Tonal timing in Articulatory Phonology: Evidence from Igbo vowel reduction Elizabeth Zsiga *Georgetown University*

Background: Tonal timing patterns are an understudied area of Articulatory Phonology (AP) [1]. While the timing of tones and tone-bearing units (TBU's) has been extensively investigated from an acoustic perspective, with theories of possible associations of H or L pitch targets to segments, moras, or syllables (see, e.g. [2,3] for overviews), little work has been done from an AP perspective. In AP, segments, moras, and syllables are instantiated as stable patterns of coordination among gestures [4], raising questions of exactly how the co-ordination of tone gestures should be described. To which other gestures are tones co-ordinated? The few studies that have examined lexical tone from this perspective, on Mandarin [5,6], Thai [7], and Serbian [8], suggest that tone gestures are incorporated into the gestural constellation in the same way as consonants, and are coordinated as part of the onset "c-center." The present study expands the typology to an African language, Igbo. Igbo is a particularly interesting test case, because of its process of vowel reduction/assimilation at word boundaries [9]. In a $V_1 \# V_2$ sequence in Igbo, the first vowel is reduced, but overall sequence length is not affected by the amount of reduction: the second vowel lengthens in compensation. What happens to the tone when vowel duration changes? Preliminary results show that the timing of tonal target and vowel target are highly correlated over changes in duration, suggesting that c-center timing for tones is not universal, and that the typology must be expanded to allow direct T-to-V coordination.

Data and analysis: 32 phrases (16 noun phrases and 16 verb phrases) containing $C_1V_1\#V_2C_2$ sequences were constructed, such that V_1 and V_2 are mismatched in both tone and vowel backness (e.g., [á#è] or [è#ó]) so that significant differences in both F0 and F2 are expected at the transition from V_1 to V_2 . Examples include: /ék^wé zótá ètè/ *Ekwe buys some rope* and /ó η^w èrè ófé/ *He has some soup* [10]. Data from 3 Igbo speakers has been collected, an additional 3 speakers are planned. Three measures are computed: overall duration of the vowel sequence, location of the F0 target, and location of the F_2 target. Targets are marked at the end of the V_1 steady state and the beginning of the transition to V_2 , and the duration in seconds from the release of C_1 to each target was computed. F0 and F2 targets were marked in separate passes through the data. Example sequences are shown in Figures 1 and 2.

Results: Preliminary results from the noun phrases are shown in Figs. 3 and 4. The locations of F0 and F2 are highly correlated (Fig. 3): F0 and F2 vary together as the amount of V_1 reduction changes. Targets are later as overall duration increases (Fig. 4), but the turning point of F2 is a better predictor of the turning point of F0 than the overall vowel duration.

Conclusion: The high correlation between target location for F0 and F2 indicates that in Igbo, vowel and tone are planned as a unit, rather than tones being timed as part of the onset. This result expands our knowledge of possible gestural constellations for tonal timing: c-center timing of tones is not universal. While a sample size of 4 languages is still far too small a typology, a possible hypothesis that emerges for future investigation involves a correspondence between the different patterns of gestural constellation and the timing patterns theorized in acoustic studies. C-center timing in the onset is argued to be indicative of syllabic organization [11]. It might be the case that c-center timing of tones corresponds to the syllable as TBU, while direct timing of tones to vowels corresponds to the mora as TBU. Much further study of this so-far marginal area of Articulatory Phonology is called for in order to test this hypothesis.



Fig, 1. An [í#a] sequence, less reduction



Fig. 2. An [é#a] sequence, more reduction



Figure 3. Correlation between F0 and F2 target location = .859.

Figure 4. Correlation between F0 and overall vowel duration = .521.

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