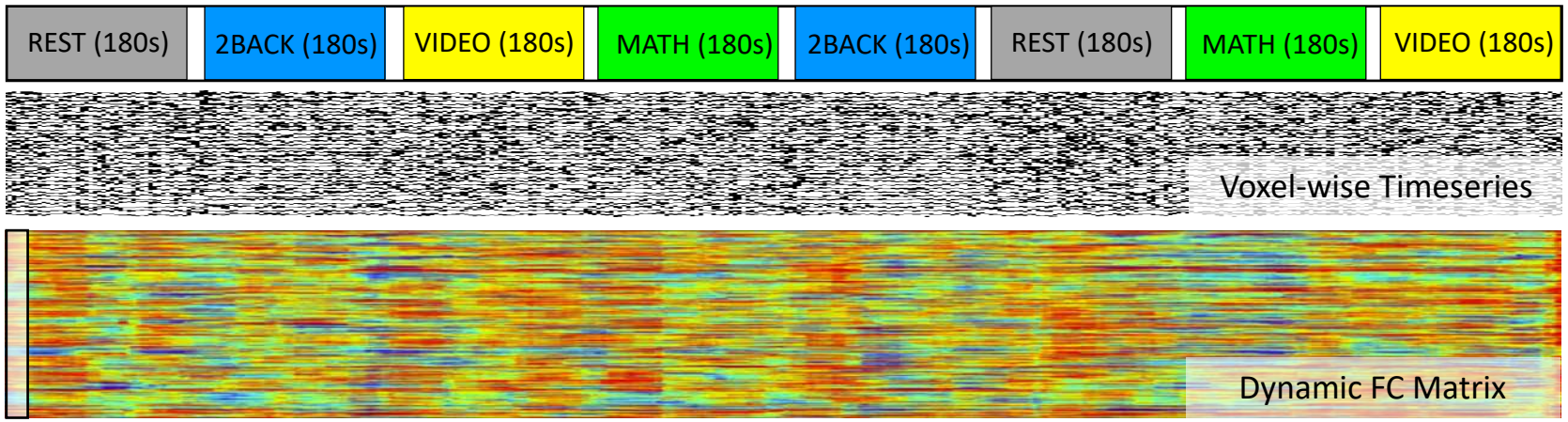
- Of these, we focused on the 20 subjects with the least amount of motion.



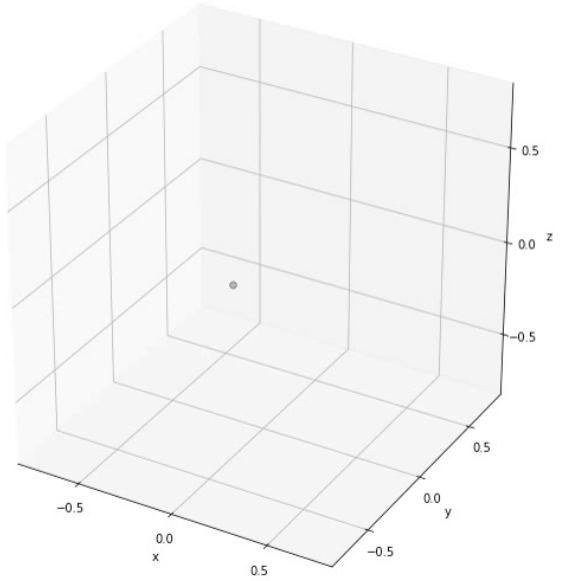
Average absolute motion was 0.27 ± 0.18 mm, and average relative volume-to-volume motion was 0.10 ± 0.07 mm.

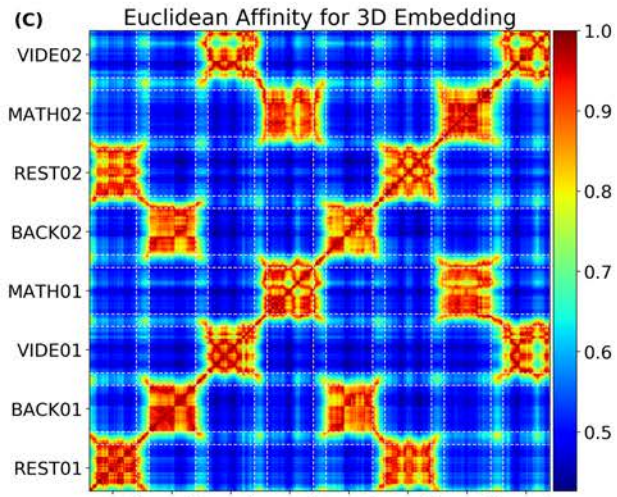
Van Essen et al. NeuroImage 2013

Testing Methods on Multi-task Data
LOW DIMENSIONAL EMBEDDINGS



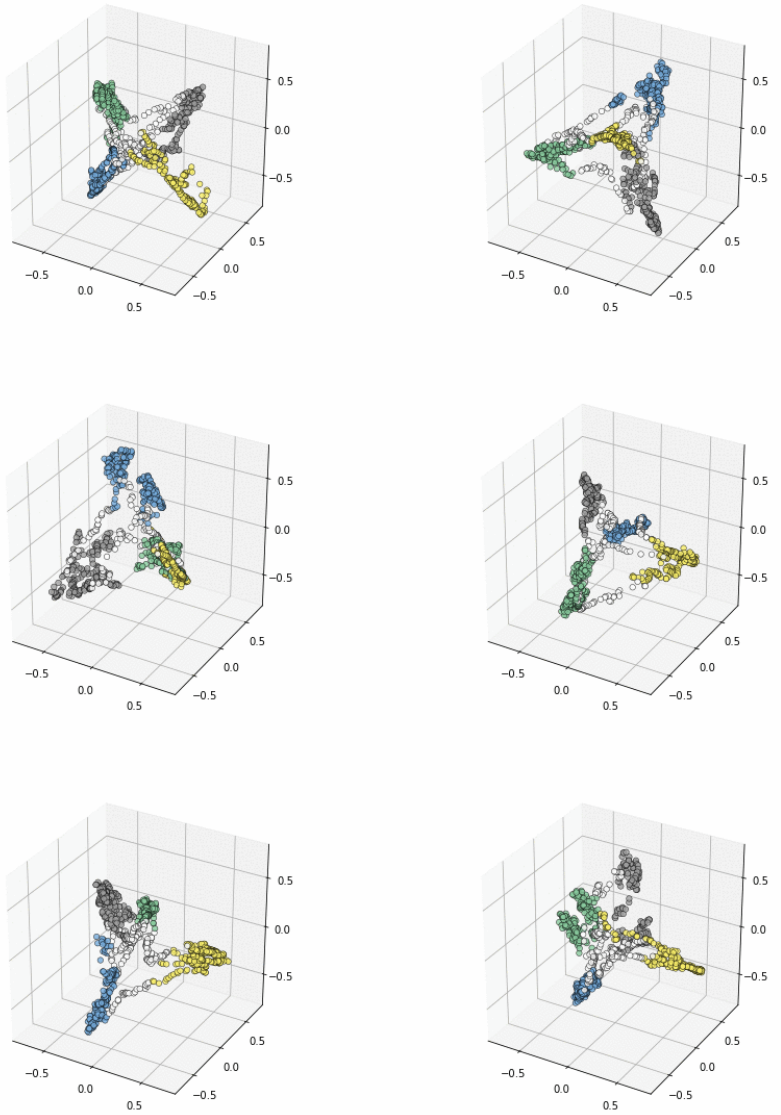
1. Generate Low Dimensional Representations of dFC Matrix



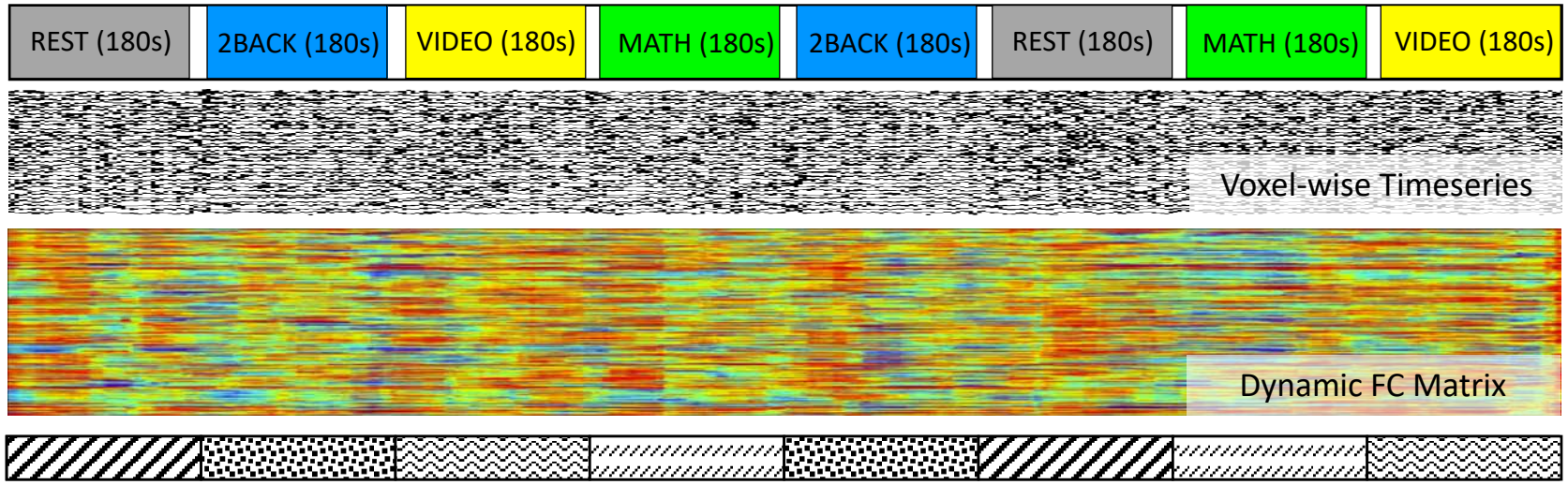


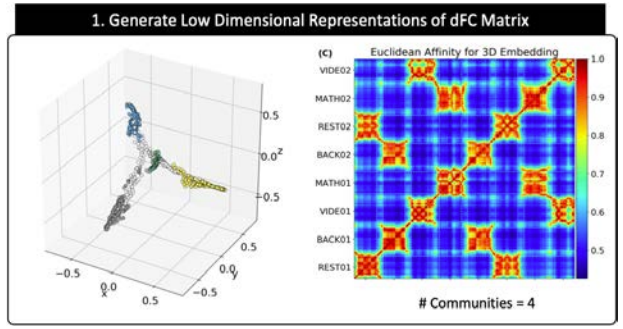
Communities = 4

Embeddings for representative subjects

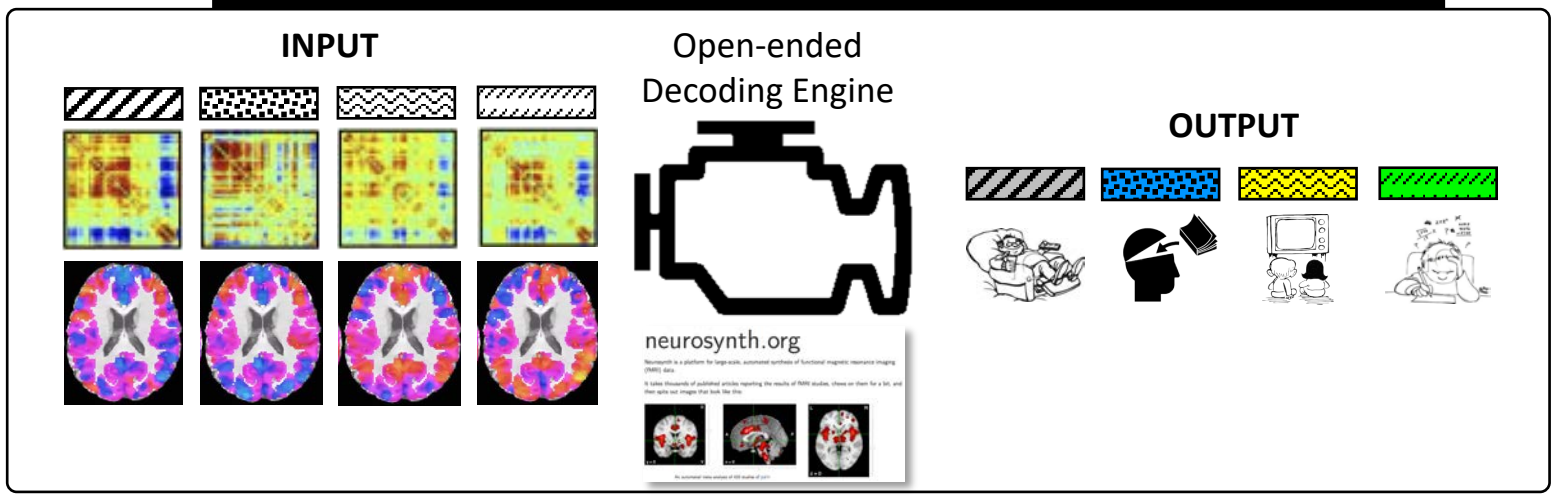


Testing Methods on Multi-task Data
INFERRING COGNITIVE CORRELATES (I)

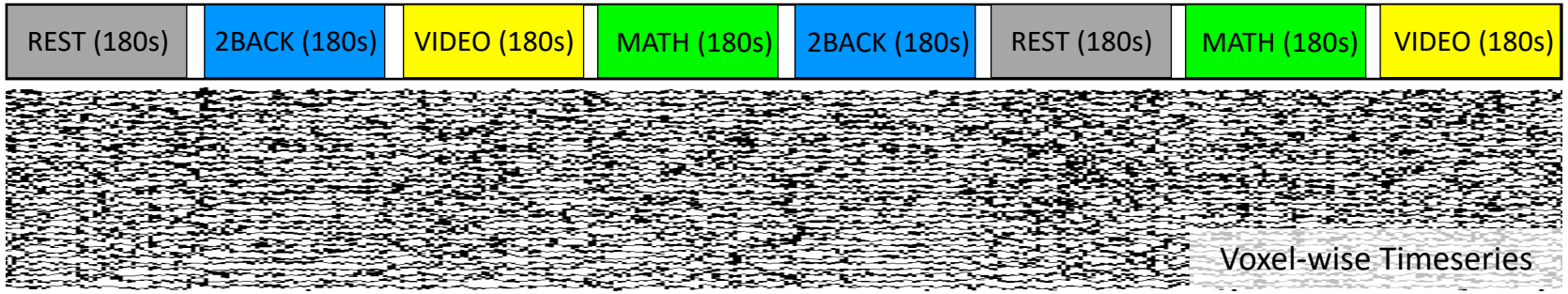




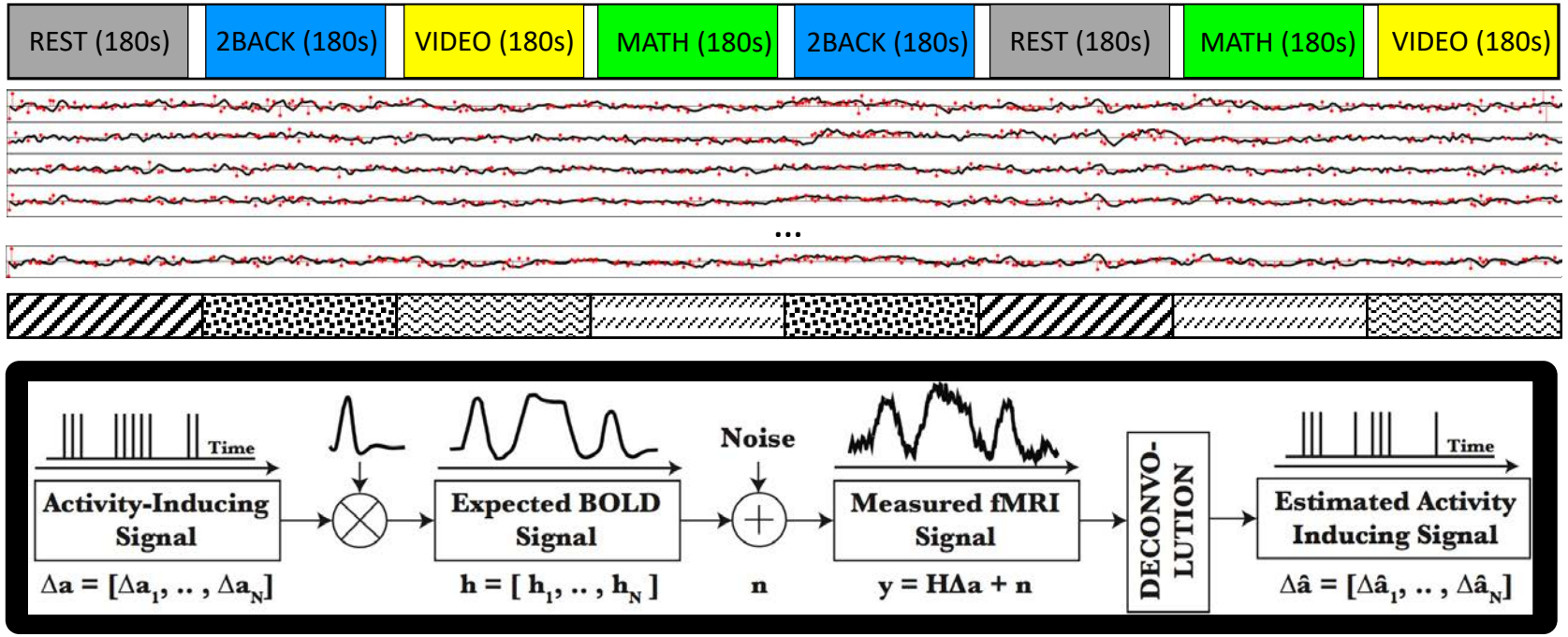
3. Decode Cognitive Processes aligned with each segment



Testing Methods on Multi-task Data
INFERRING COGNITIVE CORRELATES (II)

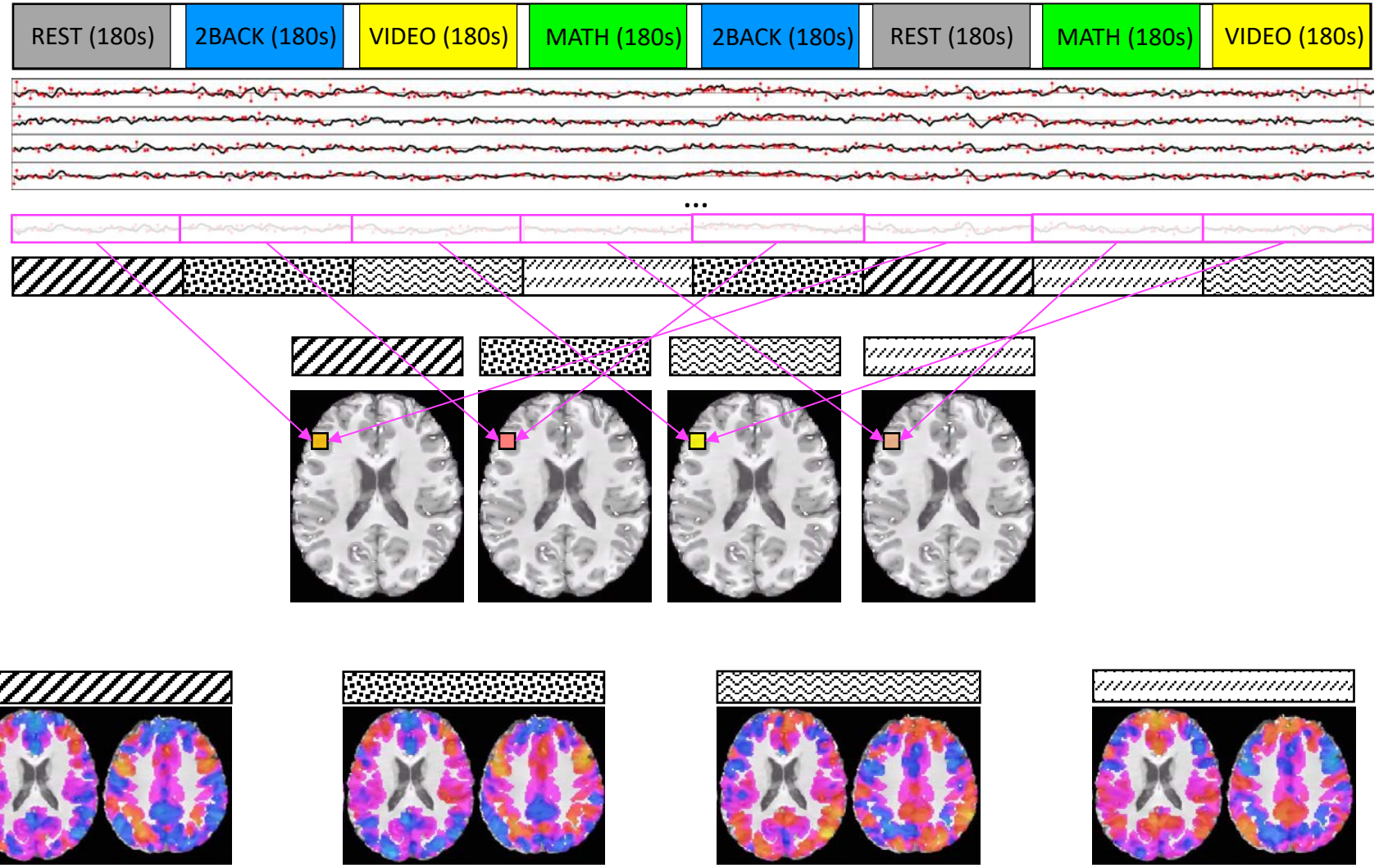


Testing Methods on Multi-task Data
INFERRING COGNITIVE CORRELATES (II)

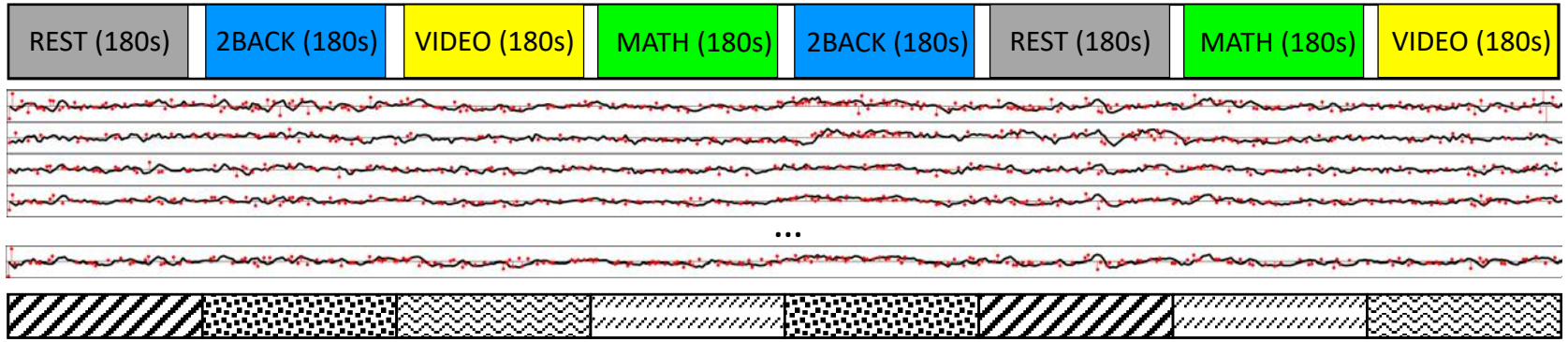


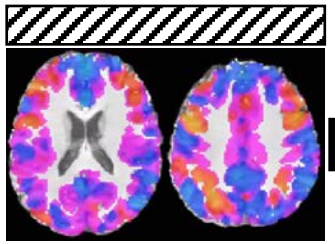
Hemodynamic Deconvolution – Find Most Prominent Activity Inducing Events
(SPFM; *Caballero-Gaudes et al. HMB 2011*)

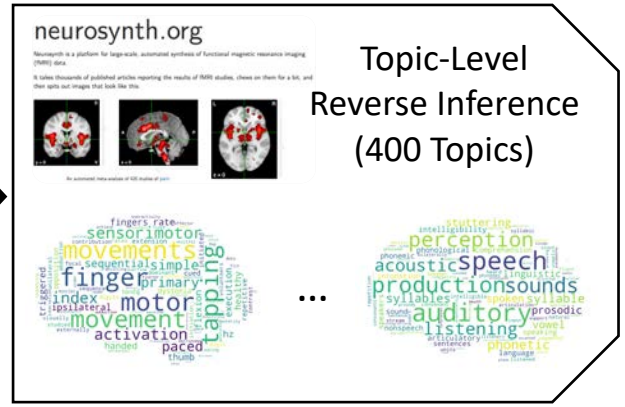
Testing Methods on Multi-task Data
INFERRING COGNITIVE CORRELATES (II)

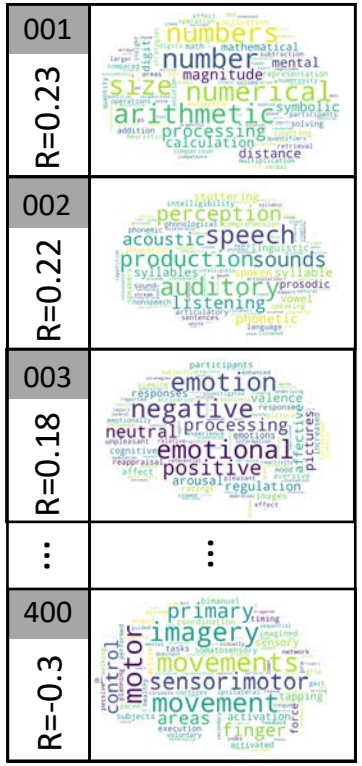


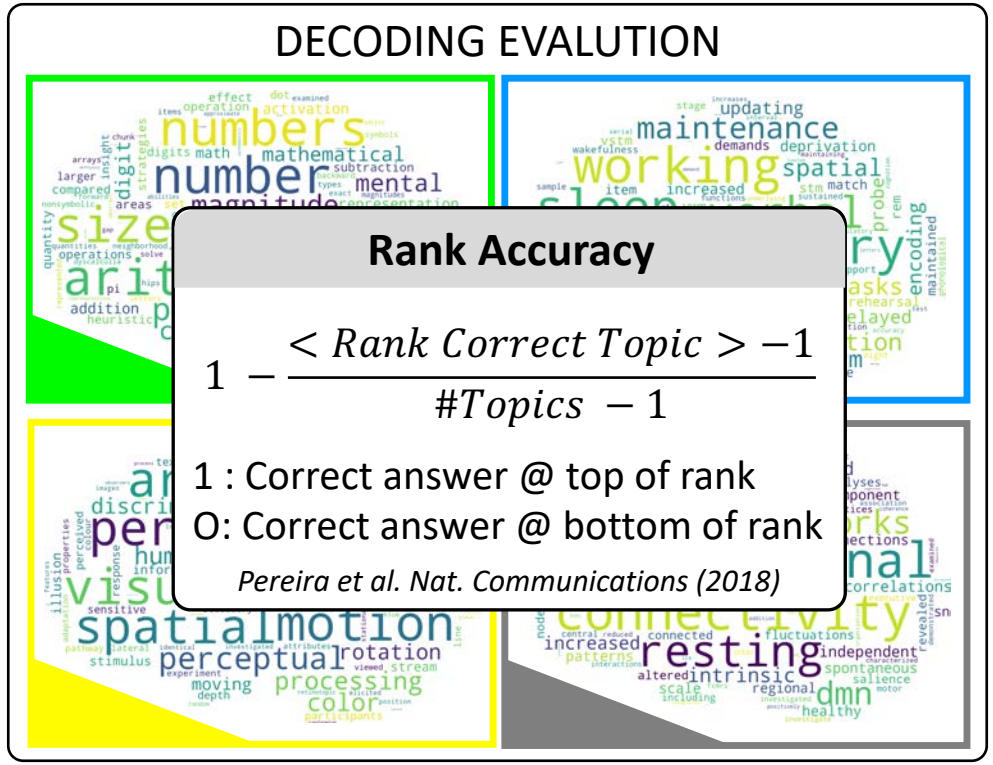
Testing Methods on Multi-task Data
INFERRING COGNITIVE CORRELATES (II)



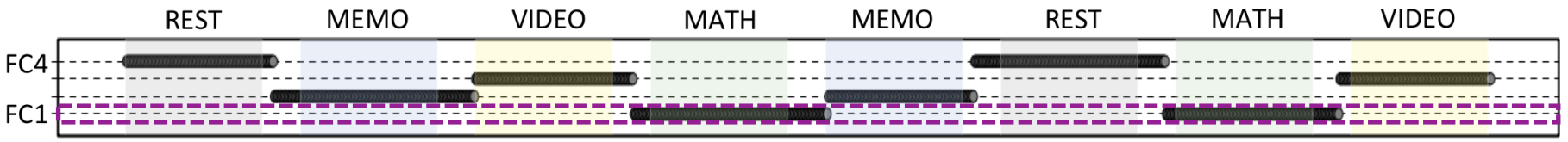




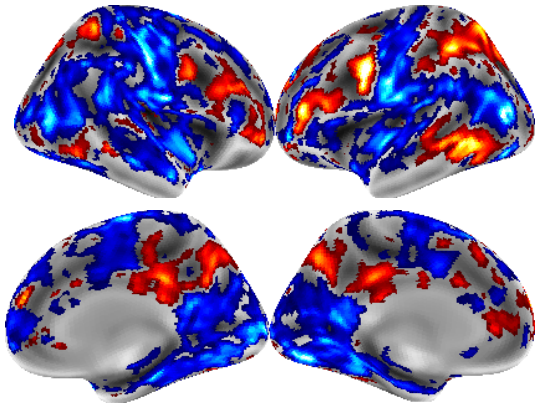


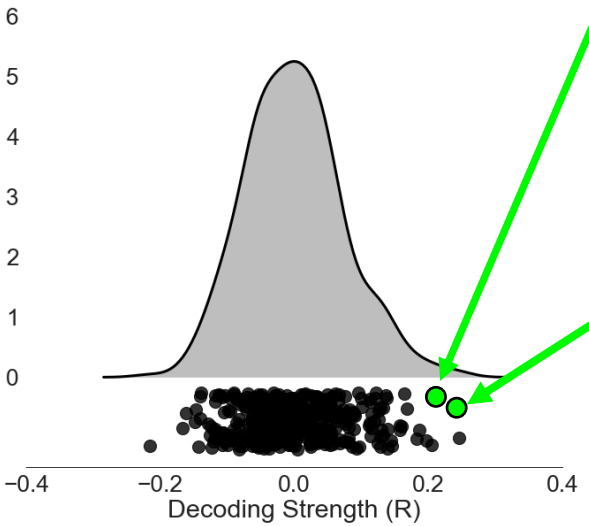


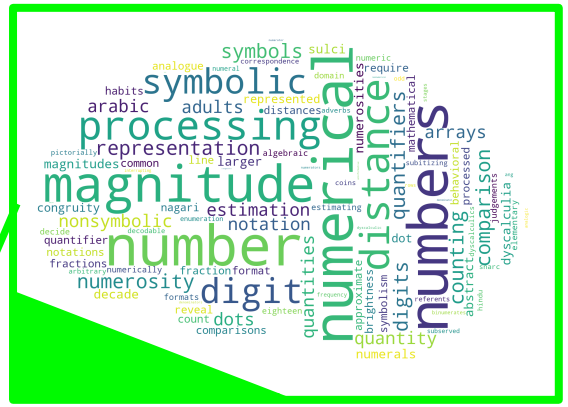
Reverse Inference in Multi-task Data (Individual Results)

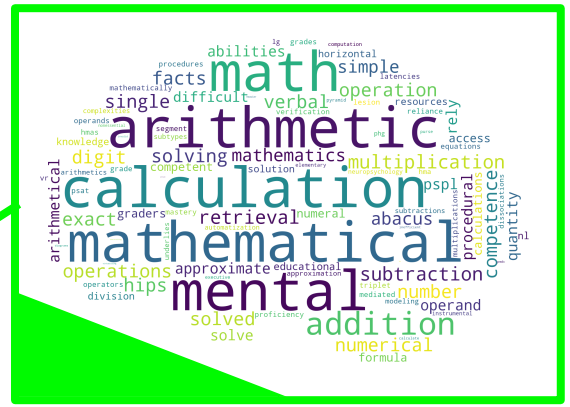


FC 1

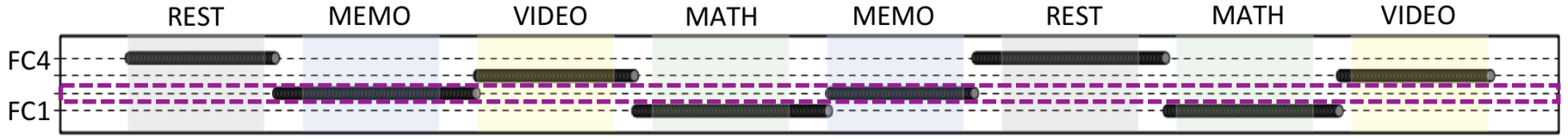




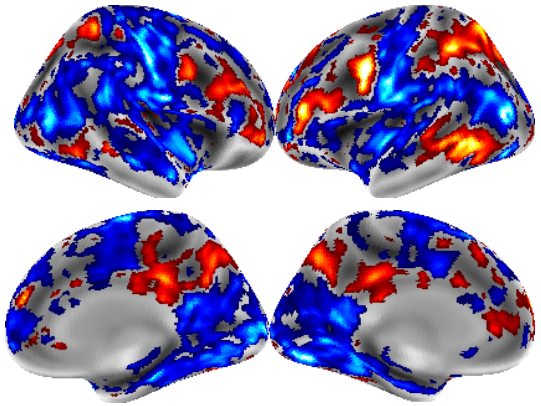




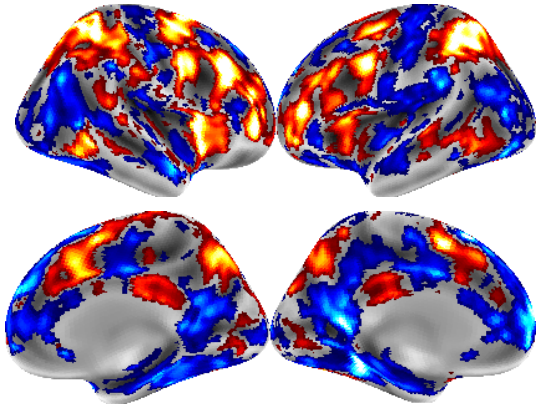
Reverse Inference in Multi-task Data (Individual Results)

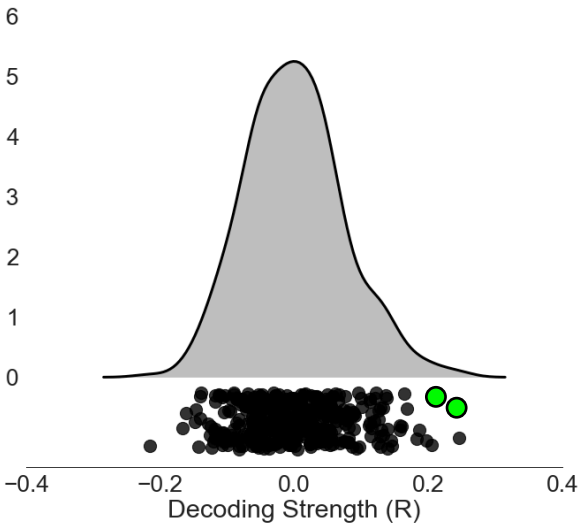


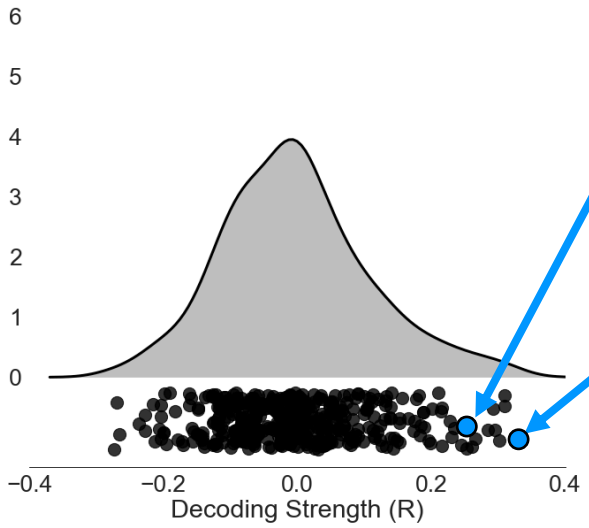
FC 1

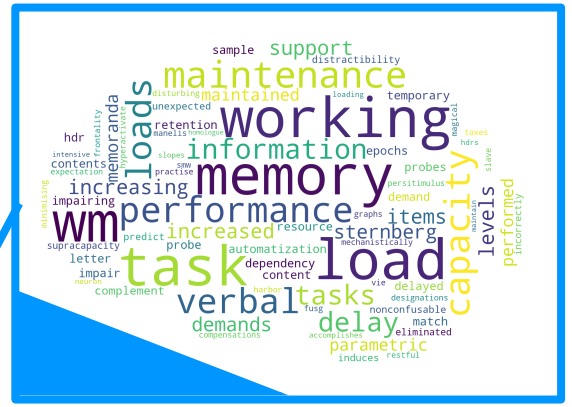


FC 2

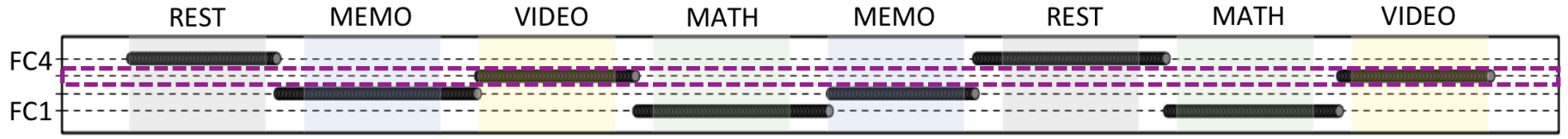




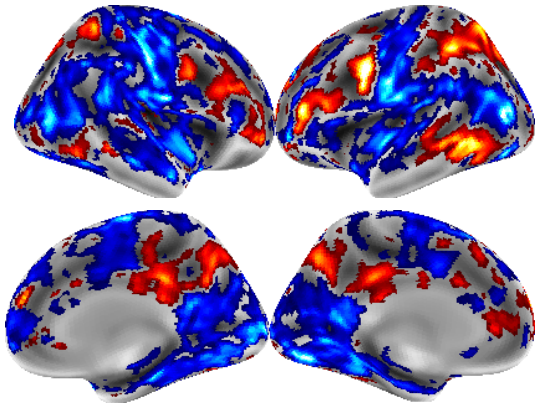


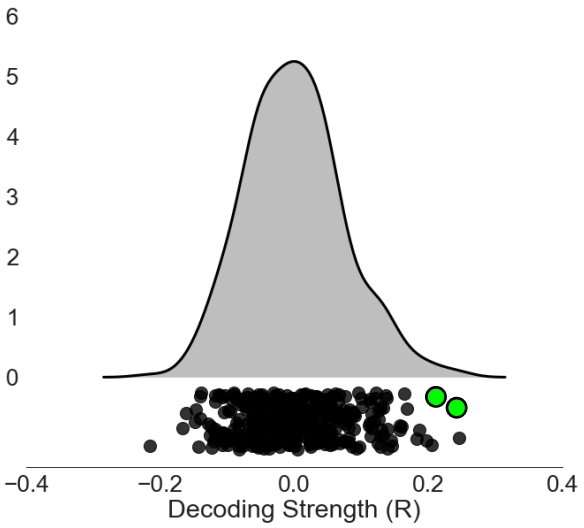


Reverse Inference in Multi-task Data (Individual Results)

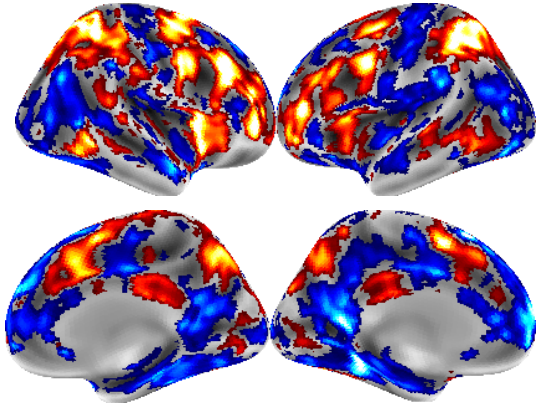


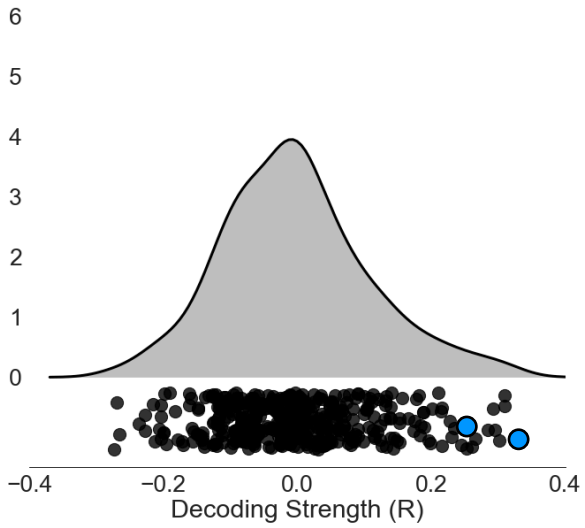
FC 1



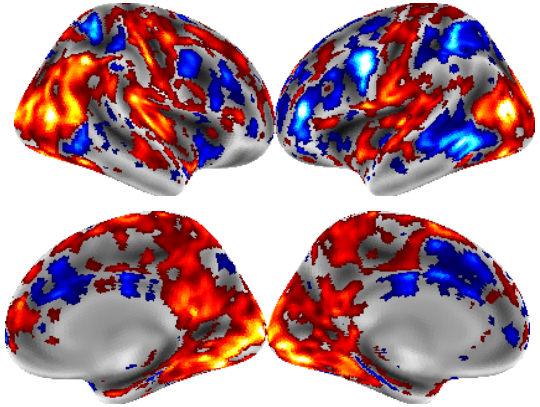


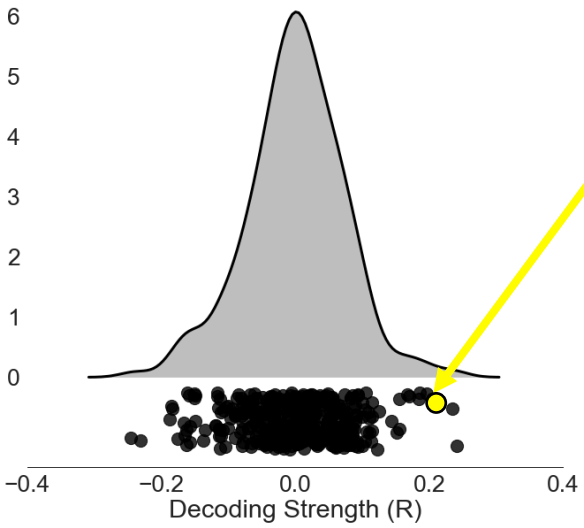
FC 2

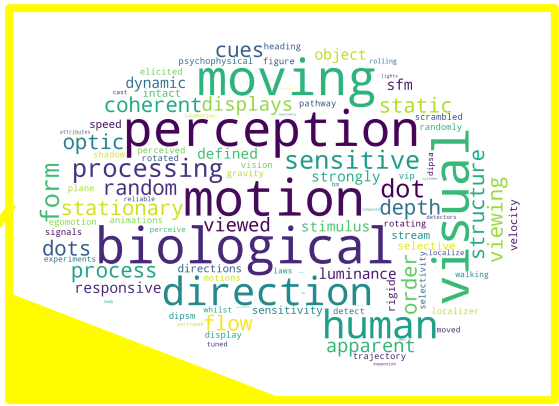




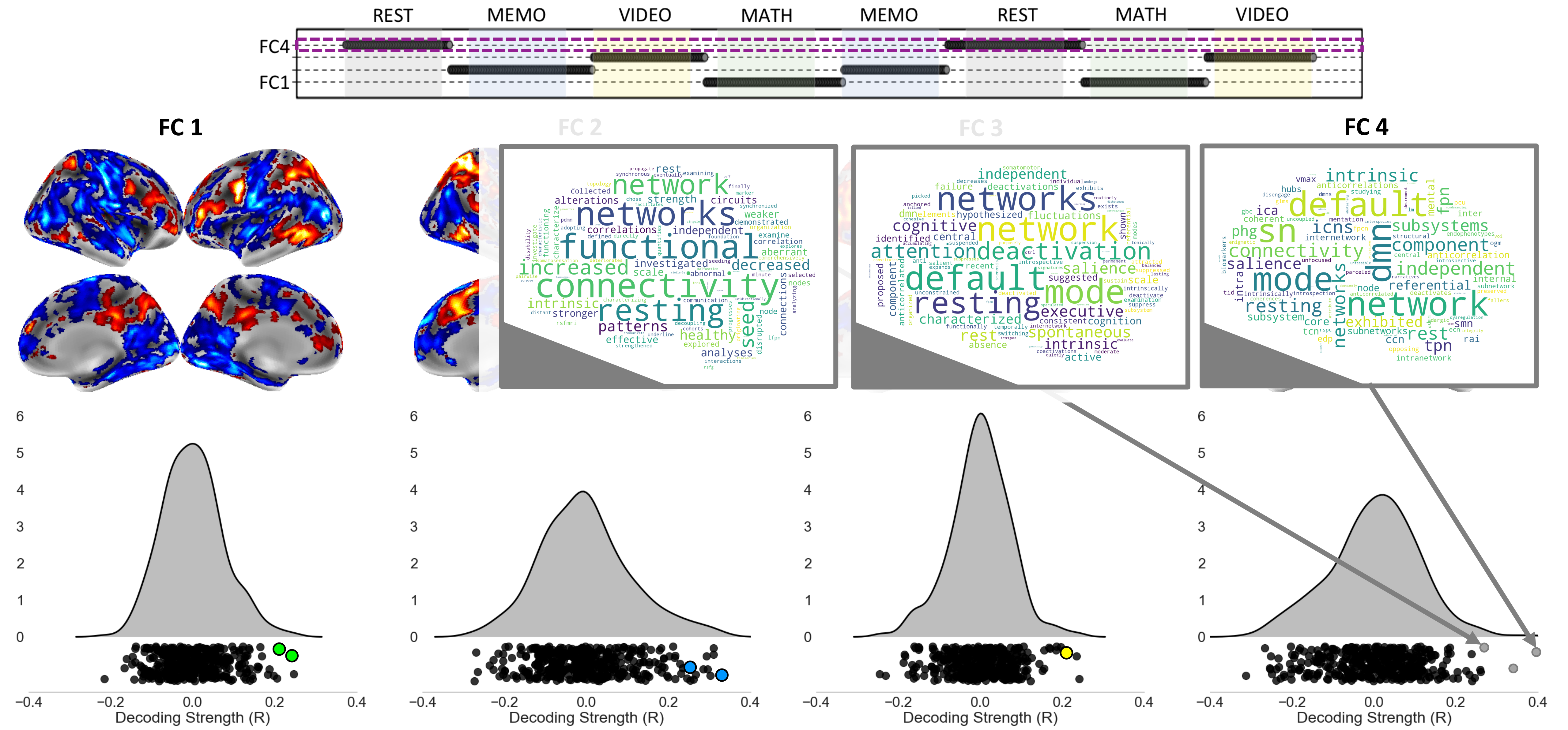
FC 3



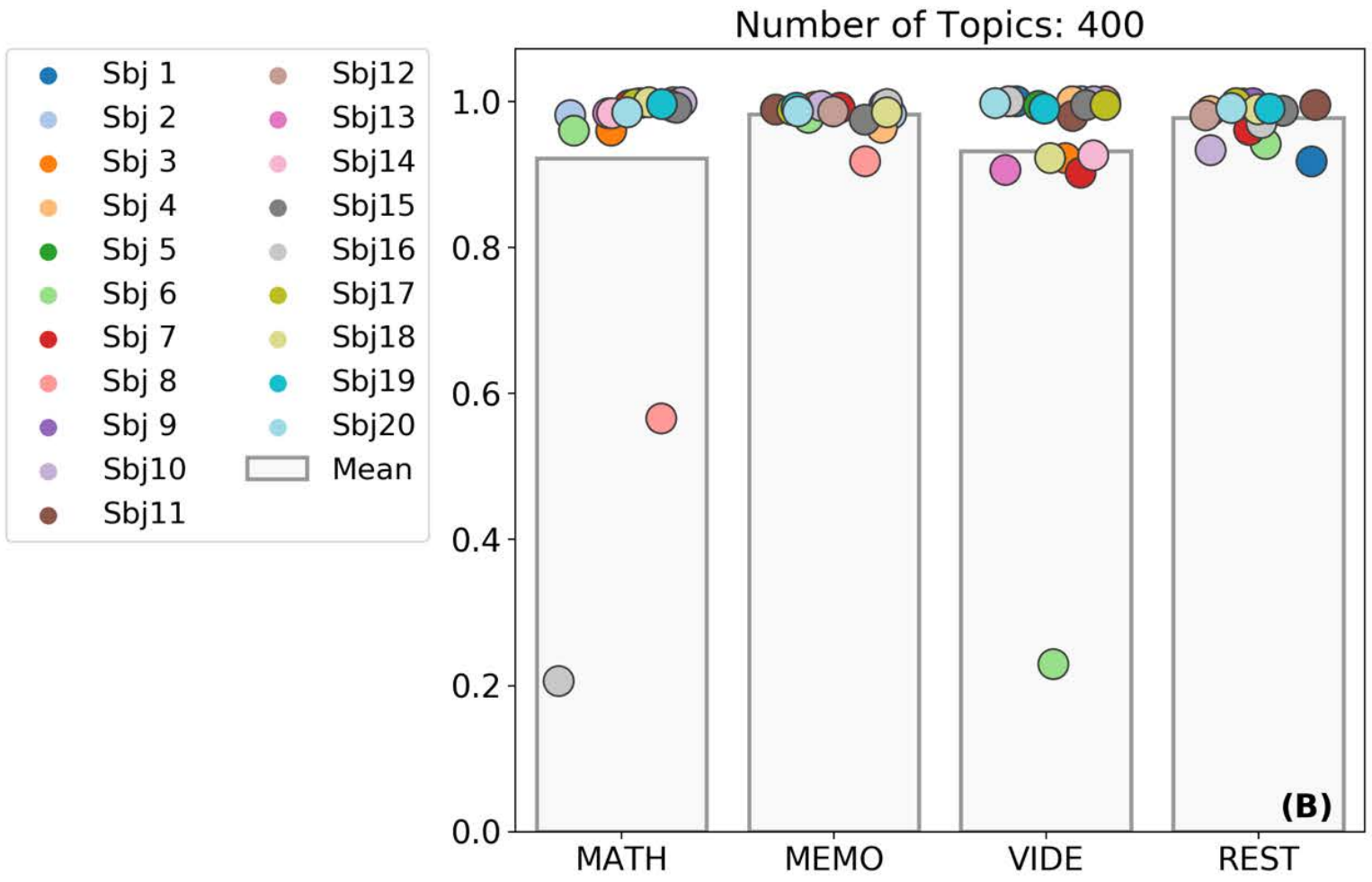




Reverse Inference in Multi-task Data (Individual Results)



Reverse Inference in Multi-task Data (Group Results)



Rank Accuracy

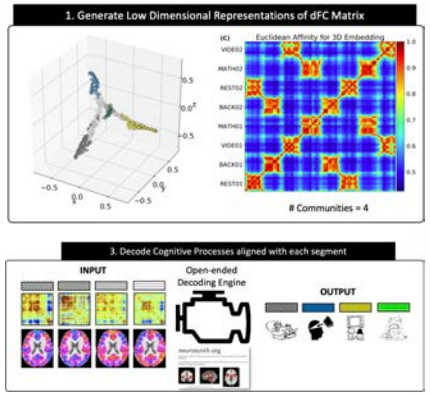
$$1 - \frac{< Rank\ Correct\ Topic > -1}{\#Topics\ - 1}$$

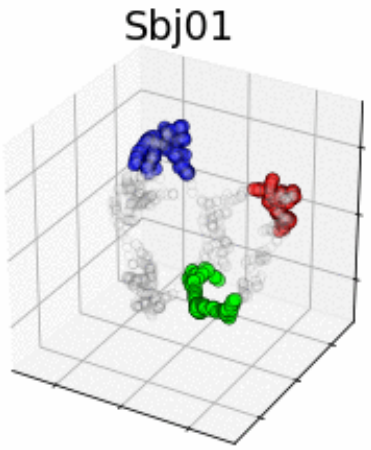
1 : Correct answer @ top of rank

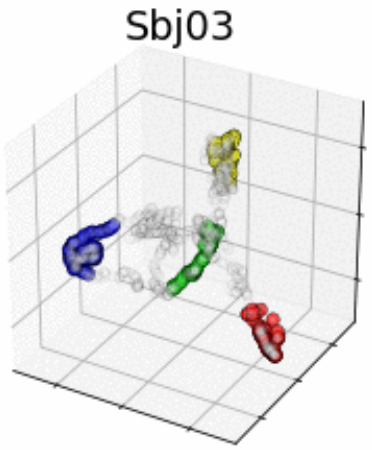
O: Correct answer @ bottom of rank

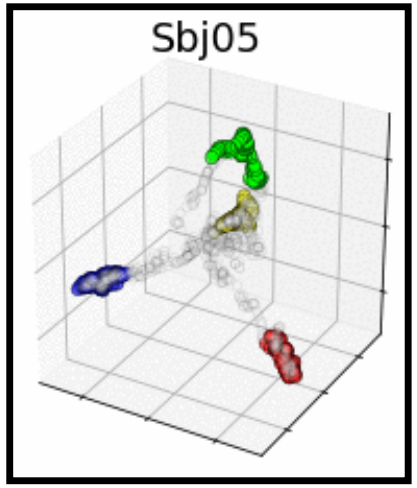
Pereira et al. Nat. Communications (2018)

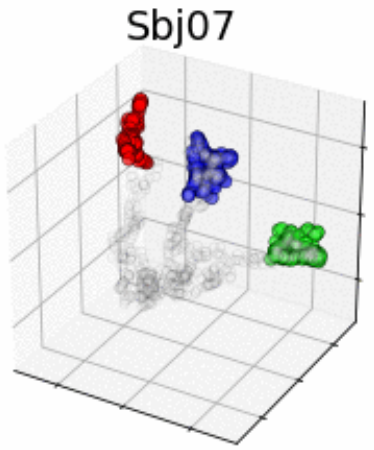
Exploration of Resting Data (Laplacian Embeddings – Distant Corners)

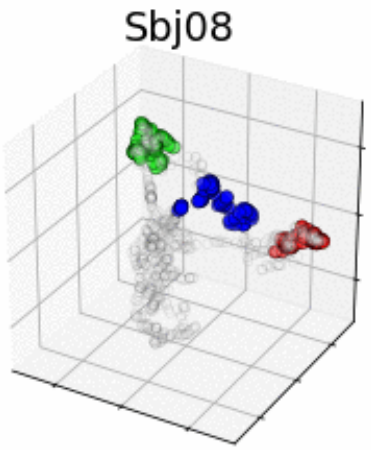


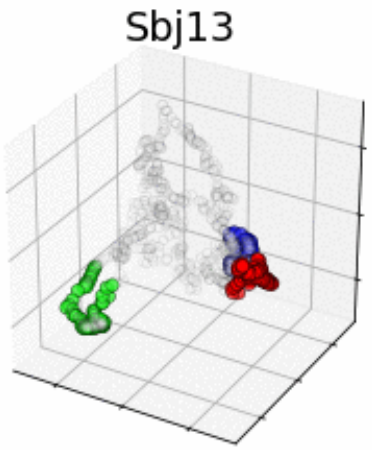


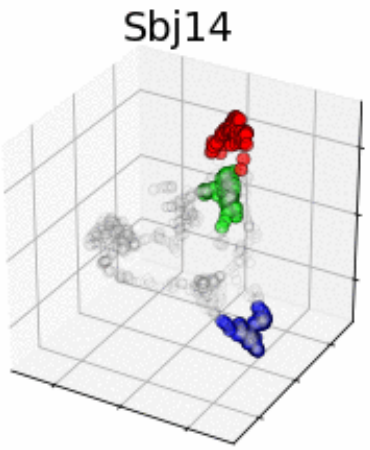


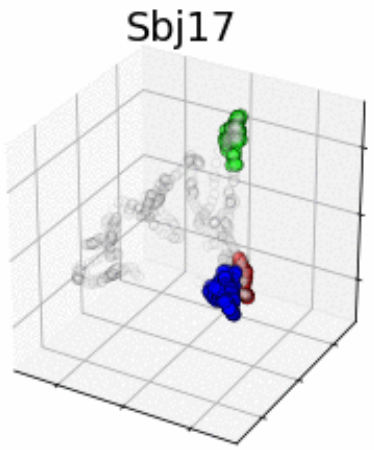




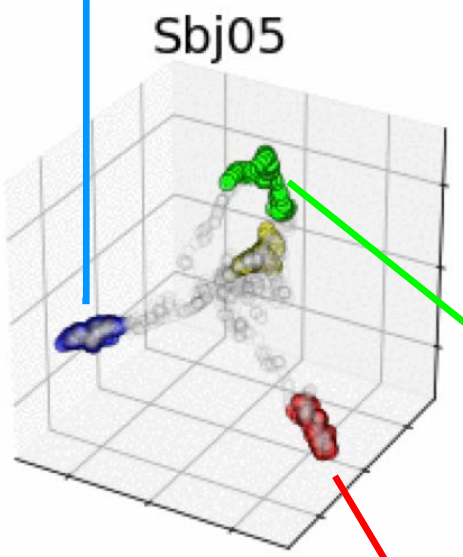


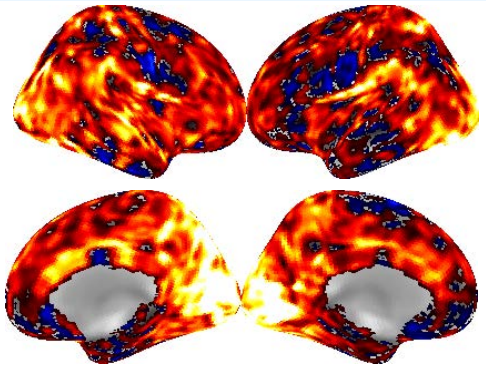


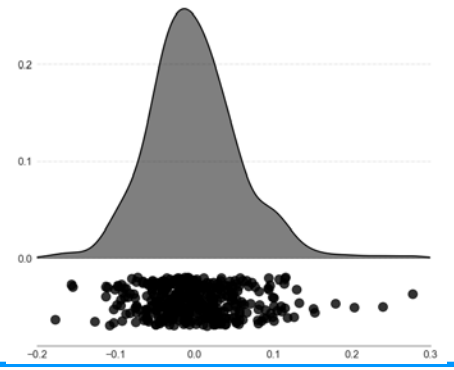




Reverse Inference in Resting Data (Individual Results)

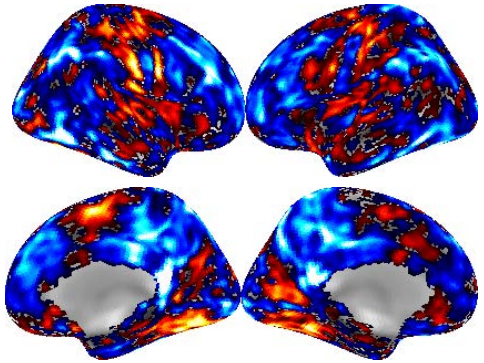


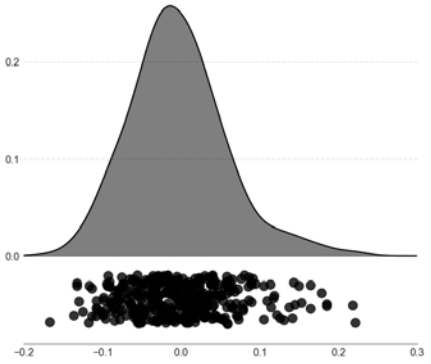




TOP 5 TOPICS

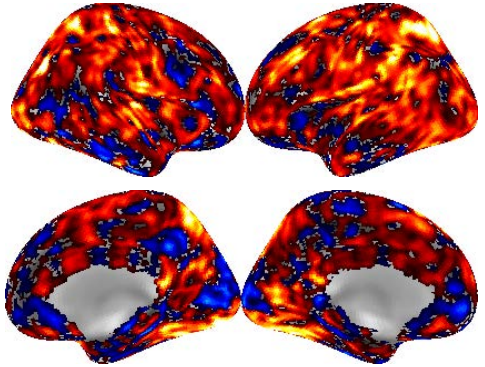
0.28	Visual, areas, stimulus,…
0.24	Blind, visual, sighted,…
0.20	Motion, biological, moving, …
0.18	Shape, shapes, texture, …
0.15	Stream, visual, streams, …

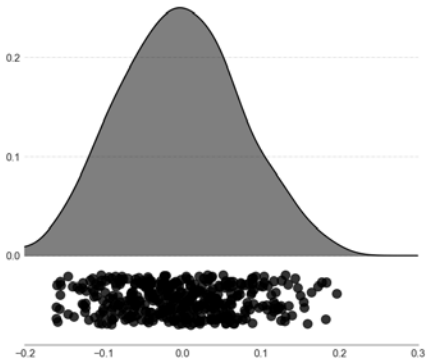




TOP 5 TOPICS

0.22	Motor, sensory, areas, …
0.22	Motor, finger, movements, …
0.19	Movement, movements, motor, …
0.19	Touch, tactile, somatosensory, …
0.18	Stimulation, somatosensory, tactile, …

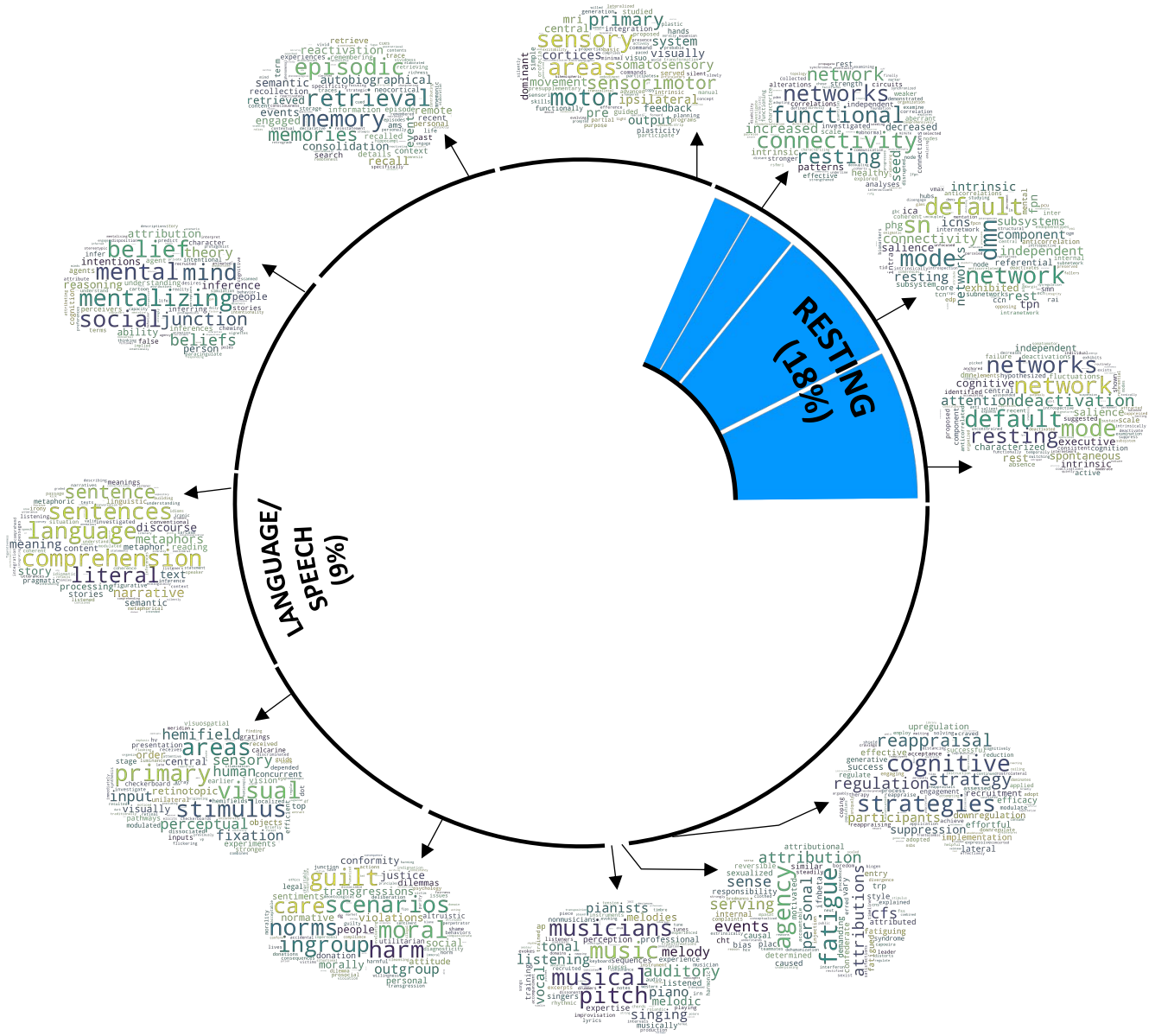




TOP 5 TOPICS

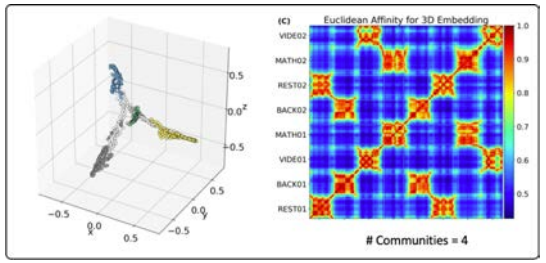
0.20	Task, tasks, matching, …
0.18	Arithmetic, calculation, mathematical, …
0.18	Spatial, location, locations, …
0.18	Number, numerical, numbers, …
0.17	Action, actions, observation, …

Reverse Inference in Resting Data (Group Results)

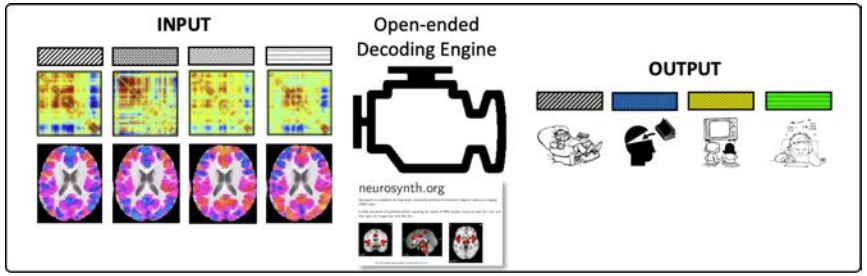


Conclusions

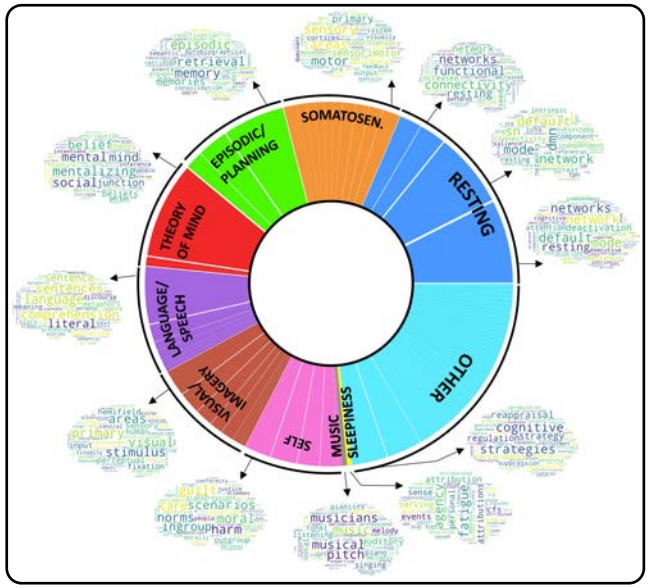
- Demonstrate the use of Laplacian Embeddings as a valuable explorative tool for dynamic FC during task and rest.



- Demonstrate the combined use of Hemodynamic Deconvolution + NeuroSynth to infer the cognitive correlates of distinct dynamic FC patterns.



- Provide evidence in support of the hypothesis that covert on-going cognition contributes to dFC estimates during awake rest.
- Data suggests that several meaningful FC configurations may be observable during rest.
- Data-driven estimates of covert cognition agree with previous reports of what the most common mental processes subjects engage with during rest are.



Gonzalez-Castillo et al., 2019 BioRxiv

Acknowledgements / Questions

Section on Functional Imaging Methods

Peter A. Bandettini
Daniel A. Handwerker
Peter Molfese
Dave Jangraw
Laurentius Huber
Emily Finn
Yuhui Chai
Natasha Topolski
Michel Elishama
Arman Khojandi

Scientific and Statistical Computing Core

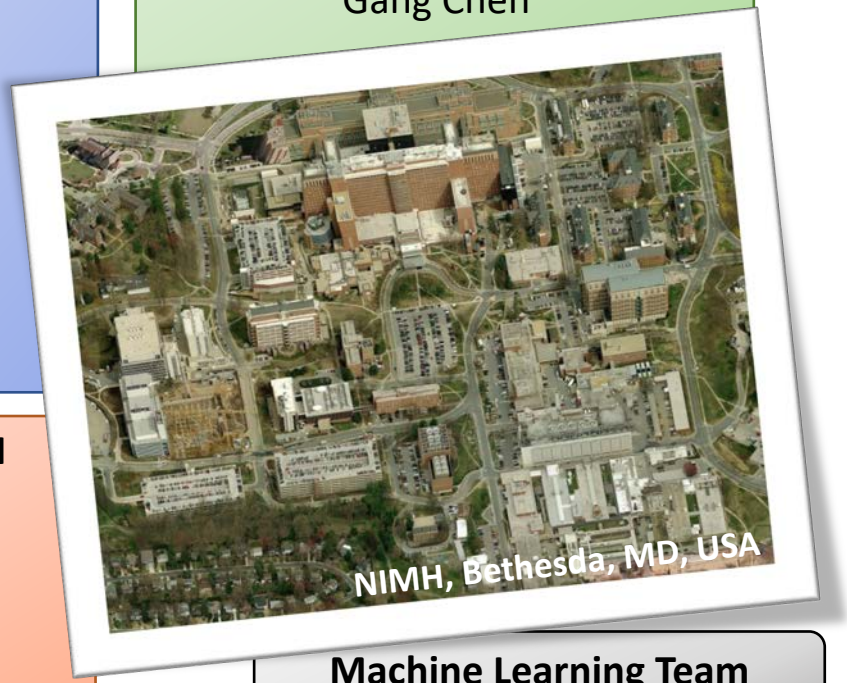
Robert W. Cox, Paul Taylor
Daniel Glen, Richard Reynolds
Gang Chen

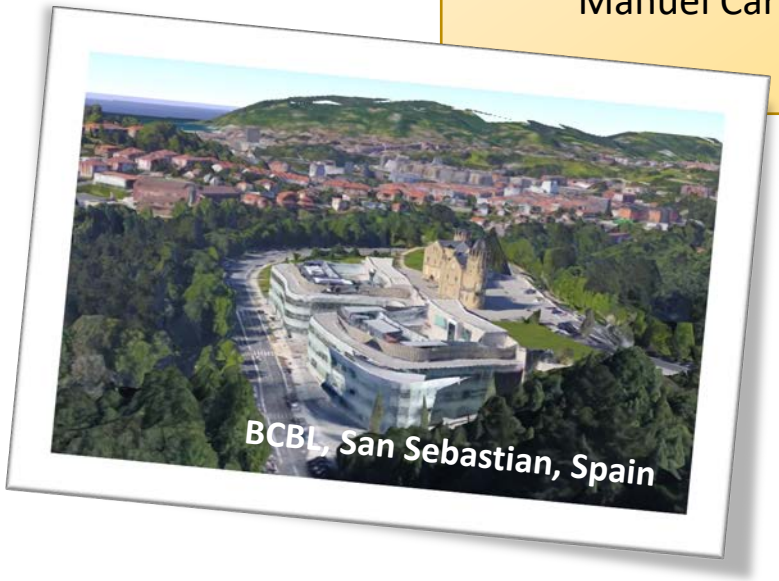
Basque Center on Cognition, Brain and Language

César Caballero-Gaudes
Manuel Carreiras

Functional MRI Facility

Sean Marrett
Vinai Roopchansingh
Andy Derbishire
Linquing Li





Machine Learning Team

Francisco Pereira
Charles Zheng
Patrick McClure