Structural plasticity with learning in the healthy brain

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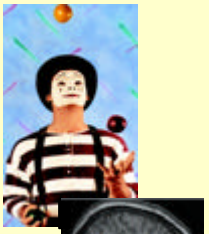
Basis of talk

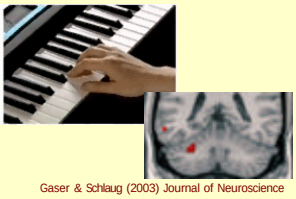
Changes in brain structure can occur beyond those associated with development ageing and neuropathology

- **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

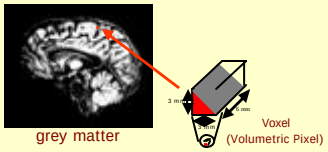


Gaser & Schlaug (2003) Journal of Neuroscience

- **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?

- **V**oxel **B**ased **M**orphometry (**VBM**)
  - An unbiased analysis technique
  - Possible to analyse the whole brain



… focus on language

Structural studies of language skills in the typical population

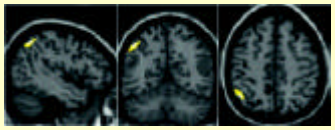
- Bilingualism
- Vocabulary learning

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

Mechelli *et al.* (2004) Nature

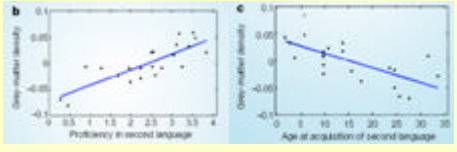
- Comparison to identify potential differences in grey matter between bilinguals and monolingual participants



- 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?

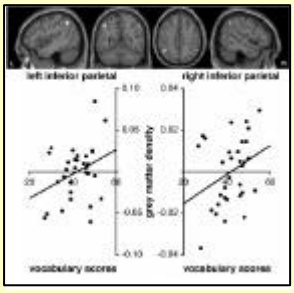
Vocabulary knowledge and the pSMG

Acquisition of vocabulary knowledge is a key property of language learning

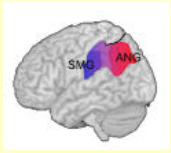
- **Learning new words and their meanings**
  - Important for first and second language learning

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

Lee *et al.* (2007) Journal of Neuroscience



Lee *et al.* (2007) Journal of Neuroscience

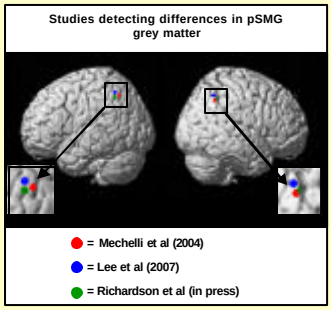


Anterior SMG:
- associated with phonological processing

ANG:
- associated with semantic processing

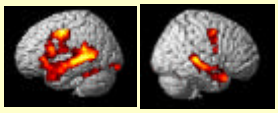
No route between anterior SMG and ANG other than pSMG

pSMG:
- links **phonological** and **semantic** word information



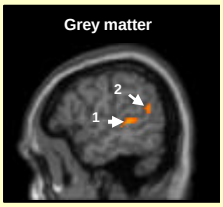
- Consistency in findings across studies
  - Monolinguals and bilinguals
- pSMG grey matter corresponds to the number of words learnt
- pSMG not typically detected in functional studies of language
  - Is activated in studies that involve learning new vocabulary

- **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.

elephant = pachyderm

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

The End