

Agnieszka Zuberer^{ae}, Eve M. Valera^{b,c}, Aaron Kucyi^d, David Rothlein^a, Michael Esterman^{a,e,f}

^a Boston Attention and Learning Laboratory, VA Boston Healthcare System, Boston, MA 02130 ^b Department of Psychiatry, Harvard Medical School, Boston, MA 02129
^c Department of Psychiatry, Massachusetts General Hospital, Charlestown, MA 02129 ^d Northeastern University, Department of Psychology, College of Science, Boston, MA 02115 ^e Department of Psychiatry, Boston University School of Medicine, Boston, MA 02130 ^f National Center for PTSD, VA Boston Healthcare System

Introduction

- Sustained attention (SA) is a key cognitive process that is uncoupled from distinct external events, and instead emerges from ongoing intrinsic fluctuations of large-scale network interdependencies.
- SA has been previously linked to patterns of whole-brain node-to-node connectivity (i.e., connectome) (Castellanos & Proal, 2012; M. D. Rosenberg et al., 2015).
- However, genuinely global attributes of this intrinsic network account of SA, i.e. the diversity of connectivity across distinct communities (Fortunato, 2010; Newman, 2006) are understudied.
- We used a unique task design that creates a gradually changing baseline state, in which continuous fluctuations in attentional readiness for rare targets can be assessed with constant motor response.
- We hypothesize that intrinsic fluctuations of SA can be mapped by fluctuations of this global information processing mode across the whole-brain connectome.

Methods

Gradual Continuous Performance Task (gradCPT)

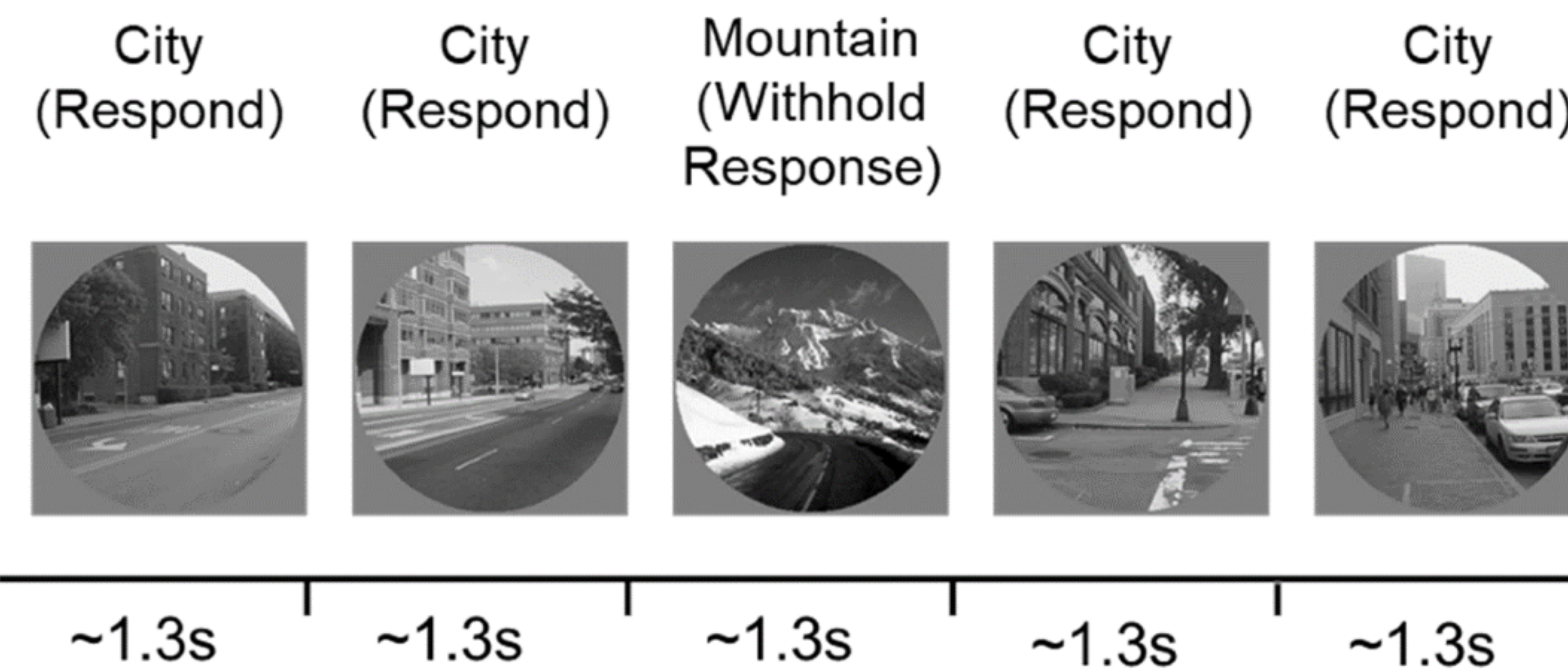
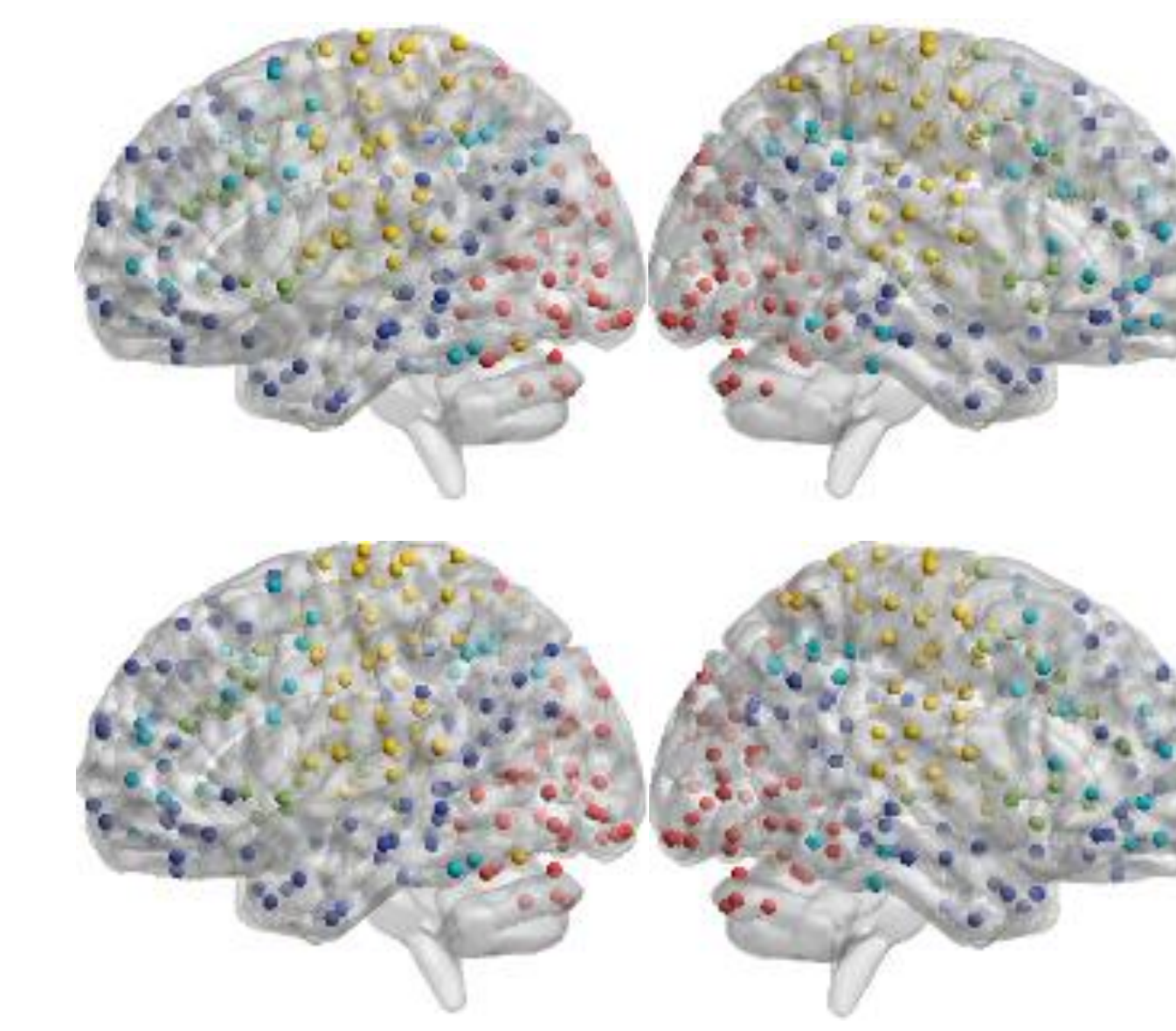
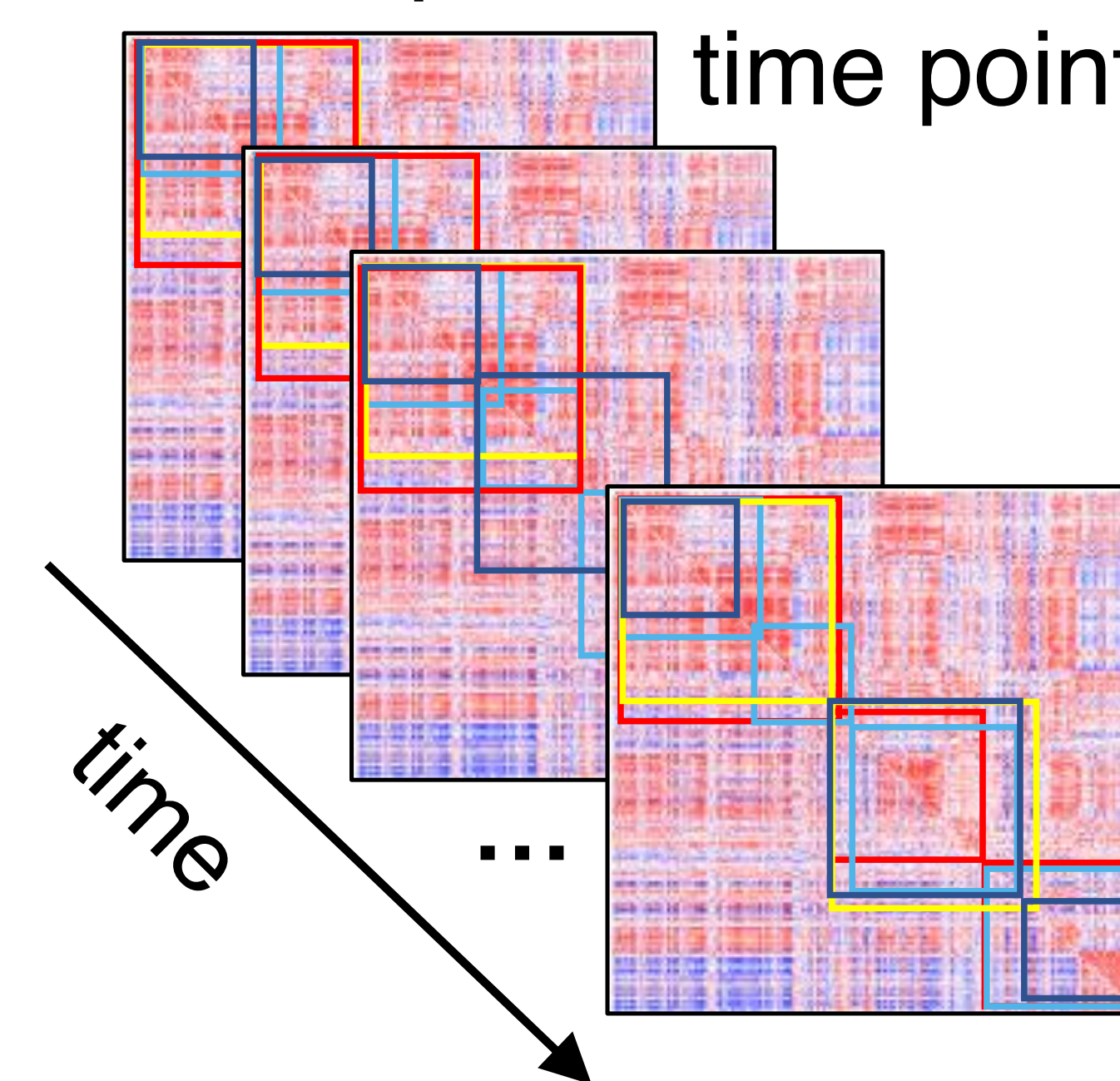


Figure 1. Description of Gradual Continuous Performance Task. In four fMRI blocks, 26 participants performed the gradCPT (Esterman et al, 2012). Stimuli were images of city and mountain scenes gradually transitioning between one another. Subjects were instructed to respond with a single press each time they saw a city scene but to withhold a response when they saw mountain scenes, which occurred pseudo-randomly in ~10% of trials. Thought-probes appeared pseudo-randomly every 44–60 s. instructing participants to rate their task focus on a continuous scale ranging from 0 (only else) to 100 (only task).

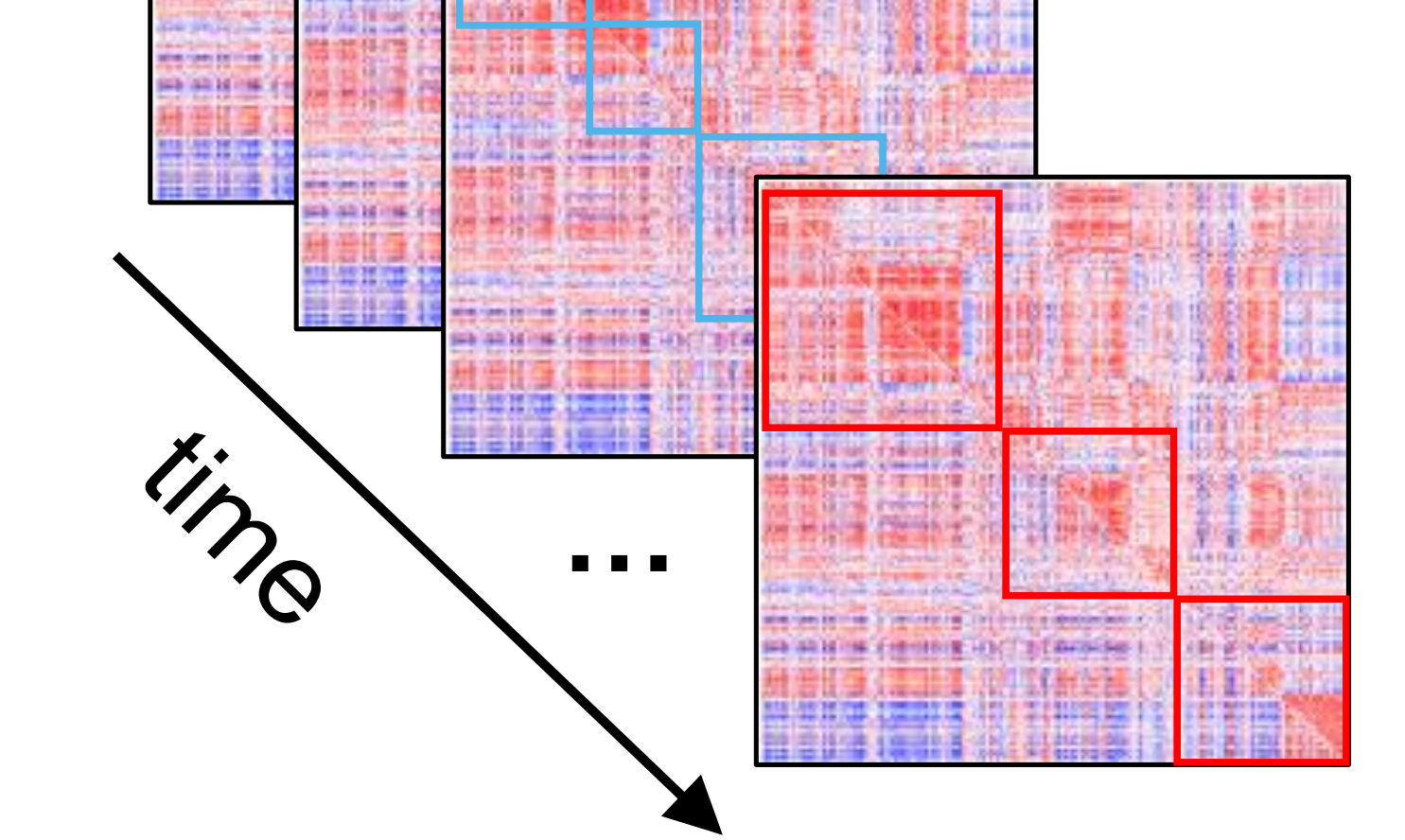
1. Parcellation Power et al. (2011)



3. Modular partitions from all time points



2. Modular partition for each time point



4. Time varying node metrics

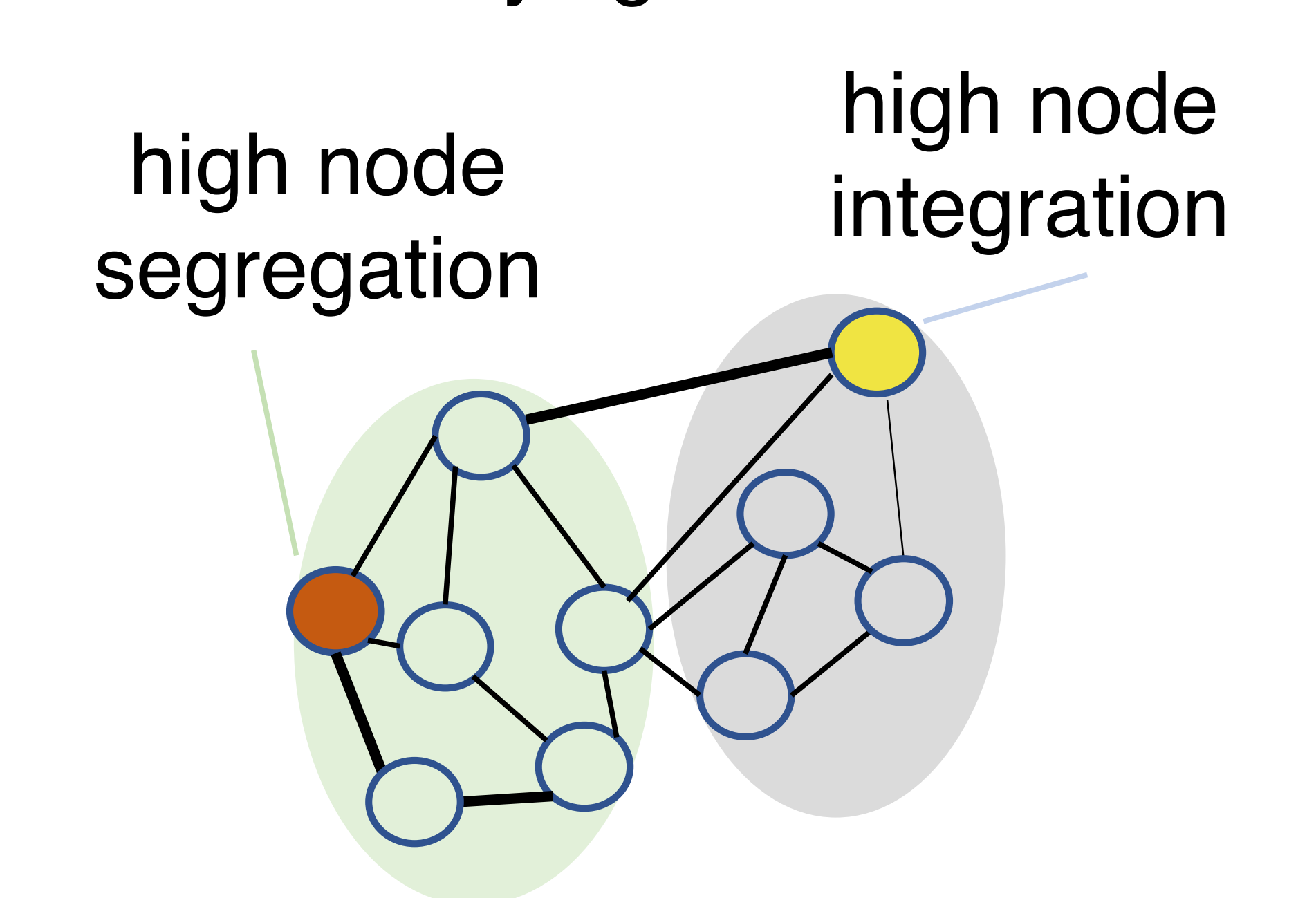
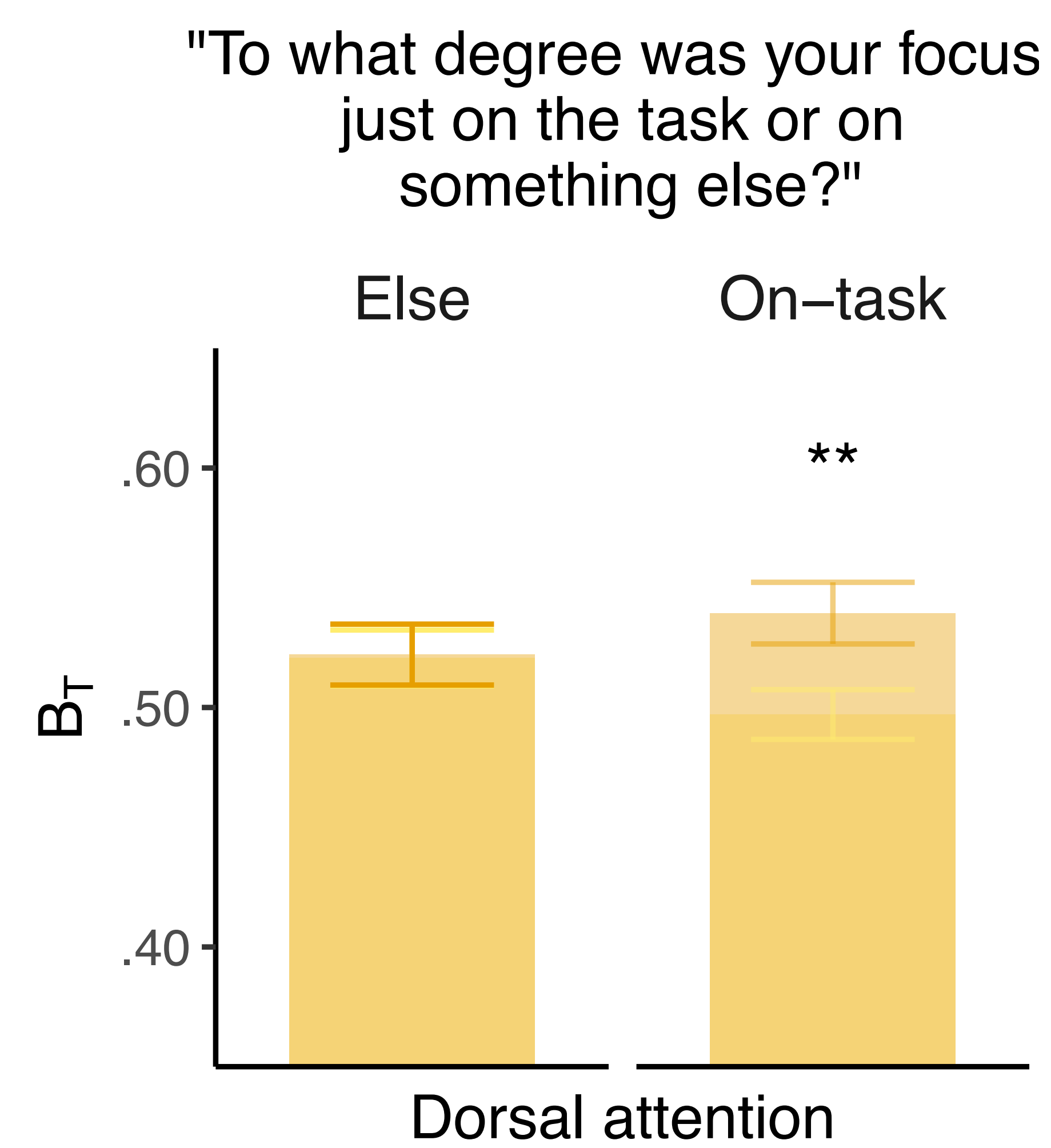
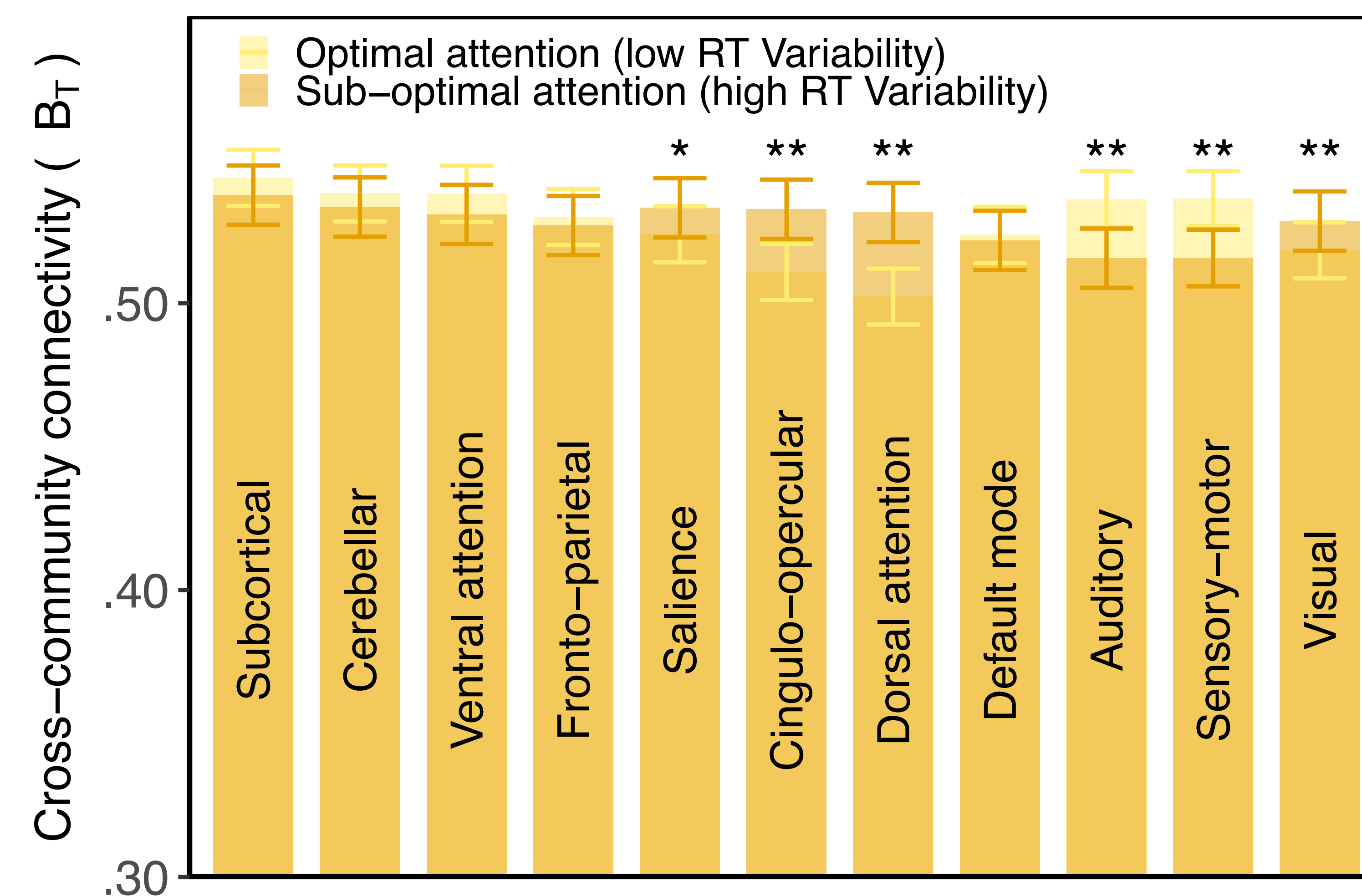


Figure 2. Visualization of effects derived from a mixed-effects model predicting cross-community connectivity, quantified by the participation coefficient. Error bars representing bootstrapped 95% confidence intervals.

- Our Sustained attention (SA) network model encompasses large-scale networks including high- and low-attention sub-systems.
- The dorsal attention network loses its specificity to sustained attention when mind wandering is high, and inversely is established when mind wandering is low/task focus is high.



Summary

Intrinsic fluctuations of sustained attention relate to fluctuations of global information processing throughout the whole-brain connectome, while mind wandering specifically draws on the dorsal attention network.

Discussion

These findings suggest that:

- The diversity of cross-community connectivity may constitute a functional property of the brain that tracks intrinsic fluctuations of SA
- This global information processing mode might reflect a modulation mechanism to tune/mobilize cognitive resources/attention.
- Mapping intrinsic fluctuations of SA with this approach may help the formulation of biomarkers for impairments in clinical populations with attentional dysfunctions.