Information Density and Phonetic Variation

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In this talk I will take an information-theoretic perspective on speech production and perception. I will explore the relation between information density and phonetic encoding and decoding. Information density of a linguistic unit is defined in terms of surprisal (the unit's negative log probability in a given context). The main hypothesis underlying our experimental and modeling work is that speakers modulate details of the phonetic encoding in the service of maintaining a balance of the complementary relation between information density and phonetic encoding.

To test this hypothesis we analyzed the effects of surprisal on phonetic encoding, in particular on dynamic vowel formant trajectories, plosive voicing, syllable duration, and vowel space size, while controlling for several basic factors related to the prosodic structure, viz. lexical stress and major prosodic boundaries, in the statistical models that accounted for phonetic effects of changes in surprisal (e.g. Malisz et al. 2018, Brandt et al. 2021). Our findings are generally compatible with a weak version of the Smooth Signal Redundancy (SSR) hypothesis (Aylett & Turk 2004, 2006, Turk 2010), suggesting that the prosodic structure mediates between requirements of efficient communication and the speech signal. However, this mediation is not perfect, as we found evidence for additional, direct effects of changes in predictability on the phonetic structure of utterances. These effects appear to be stable across different speech rates in models fit to data derived from six different European languages (Malisz et al. 2018).

Moreover, we investigated effects on subword (segmental and syllable) levels and in local prosodic structures (at phrase boundaries), in acoustically clean and in noisy conditions. Our recent findings suggest that speakers make an effort to increase the difference between syllables in high vs. low surprisal contexts in the presence of noise. No interaction was found between noise and surprisal, suggesting that noise-related modifications may be independent of those induced by surprisal. If so, speech production models should include channel-based as well as message-based formulations: although channel coding is not part of linguistic representation (message formulation) during speech planning, it does shape the phonetic output.