The goal of our study was to identify levels of phonological processing during word recognition. Psycholinguistic factors: phonotactic probability and density may modulate sublexical and lexical-phonological processing load, selectively affecting related neural networks.

Earlier fMRI studies modulated phonological processing load using density, but found contradictory patterns. (Okada & Hickok, 2006; Prahbakaran et al., 2006.)

Participants and Task

UCI students (12 male, 9 female, mean age = 22)

Participants: Right-Handed, native English speakers, free of neurological disease, normal hearing by self-report.

Task: listen, press a button if the list contained pseudowords.

Regular Trial Example: *beech, cleat, sneek, fright* (no press)

Catch Trial Example: *doves, heath, yorm, teased* (button press)

* Note: catch trials were excluded from imaging analysis.

Each run: 24 trials (6 per cond) + 2 catch trials; 4.5 min.

Jittered block design: 8.4, 10.5, 12.6 sec

Conclusions

Further evidence that spoken word recognition involves distinct phonological processes

Identical words correlated with activity in different regions, depending on lexical or sublexical focus.

Replicated Okada & Hickok (2006), density effects in bilateral posterior superior temporal lobes.

IFG activity also modulated with sublexical frequency measures in production tasks (Papoutsi et al., 2009).

This highlights different aspects of speech perceptual activity, parametrically traced to separate networks.


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Distinct levels of phonological processing in speech recognition?

The Irvine Phonotactic Online Dictionary (IPhOD)

Phonotactic Probability: Facilitation

How many words contain the same phoneme pairs?

Both measures were described in Vitevitch & Luce (1999).

Stimuli: 4 word lists presented over headphones

100 (CVCC, CCVC) words, 25 per condition. Lists were homogeneous in (high/low) density and phonotactic probability. Bootstrapping algorithm selected words according to behavioral data, recording duration, and Kucera-Francis word frequency; condition order optimized with Genetic Algorithm (Wager & Nichols, 2003).

Phonological processing

Lexical processes (access, competitive activation)

Sublexical processes (segmentation, learning)

Neuroimaging Results

Phonological Neighborhood Density

Left inferior frontal gyrus positively correlated with activity in different regions, depending on lexical or sublexical focus.

Phonotactic probability

Left pSTS, right pSTG negatively correlated with phonotactic probability.

Neighborhood density (top)

Right Hemisphere

Left Hemisphere

Phonotactic probability (bottom)

Left inferior frontal gyrus positively correlated with phonotactic probability.

Thresholded t(16) = 2.92, p < 0.005, M.C. corrected at cluster level (10 vels), p < 0.001. SVC corrected using 10mm radius sphere at a priori ROIs (SMG/AG, STS/STG).

Preprocessing

SPMS: slice-timing correction, realignment, co-registration, normalization to MNI, spatial smoothing (6mm FWHM Gaussian). De-trended with Linear Model of the Global Signal (Macey et al., 2004).

Two extra nuisance variables: one vector identified extreme whole-volume intensity shifts, another detected large numbers of coincident extreme voxel values based on timecourses (method used in Vaden, Muftuler, Hickok, 2009).

Group Analysis:

1. Phonological Neighborhood Density

Where did activity significantly correlate with the number of neighbors (positively or negatively)?

2. Phonotactic Probability

Did activity systematically change with respect to sublexical processing load?

3. Individual factors (Wilson, Isenberg, Hickok, 2009)

Summary.

Mean percent correct = 0.86 (SD = 0.11), Hit Rate = 0.71 (0.20), False Alarms = 0.14 (0.12), A' = 0.77 (0.05), A' ranged [0.74, 0.99].

4 subjects exceed 2 SD from mean FA, Misses, A', removed from analyses.

Density Effects: False Alarms (N.S.)

High (7.38) > Low (5.18).

F(1,16) = 3.62, p = 0.075.

Phonotactic Effects: False Alarms

High (7.65) > Low (5.18).

F(1,16) = 8.07, p = 0.012.

DxP Interaction (N.S., p = 0.42)

Imaging Protocol

3T Philips MRI at the Research Imaging Center, UCI. All images AC-PC oriented. Anatomical volumes: 1mm3 isomorphic, T1 weighted sequence. Functional volumes: [2.3x2.3x3mm] voxels, 34 slices, whole brain coverage, interleaved slices, zero gap.

Other EPI specs: TR=2.1s, TE=26ms; FA=90; FOV=200; 130 volumes per run; SENSE headcoil; Cogent 2000 synchronized sound delivery through Resonance Technologies headphones.

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Talking Brains Blog

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Phonotactic probability

Sublexical processes (segmentation, learning)

Phonological Neighborhood Density

Lexical processes (access, competitive activation)

Phonotactic probability

Sublexical processes (segmentation, learning)
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Works Cited

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