Exploiting the Ganong effect to probe for phonetic uncertainty resulting from hearing loss

Steven Gianakas
Matthew Winn

INTRODUCTION

When the speech signal is degraded, listeners need to guess certain phonemes and words they missed in the conversation. The speech signal becomes compromised when a person has hearing loss or uses a cochlear implant. In this study we are studying the tendency to resolve phonetic ambiguities using experience (lexical bias) rather than your ears (the signal).

The Ganong Effect

The Ganong effect is the tendency to perceive an ambiguous speech sound as a phoneme that would complete a real word, rather than completing a nonsense/fake word. [1]

An example of this:

/stʃ/ vs /θʃ/ vs /θʃ/

Kilt vs Gift

/aɪəs/ vs /isəs/

Kiss vs Giss

A sound that could be heard as either /ʃ/ or /θ/ tends to be perceived as /θ/ when followed by “it” and as /ʃ/ when followed by “is”, presumably because those sound sequences produce real words

This shows

Because the acoustic signals are the same across contexts, the effect reflects top-down influence rather than pure reliance on the signal.

This is influenced by...

• Ambiguity of speech [1, 2]
• Frequency of word in spoken language [3]
• Semantic Context [4]
• Phonemic probability [5]
• Lexical context [6]
• Stimulus blocking [7]

How can we use this?

• When speech sounds are ambiguous, we rely more heavily on our lexical knowledge
• This situation is probably very common for people with hearing loss

Hypothesis: Degrading speech stimuli as if listening with a hearing loss or cochlear implant, should render the speech more ambiguous, thus yielding an increased reliance on top-down processing, seen as an increased “Ganong effect”.

METHODS

PARTICIPANTS: 32 young listeners with normal hearing (ages 18–34 y) Listeners with cochlear implants (ages 25–75 y)

STIMULI: Three 7-step speech continua where spectral phonetic cues vary by speed:

Slow: /ʃ/ vs /θ/ Medium: /θ/ vs /θ/ Fast: /θ/ vs /θ/

Simulating auditory distortion and hearing loss

Unprocessed (normal) speech Back

Apart from normal speech, there were two kinds of stimulus degradations at two difficulty levels:

Vocalized speech to approximate spectral distortion through two methods:

A) 4 channels B) 8 channels

Low-pass filtered speech mimicking high-frequency hearing loss.

• (C) mild (a single channel) mild shift to the right
• (D) moderate/severe (23 dB/octave) increased lexical bias

RESULTS:

Understanding the perceptual shift

In all plots, the spacing between curves indicates the lexical bias effect

The difference between curves generally becomes greater as the severity of the speech stimuli increases:

• Extra details of response shift and slope
• More severe degradations elicit greater lexical bias
• People with cochlear implants show increased lexical bias with faster phonetic contrasts

CONCLUSIONS:

• Phonetic perception is informed by lexical knowledge (the same sound is perceived differently depending on lexical status)
• Listeners tend to rely more heavily on lexical knowledge when the auditory signal is spectrally degraded or band-limited
• People with cochlear implants potentially show greater dependence on lexical knowledge when acoustic cues are faster