

How do semantic likelihood and information structure affect prosodic encoding in different tasks?

I. Yuen, B. Möbius, M. Sabev, B. Andreeva

Saarland University

Predictability has been used to account for phonetic variations, often assuming a link between ‘probability’ of occurrence and signal properties of speech at multiple linguistic levels [1, 2, 5, 6, 9], including prosody [1, 5, 6]. However, other accounts turn to semantics and pragmatics, evoking linguistic notions such as information structure to directly account for prosodic variations [4]. It is uncommon to combine both viewpoints in examining the role of prosody in phonetic encoding of speech. One of the few came from [7] which manipulated meaning-based contextual probability and reported its influence on the fundamental frequency contour in different focus conditions in American English. A recent study of broadcast data in German also observed contributions of information status and surprisal on syllable duration [10]. However, [10] differed from [7]: the former is corpus-based and uses trigram surprisal (which is structure-related); whereas the latter is experiment-based and uses pragmatic contextual probability (which is discourse meaning-related). That is, data were elicited differently. In light of these differences, the current study revisited the role of information theoretical and information structure properties in prosodic encoding of duration in German using two experimental tasks: reading aloud and sentence formulation. The two experimental tasks were chosen to differ systematically in their speech planning demands.

The likelihood of semantic association, as an index of semantic surprisal, was varied between two nouns in a sentence such as, “Sie hat eine Bibel (N1) in der Kirche (N2) gefunden” (*She has found a Bible in the church*) vs. “Sie hat eine Bibel (N1) in der Arztpraxis (N2) gefunden” (*She has found a Bible in the medical practice*). N1 and N2 words served as triggers in an online word association experiment. The responses were checked against the N1-N2 test pairs for ‘a match’ (more likely) vs. ‘no match’ (less likely). The sentences were elicited via auditory prompt questions in three focus conditions: Broad, Narrow N1, Narrow N2. While the sentence stimuli were presented orthographically in the reading task, pictures of N1 and N2 were visually presented with an orthographically presented verb for the participant to formulate a sentence in the formulation task. We expect (i) duration of N1 and N2 to change as a function of focus assignment, and (ii) a reduced durational difference between N1 and N2 in a semantically less likely pair, and (iii) generalizability across experiments. N1 and N2 duration were analysed using lmer in R [3, 8], with FOCUS, SEMANTIC LIKELIHOOD and EXPERIMENTAL TASK as fixed effects. A preliminary analysis of 20, drawn from a total sample of 39 participants, showed the effect of FOCUS for N1 ($F = 14.6$, $df = 2$, $p = .0001^*$) and N2 duration ($F = 10.02$, $df = 2$, $p = .001^*$), in line with (i). The effect of SEMANTIC LIKELIHOOD reached statistical significance for N1 ($F = 4.46$, $df = 1$, $p = .04^*$), but not N2 duration, in partial agreement with (ii). In addition, there was a significant interaction between FOCUS and EXPERIMENTAL TASK on N1 duration ($F = 8.34$, $df = 2$, $P = .002^*$), contra (iii). The interaction arose for N1 duration because the Narrow N1 condition is longer than the Narrow N2 condition in the reading experiment; whereas the Broad focus condition is longer than the Narrow N1 and Narrow N2 conditions in the sentence formulation experiment (Figure 1). Posthoc analysis further suggests that SEMANTIC LIKELIHOOD on N1 is driven by the Broad focus condition in the sentence formulation experiment. As for N2 duration, the Narrow N2 condition is longer than the Broad and Narrow N1 conditions in both experiments. Together, the results suggest that information structure robustly shapes prosodic encoding, while semantic likelihood exerts more limited and position-specific effects that depend on speech planning conditions.

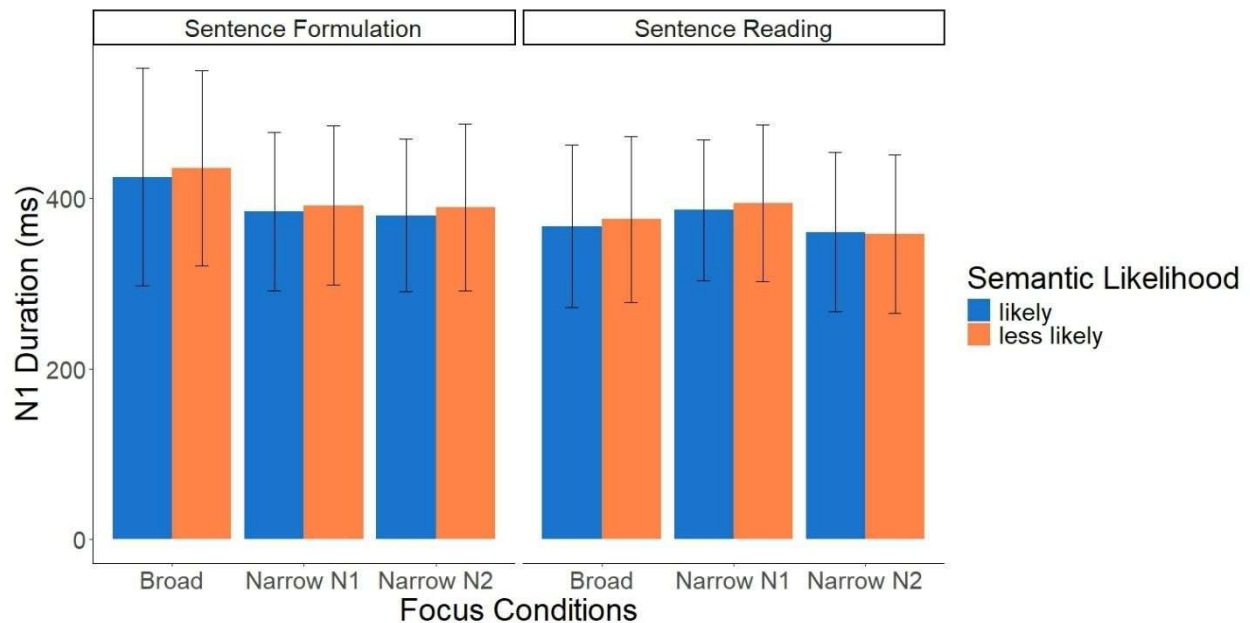


Figure 1. N1 duration as a function of focus conditions in two experimental tasks, with ± 1 SD.

References

- [1] M. Aylett and A. Turk, "The smooth signal redundancy hypothesis: A functional explanation for relationships between redundancy, prosodic prominence duration in spontaneous speech," *Language and Speech*, 47: 31-56, 2004.
- [2] R. Baker and A. Bradlow, "Variability in word duration as a function of probability, speech style and prosody," *Language and Speech*, 52(4): 391-413. 2009.
- [3] D. Bates, M. Maechler, B. Bolker, and S. Walker, "Fitting Linear mixed-effects models using lme4," *Journal of Statistical Software*, vol. 67, pp. 1-48, 2015.
- [4] S. Baumann, M. Grice and S. Steindamm, "Prosodic marking of focus domains – categorical or gradient?" *Proceedings of Speech Prosody*, Dresden. May. 2006.
- [5] E. Brandt, B. Möbius and B. Andreeva, "Dynamic formant trajectories in German read speech: Impact of predictability and prominence," *Frontiers in Communication*, 6, 2021. doi: 10.3389/fcomm.2021.643528.
- [6] Z. Malisz, E. Brandt, B. Möbius, M. O. Yoon and B. Andreeva, "Dimensions of segmental variability: Interactions of prosody and surprisal in six languages," *Frontiers in Communication*, 2018. doi: 0.3389/fcomm.2018.00025
- [7] I. Ouyang and E. Kaiser, "Prosody marks different kinds of informativity: interactions between frequency, probability and focus," *University of Pennsylvania Working Papers in Linguistics*, vol. 21, issue 1, article 24. 2015.
- [8] R Core Team, *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, 2023.
- [9] S. Seyfarth, "Word informativity influences acoustic duration: Effects of contextual predictability on lexical representation," *Cognition*, 133:140-155. 2014.
- [10] I. Yuen, B. Andreeva, O. Ibrahim and B. Möbius, "Prosodic factors do not always suppress discourse or surprisal factors on word-final syllable duration in German polysyllabic words," in R. Lemke, L. Schäfer, and I. Reich editors, *Information Structure and Information Theory*, pp. 215-234. Language Science Press, Berlin. 2024.