

Body gestures at prosodic boundaries

Jelena Krivokapić,^{1,2} Mark K. Tiede,² Martha E. Tyrone,^{2,3}

¹University of Michigan, USA, ²Haskins Laboratories, USA, ³Long Island University
Brooklyn, USA

This study examines temporal properties of body gestures at prosodic boundaries with the larger research question being what such movements, executed as co-speech gestures, can tell us about speech planning processes and prosodic structure. A long line of research has established that speakers plan upcoming utterances at pauses and more generally at prosodic boundaries (Cooper & Paccia-Cooper 1980, Krivokapić 2012, Fuchs, et al. 2013). In addition to planning processes, the phonological, syntactic and prosodic structure of the utterance preceding the pause (and thus not related to planning) also affects it, and therefore overall boundary duration is affected by both (Cooper & Paccia-Cooper 1980, Krivokapić 2012). Based on this research Ferreira (1988, 2007) argues that pauses at prosodic boundaries consist of two parts: The first part of a pause is grammatical and the second is related to planning. This account of pausing is unlikely to hold in its strong form (as stated also in Ferreira 2007), but raises the question whether different cognitive functions of prosodic boundaries can be distinguished articulatorily. The current study addresses this question by examining the temporal properties of body gestures. Body gestures have been shown to be related to speech planning (e.g., they facilitate lexical retrieval (Morsella & Krauss 2004) and the conceptual planning of utterances (Alibali et al. 2000) and there is a systematic temporal relationship between disfluencies and speech errors and body gestures (Seyfeddinipur 2006, Tiede et al. 2019). Body gestures are also related to prosodic structure, and seem to be coordinated with prosodic phrasing (Yasinnik et al. 2004, Barkhuysen et al. 2008) and with prominence (Mendoza-Denton & Jannedy 2011, Esteve-Gibert & Prieto 2013). They have also been shown to lengthen at prosodic boundaries (Krivokapić et al. 2017).

Our hypothesis is that the behavior of body gestures during pauses might differ depending on the cognitive processes taking place. Specifically, on the assumption that speech and body gestures are tightly integrated, we hypothesize that body gestures starting in speech and ending in a pause will lengthen, parallel to phrase-final lengthening in speech (Wightman et al. 1992, Fougeron & Keating), while body movements starting in the pause and ending in speech will not lengthen, because, according to Ferreira's hypothesis, that part of the pause is more reflective of planning. Initial support for this hypothesis comes from our pilot study (Krivokapić 2014) which used acoustic and video data. In the current study, we further examine the temporal properties of body movements at pauses. We have developed a paradigm that allows the simultaneous collection of audio, kinematic speech and body movement data (Krivokapić et al. 2017), making it possible to address the type of question of interest in our study. While in Krivokapić et al. (2017) we present results from read speech, in the present study we examine spontaneous speech recorded with this method.

For this study participants watched a "Tweety and Sylvester" cartoon and were then asked to retell the story to the experimenter. Data from three participants have been collected to date. Vocal tract gestures, the audio signal, and body gestures were recorded concurrently using electromagnetic articulometry (EMA) for vocal tract gestures, while body gestures were recorded using a motion capture system (Vicon). EMA sensors were placed midsagittally on the tongue tip, body, and dorsum, the lower incisors, and lips, with three additional reference sensors used to correct for head movement (mastoids and upper incisors). To record body gestures, seventeen motion capture markers were placed on the forehead and nose (these were used as references for alignment with EMA), eyebrows, arms and hands, and included one marker on each index finger. Right hand finger movements originating in speech and ending in pauses and originating in pauses and ending in speech were labeled, but only if they were

clearly identifiable as parts of speech-related gestures, thus excluding movements like knee

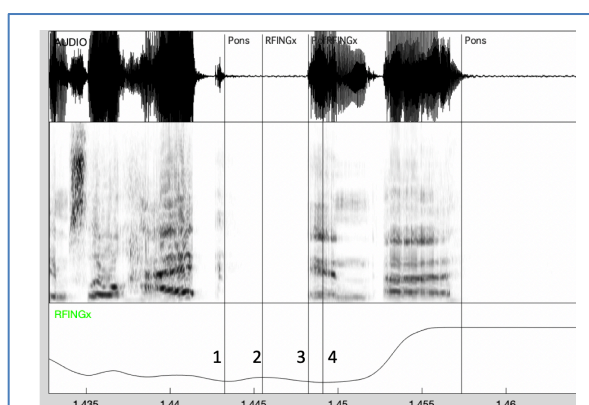


Figure 1. An example of the right-hand finger movement (posterior-anterior) during the sequence “chimp’s little hat in a” (1= pause onset, 2 = body movement onset, 3 = pause offset, 4 = body movement offset).

rubbing or ambiguous movements. Left hand finger movements were labeled as well when not part of a bimanual movement. The labeling (Figure 1) was conducted in mview (Haskins Laboratories) and in conjunction with video data, which allowed for a classification of movements into speech-related or speech-unrelated movement. Acoustic pause durations were labeled as an indicator of boundary strength. We test for correlation between pause duration and body movement duration, with analysis currently in progress. Preliminary results from the right and left hand finger movements of one participant do not support our hypothesis. However, given an initial observation that shoulder and head movements were related to

speech in the data, especially in the early parts of the story retelling when the participant was gesturing less with her hands, we will also present data from shoulder and head movement (see also Hoetjes et al. 2014, and Danner 2017 on the interdependence of different parts of the body in body movements). [Supported by NIH DC002717.]

References: Alibali, M. W., Kita, S., & Young, A. J. (2000). Gesture and the process of speech production: we think, therefore we gesture. *Language and Cognitive Proc*, 15, 593-613; Barkhuysen P., Krahmer, E., & Swerts, M. (2008). The interplay between the auditory and visual modality for end-of-utterance detection. *JASA*, 123, 354-365; Cooper, W. E. & Paccia-Cooper, J. (1980). *Syntax and speech*. Harvard University Press; Danner, S. G. (2017). *Effects of speech context on characteristics of manual gesture*. PhD Dissertation. U. of Southern California; Esteve-Gibert, N. & Prieto, P. (2013). Prosodic structure shapes the temporal realization of intonation and manual gesture movements. *J. of Speech, Language, and Hearing Research*, 56, 850-864; Ferreira, F. (1988). *Planning and timing in sentence production: The syntax-to-phonology conversion*. Ph.D. Dissertation, UMASS; Ferreira, F. (2007). Prosody and performance in language production, *Language and Cognitive Proc*, 22, 1151-1177; Fougeron, C. & Keating, P. (1997). Articulatory strengthening at edges of prosodic domains. *JASA*, 101, 3728-3740; Fuchs, S., Petrone, C., Krivokapić, J., & Hoole, P. (2013). Acoustic and respiratory evidence for utterance planning in German. *J. of Phonetics*, 29-47; Hoetjes, M., Krahmer, E. & Swerts, M. (2014). Does our speech change when we cannot gesture? *Speech Communication*, 57, 257-267; Krivokapić, J. (2012). Prosodic planning in speech production. In: Fuchs, S., Weihrich, M., Pape, D. & Perrier, P. (Eds.). *Speech planning and dynamics*. Peter Lang, pp. 157–190.; Krivokapić, J. (2014). Gestural coordination at prosodic boundaries and its role for prosodic structure and speech planning processes. *Communicative rhythms in brain and behaviour. Theme Issue of the Philosoph. Trans. of the Royal Society B*, 369, 20130397; Krivokapić, J., Tiede, M. K., & Tyrone, M. E. (2017). A kinematic study of prosodic structure in articulatory and manual gestures: Results from a novel method of data collection. *Laboratory Phonology*, 8, 1-26; Mendoza-Denton, N. & Jannedy, S. (2011). Semiotic layering through gesture and intonation: A case study of complementary and supplementary multimodality in political speech. *J. of English Linguistics*, 39, 265-299; Morsella, E. & Krauss, R. M. (2004). The role of gestures in spatial working memory and speech. *The American J. of Psychology*, 117, 411-424; Seyfeddinipur, M., (2006). *Disfluency: Interrupting speech and gesture*. Ph.D. dissertation, Radboud University; Tiede, M. K., Mooshammer, C., & Goldstein, L. (2019). Noggin Nodding: Head Movement Correlates with Increased Effort in Accelerating Speech Production Tasks. *Frontiers in Psych.*, 10, 2459; Wightman, C. W., Shattuck-Hufnagel, S., Ostendorf, M., & Price, P. J. (1992). Segmental durations in the vicinity of prosodic phrase boundaries, *JASA*, 91, 1707-1717; Yasinnik, Y., Renwick, M., & Shattuck-Hufnagel, S. (2004). The timing of speech-accompanying gestures with respect to prosody. In: *Proceedings of From Sound to Sense*, pp. 97-102.