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Linking production and perception of clear speech

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Speech communication involves multiple styles as a function of different speaking environments and communicative needs. In auditorily or visually challenging contexts, speakers often alter their speech production using a clarified, hyper-articulated speech style with the intention of enhancing speech intelligibility. Such modifications may result in perceptible articulatory and acoustic changes. Questions thus arise as to whether and what clear-speech modifications facilitate perception. This presentation surveys recent research conducted in our labs, investigating clear-speech production and its associated effects on perception. In a series of three-stream studies, this research relates analyses of visible articulatory features using computer image-processing techniques, measurements of acoustic properties, and perceptual patterns of clear-speech segments and suprasegmentals by native and non-native perceivers. Results reveal that clear (relative to plain) speech modulates different and compensatory articulatory-acoustic cues to enhance intelligibility. However, clear-speech modifications that reduce phonemic contrastivity are also found and they inhibit intelligibility. These results indicate that clear-speech effects are governed by the collateral principles of cue enhancement and maintenance of category distinctiveness.

Linking Production and Perception of Clear Speech

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Project Overview

- Examine visible articulatory, acoustic, & perceptual correlates of clear speech
- Identify clear-speech strategies used to strengthen those aspects of the signal that make it distinctive

3-stream study	Computer image analysis of visual articulatory movements	Acoustic analysis	Auditory (A), visual (V), & AV perception, native & non-native	Relating & modeling 3-stream data
Vowels	✓	✓	✓	✓
Consonants	In progress	In progress	✓	In progress
Lexical tones	In progress	In progress	✓	In progress

Background & Questions

	Previous findings	Questions addressed in this project
Types of clear-speech modification	More extreme spectral & temporal changes (1-4); Larger & longer articulatory movements (5,6); Improved A & V intelligibility (7,8)	Signal-based (overall saliency) or code-based (phoneme-specific) modifications & intelligibility? (10)
AV saliency	Weight granted to A vs. V cues affected by saliency of cues (7,9)	Signal- vs. code-based clear-speech cues vary across modality?
Linguistic experience	Clear speech less helpful or detrimental in non-native (L2) listeners (9-12)	L2 perception benefits more from signal- or code-based clear-speech cues?
Theoretical relevance	Auditory-based claims under H&H[13]: Clear speech needs to be balanced between enhancing signal saliency & maintaining phonemic distinctions (14,15)	Extend auditory-based claims to AV to explore mechanisms underlying phonetic variation

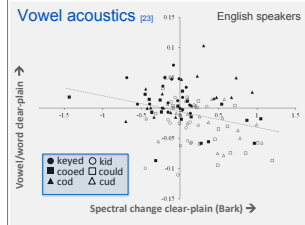
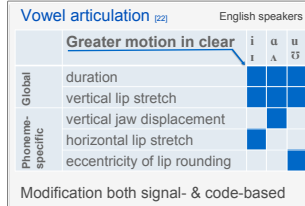
Methods

Stimuli & Participants	Predictions
English tense/lax vowels	Tensity x Style may reflect signal- vs. code-based variation in AV
English (non-)sibilant fricatives	AV weighting may differ as a function of sibilance in clear speech
Mandarin tones	Visual tonal cues in clear speech may or may not be linguistically relevant
Speakers & perceivers	L1/L2: English, Mandarin, Korean Non-natives may or may not benefit from clear speech depending on L1

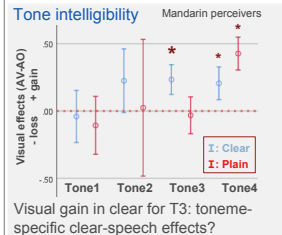
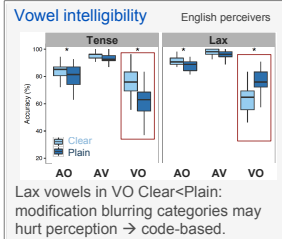
Articulatory analysis	Acoustic analysis	Intelligibility test	Linking & modeling
Eyebrow movements, Mouth velocity, Mouth velocity	Static & dynamic spectral & temporal features, e.g., Vowel: Static Duration(16), Spectral Formants & space(18) Dynamic: Vowel/word(17), Spectral change(19)	AV, AO, VO	• Multinomial logistic regression modeling cue-category mapping • C-CuRe partialling out contextual variability (20) • Mathematical modeling of equilibrium between articulatory efforts & perceptual gain (21)

Findings

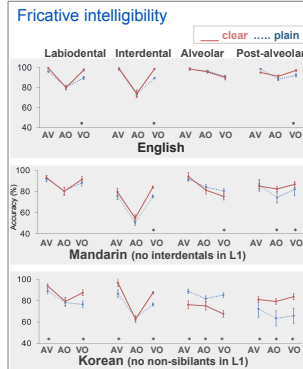
Signal- & code-based modifications



Signal- & code-based intelligibility

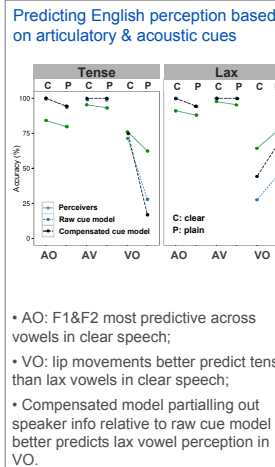


AV weighting & linguistic experience



- AV weighing:** clear speech benefits acoustically more salient sibilants in AO & visually more salient non-sibilants in VO
- L1 experience:** non-natives benefit from VO in clear speech, incl. L2 phonemes

Linking production & perception



Summary & Future Directions

- Clear speech involves signal- & code-based modifications, adopting cues that would not blur category distinctions;
- Clear speech benefits perception when its cues are compatible with those characterizing phonemes, but inhibits perception when cues are in conflict with phoneme-intrinsic characteristics;
- V clear-speech benefits found: (1) for suprasegmentals (tones) as well as segments, (2) to interact with A clear-speech benefits as a function of AV saliency, & (3) in perception of L2 phonemes;
- These AV clear speech findings provide evidence supporting the auditory-based theories on hyperarticulation, in that variation in speech needs to prioritize maintenance of phonemic category distinctiveness;
- Further research may explore (1) signal- & code-based features separately, (2) code-based clear-speech effects at higher (e.g., lexical) linguistic levels, & (3) how speakers & perceivers cooperate by adopting clear speech to achieve optimal efficiency in communication.

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