A functional and structural connectivity view of switching dynamics in aging

Pauline Baniqued
Beckman Institute & Department of Psychology

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

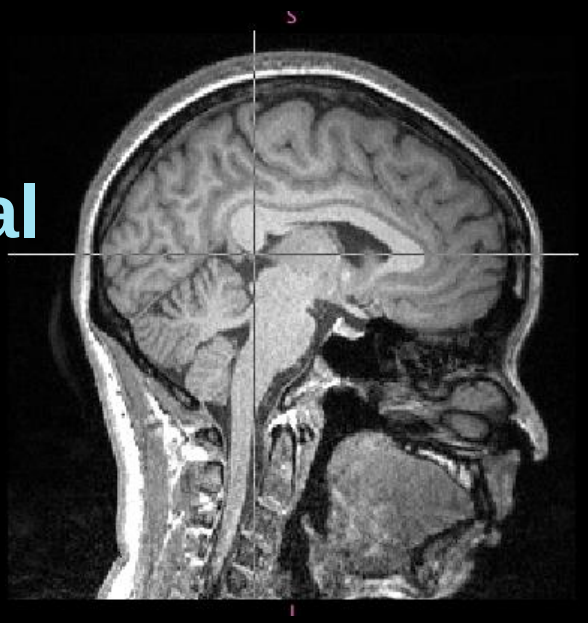
Approach

Control processes involve brain networks

functional phenomena in grey matter

structural changes in white matter

Age-related changes in behavioral control and brain structure

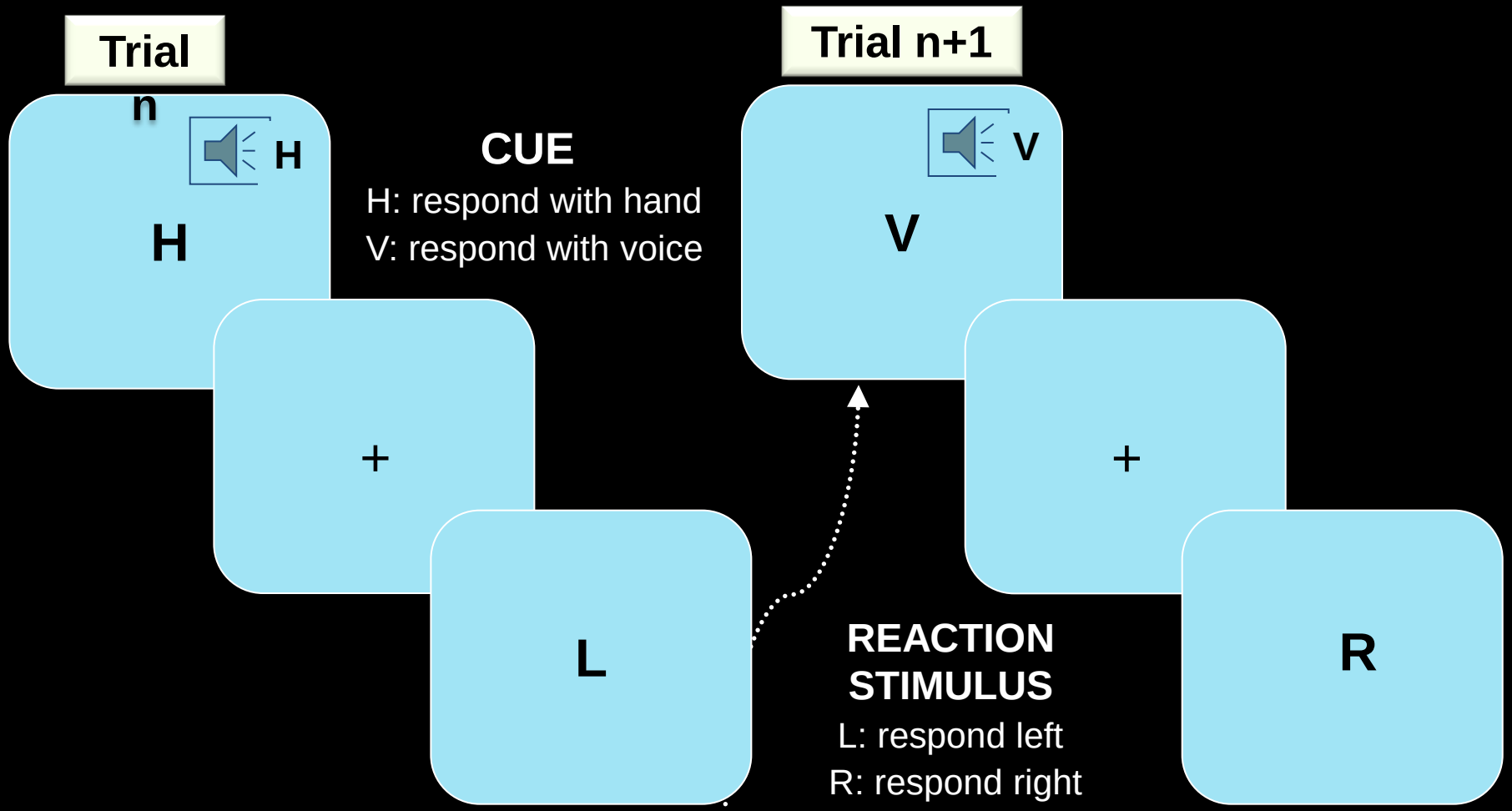


Why is this important?

Everyday we switch between tasks

- several paradigms to study task-switching

Switching experiment



Why is this important?

Everyday we switch between tasks

There are **costs** to switching

- More errors, slower responses
- Even when given time to prepare

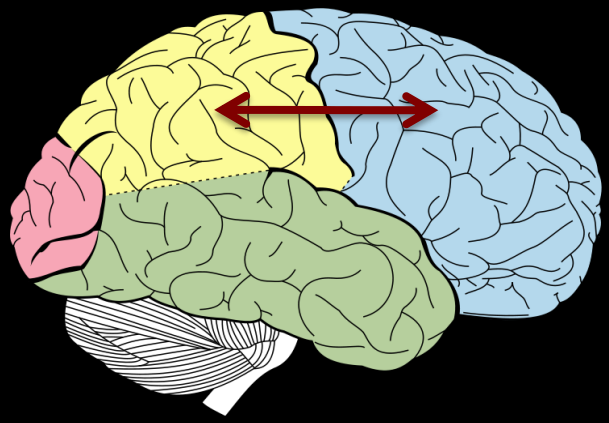
There is evidence we can be **more efficient**

- given cue, optimize preparatory period
- recruitment of frontal and parietal regions

Fronto-parietal “network”

Coactivation led to FPN“network”

Important for controlling attention in a wide array of tasks



How do these FPN-dependent control processes interact with regions that carry out the task?

Corbetta & Shulman, 2002; Hopfinger, Buonocore, Mangun, 2000; Weissman, Warner, Woldorff, 2004; Gratton, Low, & Fabiani, 2008; Baniqued, Low, Fabiani & Gratton, 2013

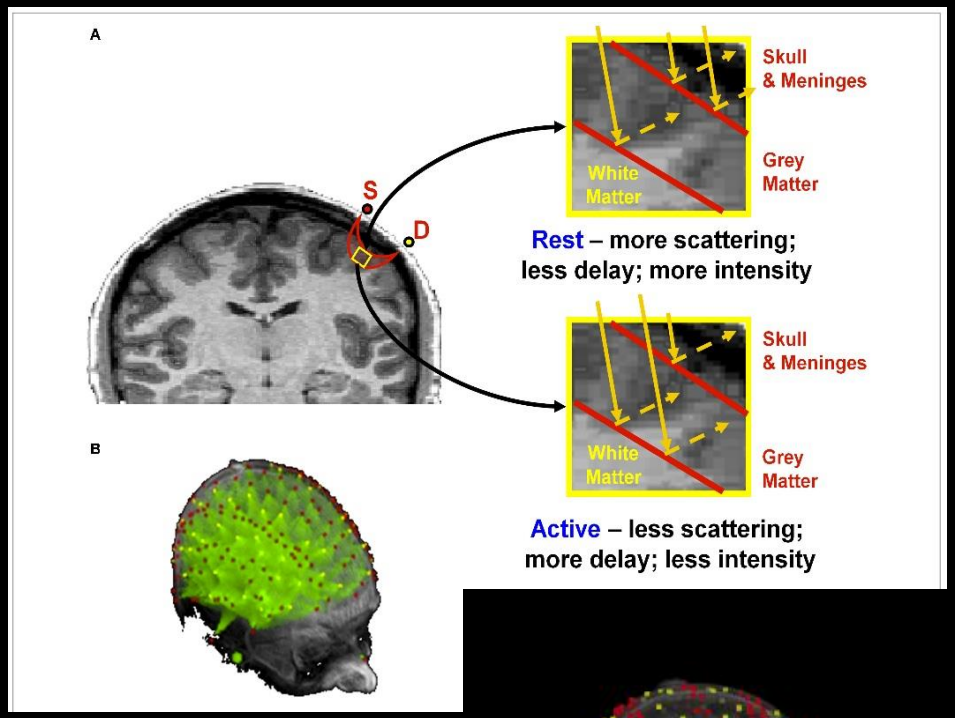
Spatiotemporal dynamics of preparation

Lagged cross-correlations

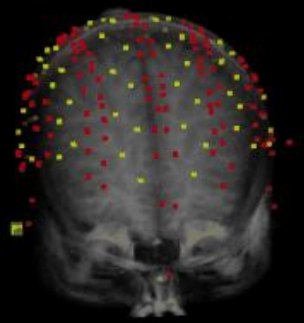
- "functional connectivity" with timing info
- LAGS, relative order of activation
- Can detect patterns of activity with different onsets

Rykhlevskaia, Fabiani & Gratton, 2006

Event-related optical signal (EROS)



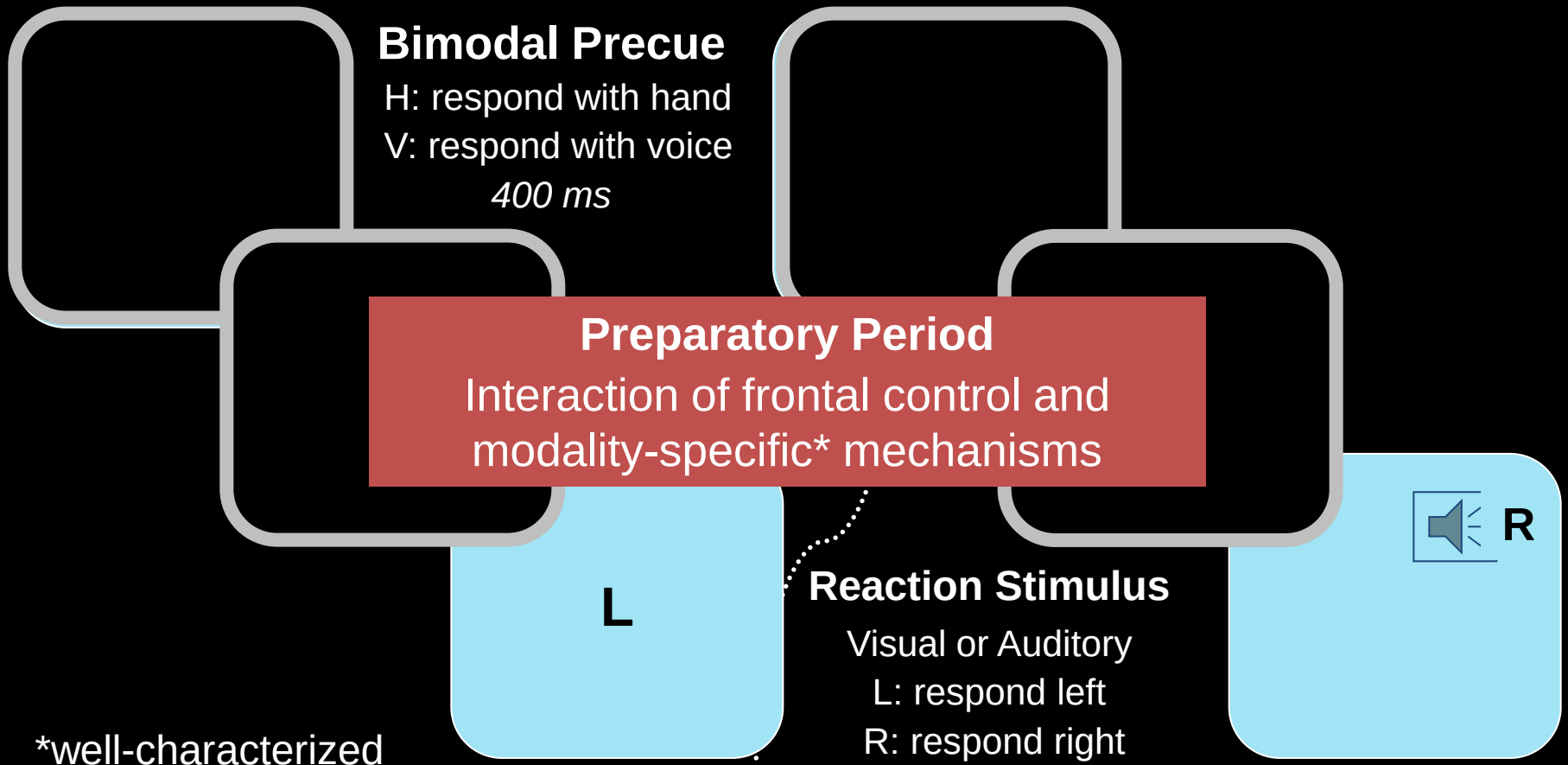
Gratton & Fabiani, 2010



- Measures changes in **optical scattering** in neural tissue (active vs. rest)
- Reaches ~3cm below scalp
- Spatial resolution ~5 mm
- Temporal resolution ~10 ms
- Recorded concurrently with **event-related potentials (ERPs)**, which measure scalp voltage changes due to neural activity

Modality Switching Experiment

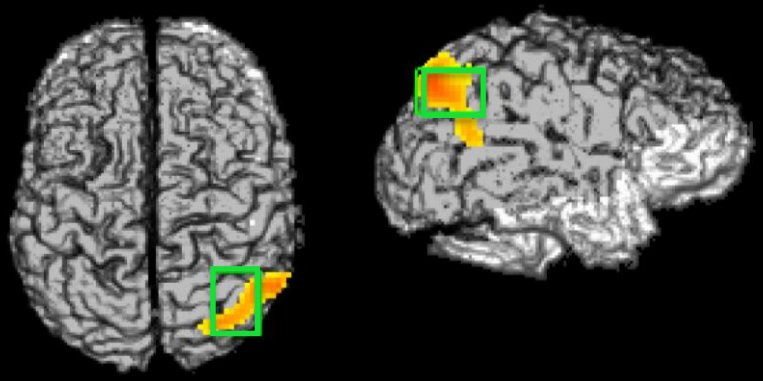
YOUNG ADULTS, N=15, 4 runs of 20 blocks with 24 trials each



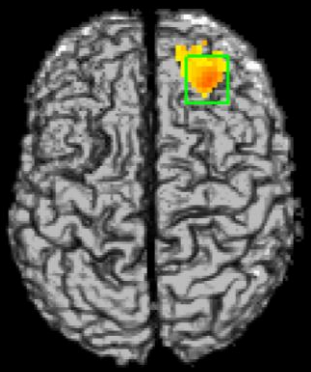
*well-characterized response regions

Greater Frontal & Parietal Activity for Switch vs Repeat Trials

230 ms
Switch Main Effect:
Switch > Repeat



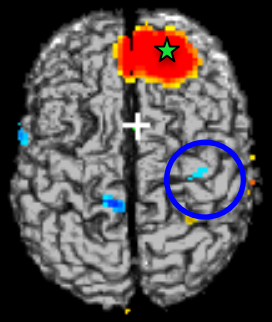
358 ms
Switch Main Effect:
Switch > Repeat



Baniqued, Low, Fabiani & Gratton, JoCN 2013

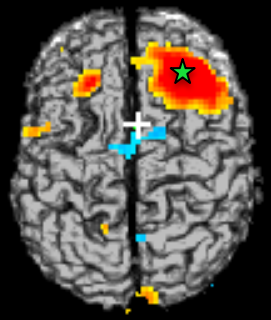
Switch-related frontal activity predicts task-specific **downregulation** and **upregulation**

VOCAL

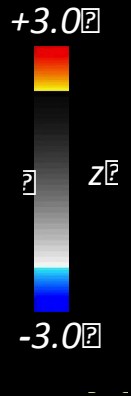


lag 0 ms

MANUAL

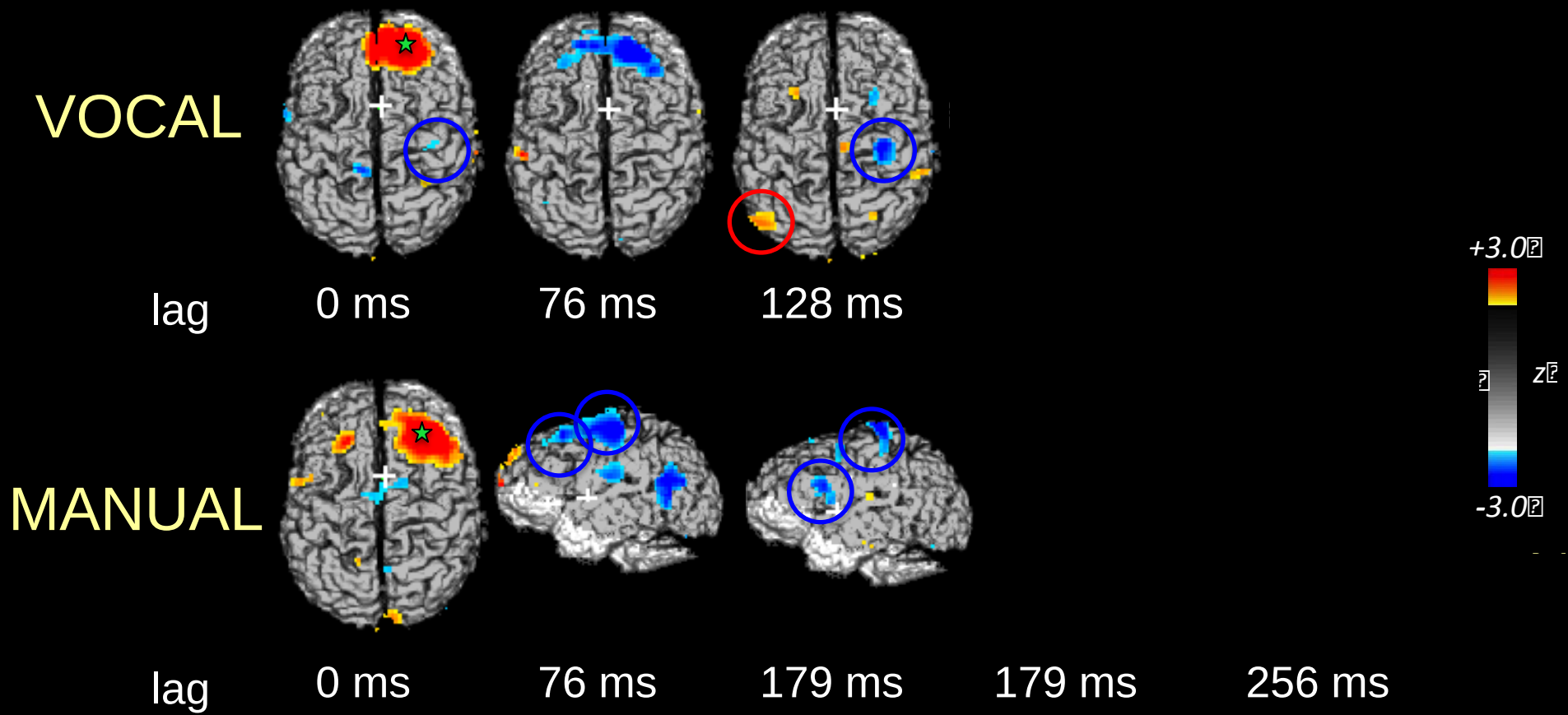


lag 0 ms 76 ms 179 ms 179 ms 256 ms



Baniqued, Low, Fabiani & Gratton, 2013

Switch-related frontal activity predicts task-specific **downregulation** and **upregulation**



Baniqued, Low, Fabiani & Gratton, 2013

Switch-related frontal activity predicts task-specific **downregulation** and **upregulation**

Baniqued, Low, Fabiani & Gratton, 2013

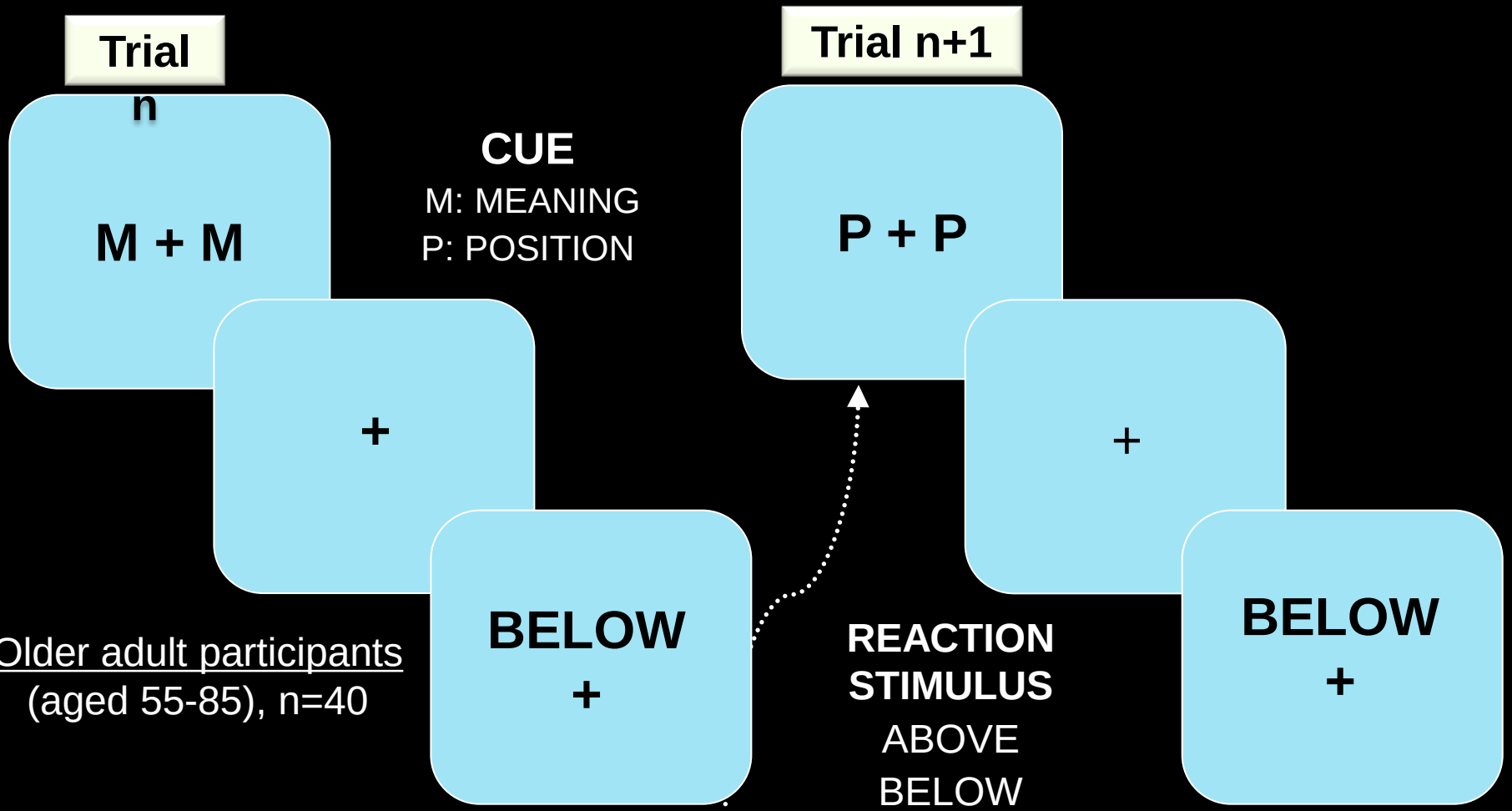
Part 1 Summary: Connectivity in young adults

- **Connectivity** between frontal control areas and task-specific regions (e.g., motor areas) is important for preparation, especially in more demanding switch trials

- **Frontal activity** predicted **downregulation** of task-irrelevant processes then **upregulation** of task-relevant processes

- **QUESTION:** What happens in older age, when frontal and parietal areas undergo age-related decline?

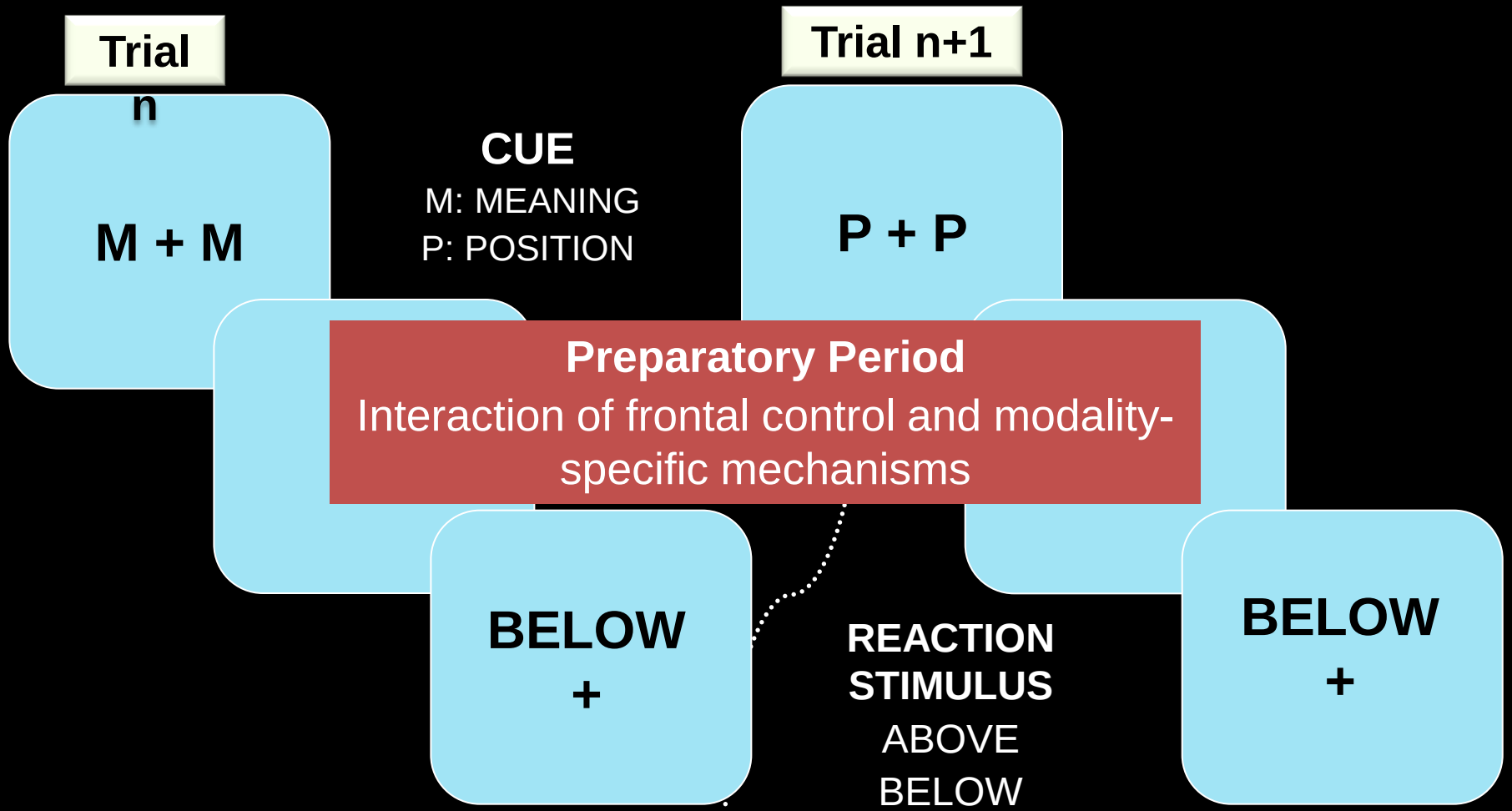
Spatial Stroop: Switching task sensitive to age, highly involves frontal regions



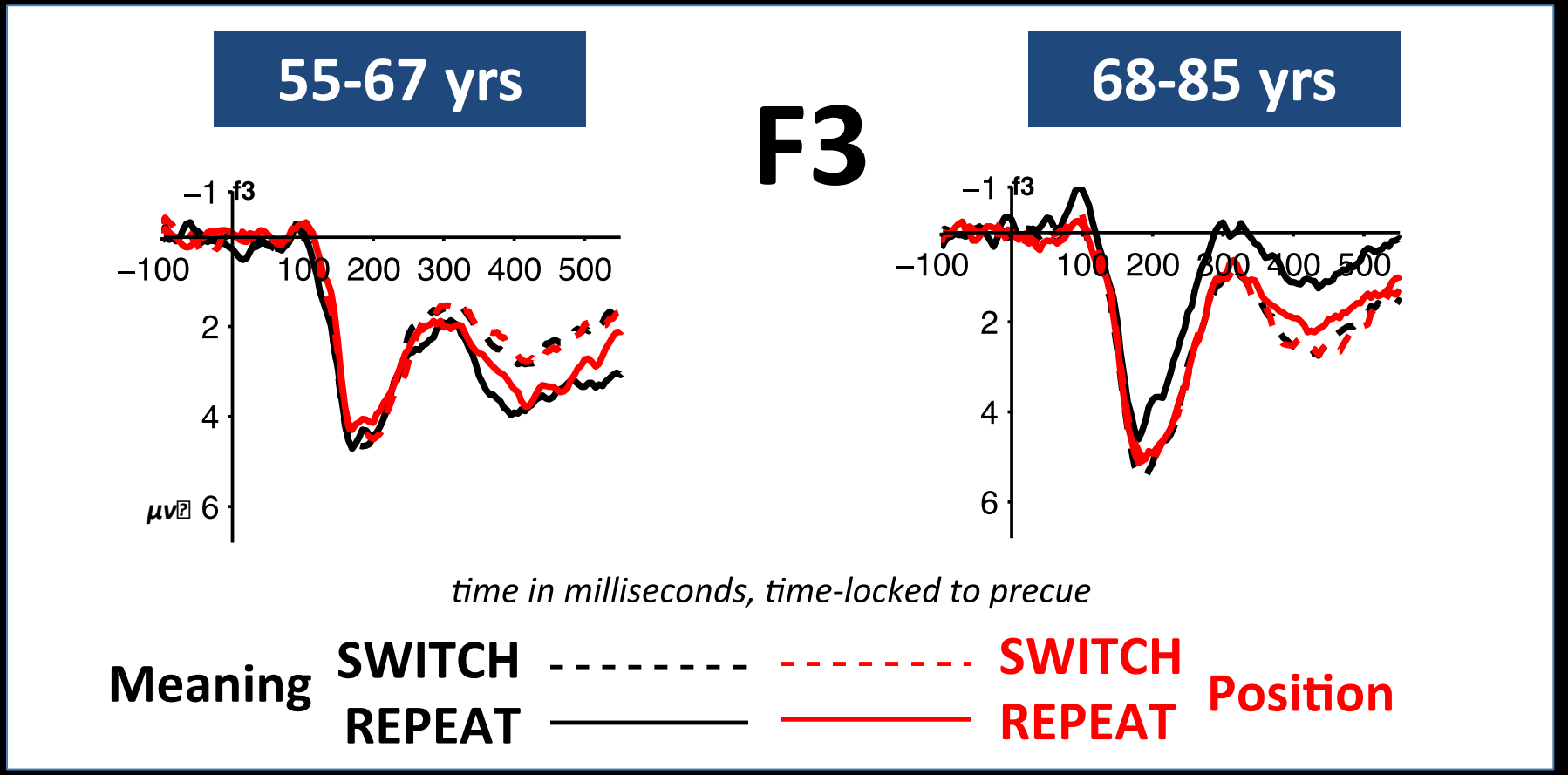
Older adult participants
(aged 55-85), n=40

Gratton et al., 2009

Spatial Stroop Switching task

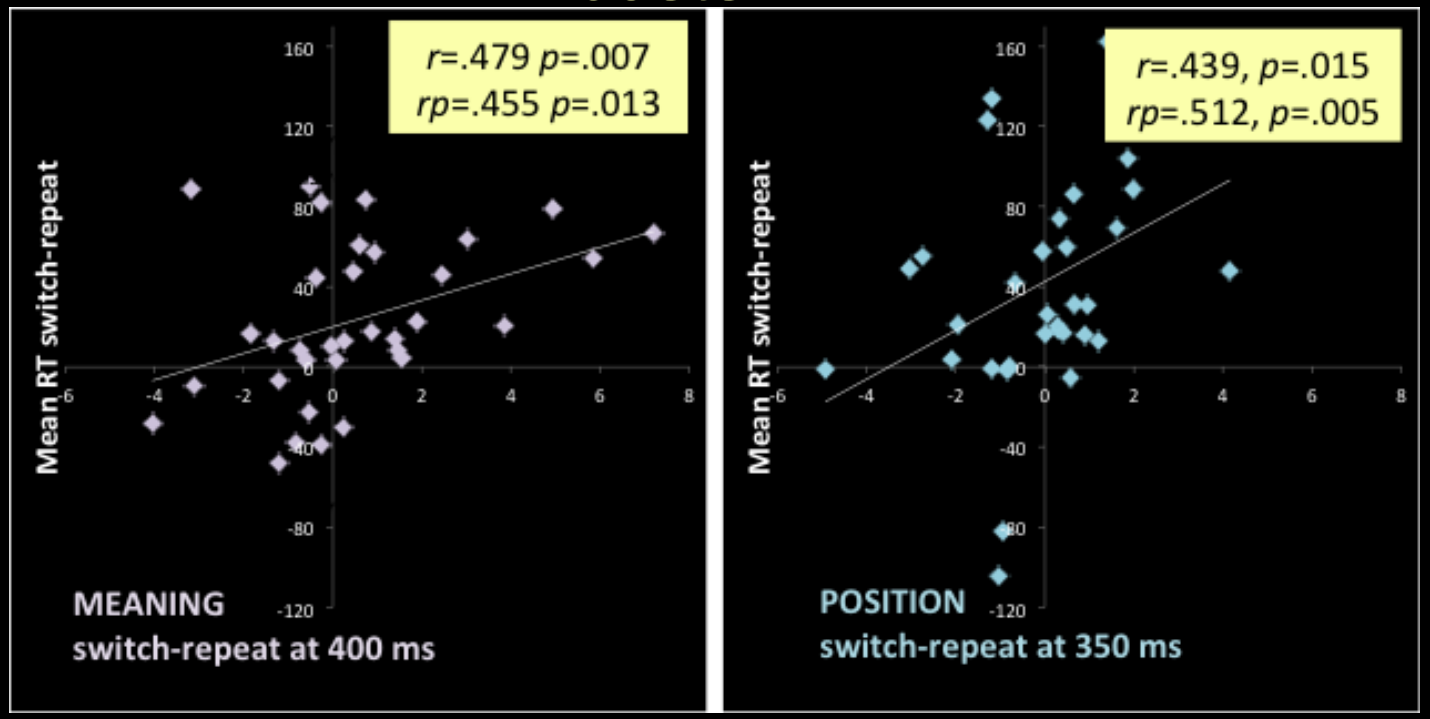


Switch-related frontal negativity, important for behavior?



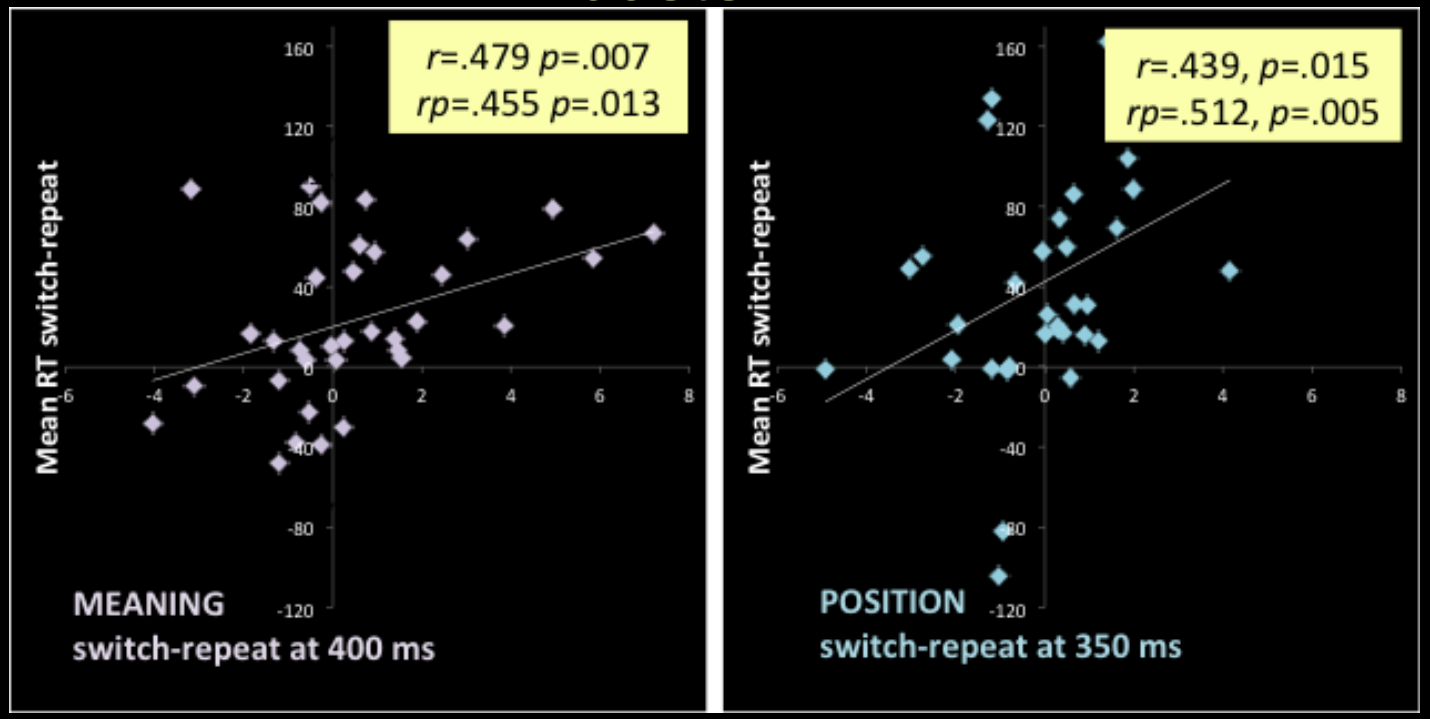
Switch-related activation in **left frontal cortex** during preparatory period predicts smaller switch costs

ERP: greater F3 negativity, smaller costs

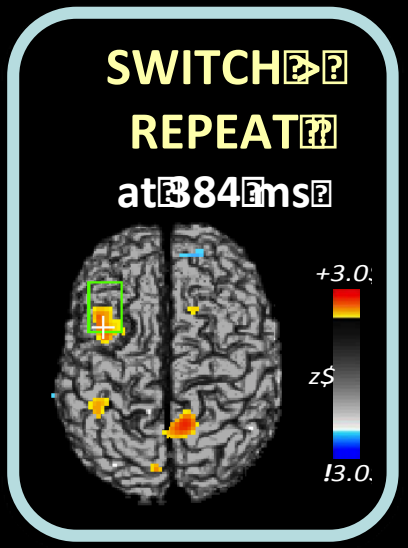


Switch-related activation in **left MFG** during preparatory period predicts smaller switch costs

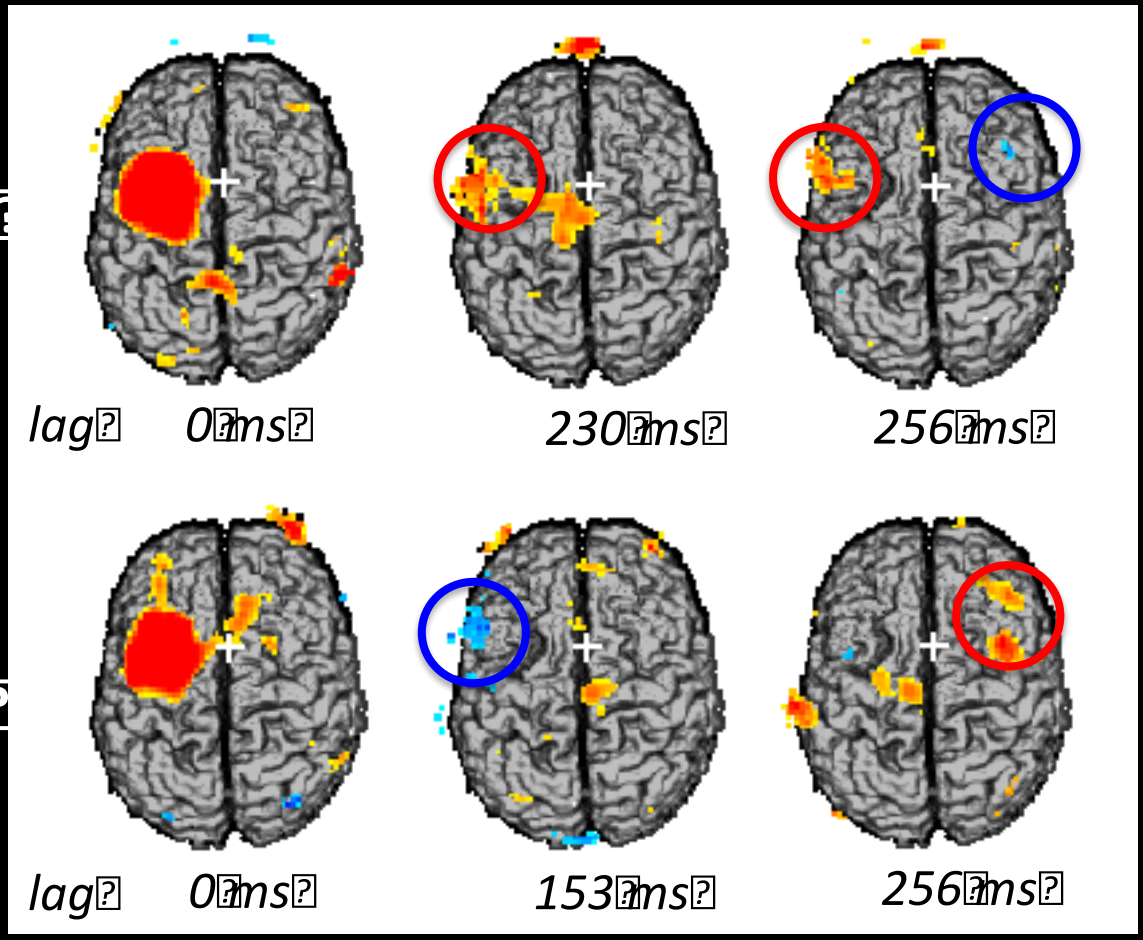
ERP: greater F3 negativity, smaller costs



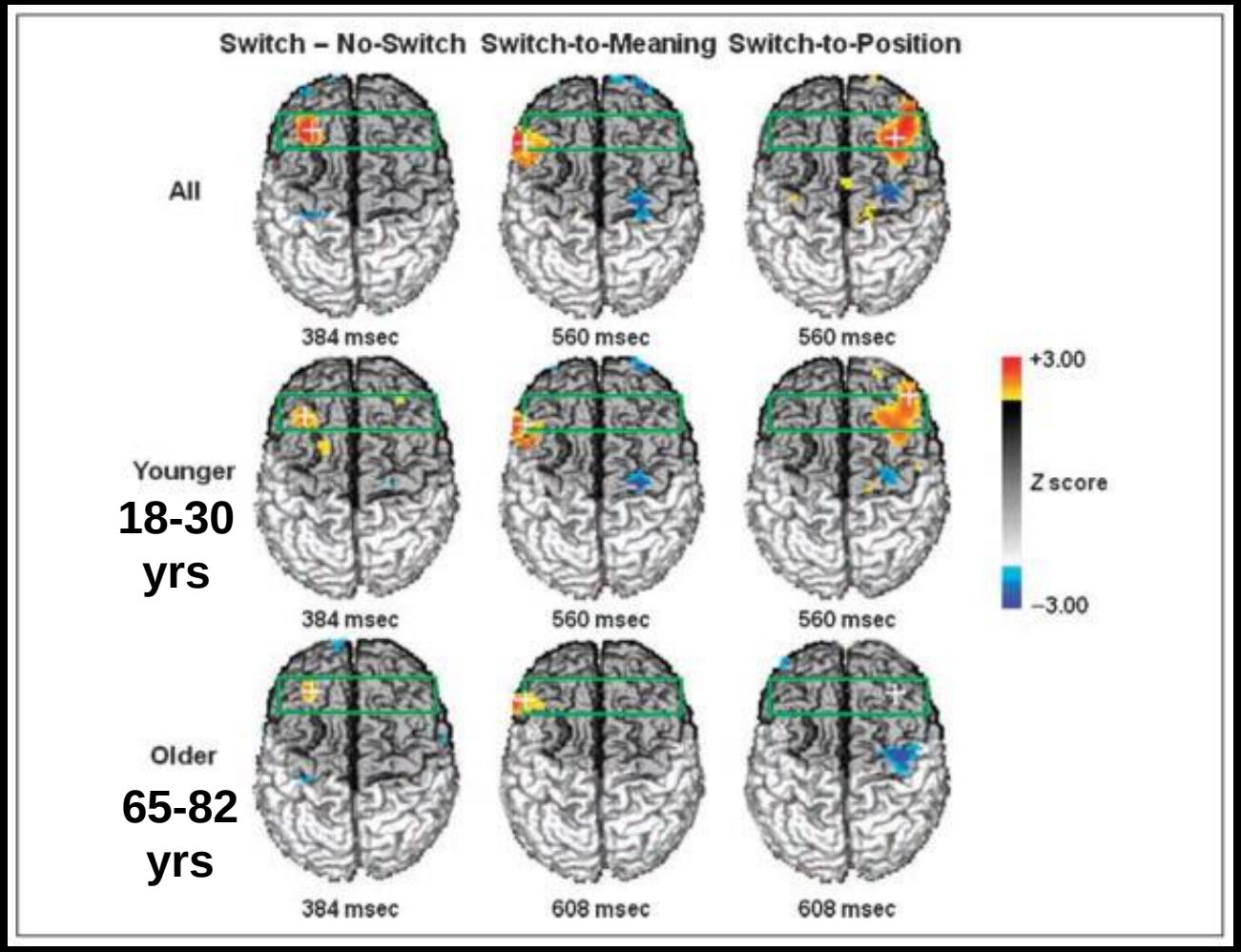
EROS



Cross-correlations: **Left middle frontal gyrus** predicts task-specific activations

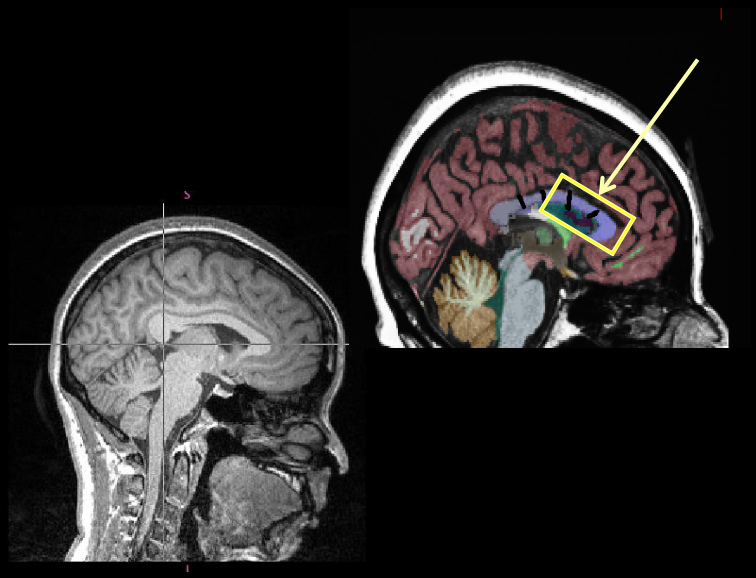


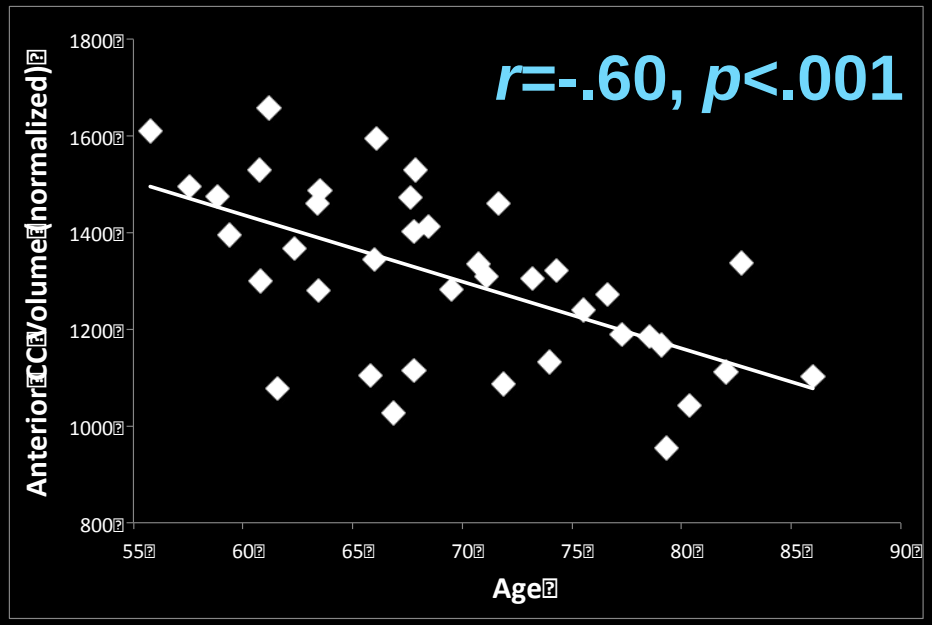
Larger switch costs, reduced switch modulation in frontal areas in older adults



Gratton et al., 2009

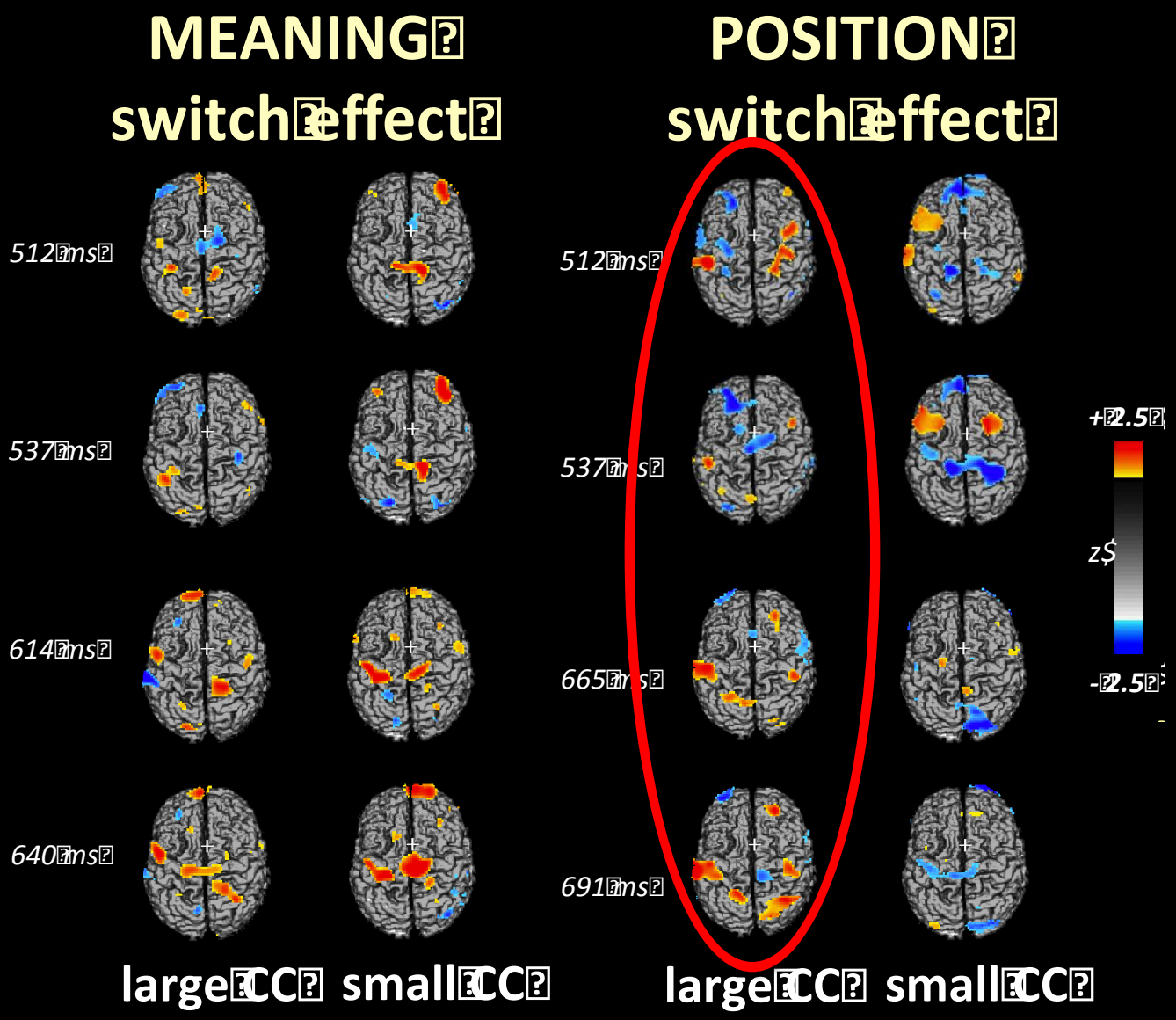
Anterior corpus callosum shrinks with **age**





Overall, larger switch costs for those with smaller CC, especially in right-hemisphere dependent position task.

Large CC group: more lateralized **switch** modulation



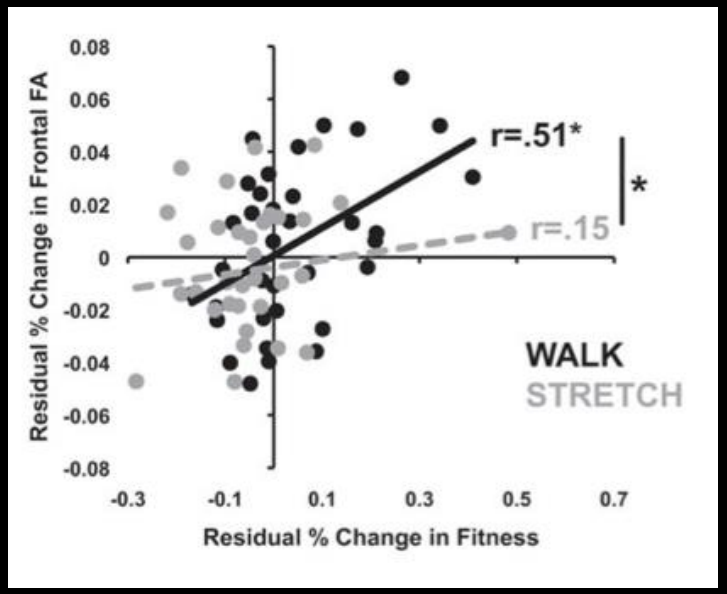
White matter matters for grey(ing) areas

- **Grey areas:** *Functional* connectivity between frontal control areas and task-specific regions is important in attention-demanding tasks

- **White matter matters:** In older adults, difficulty engaging preparatory control due to weaker *structural connections* may lead to sub-optimal performance

- **Work in progress**
  - Probe EROS-behavioral relationships
  - Investigate cross-correlation (functional) differences as a function of corpus callosum size (structural)

Target health of frontal white matter with **exercise**?



Voss et al., 2013

Burzynska et al., In Preparation

Gordon et al., 2008; Johnson et al., 2012; Zimmerman et al., 2014; Tan et al., In Preparation

Acknowledgements

Monica Fabiani
Gabriele Gratton
Kathy Low
Ed Maclin
Mark Fletcher (CC data)
Nils Schneider-Garces

Arthur Kramer
Lifelong Brain and Cognition Lab

NSF Neuroengineering IGERT (PB)
Beckman Graduate Fellowship (PB)
DARPA, ARRA Grants (MF, GG)

Cognitive Neuroimaging Lab