The role of speech planning in the articulation of pause postures

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Prior research has found that the duration of a pause is influenced by the length of an upcoming utterance, suggesting that this is the speakers' time for planning an upcoming utterance ([1-6]). A separate line of research has also begun to examine articulation during pauses ([7-9]). Katsika et al. [10] find evidence of a specific configuration of the vocal tract during pauses in Greek, termed pause posture (PP), that is coordinated with other gestures at the boundary. Combining these two lines of research, Krivokapić, Styler, & Parrell (in press) find that in American English, PPs exist as well, and occur in some but not all utterances. They suggest that both the occurrence and duration of PPs is related to the need for additional time for planning an upcoming utterance. However, that study was not designed to examine planning. Here, we continue the investigation of the relationship between articulation during pauses and the cognitive processes underlying them. We explicitly examine the hypothesis that an increase in upcoming utterance length leads to more frequent PP occurrence and that PPs are longer in pauses that precede longer phrases.

Twenty-four sentences were designed such that the target pause was between two phrases, where the first (pre-boundary) phrase was five or six syllables long, and the post-boundary phrase varied in length (short: 4 syllables; medium: 10 syllables, and long: 17 syllables). This allowed testing for an effect of the length of an upcoming phrase on PP occurrence and duration. The pre-boundary phrase ended in one of the three words (*miMA, MIma, or Ema*, capitalization showing stress), and the post-boundary phrase always started with a bilabial (the immediate post-boundary word was *Bob, Mike, MIma, miMA, or Matt* [the pre- and post-boundary words varied for another study]). Crucially, the pause was always preceded by a bilabial CV and followed by a bilabial C, allowing us to track Lip Aperture in a controlled manner. Eight to 11 repetitions were recorded for each of eight speakers (4 male & 4 female) using electromagnetic articulometery (EMA). Sensors were placed on the tongue tip, body, and dorsum, on the upper and lower lips, and on the jaw, along with three reference sensors. Acoustic data were acquired simultaneously. In post-processing, the lip aperture trajectories for the three bilabial consonants surrounding the boundary were semi-automatically labeled using mview (Haskins Labs, under devel). Pause postures (PP) in lip aperture were identified; PPs are considered to be movements that deviate from a clear interpolation trajectory between the pre-boundary and post-boundary consonant constrictions (Fig. 1). For lip aperture (LA), the following were identified: the onset of the PP as the velocity zero-crossing preceding a change in direction of movement towards the pause posture, PP offset as the velocity zero-crossing before a change of movement direction or plateau, and the target of the PP as the maximum constriction of the lips (i.e. minimum LA). From these we calculate PP duration (onset to offset of PP) and boundary duration (from maximum constriction of the LA of the pre-boundary consonant to maximum constriction of the LA of the post-boundary consonant) (Fig 1). PPs occurred in 393 out of 1446 tokens (27.18%). Generalized Linear Models (GLM) were fitted to test the effects upcoming phrase length on boundary duration, on PP occurrence, and PP duration. Model comparisons compared models that included boundary duration and post-boundary length as predictors of PP occurrence.

Results indicate that there is an *effect of upcoming phrase length (in syllables) on PP occurrence* such that longer upcoming phrases lead to more PPs for all speakers pooled (Fig 2) and all but one individual speaker (spf3) (Fig 3), although the difference between medium and large is not reliably significant in post-hoc testing. As expected, PP occurrence is also affected by boundary duration: longer boundaries lead to more frequent PPs for all speakers (Fig 4). We therefore fit a GLM in R evaluating pause posture likelihood by boundary duration and upcoming phrase length and another evaluating pause posture likelihood when only boundary duration is included. The model comparison shows that the two-parameter model gives a better fit, indicating that upcoming phrase length has an independent effect on likelihood of PP occurrence, as predicted by our hypothesis. Further results indicate no *effect of upcoming phrase length on PP duration*. There is also no effect of upcoming utterance length on boundary duration for boundaries without PPs nor with PPs, but there is an effect of upcoming utterance length on boundary duration for boundaries overall (i.e., boundaries with and without PPs combined) (Fig 5).

Overall, the result of our study shows that the frequency of PPs increases with an increase in upcoming utterance length, supporting our hypothesis, while their duration is not affected by upcoming phrase length, contrary to our predictions. We interpret this to mean that pause postures are associated with planning time for longer utterances. The lack of effect on PP duration may indicate a relatively fixed scope of planning for upcoming speech regardless of its actual length, where a stable PP duration suffices in all cases to allow sufficient time for the utterance to be produced fluently. In sum this production study provides further evidence for the existence of PPs in American English and for their role in speech planning, informing our understanding of how cognitive processes are reflected in articulation. [Supported by NSF]

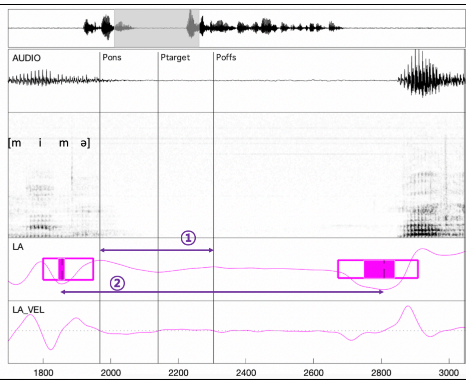

Figure 1 (at left). Constriction labeling for the sentence "They surprised *MIma*. Matt helped enormously with every aspect of the two-day party.", showing, for the lip aperture, the labeling for the pre-boundary bilabial consonant, the pause posture (PP), and the post-boundary bilabial consonant. Pink boxes indicate consonant gesture onset (left end of the box), gesture offset (right end of the box), and the dashed line indicates maximum constriction. The three vertical lines show pause posture onset, target (maximum constriction) and offset. 1 = PP duration, 2 = Boundary duration. LA: lip aperture trajectory & velocity.

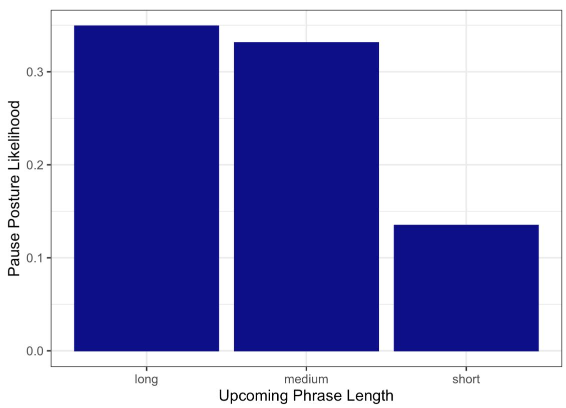

Fig 2 (above). The effect of upcoming phrase length on pause posture occurrence, all speakers pooled

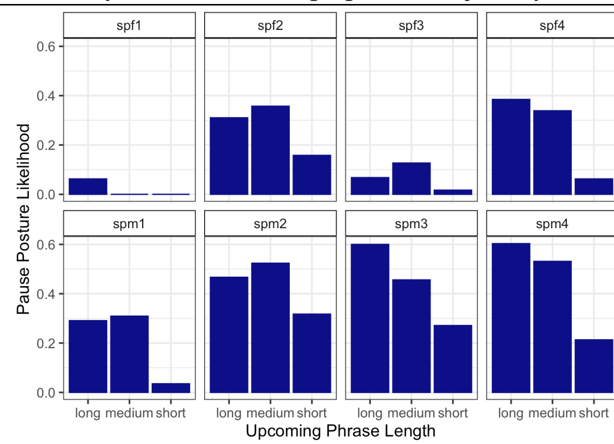

Figure 3 (above). The effect of upcoming phrase length on the occurrence of pause posture, individual speakers

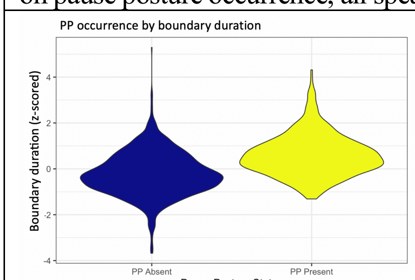

Figure 4 (at left). The effect of boundary duration on the occurrence of pause posture, all speakers pooled

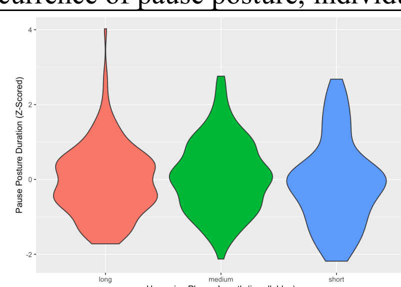

Figure 5 (at left). The effect of upcoming phrase length on boundary duration (*z*-scored by speaker)

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