A network analysis of phonemic perception in patients with persisting aphasia using Dynamic Causal Modeling
Acknowledgments

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Take-home message

- Aphasics do show robust speech mismatch responses.

- MEG source-space responses indicative of reorganization from left to right hemisphere in aphasics.

- DCM analysis of MEG data suggests distinct speech networks for aphasics vs. controls.

- Speech comprehension deficits in aphasics can be explained by a predictive coding theory of brain function (cf. Friston).

- Left-STG => Right-STG connection strength in aphasics predicts behaviour on phonemic perception tests.
Aphasia

$N_A = 25$ (avg. 3.6 years post-stroke)

$N_C = 17$
Aphasia & MMN

Pure Tones

Speech

ERPs ->

MMN ->

Aaltonen et al., 1993
### Stimuli

<table>
<thead>
<tr>
<th>Vowel Stimulus</th>
<th>Percept</th>
<th>Formant F1 (Hz)</th>
<th>Formant F2 (Hz)</th>
<th>Distance from Standard (ERB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STD</td>
<td>“Bart”</td>
<td>628</td>
<td>1014</td>
<td>0</td>
</tr>
<tr>
<td>D1</td>
<td>“Bart”</td>
<td>565</td>
<td>1144</td>
<td>1.16</td>
</tr>
<tr>
<td>D2</td>
<td>“Burt”</td>
<td>507</td>
<td>1287</td>
<td>2.32</td>
</tr>
<tr>
<td>D3</td>
<td>“Beat”</td>
<td>237</td>
<td>2522</td>
<td>9.30</td>
</tr>
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**D1:** acoustic deviant (same vowel category)

**D2 & D3:** phonemic deviants (different vowel type)

**D2&D3 vs. D1:** phonemic contrast
• 274 channel MEG (CTF)
• Fs = 480 Hz
• ISI = 1.08s
• STD:DEV = 4:1, ~60dbSPL
• # Deviants = 120 x 3
• Concurrent visual task

• Best model: 4 sources bilateral A1 & STG
• Aphasics sources constrained by lesion topography

Kiebel et al., 2008
Source-space MMN responses
MMN amplitude

![Graph showing MMN amplitude with bars for different conditions and subjects. The x-axis represents subjects (LH, D1, RH) and the y-axis represents mismatch amplitude (nA). The graph includes bars for CTR, APH, (N_C = 16), and (N_A = 24).]
MMN latency

- **CTR**: (N_C = 16)
- **APH**: (N_A = 24)

<table>
<thead>
<tr>
<th>LH</th>
<th>D1</th>
<th>RH</th>
<th>LH</th>
<th>D2</th>
<th>RH</th>
<th>LH</th>
<th>D3</th>
<th>RH</th>
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Mismatch latency (ms)
DCM for evoked MEG

Neural mass model

Inhibitory interneurons
- Lateral

Spiny stellate cells
- Forward and input

Pyramidal cells
- Backward

Jansen and Rit, 1995
Felleman & Van Essen, 1991

L STG
R STG
LA1
RA1
DCM analysis

- **Predictive coding**: (Kiebel & Friston, 2009)
  Prediction error = Predictions - Sensory input

- **Self-connections**: sensitivity or precision of neural response to sensory input

- **Forward connections**: bottom-up propagation of prediction error from lower to higher level of the hierarchical system

- **Backward connections**: top-down predictions from higher to lower levels.
DCM analysis

**Aim:** To investigate modulation of the connections as a function of phonemic deviancy: \((D3 \& D2)\) vs. \(D1\)

**Models:** 12 connections between A1 and STG were modelled, yielding 255 models for each participant.

**Hypotheses:** Aphasics may show deficits at the higher level of the network (STG) and impaired left hemisphere function.
C

CONTROLS vs. APHASICS

0.99
L STG → R STG
0.60
0.67
0.87
0.90
0.91
LA1 → RA1
0.51
0.91
0.76
INPUT

0.59
0.92
INPUT

0.91

0.91

0.91
Summary

• Aphasics do show robust speech mismatch responses.

• MEG source-space responses indicative of reorganization from left to right hemisphere in aphasics.

• DCM analysis of MEG data suggests distinct speech networks for aphasics vs. controls.

• Speech comprehension deficits in aphasics can be explained by a predictive coding theory of brain function (cf. Friston).

• Phonemic prediction errors and prediction signals may have different oscillatory signatures (cf. Poeppel/Giraud)

• Next: longitudinal analysis following drug/phonological therapy