



# The Effect of Parabolic Intonation on Speech Intelligibility

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## Intonation and Intelligibility

- Intonation is the variation of pitch over time in speech.
- Intelligibility is the degree to which the listener receives the intended content of speech.
- Several studies, (Watson & Schlauch, 2008; Binns & Culling, 2007; Laures & Weismer, 1999), have shown that decreased degree of pitch variation results in a decrement in intelligibility.

## Limited Intonation in Clinical Populations

- Intelligibility of speech with limited pitch variation is a clinically relevant question. Individuals with certain neurodegenerative disorders experience dysarthria, which inhibits motor control and, thereby, pitch modulation.
- Individuals who have undergone laryngectomy and use an electrolarynx (EL) also often have monotone speech, as many of these devices only vibrate at a specific frequency.
- Watson and Schlauch (2009) conducted a study of a single EL user who had undergone total laryngectomy. This individual used a variable pitch EL and the researchers found that the EL user was able to improve his intelligibility by modulating the pitch of voicing, despite the fact that the intonation contour was much less complex than natural intonation. This led to the research question for the current study.

## Purpose

- To determine whether a relatively simple parabolic rise-fall pitch contour is sufficient to improve intelligibility, compared to monotone speech. This was an attempt to recreate the main attributes of the pitch modulation observed in Watson and Schlauch (2009) and to add statistical validity to that earlier study's results.
- To gauge the naturalness of the simple parabolic rise-fall pattern, compared to monotone speech.

## Significance

- If a relatively simple rise-fall pitch contour does improve intelligibility, that finding could guide future treatment goals for dysarthric patients and users of variable pitch EL. Such a simple intonation contour would be fairly easy to realize and could contribute significantly to overall communicative ability.

## Speech Stimuli

- The speech samples used in this study were drawn from the IEEA corpus of low-predictability sentences. Low-predictability means that little to none of the content of the sentences provided cues to any other part of the content. This helped to minimize the confounding influence of guesswork.
- All sentences were flattened to monotone pitch at the median frequency of the natural speech of the given talker. Then, two parabolic intonation contour conditions were created, one with a pitch range of 50% of natural pitch range and one with a range of +/- 1 standard deviation about the median frequency. These pitch contours were imposed over phrases within the sentences. Phrase boundaries were determined by experimenter consensus. All modifications were made using the Praat signal-processing program.
- 119 sentences comprised the stimulus sets. 60 sentences were presented in monotone condition to group one and 59 sentences were presented in parabolic condition.

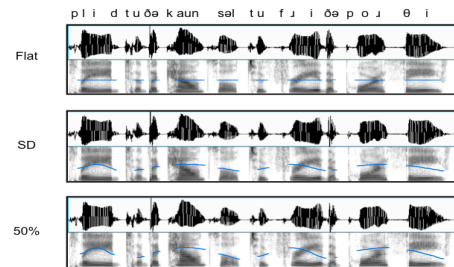
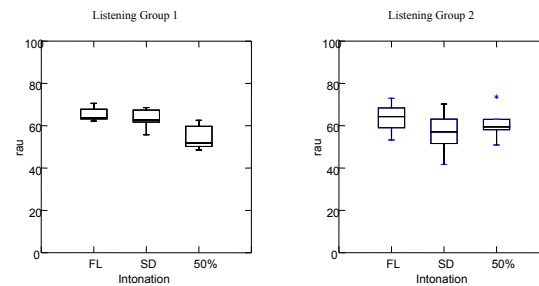


Figure 1 shows waveforms and spectrograms of the three re-synthesis conditions (Flat, +/- 1 standard deviation, and 50% of natural pitch range) for an example sentence.



Figures 2 and 3 show the results of intelligibility rating for the three intonation conditions (Flat, +/- 1 Standard Deviation, and 50% of natural intonation range parabolas). No significant difference was observed between conditions or groups.

## Procedures

- Participants listened to the stimuli in a sound-treated booth and transcribed what they heard.
- These transcriptions were then scored by the experimenters for percent of words correct.
- For the naturalness rating portion of the experiment, a set of 20 examples from the stimulus set (10 monotone and 10 parabolic) were presented via sound-field to a group of listeners. Listeners rated naturalness on a Likert-type scale.

## Results: Intelligibility

• No significant difference in intelligibility was evident between re-synthesis conditions. The trend was toward higher intelligibility in the flattened condition, but this was not a statistically significant finding. However, the parabolic pitch contour conditions were both rated significantly more natural than the flattened condition.

## Discussion

- This research was the first, to our knowledge, to explore the effect of a simple parabolic pitch contour on speech intelligibility. The absence of improvement in intelligibility for speech in the parabolic intonation conditions suggests that this simple pitch pattern is not sufficient to provide the necessary cues for speech understanding. But, the results do indicate that this pitch pattern is sufficient to improve naturalness of speech.
- The absence of improvement in intelligibility for the intoned conditions is contrary to findings of previous research. Possible explanations for the lack of improvement include:
  - High fundamental frequency (F0) of stimuli. The median F0 of the stimuli ranged from 167 Hz to 234 Hz. Higher F0 results in wider spacing of harmonics and less acoustic energy at the formant frequencies that identify vowels.
  - Low rate of frequency modulation. The parabolic pitch contour spanned several syllables, unlike natural speech which modulates frequency rapidly.
  - Error in boundary placement. The placement of phrase boundaries may have resulted in peak pitch placement (analogous to pitch accent) at locations that were contrary to the semantic content of the speech stimuli.

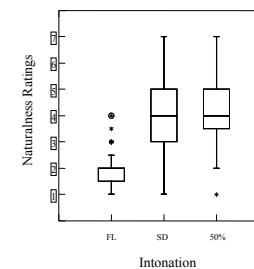


Figure 4 shows the results of the naturalness rating portion of the experiment. Here, a significant effect was observed. The parabolic conditions yielded higher ratings of naturalness.