

The relation of the temporal variation of F1, F2, and F3 to articulator movement

5pSC12

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I. Introduction

Background:

Formant trajectories are often used as an indirect measure of articulator movement (Weismer & Berry, 2003, Weismer et al., 1992).

Purpose:

Determine the specific relation of the temporal variation of the first, second and third formants (F1, F2, F3) to tongue and lip motion.

II. Methods

Subjects:

- UWI X-ray Microbeam Database (XRMBD) (Westbury et al., 1994)
- 6 males and 6 females

Items:

- Six vowel-to-vowel (VV) transitions
- iu, ia, ua, au, ai, ui

Procedure:

- Time dependent displacements were extracted from individual VV articulations for the lower lip pellet, four tongue pellets and the jaw pellet (see Figure 1).
- Using Praat, measurements of F1-F3 were extracted frame by frame (sampling interval=0.006866 sec) for each VV transition (e.g. Figure 1).
- Outliers in the formant contours due to mistracking were removed by a smoothing algorithm.
- Using data from the jaw pellet, the effect of jaw movement could be decoupled from the other articulators (Westbury, 1994, 2002) (see Figure 4).
- The correlation for each articulatory flesh point (lower lip (LL), tongue (T1, T2, T3 and T4)) with each formant (F1, F2 and F3) was calculated (see Figure 2 & 3).

Figure 1 Illustration of XRMB data for /ui/ transition.

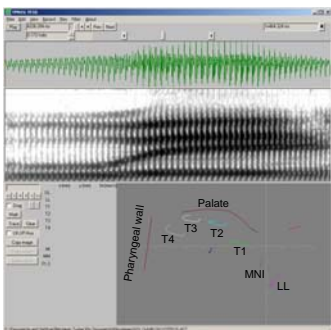


Figure 2 T1 x-axis location versus formant frequency for /ui/ transition.

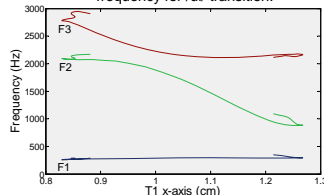


Figure 3 LL x-axis location versus formant frequency for /ui/ transition.

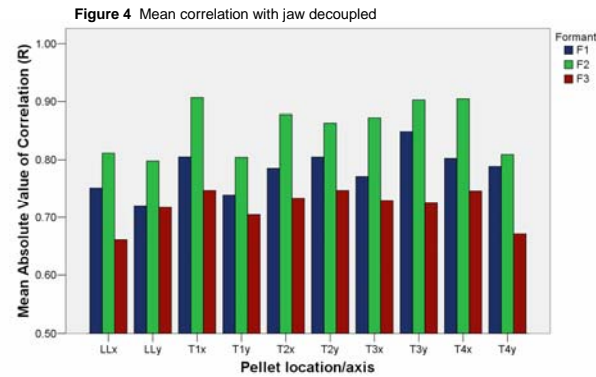
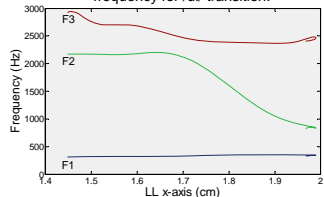


Figure 5 Mean correlation with the jaw

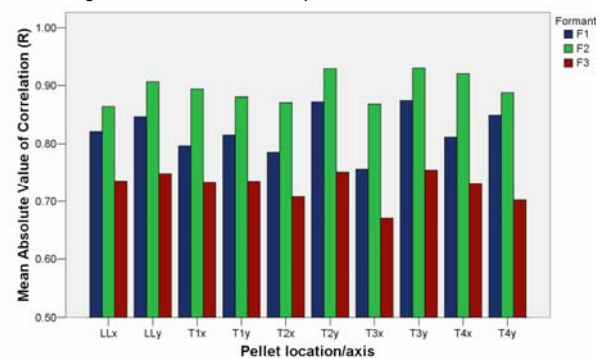
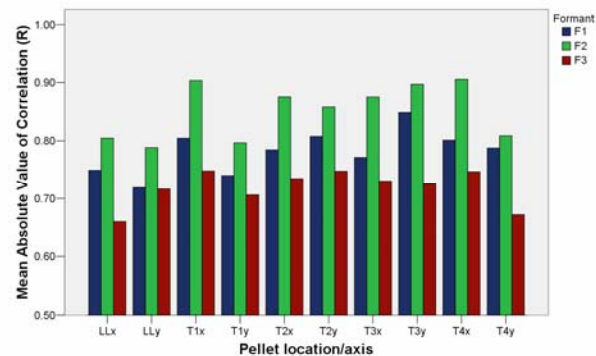


Figure 6 Mean correlation with jaw decoupled using the Bark scale for male speakers

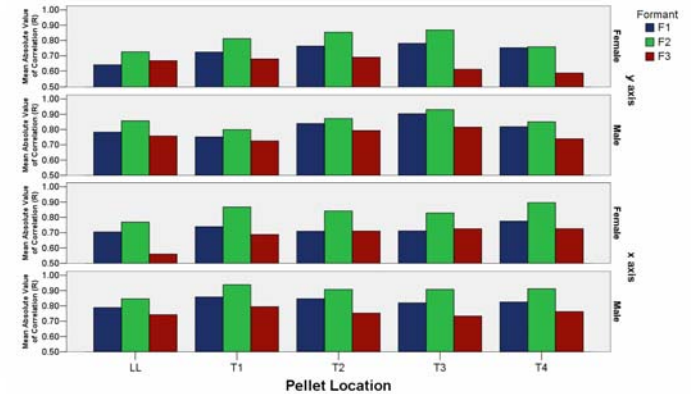


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III. Results

- **Figures 4 & 5** F2 has the highest mean correlation by location, and F3 has the weakest mean correlation.
- **Figure 5** The mean correlation decreases when the jaw is decoupled. This decrease is most sharply seen in F1.
- **Figure 6** Frequency calculations based on the Bark scale as opposed to Hertz. The correlation pattern as seen in Figures 3 & 4 remains but the mean correlations are stronger.
- **Figure 7** Mean correlations are higher for male speakers as opposed to female speakers. The effect of axis seems to be fairly equal.
- A one factor within-subjects ANOVA showed that F2 is significantly different from F1 and F3.

Figure 7 Mean correlation with jaw decoupled split by sex and axis



IV. Conclusion

- The significance of F2 remains even when using a psychoacoustic scale, like the Bark scale.
- F2 plays a larger role reflecting articulator movement than other formants.
- Use of F2 as indirect indicator of articulator motion is justified.

Limitations:

- VV transitions were produced in a "laboratory" speech style.
- Data limited to the front portion of the vocal tract.

V. Future Work

- Do these trends hold for diphthongs in connected/conversational speech?
- Are there extensions to disordered populations?
- What are the formant correlations for rhotics and laterals?