Hippocampus activity differentiates good from poor learners of a novel lexicon

C. Breitenstein et al. (2005)
Introduction

• The importance of learning foreign languages.
• Why do some people rapidly evolve into language experts while others remain novices?
• Identification of brain regions whose activity predicts differences in language learning success.
• Mechanisms underlying the acquisition of novel vocabularies.
• Neural networks a novel lexicon is mediated by.
Hippocampus
Hippocampus & associative learning

- Formation of memories: **episodic** and **semantic**?
- Initial binding of new multimodal associations in a variety of domains.

- Is semantics one of these domains?
- fMRI study investigating the neurological processes behind naturalistic acquisition of novel vocabulary.
Research questions

(1) What is the neural network mediating the acquisition of a novel vocabulary?

(2) Does the hippocampus contribute to the acquisition of a novel vocabulary?

(3) Does learning-related activation strength in any of the contributing brain systems predict how well subjects acquire a novel language and how well they master semantic language aspects in everyday life?
Methods: participants

• 14 healthy subjects (8 men, 6 women; 19-26 years)
• Native speakers of German, speaking 1-3 languages fluently.
• Right-handed, left-hemisphere dominant for language.
Methods: procedure

- Pictures & auditory pseudowords presented in two conditions during fMRI scanning:
  - Learning (on basis of frequency),
  - No-Learning (each object-pseudoword pairing occurring only once).
Methods: procedure

• Outside the scanner:
  • lexical knowledge test,
  • free recall test.
• Battery of neuropsychological tests.
Variables used

1. Independant:
   - 2 conditions (Learning & No-Learning),
   - 5 blocks in the „Learning” condition.

2. Dependant:
   - activations of particular brain regions in both conditions,
   - activity decreases & increases across the blocks,
   - behavioural data.

3. Correlations of degree of signal changes in brain regions with each other and with the behavioural data.
Results

(1) What is the neural network mediating the acquisition of a novel vocabulary?

- Linear increase in vocabulary proficiency over the 5 learning blocks.
- Changes in the brain activity correlated with the behavioural data:
  - initial activation of the hippocampus and adjacent cortices (fusiform gyrus);
  - increase of activity in left inferior parietal lobe paired with growing vocabulary proficiency.
Results

(2) Does the hippocampus contribute to the acquisition of a novel vocabulary?

- Yes, the increase in vocabulary proficiency was paralleled by a linear activity decrease of the left hippocampus.

![Learning curve and learning-related changes of BOLD signal in the left hippocampus](chart.png)
Results

(3) Does learning-related activation strength in any of the contributing brain systems predict how well subjects acquire a novel language and how well they master semantic language aspects in everyday life?

- Yes, degree of signal decrease from block 1 to 5 in the left hippocampus predicts **vocabulary learning success & general semantic knowledge**.

- Less decline in hippocampus activity:
  -> greater training improvement
  -> higher score on general verbal semantic abilities

- Trait variable contributing to learning and mastering languages.
Conclusions & implications

- The successful acquisition of a new lexicon depends on correlated amplitude changes between the left hippocampus and neocortical regions.
- Learning-related hippocampus activity is a stable marker of individual differences in the ability to acquire and master vocabularies.
- Foundation for probing the effects of pharmacological substances in increasing hippocampus activity to boost language learning.
- First step in developing strategies for restitution of language after stroke with aphasias.
Comment

• „A comprehensive battery of neurological tests”
  • no language aptitude test, which the best predictor of achievement in a second language (Gardner & McIntyre 1992).

• Validity for Second Language Acquisition
  • incidental learning and SLA
  • no correlation between hippocampal activity and scores on the word list learning test

• Farmacologically induced language aptitude?
Thank you!