

Clear Speech at Normal Rates: Intelligibility for Older Hearing-Impaired Adults

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Background

Clear speech is a type of speaking style that **improves speech intelligibility** for many populations, including hearing impaired (Picheny et al., 1985) and normal hearing individuals (Uchanski et al., 1996). Although typically slower, clear speech can be produced at **normal rates** with training (Krause & Braida, 2002). For normal-hearing listeners, clear speech at normal rates is more intelligible than conversational speech, regardless of age (Krause & Braida, 2002; Panagiotopoulos, 2005). For hearing-impaired listeners, however, the effectiveness of clear speech at normal rates is not yet known. A preliminary study involving three older adults with hearing loss found that clear speech at normal rates provided a small intelligibility benefit, but the benefit was not statistically significant (Krause, 2001). Therefore, more subjects are needed to determine if **hearing loss** is a factor in the benefit of clear speech at normal rates.

Properties of Clear Speech

- Clear Speech is a type of **speaking style** used instinctively by talkers to facilitate communication:
 - Noisy situations, Non-native listeners, Listeners with hearing loss
- It is roughly **17% more intelligible** than conversational speech for listeners with mild to moderate hearing loss or simulated loss e.g., Picheny et al. (1985), Uchanski et al. (1996), Payton et al. (1994)
- Clear speech has many **acoustic characteristics** different than in conversational speech
 - Fewer vowel reductions, burst eliminations

Role of Rate

- Clear speech is **typically half the rate** of conversational speech
- As a result, some clear speech studies have focused on whether a slower rate was necessary for increased intelligibility:
 1. **Artificially** produced clear speech at normal rates
 - Uniform time scaling: sped up rate by decreasing duration of all phonemes by a single constant (Picheny et al., 1989)
 - Attempts were unsuccessful
 - Non-uniform time scaling: sped up rate by decreasing duration of each phoneme by different constants (more natural) and pauses were added or deleted (Uchanski et al., 1996)
 - Attempts were unsuccessful
 2. **Naturally** produced clear speech at normal rates
 - Talkers were trained and produced clear speech without altering rate (Krause & Braida, 2002)
 - **clear speech can be produced at normal rates with training** (Krause & Braida, 2002)
- The benefit of clear speech at normal rates still needs to be investigated: Does clear speech at normal rates provide similar benefits for as many populations as clear speech at slow rates?

Relevance of Clear Speech

1. Investigating the two speaking styles at various rates can further the understanding of the **acoustical differences** between clear and conversational speech.
2. Hearing aid technology may improve: the **hearing aid** can process conversational speech into clear speech to benefit the wearer in difficult communication settings.
3. Clinical setting: using clear speech compared to conversational speech may increase the efficiency of a **treatment session** and reduce communication breakdowns.

Purpose of Present Study

1. How does speech intelligibility, measured by %-correct key word scores, vary with:
 - Speaking mode:** clear vs. conversational
 - Speaking rate:** slow vs. normal
 - Talker:** 4 talkers
 - Listener:** 6 listeners
2. Compare results to older normal hearing data in order to examine hearing loss as a factor

Methods

Participants

- 6 older listeners with hearing loss
- 55-75 years of age
 - Moderate loss: PTA=35-60 dB
 - Sloping loss: 2000Hz threshold at least 15 dB greater than 500 Hz threshold
 - Native English speakers
 - Passed cognitive screening (Mini Mental State Exam)

Materials

- Nonsense sentences to avoid guessing from context cues (Picheny et al., 1985)
- Example: *The log will name your aid.*
 - 4 talkers, pre-recorded from previous study, who improved speech intelligibility without altering rate
 - 4 conditions per talker (2 modes x 2 rates)
 - conv/normal
 - conv/slow
 - clear/normal
 - clear/slow

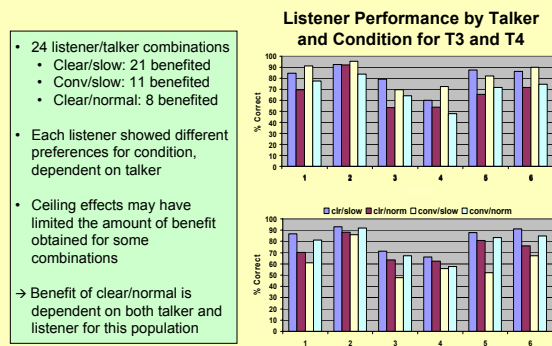
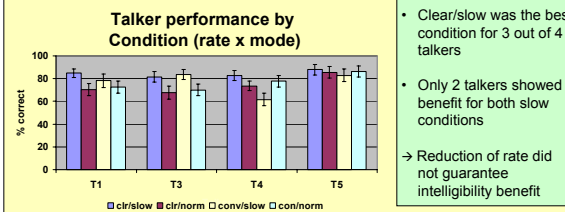
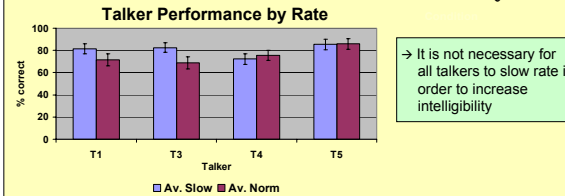
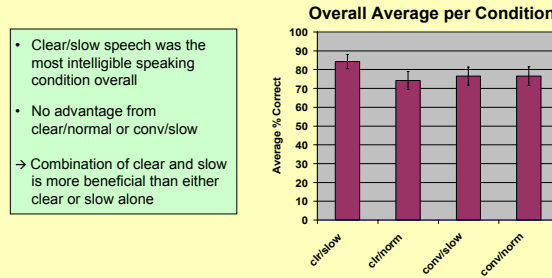
Procedures

- Participants were conditioned to procedures of the study
- Sentences were presented in **quiet** over headphones
 - Hearing was corrected individually utilizing the National Acoustic Laboratory (NAL-R) procedure
 - Listeners wrote or typed responses
 - Scores based on percentage of key words correct
 - example: *The log will name your aid.*
 - rules for scoring followed Picheny et al. (1985)
 - Stimuli were broken up into four sessions and counterbalanced to minimize learning effects

Statistics

- Data were analyzed to determine significance of results
- 4-way ANOVA performed on key-word scores
 - factors: Mode, Rate, Talker, Listener
 - significance level: $p < 0.01$
 - All main effects and several interactions were significant
 - post-hoc tests are planned to analyze differences between conditions (i.e. mode x rate interaction)
 - preliminary t-test results reported here ($p < 0.01$)

Results



Audiological Configuration Factor

- Clear speech at normal rates provides no benefit on average to older adults with hearing loss. However,
 - Some of these listeners benefit from the clear/normal speech of **some talkers**
 - **Other listeners** with hearing loss have shown an overall benefit from clear/normal speech (Krause, 2001)
 - Two older listeners with flat losses benefited from clear/normal
 - One older listener with sloping loss did not benefit on average
- Audiometric characteristics may be factors in clear/normal benefit

Comparing Intelligibility Across Studies: Hearing Loss Factor

	Current Study Older Hearing Loss SNR = ∞ (quiet)	Panagiotopoulos (2005) Older Normal Hearing SNR=0 dB
Conv/normal	77%	45%
Conv/slow	77% (+0)	66% (+21)
Clear/normal	74% (-3)	59% (+14)
Clear/slow	84% (+7)	68% (+23)

- Older listeners with hearing loss benefited from clear/slow but not clear/normal speech
- Older listeners with normal hearing benefited from clear/normal but not clear/slow speech (relative to conv/slow)
- Both groups benefited from clear speech at slow rates relative to conversational speech at normal rates

Conclusions

1. For older listeners with moderate, sloping hearing loss in quiet conditions,
 - **clear/slow is more intelligible** than conversational speech (and other conditions tested)
 - **clear/normal is only effective for certain talker/listener combinations**
 - Possibly due to general effects of hearing loss or configuration of loss (flat vs. sloping)
2. Older listeners with hearing loss (compared to normal hearing listeners in previous studies) exhibit less benefit from both clear/slow and clear/normal
 - Possible ceiling effects in both studies limit conclusions that can be drawn from comparisons
3. Some effects of hearing loss are still uncertain
 - Need to equate baseline performance across groups for fair comparison to rule out ceiling effects

Clinical Implications

1. Clear and slow speech is most effective with this population
2. Some clients may be justified in requesting normal rates from certain talkers
 - Data shows that some talker/listener combinations do benefit from clear/normal speech
3. Potential hearing aid applications: continuing research may pinpoint acoustic characteristics that provide benefit at normal rates

Future Work

1. Collect data for additional subjects
2. Conduct similar experiments in a sound field with listeners using their own hearing aids
 - NAL-R amplification strategy is most common in analog hearing aids
 - Digital hearing aids are now popular, and listeners in the current study may not have taken full advantage of available acoustic cues
3. Examine different audiological configurations (e.g. flat)
4. Determine psychometric functions for all populations under investigation to rule out ceiling effects

References Available Upon Request

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Who Benefits from Clear Speech at Slow Rates?

1. **Listeners with hearing loss**
 - 17-26 percentage point benefit (Picheny et al., 1985; Payton et al., 1994)
2. **Listeners with normal hearing**
 - 14-21 percentage point benefit (Uchanski et al., 1996; Payton et al., 1994; Krause & Braida, 2002)
3. **Older normal hearing and hearing-impaired listeners**
 - 15 RAU benefit for Auditory only
 - 18 RAU benefit for Auditory-Visual (Heffer, 1998)
4. **Children with diagnosed learning disabilities** (Bradlow et al., 2003)
 - 9.2 RAU benefit
5. **Non-native listeners**
 - 25.5 percentage points (Krause & Braida, 2003)
 - 5 RAU (Bradlow & Bent, 2002)