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Brain Plasticity Related to Psycho-motor Skills in Catheter-based Interventions

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Introduction

- A fascinating property of the human brain is its ability to reorganize as a result of experience.
- Experimental evidence of practice-related brain change has been shown as a result of simple and increasingly complex visuo-motor training tasks, even after brief training periods.

Previous studies examining brain plasticity related to complex visuo-motor skill training found:
- Increased grey matter volume in MT/V5 and posterior intraparietal sulcus
- Increased fractional anisotropy of white matter underlying the right posterior intraparietal sulcus
- Increased connectivity in fronto-parietal (and cerebellar networks)

Catheter-based interventions (CBIs):
- Minimal access procedures, where a catheter is used to diagnose and/or treat the target site
- CBIs have many advantages over open procedures
- CBIs have many advantages over open procedures

Research questions and hypotheses:

- Are there specific functional & structural neural changes after overall learning and do specific neural changes correlate with performance gain?
  - Hypothesis: Specific training-related changes in MT/V5 and hippocampus, intraparietal sulcus & fronto-parietal networks are expected, the correlation with performance gains will be explored

Do structural and/or functional baseline MRI parameters predict learning of catheter-based interventions?
- Hypothesis: MT/V5 and intraparietal areas are expected to predict learning of CBIs

Methods

Participants:
- 2 groups (n=40), healthy young medical students
- passed “Physikum”, no experience with CBIs
- Normal or corrected to normal vision, right-handed
- No MRI contraindications

Measures:

Cognitive
- Accuracy & reaction time in cognitive tasks (cognitive control, task-switching and visuo-spatial ability)
- Average amount of pegs inserted with the right hand in the manual dexterity task

Behavioural
- Total time required to complete the task
- Total fluoroscopy, cine time and contrast agent used to complete the task
- Number of catheter handling and table movement errors

Neuronal
- Change in grey matter (T1-weighted scan)
- Change in white matter (diffusion weighted scan)
- Change in functional connectivity (resting-state fMRI)

Analysis:
- Region of interest analysis (MT/V5, hippocampus, intraparietal sulcus) as well as whole brain analysis
- Eigenvector centrality analysis to examine network changes
- Group*time-point interaction (controlled for multiple comparisons)
- Changes in experimental group > control group?
- Correlation between structural and functional changes (in %) with performance gains (% improvement day1+ day2+day3/3)
- Correlation between certain baseline MRI parameters (before learning) and performance gains (%)

Procedure

MRI scanning protocol:
- T1-weighted scan: MP2RAGE sequence
- Diffusion weighted imaging: multiband EPI sequence
- Resting state fMRI, multiband BOLD EPI-sequence

Training on the catheter-lab simulator:
- Aim: perform selective access to the right internal carotid artery
  - Individual training for 2 hours on three consecutive days
  - Motor proficiency questionnaire
  - Instruction video about the task & written instructions
  - During the first trial, participants are walked through the procedure
    - On each training day, catheter-handling tips are given until selective access to the target artery is successfully performed once
    - The training complexity advances as the training progresses
    - Training complexity is defined by patient anatomy and morphology

Control group:
- Participants are age and gender matched to the experimental group
- Simplified training task on the simulator
- Participants also watch an instruction video, receive written instructions and perform the task under supervision
- The simplified task does neither require table movements, spatial sense (converting 2D image into 3D environment) nor selective access with the catheter
- The rest of the work-flow is exactly the same

References