

## Stress As a Prosodic Gesture

In Articulatory Phonology, there is an insufficient understanding of the kinematic properties of stress (Byrd and Krivokapić, 2021). Previous observations suggest that a prosodic gesture or  $\pi$ -gesture may be attracted to stress (Byrd and Saltzman, 2003), and the prosodic gesture shifts towards the stressed syllable (Katsika, 2012; Byrd and Krivokapić, 2021). However, as far as I know, there was no research further probed stress as a prosodic gesture. In this study, I measured and compared the CV lag—the gestural lag between a consonant and a vowel—of stressed and unstressed syllables. I found that the CV lag of stressed syllables is statistically significantly larger, in terms of both duration and proportion, than that of unstressed syllables. The contribution of the study is threefold. First, the current study shows a novel kinematic correlation of stress–CV lag. Second, it reveals a source of variation in CV coordination, which can inform other kinematic studies. Thirdly, it proposes the argument that stress should be analyzed as a prosodic gesture.

The current study analyzed English kinematic data from 45 participants of the Wisconsin X-ray Microbeam Database (Westbury et al., 1990)—a publicly available corpus containing simultaneous recordings of acoustic and articulatory information of different tasks and speakers. The consonant gesture and the vowel gesture for each syllable in stressed and unstressed conditions were annotated in Matlab using the *lp\_findgest* algorithm of the *Mview* package (Tiede, 2005). The vowel gesture was measured by tongue blade (T2), and tongue tip (T1) or lower lip (LL) was annotated for the consonant gesture based on previous literature (Gao, 2008; Zhang et al., 2019; Hall, 2010). The stimuli of the current study can be found in Table 1.

	Stressed	Unstressed	C-measurement	V-measurement	Task Type
(1)	<b>ba</b> nana [næ]	ban <b>a</b> na [nə]	[n]-T1	[æ/ə] -T2	paragraph reading
(2)	<b>mo</b> ment [mo]	al <b>mo</b> st [mo]	[m]-LL	[o]-T2	citation words
(3)	<b>thi</b> ngs [θɪ]	no <b>thi</b> ngs [θɪ]	[θ]-T1	[ɪ]-T2	citation words

Table 1: Stimuli

The timestamps for gestural onsets, gestural offsets, target onsets, and target offsets were recorded for the consonant gesture and vowel gesture of each token. CV lags were computed by subtracting the timestamp of a consonant from the corresponding timestamp of a vowel. To normalize the speech rate effect and the duration effect that stressed syllables are longer, normalized CV lags were calculated by dividing a CV lag by the difference between the maximal and the minimal timestamps in a CV syllable. Descriptive analysis in Figure 1 and two-sample t-test clearly showed that the CV lag in stressed syllables is statistically significantly larger than the CV lag in unstressed syllables.

One contribution of the study is that it enhances the understanding of stress in articulation by linking stress directly to consonant and vowel gestural coordination. Not only does stress elongate a single gesture as argued by previous studies (Saltzman et al., 2008; Katsika, 2018), but it also enlarges the lag between consonant and vowel gestures, independently of its duration effect. Since the prosodic or  $\pi$ -gesture could slow down the clock and make its co-activated gestures less overlapped (Byrd and Saltzman, 2003), stress may be analyzed as a  $\pi$ -gesture. The observation

from Greek that lexical stress makes articulatory gestures longer and larger (Katsika, 2018) could further support the claim that stress should be analyzed as a prosodic gesture.

Another contribution of the current study is relevant to CV coordination, which serves as one of the fundamentals in Articulatory Phonology. Since stress can introduce variation in CV coordination, the variable of stress needs to be carefully controlled and considered in articulatory studies to avoid experimental confound or misinterpretation. For example, stress' induced effect on CV alignment surfaced as the observation in Zhang et al. (2019) that the tone gesture has a sequential relationship with CV gestures. Specifically, Zhang et al. (2019) analyzed the kinematic data in Mandarin and argued that the CV lag for the full-tone condition was significantly greater than the lag in the toneless condition, overlooking the fact that Mandarin toneless syllables are always weakened and unstressed (Chao, 1965; Lin, 2000; Yip, 2002; Lee, 2003).

The current study has pushed forward the kinematic research on stress. The claim that cross-linguistically, stress makes articulatory gestures longer, larger, and further apart needs future investigation.

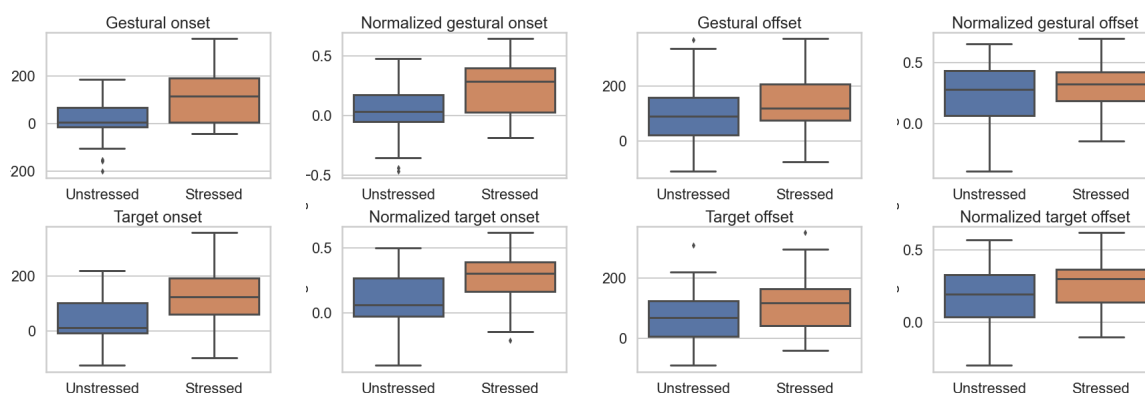


Figure 1: The CV Lags in Stressed Versus Unstressed Conditions

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