Structural plasticity with learning in the healthy brain

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Basis of talk
Changes in brain structure can occur beyond those associated with development, ageing, and neuropathology

• Learning a new skill can result in local changes in brain structure
  - Regional differences in the amount of grey/white matter

Maguire et al. (2000) Science
Draganski et al. (2004) Nature
• Local experience-dependent structural changes
  - Suggests a relationship with learning
  - Change in grey matter lasting for as long as the skill is practiced

• Many of these regions can be linked to a functional role
  - Functional imaging data showing region active during task

How are regional differences detected?
• Voxel Based Morphometry (VBM)
  - An unbiased analysis technique
  - Possible to analyse the whole brain

... focus on language

Structural studies of language skills in the typical population
  - Bilingualism
  - Vocabulary learning
Structural plasticity in bilinguals

- We have the capacity to learn multiple languages
- Does learning an extra language have an effect on local brain structure?
  - Is this affected by the age at which the second language was learned or second language proficiency?
- Study of European bilinguals
  - 'early' bilinguals
    - acquired 2nd language before age of 5 years
  - 'late' bilinguals
    - acquired 2nd language between age of 10-15 years


Comparison to identify potential differences in grey matter between bilinguals and monolingual participants

• Grey matter density greater in the inferior parietal cortex of bilinguals than monolinguals
  - Significant effect in the left hemisphere
  - Trend in the right hemisphere

Relationship between grey matter, proficiency, and age of acquisition

- English-Italian bilinguals: acquired 2nd language between ages 2 and 34 years

• Second language proficiency correlated with grey matter density
• Grey matter density correlated negatively with age of second language acquisition
• What do different grey matter values correspond to?
• Is this region specific to individuals who learn multiple languages?
  Or
• Is this region associated with language learning in general?

Is there a relationship between grey matter in this region and language proficiency monolinguals?

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**Vocabulary knowledge and the pSMG**

*Acquisition of vocabulary knowledge is a key property of language learning*

• **Learning new words and their meanings**
  - Important for first and second language learning

Vocabulary knowledge assessed in 32 right-handed English-speaking adolescents aged between 12-16 years

Lee et al. (2007) *Journal of Neuroscience*
Anterior SMG:
- associated with phonological processing

ANG:
- associated with semantic processing

No route between anterior SMG and ANG other than pSMG

pSMG:
- links phonological and semantic word information

Studies detecting differences in pSMG grey matter:
- Consistency in findings across studies
  - Monolinguals and bilinguals
- pSMG grey matter corresponds to the number of words learnt
- pSMG not typically detected in functional studies of language
  - Is activated in studies that involve learning new vocabulary

- Do regions typically active during language tasks show a relationship between word knowledge and brain structure?

activation for sentences
Regions positively correlated with vocabulary knowledge

1) Posterior superior temporal sulcus (pSTS)
2) Posterior temporo-parietal region (pT-P)

Richardson et al. (in press) Journal of Cognitive Neuroscience

• Differential effects of vocabulary knowledge in temporal and parietal regions across lifespan
  - Temporal (pSTS and pT-P) consistent across lifespan
  - Parietal (pSMG) detected in monolingual adolescents (not monolingual adults) and in bilingual adults

Could these reflect different ways of learning?

Definitions/Equivalents:
- i.e.

Context:
- Everyday language experience

Summary

Language proficiency can be reflected in regional differences brain structure

• Identify regions not typically identified in functional studies
  - Relationship specific to learning

• Common influence of proficiency on structure and function during language processing
  - Changes as a consequence of learning
**Final caveat...**

- Differences/changes?
  - Cross-sectional
  - Longitudinal

- Difference between identifying a relationship and establishing a causal connection

**Future**

- Causal link

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**The End**