Recognition memory in noise for speech of varying intelligibility

Past Research

Clear Speech (CL)

- Listener-oriented types of speech production can enhance intelligibility, easing perceptual effort

- Speaker can adopt a "clear" speaking style with awareness of listener perception difficulty (e.g. hearing impairment, low language proficiency)

Lombard or Noise-Adapted Speech (NAS)

- Environment-oriented type of speech production can also enhance intelligibility

- Past studies found NAS is more intelligible in noise than quiet speech (QS) mixed with noise

Research questions & Predictions

To what extent does noise impact recognition memory for speech of varying intelligibility?

What are the differences between the processing of speech recorded in quiet and mixed with noise vs speech recorded in response to environmental noise (NAS)?

Both clear (CL) and noise-adapted speech (NAS) modifications are expected to enhance listeners' recognition memory

NAS will be most intelligible and show the largest recognition memory boost than QS mixed with noise

If processing difficulty only affects word identification rate and not recognition memory then recognition of conversational (CO) and QS ≥ NAS and CL

Participants

Speaker: 26 yo native female English speaker

Listeners: Native monolingual English speakers
- Exp 1: 16 adults between 18-34 yo
- Exp 2: 60 adults between 18-30 yo

Materials: Stimuli

- 80 meaningful sentences by Van Engen et al. (2012) produced by speaker over 2 sessions
- Sentences each contained 4 keywords for intelligibility scoring
  - e.g. The <u>small</u> animal scared the <u>baby.</u>
- In each session, sentences read in a conservational speaking style (CO) and in a clear speaking style (CL)
- Session 1: Productions in quiet (QS)
- Session 2: Same productions while listening to 6-talker babble via headphones (NAS)

Procedure & Listener Tasks

Exp 1: Intelligibility

- Sentences mixed with noise at SNR -5 dB sound pressure level

- Tasked to listen to stimuli via headphones and transcribed 80 pseudorandomized sentences from either QS or NAS recordings

- Scored by number of keywords correctly identified (4 per sentence), 160 keywords total

Exp 2: Recognition Memory

- Sentences mixed at SNRs of 0 and +3 dB SPL

- 4 experimental conditions: conversational + clear QS (at 0 dB and +3 dB) and conversational + clear NAS (at 0 dB and +3 dB)

- Exposure phase: Instructed to listen 1st set of sentences, then in Test phase: listen to 2nd set and indicate if each sentence old (from exposure phase) or new

Procedure: Acoustic Analyses

Comparison of acoustic-articulatory characteristics of

2 listener-oriented speaking styles (CL vs CO)

2 environment-oriented speaking styles (QS vs NS)

Measurements

speech rate

F0 range

mean F0

energy in 1-3kHz range

Findings: Experiment 1 & 2

Exp 1: Intelligibility

- In both QS and NAS, listeners identified more keywords in CL than CO
  - Higher correct keyword identification scores for NAS than QS
  - Higher correct identification scores for CL than CO
- Significant interaction between Listener-oriented and Environment-oriented speaking styles
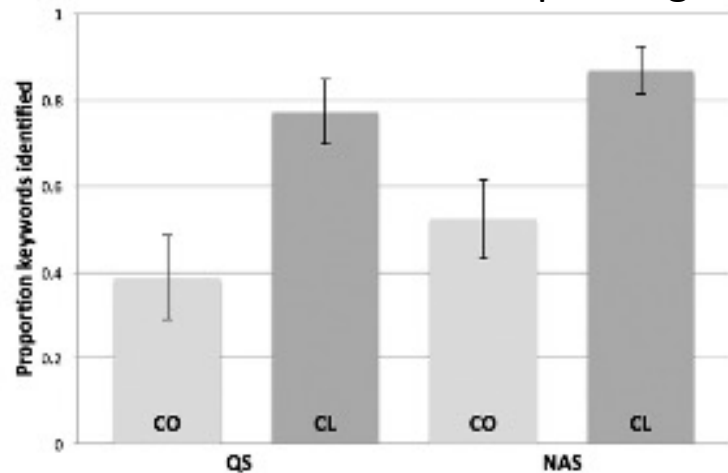
Exp 2: Recognition Memory

- Listeners biased to respond 'new' more often than 'old' especially in clear vs conversational speaking style
- Better recall for CL than CO
- Better recall for QS than NAS
- Scores did not significantly differ across QS and NAS clear speech like Exp 1
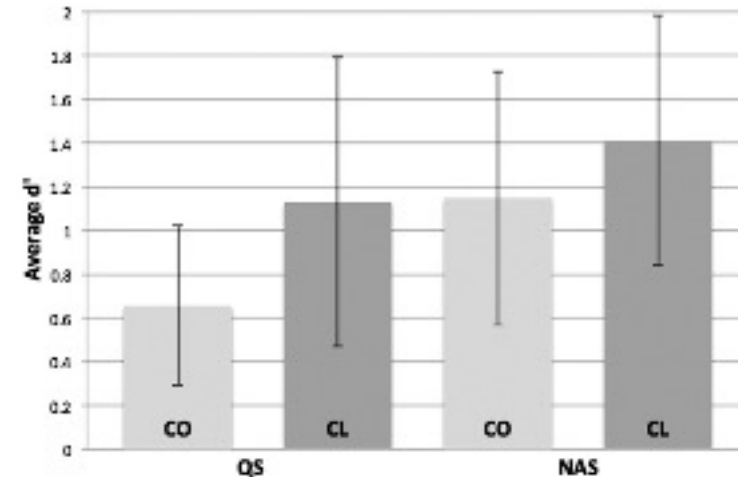
Findings: Acoustic Analyses

- CL compared to CO:
  - Slower speech rate
  - Larger F0 ranges
  - Higher mean F0

- NS compared to QS:
  - Slower speech rate
  - Smaller F0 ranges
  - Higher mean F0
  - Greater energy

- However,
- CO-QS slightly higher 1-3kHz energy compared to CL-QS
- CL-NAS greater energy compared to CO-NAS

Summary

- Exp 1: listener- and environment-oriented acoustic-phonetic enhancements to speech (CL and NS) resulted in enhanced intelligibility (supports predictions)

- Exp 2: new evidence that CL and NAS extend to better recognition memory compared to CO and QS
    - Speaking style adaptations enhancing intelligibility in Exp 1 also enhanced recognition memory in noise

- NAS both more intelligible for word recognition and recognition memory

Implications:

- Simple speaking style adaptations can improve listener comprehension & recognition memory in real world, noisy situations (e.g. classrooms)

- Recognition memory may be negatively impacted by other sources of varying speech intelligibility (e.g. speech production impairments, foreign-accented speech)

- Memory difficulties for older adults or cochlear implant users may be due to additional effort to perceptually process speech

- Speech-in-noise results from QS with mixed noise may be overstimulating effects of noise on speech perception