Introduction

- Previous studies have found that stroke alters the effective connectivity of motor execution networks (James, Lu, VanMeeter, et al., 2009).
- Here we examined the intrinsic effective connectivity of top-down motor control in stroke survivors relative to healthy participants.
- Stroke survivors with heterogeneous stroke location (8 males) demonstrated moderate deficits in upper limb motor function.
- The relationship between these observed deficits in motor function and intrinsic effective connectivity between brain regions involved in motor control and motor execution were investigated with structural equation modeling (SEM) of resting-state fMRI data (rs-fMRI).

Background

- Stroke is now the leading cause of severe, long-term disability in the United States (Rosamond, Flegal, Friday, et al., 2007).
- Functional neuroimaging has improved stroke research by identifying the neuro-anatomical components of the human motor system and elucidating the complex, dynamic neural interactions underlying task-related motor function (Cabeza and Nyberg, 2000).
- rs-fMRI of the motor network circumvents the confounds introduced by task difficulty.

Research Goals

- To evaluate rs-fMRI connectivity of motor circuits in the brains of healthy individuals through exploratory SEM.
- To characterize any potential alterations in rs-fMRI between motor control and execution circuits in stroke survivors based on an exploratory model of healthy controls.

Hypotheses

- We propose that stroke survivors’ data will differ significantly from an exploratory SEM derived from able-bodied participants’ data. Specifically, in connectivity from motor control (fronto-parietal) to motor execution circuits (primary motor).
- Furthermore, differences between the healthy control and stroke survivor models will reflect how stroke affects motor network connectivity.

Methods

Participants

- 15 stroke survivors (8 male) who had sustained a single stroke with upper extremity hemiparesis
- 6 patients had left hemiparesis
- 7 patients had right hemiparesis
- 12 able-bodied volunteers (5 males; Controls)

Data Analyses

- rs-fMRI: 130 time points (<5 mm each)
- Pre-Processing: SPM5; slice-timing, band-pass filter, motion-corrected, realigned, and unwarped.
- Unified Segmentation Normalization
- Smoothing at FWHM, 6 x 6 x 6 mm
- ROI Definition
  - Defined using a mixed seed-based and data-driven correlation mapping procedure
  - Primary motor cortex (M1) and superior parietal (PAR) were selected as seeds.
  - M1 seed was identified by “hand knob” anatomic landmark (Lamee et al., 2009).
  - M1 seed map guided the subject-wise placement of 4 additional 6-mm ROIs:
    - Bilateral primary motor cortex (M1)
    - Bilateral dorsal lateral premotor cortex (pMPC)
    - Supplementary motor area (SMA)
  - PAR seed defined using the WFU PickAtlas (Alexander, Launet, et al., 2003) according to AAL coordinates.
  - PAR seed map guided the subject-wise placement of 4 additional 10-mm ROIs:
    - Bilateral superior parietal (PAR)
    - Bilateral inferior parietal (IF)

- Structural Equation Models
  - Above each path is the path coefficient for that path. Below each path in parentheses is β score for that path. Dotted lines signify non-significant paths or paths that are significantly different between groups.

IMPLICATIONS

Motor control deficits following stroke may stem from disconnect between motor guidance systems and the primary motor network.

- Fronto-parietal inputs into primary motor regions guide motor intentions, decision-making, trajectories of movement, and coordination of multiple body parts (Andersen and Cui, 2009).
- Multi-group shows top-down connections are critical for normal functioning and are damaged in stroke survivors with impaired upper extremity control.
- Stroke survivor model distinct from both the execution model and healthy exploratory model.
- Variability of PAR to M1 path weights across patients makes the PAR’s influence on M1 negligible in stroke survivor confirmatory model.
- Similar to our findings, James et al. (2009) found altered rs-fMRI primary motor connectivity in stroke survivors through exploratory SEM after rehab. i.e., Bilateral motor plasticity from affected to unaffected regions and vis versa
- Characterizing resting-state networks in stroke informs rehabilitation therapists of cognitive mechanisms that need therapeutic attention following stroke.