Robust fMRI activations across preprocessing pipelines and sites during task switching in healthy aging and their relationships with cognitive functioning

Paulina Skolasinska, Shuo Qin, Nicholas Ray, Evan Smith, Chris Oehler, Kyu Lee, Michelle Voss and Chandramallika Basak

Introduction

In this multi-site fMRI study, we investigated different preprocessing methods within and across two study sites using the same task-switching paradigm healthy aging. We also examined the relationships between cognitive control cost and BOLD signal during task-switching and performance across various executive function tasks. We collected data on 133 older adults from University of Texas at Dallas (UTD) and University of Iowa (UI).

To investigate the preprocessing methods we applied semi-automated preprocessing (SAP) steps and a fully automated fMRIPrep pipeline (AFNI) to the UTD dataset to compare BOLD signal for various cognitive control costs. To investigate the site differences - we preprocessed UI data using the AFN approach and compared it with outputs of UTD's AFNI output. Finally, we combined participants across the sites. We took a data-driven approach to investigate the relationship between BOLD signals between the BOLD signal in the identified cost-sensitive brain regions and task performance on various executive functions task (including the R0F task, N-Back and Flanker) and on general cognition.

Participants

- **Sex (Male %)**: 54 (41%), 21 (34%), 33 (46%)
- **Age (M/SD)**: 71.56 (4.56), 71.74 (4.53), 71.39 (4.62)
- **Education (M/SD)**: 16.74 (2.44), 16.52 (2.16), 16.94 (2.66)
- **MoCA (M/SD)**: 27.23 (2.09), 27.18 (2.03), 27.27 (2.16)
- **LSC (M/SD)**: 83.11 (87.14), 71.46 (72.68), 94.88 (12.92)
- **MC (M/SD)**: 208.94 (107.31), 185.99 (105.77), 230.41 (104.68)
- **CSC (M/SD)**: 102.79 (72.01), 100.86 (64.76), 104.6 (78.67)
- **Flanker (M/SD)**: 129.93 (83.22), 133.86 (78.62), 124.65 (87.71)
- **R Back accuracy (M/SD)**: 0.9 (0.09), 0.9 (0.07), 0.9 (0.12)

No significant site difference (UTD vs. UI) across any of these measures (t < 1.5, with exception of R % < 0.05).

Task Switch fMRI Task

A hybrid block and event-related task-switching paradigm was used (Nashiro et al., 2018). It consisted of two Single task blocks and three Dual blocks in which the tasks were mixed. There were five types of event-related trials across all task blocks: 1) “Single”, 1) “NSC”, 1) “NSC”, 1) “SC”, Switch Incompatible, 1) “SC” - Switch Compatible, 1) “SCC” - Switch Incompatible. Response times were used to calculate cognitive costs: Local Switch Cost (LSC, Switch Incompatible), Mixed Cost (MC, Switch-Incompatible-Switch-Compatible, Compatibility Switch Cost (SC, Incompatible-Compatible), and Global Switch Cost (GSC, Dual-Single). Two-out-of-scanner executive function tasks were: Flanker and N-Back. For Flanker, Incongruency Cost (Congruent-Incongruent) and for N-Back, total accuracy were used.

Conclusions

For the UTD dataset, both PPMs resulted in comparable cluster locations including vast lateral and medial frontal and parietal, cerebellum, insular, and sub-cortical regions. However, the automated pipeline resulted in larger spatial clusters for most contrasts, suggesting that SAP is a more conservative approach. Results were also similar across sites for most cognitive cost-related contrasts. As the two PPMs were very comparable, the AFIP approach seems more appropriate, saving a lot of time and allowing for reproduction of results across sites. PLSC results suggested that BOLD signals elicited in task-switching can predict other executive function task (Flanker). Moreover, these BOLD signals during MC are associated with task performances in both maladaptive (Insula, right Cerebellum) and compensatory manner (Caudate, left/central Cerebellum), suggesting that BOLD signals related to cognitive control costs form dynamic patterns of activation in the aging brain.

Contact: cska@utdallas.edu
This grant was funded by: NIH R44AG047722-04