What Neuroimaging tells us about Brain Plasticity

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Overview

• Structural MRI can track changes in grey and white matter as we develop and learn new skills

• Functional MRI can track brain activity as we learn new tasks and perform practiced tasks

• Use MEG (and fMRI) combined with connectivity models for studying signalling among brain regions
MRI Scanner
Grey and white matter

White matter: Glial cells and myelinated axons

Grey matter: glia, vasculature, and neurons with dendritic and synaptic processes
Development

Gogtay et al. PNAS, 2004

13 children scanned every 2 years
Development

13 children scanned every 2 years

Gogtay et al. PNAS, 2004
Development

289 children, each scanned twice. Ziegler et al. in prep, 2015

Gray Matter Density for Boys (blue) and Girls (red). Most areas “inverted –U” except e.g. hippocampus.
“Fractional Anisotropy (FA)” from MRI measures how directed are white matter tracts.

Eight concert pianists versus age-matched non-musicians (controls)

White Matter tracts in Internal capsule

Bengtsson et al., Nature Neuroscience, 2005
Pianists who practiced for longer during childhood have more directed white matter tracts

Bengtsson et al., Nature Neuroscience, 2005
The posterior hippocampus is larger in taxi drivers than control subjects (matched for age, IQ)

Maguire et al. PNAS, 2000
The longer they’ve been driving taxis the bigger this increase

Maguire et al. PNAS, 2000
Cognitive neuroscience

Behavioural experiments + Neuroscience
fMRI-signal

BOLD

Blood Oxygen Level Dependent signal

Logothetis, 1993
Learning – Redistributed Activity

Motor Sequence Activity:
A: 13224134 versus
B: 12121212
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After a Little Practice

Ramnani et al., 2002

“Fronto-Parietal Attention Network”
Learning – Redistributed Activity

Motor Sequence Activity:
A: 13224134 versus
B: 12121212

After a Little Practice

After a lot of practice

Rammanni et al., 2002

Woodhead et al. Brain, 2013 studied 8 people with a focal brain injury in left occipito-temporal cortex. They have problems reading, especially longer words.
Plasticity after Brain Injury

Diagram showing a timeline with stages labeled 2-4 weeks, 6 weeks, and 2-4 weeks, with points t1, t2, t3, and t4. The diagram includes a box labeled "Cross-modal Reading Training." Below the timeline, there is a table comparing Patients and Controls for reading tests and imaging scans:

- **Patients**
  - Reading tests: ✔ ✔ ✔ ✔>20 minutes/day ✔
  - MRI scan: ✔ ✔
  - MEG scan: ✔

- **Controls**
  - Reading tests: ✔ ✔
  - MRI scan: ✔
Plasticity after Brain Injury

Present both text and speech.

(i) Listening component: Press button.

(ii) Testing Component: Do text and speech match?
Plasticity after Brain Injury

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Plasticity after Brain Injury

Measure electrical activity of the brain as they read words after cross-modal training

**Figure 6** Global field power during word reading in the patient group (trained words, pink solid line; untrained words, pink dotted line) and a group of age-matched healthy controls (blue) using data from Woodhead et al. (2012).
Plasticity after Brain Injury

Estimate signalling between brain regions using a brain connectivity model. Stronger effective connections on the left side of the brain for trained words.
Summary

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• Use MEG (and fMRI) combined with connectivity models for studying signalling among brain regions.
M. M. Mesulam, “From sensation to cognition,” Brain, 121, no. 6, pp. 1013–1052, 1998
The Hierarchical Brain