### Neuroimaging evidence for effects of lexical status on phonetic categorization

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**Introduction**

Subjects show sensitivity to high-level information when making lower-level decisions in language tasks. For instance, subjects performing a phonetic categorization task for stimuli presented along an acoustic-phonetic continuum exhibit lexically-based shifts in the phonetic boundary, a phenomenon known as the lexical effect (Ganong, 1980).

Psycholinguists disagree about the source of this effect, arguing that it is either:

A. A post-perceptual effect which is an artifact of the decision process

B. A perceptual effect inherent in the phonetic processing of the stimulus.

Previous work (Blumstein, et al., 2005) has shown sensitivity to phonetic category structures in perceptual areas such as the superior temporal gyrus (STG) as well as in areas linked to decision-making, such as the anterior cingulate. In this study, this sensitivity is exploited to determine whether lexically-biased shifts in phonetic category boundaries are perceptual or post-perceptual in nature.

In general, we expect to see more activation for the boundary-value stimulus influenced by the lexical effect, compared to that same VOT value stimulus in the control continuum, which is not influenced by the lexical effect.

If the lexical effect is perceptual, we expect to see this difference in perceptual areas such as the STG, as well as in decision-making/execution function areas such as the anterior cingulate.

If the lexical effect is post-perceptual, we expect to see this difference exclusively in decision-making areas.

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**Methods**

**TASK 1: Phonemic categorization**

*Stimuli:* Modified natural speech ranging from /g/ to /k/ in VOT in 7 msec steps

*Two continua:*

- **GIFT-KISS (control continuum)**
- **giss-KISS (lexically biased continuum)**

The giss-KISS continuum was established as a control using the pilot study pictured at right (Figure 1) because it does not show a boundary shift in comparison to a non-word to non-word continuum.

**TASK 2: Tone categorization task**

PARTICIPANTS: 19 adult native speakers of English, two excluded because they did not show the lexical effect.

**EXPERIMENTAL DESIGN:** Rapid event-related fMRI using a design where stimuli were presented in silent periods between scans.

**Scans:**

- **15 functional scans:** 15x3x5 mm slices, covering periventricular areas
- **MPRAGE** anatomical scan for coregistration.

**Data Analysis:** Used AFNI for all data analysis. Planned comparisons: statistical contrast across left and right STG for each VOT value. The critical comparison is the boundary-value comparison.

**Data thresholds** at a voxel level p<0.05, cluster size of 62 voxels, cluster-level threshold of p<0.025

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**Results**

**Behavioral**

**Figure 2:**

Significant main effect of VOT on phonetic categorization type (/g/ or /k/)

Subjects show the typical ‘categorical perception’ identification function in both continua (Figure 2). Significant main effect of Continuum on the phonetic category boundary (Figure 3). The presence of a word (GIFT) on one end of the continuum shifts the categorization function approximately 7 msec towards the voiceless end of the continuum.

=> Subjects show the lexical effect in the scanner.

**Discussion**

The left and right posterior STG show sensitivity to the phonetic boundary, with increased activation for the same VOT value when it is perceived as the boundary due to the lexical context (Figure 4). No difference in activation is seen in the STG when comparing the baseline boundary, Stimulus #4 (the giss-KISS boundary stimulus) across the two continua. More activation is also seen in the cingulate and left middle frontal gyrus for the lexical effect boundary stimulus than for the same stimulus in the control continuum.

Taken together, these results suggest that the baseline response of the STG to boundary stimuli is boosted when the lexical effect shifts the phonetic boundary. Since there seems to be an executive component to this process, as indicated by activation in the cingulate and MFG, the lexical effect itself seems to be mediated by the STG.

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**Conclusions**

The superior temporal gyrus (STG) is sensitive to a shift in phonetic boundary which is mediated by the lexical status of the endpoints of the continuum.

The involvement of the STG in the mediation of the lexical effect provides strong evidence that the lexical effect itself is perceptual in nature.

Data from aphasic populations also supports the view that the lexical effect is mediated by posterior structures. Blumstein et al. (1994) showed that Broca’s aphatics, who have damage to left anterior structures, showed a larger lexical effect than normals, whereas Wernicke’s aphatics, who have damage to left posterior temporal and parietal structures, showed no lexical effect.

In addition, this study shows that activation of the superior temporal gyrus in response to phonetic stimuli is influenced by higher-level linguistic information, in this case, information about the lexical status of the word. This activation may arise as a function of:

A. Involvement of the STG in both lexical and phonetic processing.

B. Feedback to the STG from separate lexical-semantic areas.

C. Feedback to the STG from decision-making areas.

The executive component of this explicit phonetic categorization task is reflected by activation in frontal areas. Activation in frontal areas is greater for stimuli which fall near the phonetic boundary. Such activation may have a role in resolving competition between phonetic categories.

**References**


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