

Investigating the Neural Bases of Language and Cognitive Processing in Healthy Adults Using Functional Near-Infrared Spectroscopy

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INTRODUCTION

- Language processing recruits a rich network of frontal, temporal and parietal brain areas.
- Domain-general cognitive control is supported by frontal and parietal regions.
- These areas are often damaged after brain injury, leading to language and cognitive impairment.
- Neuroimaging can be used to study neuroplasticity associated with recovery.
- Magnetic resonance imaging (MRI) may be contraindicated in individuals with brain injury (e.g., ferrous material).
- Functional near-infrared spectroscopy (fNIRS) can circumvent these challenges.¹

STUDY AIM

- To investigate brain regions recruited by healthy individuals during language and cognitive tasks via fNIRS

PARTICIPANTS

Twenty-nine healthy controls recruited from greater Boston.

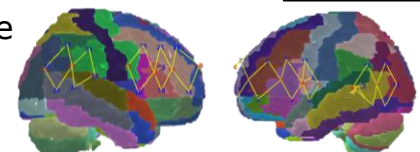
Group	Mean Age	Sex	Handedness
Younger (n = 20)	25	8 M	19 RH
Older (n = 9)	65	5 M	All RH

METHODS

DATA ACQUISITION

TechEn continuous-wave NIRS device

- 690 nm & 830 nm wavelengths
- 25 Hz sampling frequency

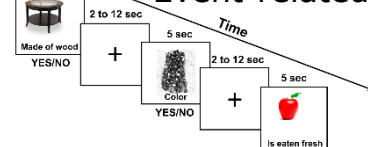


PROBE

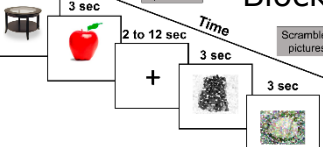
- 56 channels
- 16 sources
- 32 detectors
- 24 long
- 8 short

BEHAVIORAL TASKS

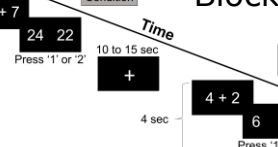
Semantic Feature²
15 items/condition
Event-related



Picture Naming²
35 items/condition
Block



Math³
32 items/condition
Block



Note: ~30 min. measurement, 5-6 minutes/run, 2 runs/task, 2 conditions/task

PRE-PROCESSING & ANALYSIS

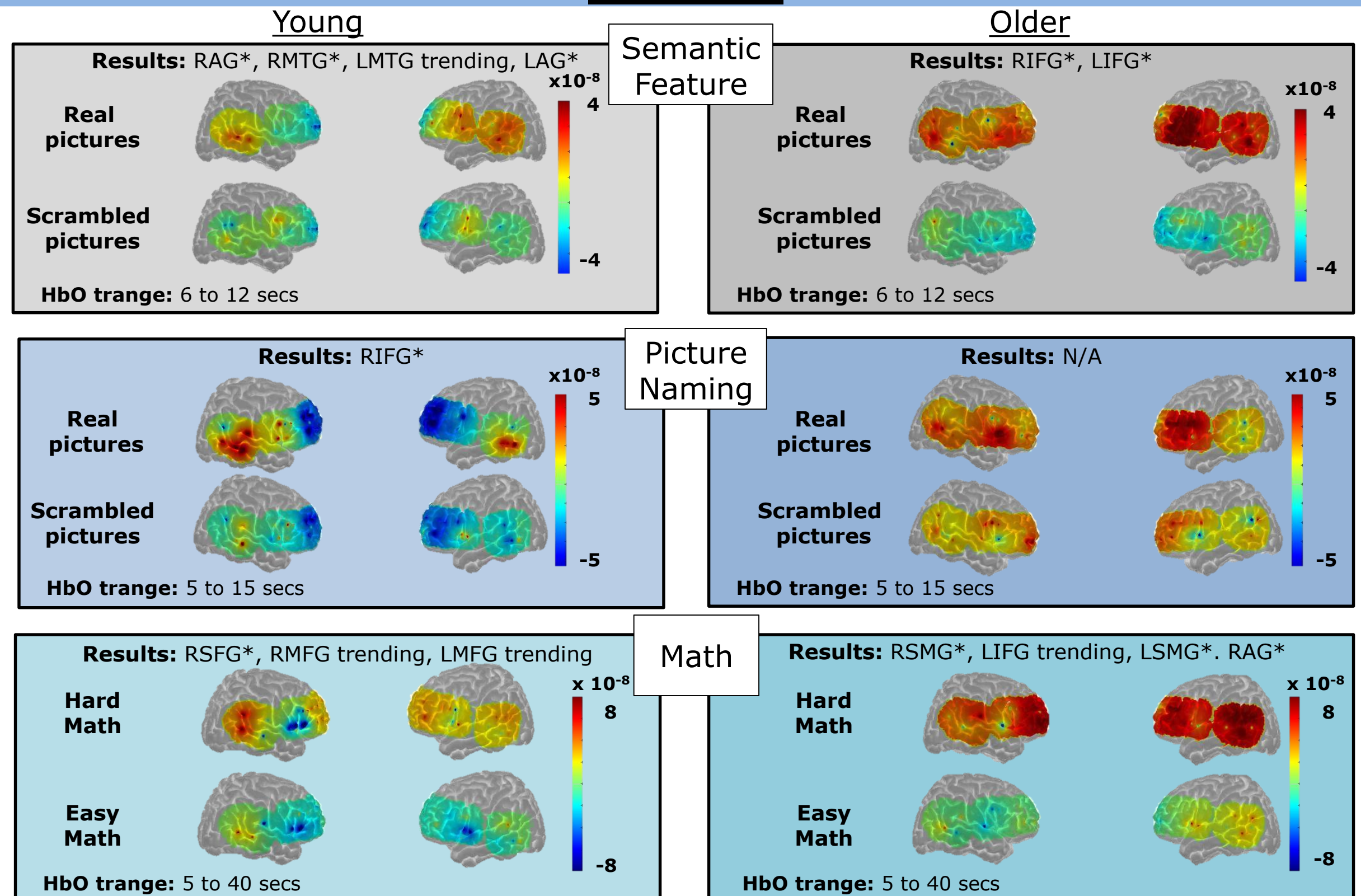
- Pruned channels with poor SNR
- Raw fNIRS → optical density (OD)
- Motion detection & correction
- High & low band pass filtering
- OD → concentration Δ in hemoglobin
- GLM → hemodynamic response
- Paired t-tests comparing concentration changes in oxygenated hemoglobin (HbO; averaged across peak time range) across two task conditions within regions of interest (ROIs)

VISUALIZATION

- 3-D locations of reference landmarks with Polhemus digitizer
- Register landmarks to brain atlas & probe to subjects' head surfaces
- Project probe to brain atlas → MNI coordinates for sources/detectors
- Generate HbO overlay from group results

Note: Data processed/analyzed in Homer²⁴, visualized with AtlasViewer⁵ & statistics conducted in MATLAB.

RESULTS



Note: "warm" colors = increase in HbO → activation and "cool" colors = decrease in HbO → deactivation, Trange = time range, ROIs created by averaging across channels using estimates of MNI coordinates obtained via AtlasViewer. MFG = middle frontal gyrus, IFG = inferior frontal gyrus, MTG = middle temporal gyrus, SMG = supramarginal gyrus, AG = angular gyrus. ROIs with significantly greater HbO concentration change (i.e., average across Trange) in experimental vs control condition listed in figure. * reflects significant difference at $p < .05$ level.

CONCLUSION OF FINDINGS

- Align with previous fMRI studies using these tasks^{2,3}
 - Bilateral language regions active during language tasks
 - Bilateral domain general regions (i.e., frontal, parietal active) with deactivation in language regions during hard vs. easy math
- Picture naming task results limited by motion associated with speaking during task
- Healthy older recruited more frontal regions than healthy young across all 3 tasks
- Provides foundation for understanding activation patterns in people with brain injury
- Administer tasks to assess therapy-induced neuroplasticity related to brain injury recovery

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