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

Paul, Katja; Cnossen, Fokeltje; Taatgen, Niels; Lanzer, Peter; Sehm, Bernhard ; Villringer, Arno

Publication date:
2017

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

Katja Isabel Paul[1,2], Fokie Cnossen[2], Peter Lanzer[3], Niels Taatgen[2], Bernhard Sehm[1] & Arno Villringer[1]

[1]Department of Neurology, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
[2]Institute of Artificial Intelligence and Cognitive Engineering, Faculty of Science and Engineering University of Groningen, The Netherlands ,
[3]Medical Center Bitterfeld, Germany
kpaul@cbs.mpg.de

university of groningen
faculty of science and engineering

MAX-PLANCK-GESELLSCHAFT

MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES LEIPZIG

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

http://uccerebrovascularcenter.com/press-releases/analysis-shows-benefits-of-endovascular-therapy-for-severe-large-vessel-stroke/

- However, patient outcomes heavily dependent on the catheter-handling skills of the operator and there are great performance differences
- CBIs are complex procedures and cognitively challenging to execute. Therefore, they constitute an interesting real-life task to study brain plasticity related to acquiring complex skills and to explore whether expected changes are behaviourally relevant

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)

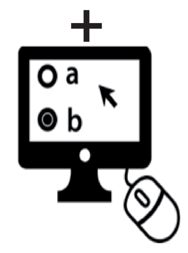
Analysis:

- 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

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
	MRI 			MRI 	 Training	 Training	 Training
+ 							+ MRI 

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

Albert, N. B., Robertson, E. M., & Miall, R. C. (2009). The resting human brain and motor learning. *Current Biology*, 19(12), 1023-1027.

Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U., & May, A. (2004). Neuroplasticity: changes in grey matter induced by training. *Nature*, 427(6972), 311-312.

Gryga, M., Taubert, M., Dukart, J., Vollmann, H., Conde, V., Sehm, B., ... & Ragert, P. (2012). Bidirectional gray matter changes after complex motor skill learning. *Frontiers in systems neuroscience*, 6.

Karni, A., Meyer, G., Jezzard, P., & Adams, M. M. (1995). Functional MRI evidence for adult motor cortex plasticity during motor skill learning. *Nature*, 377(6545), 155.

Sagi, Y., Tavor, I., Hofstetter, S., Tzur-Moryosef, S., Blumenfeld-Katzir, T., & Assaf, Y. (2012). Learning in the fast lane: new insights into neuroplasticity. Neuron, 73(6), 1195-1203.

Scholz, J., Klein, M. C., Behrens, T. E., & Johansen-Berg, H. (2009). Training induces changes in white-matter architecture. *Nature neuroscience*, 12(11), 1370-1371.

Van Herzeele, I., O'donoghue, K.G., Aggarwal, R., Vermassen, F., Darzi, A. and Cheshire, N.J., 2010. Visuospatial and psychomotor aptitude predicts endovascular performance of inexperienced individuals on a virtual reality simulator. *Journal of vascular surgery*, 51(4), pp.1035-1042.