# Velocity profiles and prosodic variation in younger and older speakers

Jane Mertens[1], Anne Hermes[1] & Doris Mücke[1]
[1]IfL Phonetik, University of Cologne, Germany

Prosodic marking is a complex phenomenon which applies to different levels in the prosodic hierarchy, requiring a fine-tuning of the physical system. This involves modifications of (supra)segmental tiers to make single prosodic constituents such as a syllable or a word stand out [1]. It has been shown that speakers systematically vary between more and less distinct articulations within each utterance, phrase or even within a word [2]. On the textual tier, they mark prosodic structure by producing longer and larger movements of the lips, tongue and jaw in syllables in prominent positions [3-5]. However, as we age, we experience changes at several physiological levels, resulting in inter alia asymmetric velocity profiles of the movements of the limbs and speech organs [6,7]. A common reported effect in studies on aging in speech is a slowing down (segment/word/sentence duration [8-10]). In the present study, we investigated temporal strategies of prosodic marking in the articulatory substance of younger and older speakers. We focus on acoustic syllable durations and the corresponding velocity profiles of vocalic gestures. Therefore, we measured the symmetry of acceleration and deceleration performances during V-to-V articulation in sequences of unstressed-stressed-unstressed syllables. We expect longer durations in stressed compared to unstressed syllables for both age groups. For the older subjects, we expect longer durations as well as asymmetric velocity profiles.

We recorded 7 older native German speakers (2f, 5m; aged 70-80 years) and 7 younger native German speakers (2f, 5m; aged 20-30 years) using electromagnetic articulography (EMA, AG 501). Target words were presented in contrastive focus, structured ˈCV.CV (/bina, pina, dina, tina/), embedded in a carrier sentence ('Er hat wie**der 'CV.CV** gesagt' – *'He said again.'*). We labelled acoustic syllable boundaries as well as articulatory landmarks for the vocalic gestures in the vertical dimension: onset, peak velocity and target of the accented (V1) and unaccented vowel (V2) as well as the preceding one (V0) in the EMU webAPP [11].

Fig. 1 shows the acoustic durations of the stressed and unstressed syllable. A linear regression analysis (fixed: *age*, *position*; random: *speaker*) revealed an effect of *age* on the acoustic syllable duration ($\chi2(1)=7.2484$; $p=0.007097$) with an interaction of *age* and *position* ($\chi2(1)=56.456$; $p=5.748e-14$) with longer durations for stressed syllables than following unstressed ones and longer durations in older compared to younger subjects. Fig. 2 displays the movement components of the vocalic gestures: (a) acceleration, (b) deceleration and (c) symmetry of these two (values >1 indicate a longer deceleration phase and values <1 indicate a longer acceleration phase). Both groups showed an asymmetrical pattern with rather long deceleration phases into the stressed V1, followed by long acceleration phases into the unstressed V2. The model revealed an effect of *position* ($\chi2(1)=327.63$; $p<2.2e-16$), an interaction of *position* and *age* ($\chi2(1)=122.24$; $p<2.2e-16$), with *age* effects on unstressed V0. For the deceleration phase, there was an effect of *position* ($\chi2(1)=1691.1$; $p<2.2e-16$), an interaction of *age* and *position* ($\chi2(1)=24.676$; $p=4.382e-06$), with *age* effects on stressed V1. The symmetry measure revealed an effect of position ($\chi2(1)=710.35$; $p<2.2e-16$) and an interaction ($\chi2(1)=96.966$; $p<2.23-16$), with *age* effects on stressed V1.

Both age groups highlighted prosodically important information by *longer* acoustic durations in stressed than unstressed syllables, but older speakers show a further slowing down (and also more variability). The velocity profiles were affected by the prosodic pattern in terms of shifting asymmetries in the respective movement components: both groups showed longer deceleration phases than acceleration phases of the vocalic tongue body movements in the stressed syllables, while the opposite was found for unstressed syllables. Segmental effects of the tested /ɐ-i-a/-sequences play an additional role, but cannot explain the shifts ofthe tongue velocities towards and away from the stressed V1. These modifications span the acoustic syllable, mostly affecting the stressed vowel, but also spreading to its left and right, contributing to the sonority expansion of the prominent vowel. This asymmetry was stronger for older than younger speakers indicating an adaption of the (slower) physical control system to the needs of the prosodic system.

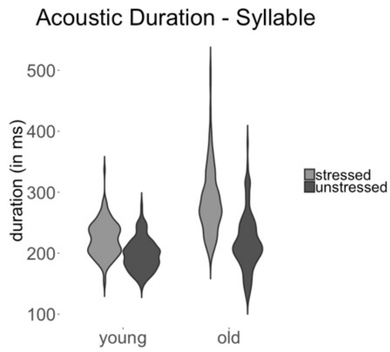


Figure 1. *Acoustic syllable durations (in ms) for younger and older speakers in stressed and unstressed positions.*

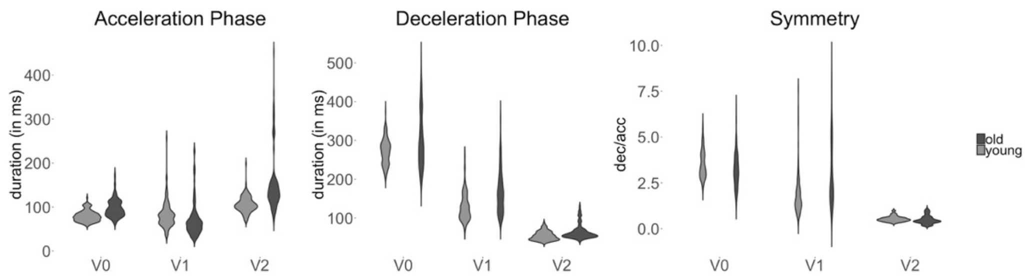


Figure 2. *Duration of (a) acceleration, (b) deceleration phases (in ms) and their (c) symmetry (dec/acc) for younger and older speakers in unstressed V0, stressed V1 and unstressed V2 positions.*

**References**

[1] Cho, T. (2011). Laboratory Phonology. *The Continuum Companion to Phonology*, 343-368.
[2] Lindblom, B. (1990). Explaining phonetic variation: A sketch of the H&H theory. In *Speech production and speech modelling* (pp. 403-439). Springer, Dordrecht.
[3] De Jong, K. J. (1995). The supraglottal articulation of prominence in English: Linguistic stress as localized hyperarticulation. *The journal of the acoustical society of America*, *97*(1), 491-504.
[4] Shattuck-Hufnagel, S., & Turk, A. E. (1996). A prosody tutorial for investigators of auditory sentence processing. *Journal of psycholinguistic research*, *25*(2), 193-247.
[5] Mücke, D., & Grice, M. (2014). The effect of focus marking on supralaryngeal articulation–Is it mediated by accentuation? *Journal of Phonetics*, *44*, 47-61.
[6] Ketcham, C. J., & Stelmach, G. E. (2004). Movement control in the older adult. In R.W. Pew, S.B. Vanhemel (Eds.), Technology for Adaptive Aging, National Academies Press, Washington, D.C.
[7] Hermes, A., Mertens, J., & Mücke, D. (2018). Age-related Effects on Sensorimotor Control of Speech Production. *Proc. Interspeech 2018*, 1526-1530.
[8] Amerman, J. D., & Parnell, M. M. 1992. Speech timing strategies in elderly adults. *Journal of Phonetics*, 20(1), 65-76.
[9] Smith, B. L., Wasowicz, J., & Preston, J. 1987. Temporal characteristics of the speech of normal elderly adults. *Journal of Speech, Language, and Hearing Research*, *30*(4), 522-529.
[10] Ramig, L. A. 1983. Effects of physiological aging on speaking and reading rates. *Journal of Communication Disorders*, 16(3), 217-226.
[11] Winkelmann, R., & Raess, G. (2014, May). Introducing a web application for labeling, visualizing speech and correcting derived speech signals. In *LREC* (pp. 4129-4133).