

## **Articulatory encoding of prominence in habitual and loud speech**

*Lena Pagel, Simon Roessig, Doris Mücke*

IfL Phonetics, University of Cologne

A key function of prosody is the distribution of prominences, which is influenced by the focus structure of an utterance (Cho & Mücke, 2020; Uhmann, 1991). Focus structure is expressed by changes in the acoustic signal (e.g.  $f_0$  and sound pressure level) and in the underlying articulation of consonants and vowels (e.g. lip and tongue movements) (Baumann & Winter, 2018; Cho, 2004; Roessig & Mücke, 2019). Notably, focus structure affects the whole utterance and not merely the production of a prominent entity (Féry & Kügler, 2008; Rump & Collier, 1996).

The present study investigates the articulatory encoding of focus structure in habitual and loud speech. It examines modulations of lip kinematics in the most prominent entity of an utterance but, importantly, extends the analysis to a less prominent entity to inquire prominence marking from a comprehensive perspective. Furthermore, the study investigates whether prominence relations are articulatorily encoded in loud speech. This is interesting because loud speech is produced with a high degree of vocal effort, which may impede the rather subtle encoding of focus.

An experiment with 20 German speakers was carried out using 3D Electromagnetic Articulography, of which 10 have been analysed to date. The speakers were engaged in an interactive question-answer task with a virtual avatar. They produced target words containing the syllables /bi, mi/. Target words were embedded in carrier sentences in two utterance positions (initial or medial). Two focus conditions were elicited through the avatar's questions: In condition 1, both the initial and the medial word were moderately prominent (in broad focus); in condition 2, the medial word was emphasised (in contrastive focus) and the initial word was less prominent (in the background). This design made it possible to study an increase and decrease in prominence and therefore the relations between focus types.

Figure 1 displays the results for the Euclidean lip distance during the target vowel /i/ in two utterance positions, focus conditions and speaking styles. In habitual speech, lip opening increases when prominence increases, i.e. in contrastive as opposed to broad focus (cf. panel A). Concurrently, lip opening decreases when prominence decreases, i.e. in the background as opposed to broad focus (cf. panel B). The same qualitative pattern can be observed in loud speech (cf. panels C/D), with an overall larger lip opening (cf. panels A/B vs. C/D). Interestingly, the differences between prominence degrees appear even larger, showing that prominence relations in lip aperture are not only preserved but enhanced – despite the fact that the lips are already generally opened wider in loud speech.

In summary, the study shows that prosodic prominence is encoded by systematic changes in supra-laryngeal articulation. Crucially, not only are those entities strengthened that are emphasised; at the same time, other entities are weakened, thereby potentially increasing the perceptual prominence of the strengthened entity. This can not only be observed in a habitual speaking style but even in loud speech. Our results underline the flexibility of the prosodic system adapting to communicative demands. These adaptations are best conceived of as the maintenance of parameter relations in a dynamical model of speech production rather than fixed, hard-coded parameter sets.

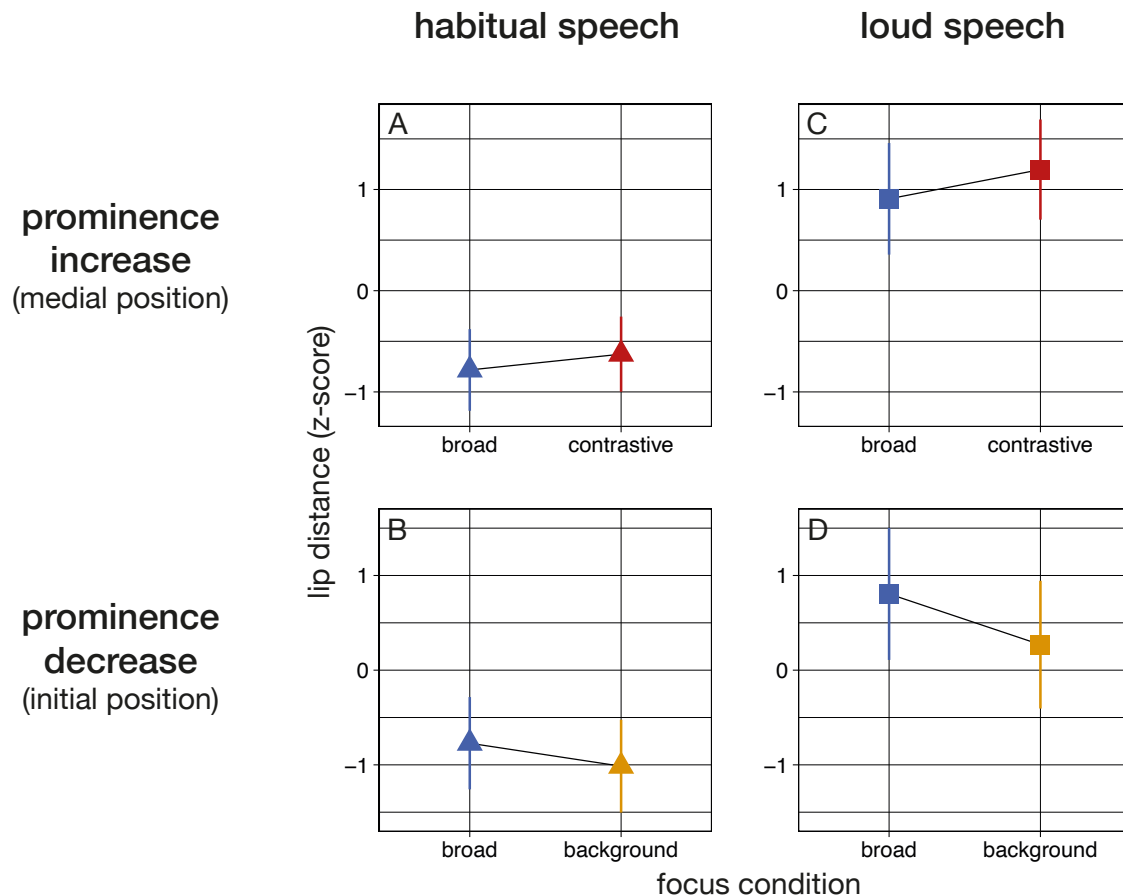


Figure 1: Lip aperture modifications under increased and decreased prominence in habitual and loud speech. Plot shows means and standard deviations of z-score Euclidean lip distance.

## References

- Baumann, S., & Winter, B. (2018). What makes a word prominent? Predicting untrained German listeners' perceptual judgments. *Journal of Phonetics*, *70*, 20–38. <https://doi.org/10.1016/j.wocn.2018.05.004>
- Cho, T. (2004). Prosodically conditioned strengthening and vowel-to-vowel coarticulation in English. *Journal of Phonetics*, *32*, 141–176. [https://doi.org/10.1016/S0095-4470\(03\)00043-3](https://doi.org/10.1016/S0095-4470(03)00043-3)
- Cho, T., & Mücke, D. (2020). Articulatory Measures of Prosody. In C. Gussenhoven & A. Chen (Eds.), *The Oxford Handbook of Language Prosody* (pp. 16–38). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780198832232.013.2>
- Féry, C., & Kügler, F. (2008). Pitch accent scaling on given, new and focused constituents in German. *Journal of Phonetics*, *36*(4), 680–703. <https://doi.org/10.1016/j.wocn.2008.05.001>
- Roessig, S., & Mücke, D. (2019). Modeling Dimensions of Prosodic Prominence. *Frontiers in Communication*, *4*, art. 4: 1-19. <https://doi.org/10.3389/fcomm.2019.00044>
- Rump, H. H., & Collier, R. (1996). Focus Conditions and the Prominence of Pitch-Accented Syllables. *Language and Speech*, *39*(1), 1–17. <https://doi.org/10.1177/002383099603900101>
- Uhmann, S. (1991). *Fokusphonologie: Eine Analyse deutscher Intonationskonturen im Rahmen der nicht-linearen Phonologie (Linguistische Arbeiten, 252)*. Niemeyer.