Neuroimaging evidence for changes in phonological and structural frame representations in subsyllabic speech motor sequence learning

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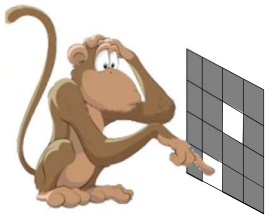
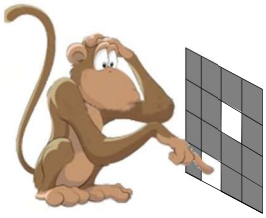
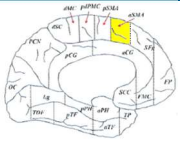
Motor sequence learning



Motor sequence learning: Neural correlates



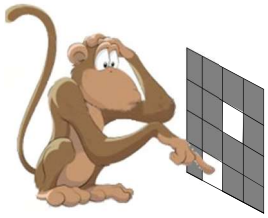


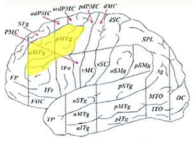
pre-SMA

- *More active during learning of novel sequences in single cell recordings, fMRI*
- *Lesions prevent learning of new sequences but not performance of previously learned ones*

Floyer-Lea & Matthews, 2004; Hikosaka et al, 1999; Lehéricy et al, 2006; Nakamura et al, 1998; Nakamura et al.,1999; Sakai et al, 1998; Wu et al, 2004

Motor sequence learning: Neural correlates





dlPFC

- *More active during learning of novel sequences in fMRI*
- *BUT… dlPFC involved in visuospatial working memory!*

Floyer-Lea & Matthews, 2004; Grafton et al, 1994; Hikosaka et al, 1999; Jueptner et al, 1997; Lehéricy et al, 2006; Sakai et al, 1998; Wu et al, 2004
Levy & Goldman-Rakic, 2000; Robertson et al, 2001

Speech motor sequence learning

- Limitations of past studies
  - Many purely behavioral results
  - Covert "production"
  - Focus on novel word learning

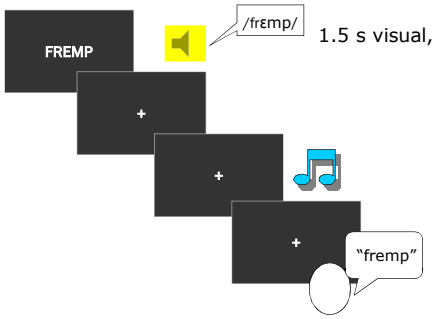
Davis et al, 2009; Rauschecker et al, 2008; Shtyrov et al, 2010; Smits-Bandstra & De Nil, 2009; Veroude et al, 2010

Paradigm: Learning

Practice over 2 days
60 repetitions per sequence

1. Overlearned
   - e.g. FREMP
   - **Legal** consonant clusters in English
2. Learned
   - e.g. FSEFK
   - **Illegal** consonant clusters in English

Paradigm: Learning



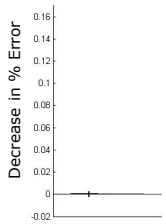
1.5 s visual, 500 ms auditory

0.5-1.5 s

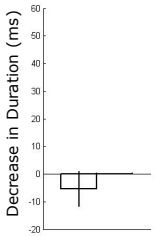
GO signal

Behavioral measures of learning

Δ Accuracy (Day 1 – Day 2)

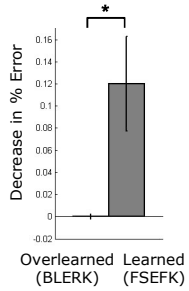


Δ Utterance Duration

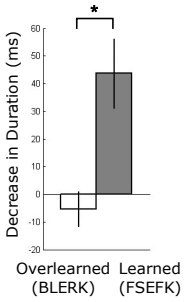


Behavioral measures of learning

Δ Accuracy (Day 1 – Day 2)



Δ Utterance Duration

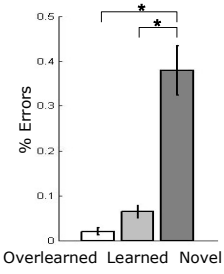


fMRI Paradigm

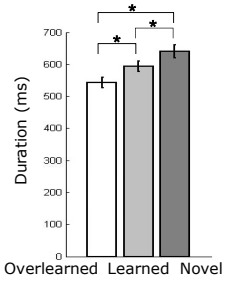
1. Overlearned
   - e.g. FREMP
   - **Legal** consonant clusters in English
2. Learned
   - e.g. FSEFK
   - **Illegal** consonant clusters in English
3. Novel
   - e.g. FSHIZG
   - **Illegal** consonant clusters in English
4. Baseline

Behavioral measures of learning

Accuracy

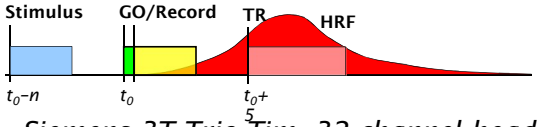


Utterance Duration



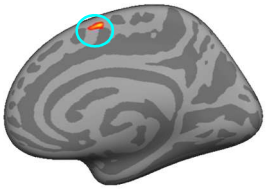
fMRI Methods

- *Sparse sampling (TR=10s)*



- *Siemens 3T Trio Tim, 32 channel head coil*
- *Voxel size=1.3 x 1 x 1mm*
- *Nipype: SPM8 & Freesurfer*
- *Utterance duration regressor*

Novel > Learned: pre-SMA

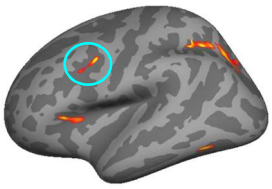


Speech

- Lexical status v syllable length interation (Alario, 2006)
- Effect for syllable complexity and syllable v. sequence interaction (Bohland, 2008)

Metrical sequencing

Novel > Learned: IFS



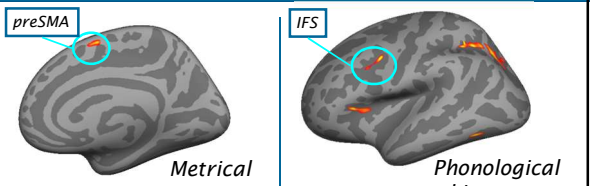
Speech

- Human homologue of dlPFC
- Involved in when items are phonological rather than visual-spatial

Phonological working memory

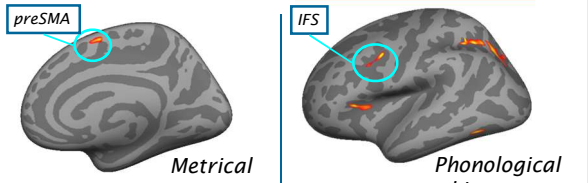
Awh et al, 1996; Chien et al, 2003; Gruber, 2001; Gruber & von Cramon, 2001; Koelsch et al, 2009; Paulesu et al, 1993; Rypma, 1999; Smith et al, 1998; Zurowski et al, 2002

Chunking with learning



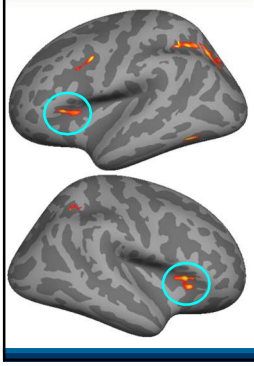
8 6 7 5 3 0 9	7 items
8 67 5 309	4 items
867 5309	2 items

Chunking with learning



Learning → Fewer (e.g. larger) chunks
Fewer chunks → Reduced load on preSMA & IFS

Novel > Learned: FO/aINS

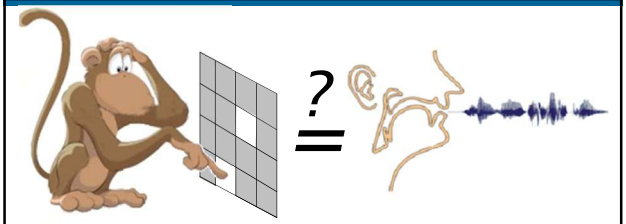


Speech

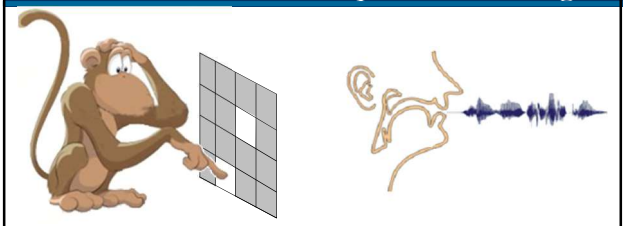
- fMRI activity neg. correlated w/ learning new contrast (Golestani & Zatorre, 2004)
- Faster contrast learners - ↑ WM density (Golestani & Pallier, 2007)
- fMRI: learning new speech sounds (Moser et al, 2009)

Learning of new subsyllabic representations.

Motor sequence learning

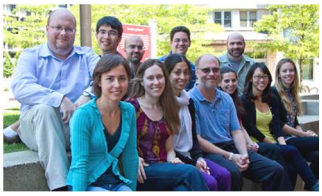


Subsyllabic speech motor sequence learning



Reduced load on timing and working memory processes + *Addition of new subsyllabic representations*

Thank you



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…and the rest of the Speech Lab

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David Gow
Jonathan Barnes
Ron Killiany

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