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Clear speech for older hearing-impaired listeners: Effect of rate

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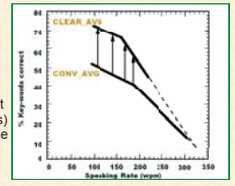
-Background-

Clear Speech

- Style of speaking adopted **naturally** by many talkers in difficult communication situations (e.g. Picheny et al., 1985; Payton et al., 1994; Uchanski et al., 1996)
  - Noisy environments (e.g. airplane, rock concert)
  - Listeners with hearing loss
  - Listeners with non-native English skills
- Typically differs from conversational speech in (Picheny et al., 1986; Picheny et al., 1989; Uchanski et al., 1996)
  - **Intelligibility:** Speaking clearly increases intelligibility by 17% for listeners with mild to moderate hearing loss or simulated loss in a variety of listening backgrounds (e.g. noise, reverberation)
    - Measured in %-correct key word scores
    - Nonsense sentences, normalized for RMS level
  - **Acoustics:** Many acoustic differences between clear and conversational speech have been identified, including
    - More frequent and longer pauses
    - Increased duration of some speech sounds
    - Wider dynamic range of F0
    - Longer formant-transition durations
    - Speaking rate

-Role of Speaking Rate-

- Typical clear speech (100 wpm) is half as fast as conversational speech (200 wpm)
- Artificial manipulations of rate have yet to produce clear speech at normal rates (Picheny et al., 1989; Uchanski et al., 1996; Liu & Zeng, 2006)
- Talkers can produce clear speech at normal rates with training (Krause & Braida, 2002)
  - All five talkers achieved clear speech at normal rates
  - Benefit (in noise) was consistent across eight young (18-29 years) listeners with normal hearing, the benefit was largely independent of both talker and listener



- However, talker strategies for achieving clear/normal speech may vary (Krause & Braida, 2003; Krause & Braida, 2004)

→ ***If so, benefits of clear/normal speech could vary by listener group and/or listening environment***

-Methods-

Purpose

In older hearing-impaired (OHI) listeners, how does intelligibility vary with:

- ***Speaking mode:*** clear vs. conversational
- ***Speaking rate:*** slow vs. normal
- ***Talker***

Does the benefit of clear/normal speech vary with talker for these listeners?

Participants

- 11 OHI listeners (7 males, 4 females)
  - 55 - 75 years old
  - Native speakers of English
  - Normal cognitive function (Mini Mental State Exam)
  - Symmetric, sloping, moderate sensorineural hearing loss (SNHL)
    - 3-frequency PTA: 35 – 60 dB HL
    - Sloping:
      2000Hz threshold at least 15 dB > 500 Hz threshold
      thresholds at 4000 Hz and 8000 Hz ≥ thresholds at 2000 Hz

Speech Materials

- Drawn from speech collected in previous work on clear/normal speech (Krause & Braida, 2002)
  - 4 talkers selected: T1, T3, T4, T5
  - T2 not included because rate difference between "normal" and "slow" was relatively small
- 4 conditions (2 modes x 2 speaking rates)
  - **conv/normal:** conversational speech at talkers' normal rates
  - **conv/slow:** conversational speech at talkers' slow rates
  - **clear/normal:** clear speech at talkers' normal rates (after training)
  - **clear/slow:** clear speech at talkers' slow rates (typical clear speech)
- 800 nonsense sentences (Picheny et al., 1985)
  - 200 sentences per condition
  - 100 unique sentences per talker, each recorded in two conditions (conversational and clear at the same rate)
  - Additional conv/normal sentences used to establish SNR-50

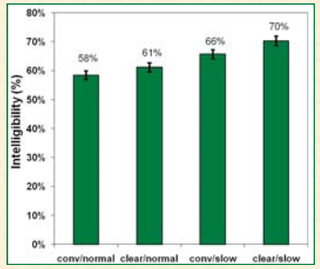
Test conditions

- Hearing corrected individually based on listener's audiogram, using the National Acoustic Laboratory (NAL-R) procedure (Byrne & Dillon, 1986)
- Sentences presented
  - Monoaurally, via headphones (without hearing aids)
  - In speech-shaped noise at (approximate) SNR-50

-Results-

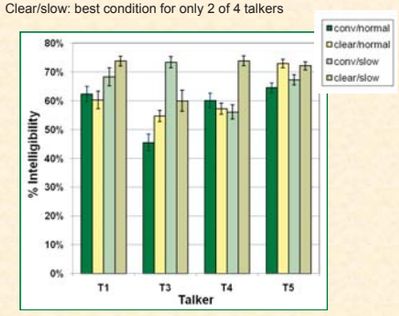
Overall Results

- **On average, clear/slow provided the largest intelligibility advantage** (12 points, relative to conv/normal)
  - Conv/slow also provided some advantage (8 points)
  - No significant advantage from clear/normal on average
- **All main effects were significant** ($p < 0.001$) in 3-way ANOVA (mode, rate, talker)



Talker interactions

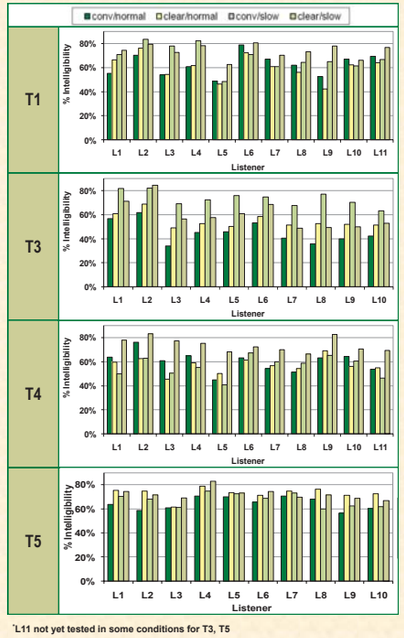
- **Effect of condition varied across talker** (Talker x Rate x Mode interaction, $p < 0.001$)
- **Reduction of rate did not guarantee intelligibility benefit**
  - Slow rate: provided benefit in both modes for only 2 of 4 talkers
  - Clear/slow: best condition for only 2 of 4 talkers



- ***Two talkers obtained a sizeable benefit with clear/normal speech***
  - T3, T5
  - T5: Clear speech benefit comparable at normal and slow rates

Listener variability

- **Benefit of clear/slow speech was the most robust**
  - All talkers (averaged across listeners)
  - All listeners (averaged across talkers)
  - Nearly all talker/listener combinations (except T1/L10 and T5/L7)
- **Conv/slow benefit (except for T3) was not consistent across listeners**
  - T1, T4, and T5: no conv/slow intelligibility benefit in many cases
  - T4: conv/slow condition *reduced* intelligibility for 7 of 11 listeners
- **Clear/normal benefit was mostly talker-dependent**
  - T3 and T5: consistent clear/normal benefit (all but T5/L3)
  - T1 and T4: no clear/normal benefit in most cases



*L11 not yet tested in some conditions for T3, T5

-Conclusions-

- For older listeners with moderate, sloping hearing loss in quiet conditions:
  - Greatest (and most consistent) benefit from clear speech at slow rates
  - Very small benefit from clear speech at normal rates *on average*
- However, **large benefits from clear/normal speech can be obtained by certain talkers**

→ ***Talkers appear to retain different acoustic properties of clear/slow speech when speaking clearly at normal rates***

→ ***Properties retained by T3, T5 most effective in improving intelligibility for OHI listeners with moderate, sloping loss***

Future work

- Evaluate intelligibility of clear/normal speech (especially T3, T5) for other listener populations and environments
- Analyze acoustical properties of T3 (and other talkers) and compare to data previously reported for T5

Long term goals

- Improved digital hearing aids (amplification + "clarification")
- Improved techniques for predicting intelligibility
- Intervention strategies (e.g. Schum, 1997) / Aural Rehab techniques
- Public address systems, front end to speech recognizers, ...

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