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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

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/or 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?
• Changes from pre to post scan > baseline to pre scan?
• 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

Day 1     Day 2     Day 3     Day 4     Day 5     Day 6     Day 7     Day 8

MRI

Training

References