LANGUAGE LEARNING, BILINGUALISM AND THE BRAIN

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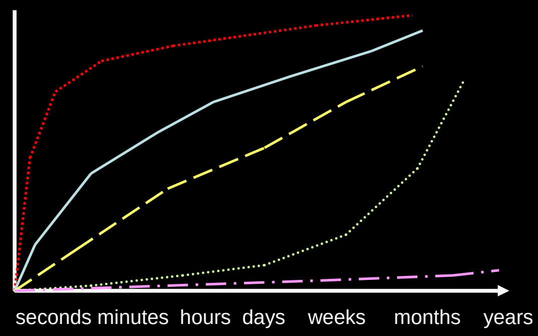
What is happening when we learn a language?



The main themes of my talk:

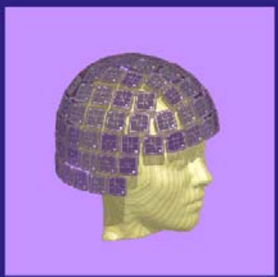
1. What happens in an adult's mind/brain when attempting to learn (or re-learn) words in the native language?

2. How does a bilingual person's single mind/brain process two languages?

What happens in a damaged adult brain when re-learning words?

Cornelissen, K., Tarkiainen, A., Salmelin, R., Laine, M., Järvensivu, T., & Martin, N. (2003) Adult brain plasticity elicited by anomia treatment. *Journal of Cognitive Neuroscience*, 15, 444-461.

MAGNETOENCEPHALOGRAPHY (MEG)



* Excellent temporal resolution
* Good spatial resolution
* Totally non-invasive

* Represents synchronous activity of large neuron populations
* Signals originate mainly from cortical currents

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Materials and Methods

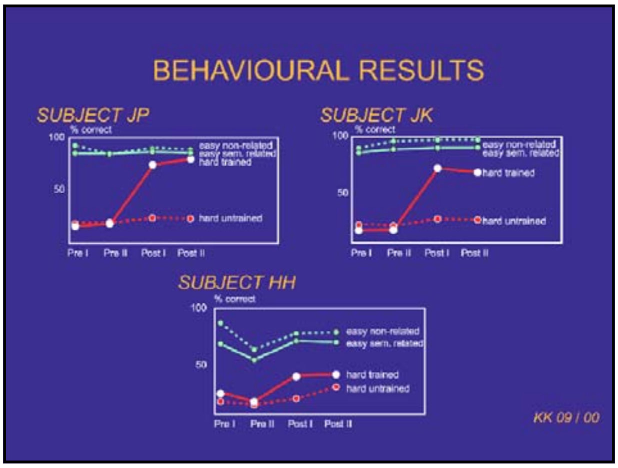
•three chronic aphasic patients suffering from moderate naming difficulties (JP, JK, and HH) served as subjects

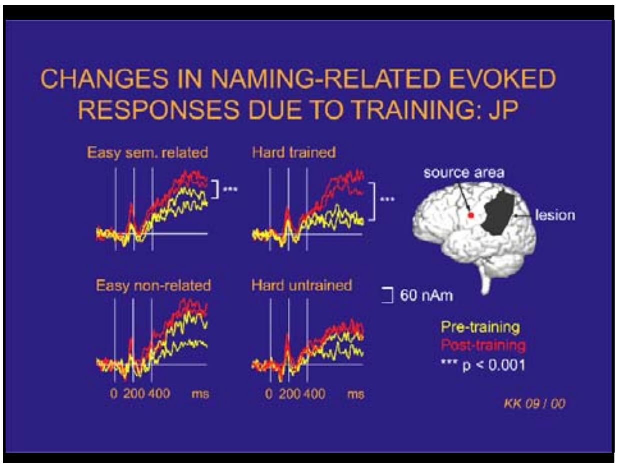
•three-week training of picture naming with individually selected hard-to-name items

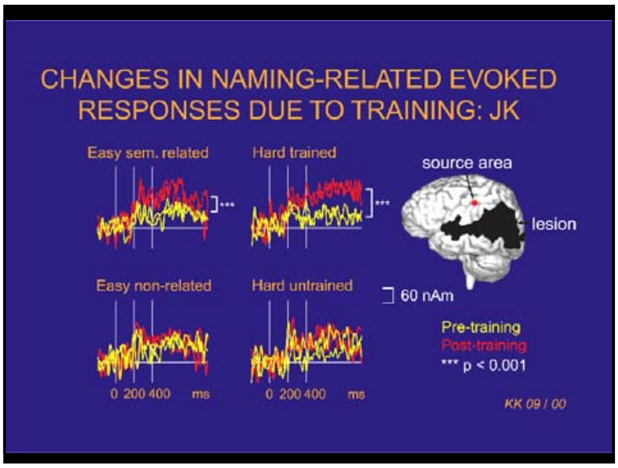
•MEG measurements during naming of target pictures and control pictures two times before and two times after the training

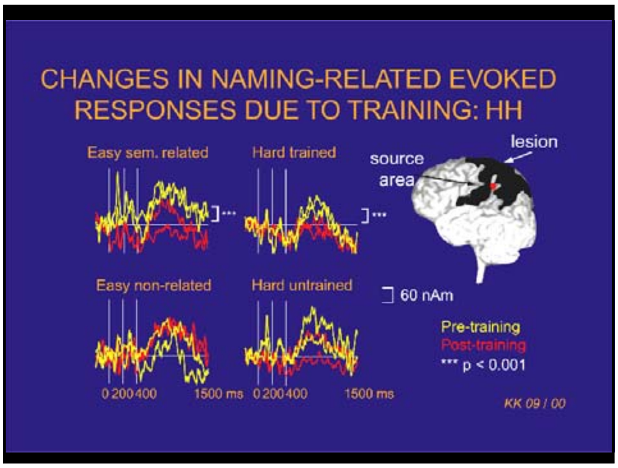
•a delayed naming paradigm was used to avoid motor artefacts

•naming-related activation sources in the MEG were modeled as equivalent current dipoles







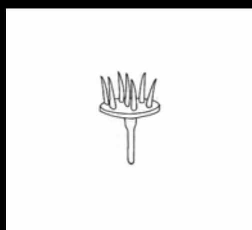


Conclusions of the anomia treatment study:

•the three aphasics showed a spatiotemporally surprisingly similar cortical response (left inferior parietal, of long latency) to re-learning of object names

•the training effect may reflect more effective phonological encoding and storage of the trained items

Cornelissen, K., Laine, M., Renvall, K., Saarinen, T., Martin, N. & Salmelin, R. (2004) Learning new names for new objects: cortical effects as measured by magnetoencephalography. *Brain and Language*, 89, 617-622.



The five stimulus categories included in the learning experiment

SemPhon

Sem

Phon

UnFam

Fam

LÖYHYTIN. A tool used in threshing grain. It is made of forked branch to which two strips of bark sewn together are attached.

Rectangular wooden bread drying ”basket” which hangs from the ceiling. ”Basket” is supported by a parallel array of wooden loops between pairs of which bread is placed for drying.

HÄRKIN

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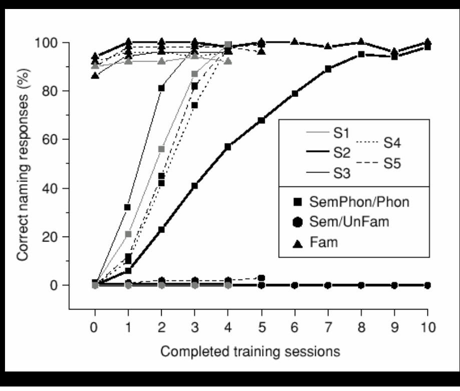
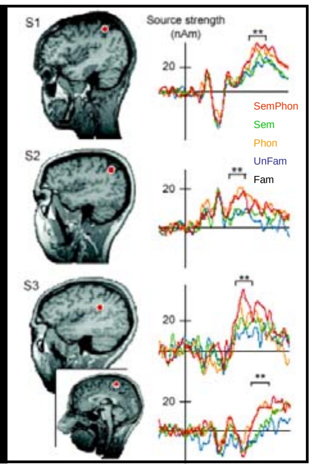
Materials and Methods

•5 normal young males served as subjects
•the task was to acquaint oneself with 150 unfamiliar and 50 familiar objects and to learn the names of those unfamiliar items (100/150) for which a name was provided
•training consisted of a computerized session performed each weekday
•MEG measurements of picture naming were performed three times: (a) prior to training, when at least (b) 50% and (c) 98% of the items with names were named correctly
•a delayed naming paradigm was employed

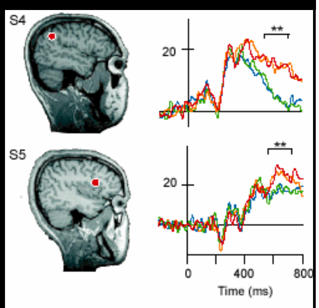
Learning to name unfamiliar items: individual learning curves of the 5 normal subjects



Cortical areas showing significant (p<0.01, **) learning effects in each subject, and the time courses of activation, in the MEG recording where 98% of the items in categories SemPhon and Phon were named correctly. **Subjects 1-3**.



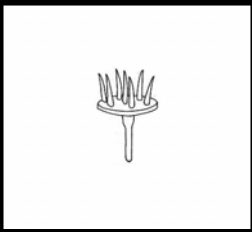
Cortical areas showing significant (p<0.01, **) learning effects in each subject, and the time courses of activation, in the MEG recording where 98% of the items in categories SemPhon and Phon were named correctly. **Subjects 4-5**.



Conclusions of the word learning study:

- The inferior parietal cortex plays an important role in the “word learning device”, being related to phonological acquisition of to-be-learned items
- Learning names and/or meaning of unfamiliar items utilizes the same cortical network that is involved in naming of familiar items

Grönholm, P., Rinne, J.O., Vorobyev, V., & Laine, M. (2005) Naming of newly learned objects: a PET activation study. *Cognitive Brain Research*, 25, 359-371.

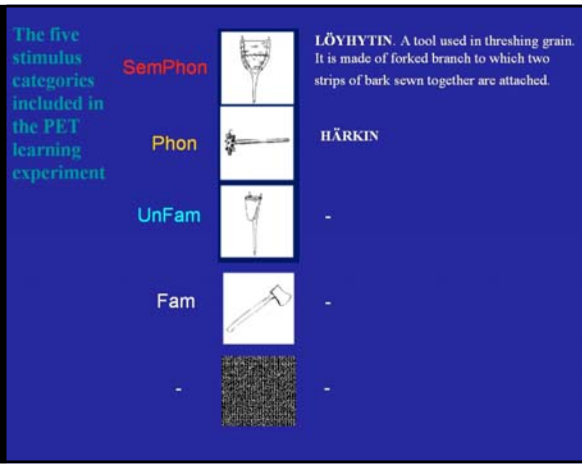


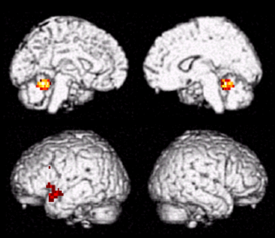
Positron Emission Tomography (PET)

- Excellent spatial resolution, poor temporal resolution
- Invasive
- Reflects local neural activity via metabolic measures (our radiotracer was oxygen-15)
- Taps both cortical and subcortical structures

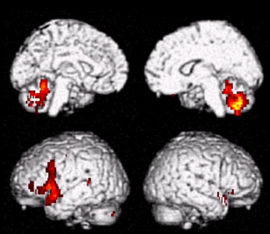
Materials and Methods

- 10 elderly normals (56-77 yrs) served as subjects
- the task was to to learn to name 40 unfamiliar items
- supervised training for four days
- PET measurement within a week after training (mean correct at that point 88%)
- Immediate naming during PET scanning





Trained (SemPhon+Phon) vs. Familiar



Trained (SemPhon+Phon) vs. Unfamiliar

Conclusions

(1) Newly acquired names elicited relatively stronger activations in the left inferior frontal lobe, anterior temporal regions, and the cerebellum

(2) Similar to the MEG experiment, the semantic support given did not affect neural or cognitive processing, suggesting that associative learning and phonological processing played a central role in the task

(3) Why the MEG and PET results did not overlap? Several differences between the two experiments: the brain imaging method, the naming setup, and the subject groups

All four studies point to left-hemisphere dominance in word learning/re-learning, but why are the specific activation loci different?

•could a change in the learning goal affect phonological word learning patterns?

•”learn names” → associative learning → left parietal lobe?

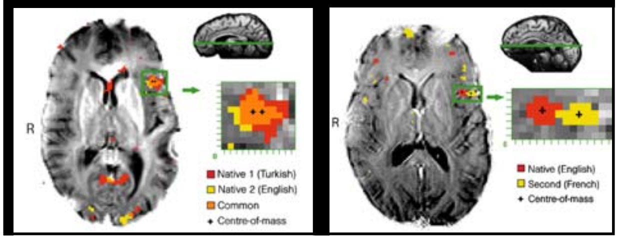
•”learn names & meanings” → lexical learning → left frontal & temporal lobe?

2. How does a bilingual person’s single mind/brain process two languages?

Kim, Relkin, Lee & Hirsch (1997) Distinct cortical areas associated with native and second languages. Nature, 388, 171-174.

fMRI results on representative subjects

Early bilingual subject | Late bilingual subject



Some questions related to the Kim et al. (1997) study:

1. Second language proficiency in the late bilinguals?
2. What is the task condition measuring?
3. What is the functional role of Broca’s area in this task condition?

How to verify a processing difference in a bilingual brain?

→ focus at some specific linguistic aspect upon which the two languages clearly differ

→ for Finnish-Swedish bilinguals, such an aspect is inflectional morphology

Main conclusions drawn from our previous morphology-related studies:

•most inflected **Finnish** nouns show a processing cost when contrasted with matched uninflected nouns → too many forms to store in memory, so they are recognized in a piecemeal fashion that takes some time & computation

SAUNA + -LLE

•most inflected **Swedish** nouns do not show a similar processing cost → a limited number of forms that can thus be stored in memory, so they are recognized as full entities

BIL(+)EN

Language-Specific Activation Patterns in the Bilingual Brain: Evidence from Inflectional Processing in a Morphologically Rich vs. Limited Language. *Manuscript by M. Lehtonen, V. Vorobyev, A. Soveri, K. Hugdahl, T. Tuokkola & M. Laine*

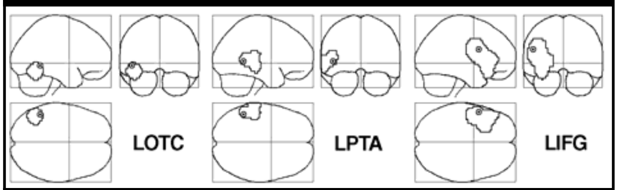
•16 early simultaneous high-proficient Finnish-Swedish bilinguals

•visual lexical decision with inflected vs. base form nouns in Finnish and in Swedish

•earlier PET study: processing of inflected words in Finnish activates Broca's and partly Wernicke's area (Laine et al., 1999)

Location of peak activations (small circles with a black dot) found in the Inflected words vs. Monomorphemic words comparison for the Finnish language. <u>Swedish language contrasts were non-significant</u>.

LOTC = fusiform gyrus and inferior temporal gyrus; LPTA = posterior parts of the middle and superior temporal gyri; LIFG = inferior frontal gyrus.



Conclusions

- the results show both behavioral and neural differences for the processing of a specific aspect of the bilinguals' two languages, Finnish and Swedish
- ”now you see it, now you don't”: depending on a bilingual's language pair and the linguistic feature under study, a neural difference between a bilingual's two languages is either present or absent