Language sound structure:
Linguistics at the interface between biology, cognitive psychology, and neuroscience

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The acoustic results of the process of speech production have been the subject of instrumental analysis for over 60 years and an object of scientific inquiry for much longer. The concept behind a representation like /k/ seems simple, but the reality in both acoustics and articulation is far more complex and still not completely understood. The production of onset /k/ in English involves making a tongue dorsum closure against the palate. A detailed study of /k/ in articulation using ultrasound imaging finds both broad phonological adjustment of the articulatory target based on vowel context as well as fine phonetic differences in the execution of stop closure (Frisch & Wodzinski, 2016). When the articulation of /k/ is studied under more difficult articulatory and cognitive conditions, such as in tongue twisters designed to induce errors, we find both bottom-up and top-down influences on production (e.g. Frisch & Wright, 2001; Goldrick & Blumstein, 2006; Pouplier & Goldstein, 2005). Bottom-up effects are seen, for example, in the competition between gestural components in the speech plan that result in slips of the tongue. However, these slips are mediated by top-down constraints from prosodic and lexical patterns in the language. Additional insight into both phonetic and phonological processes in speech production can be seen. On the phonetic side, there are individual differences between typical speakers in their articulatory stability and speech error rate (Frisch & Reddick, 2015). On the phonological side, differences between speaker groups such as those found in speech disorders or between monolingual and bilingual speakers provide insight into the multiple prosodic and lexical planning stages involved in speech production (Frisch, Maxfield, & Belmont, 2016; Gollan & Goldrick, 2012).

And turning the focus from performance to competence, these same influences on speech production do impact phonological and lexical patterns within and across languages of the world, demonstrating that space of possible languages is restricted by articulatory and cognitive constraints (e.g. Frisch, 2015). These constraints impact both the micro/segmental structure and the macro/lexical-prosodic structure of the lexicon. Many common phonological patterns are robust to individual differences in language experience due to the granularity of phonological representation and the importance of type frequency in the learning of phonological generalizations (Pierrehumbert, 2001). However, individual differences still affect performance at the phonological level in metalinguistic tasks or as reflected in neuroplasticity for language change in the adult (Frisch & Brea-Spahn 2009; Harrington, 2006; Steele, Colantoni, & Kochetov, 2018). When the full scope of phonetic and phonological generalization across articulatory, prosodic, and sociolinguistic contexts are considered, language sound structure is seen as a multidimensional learning space that is subject to numerous influences beyond the scope of a phonological grammar (Munson, Edwards, & Beckman, 2011). Discovering the full dimensionality of language sound structure requires a multidisciplinary investigation using computational, quantitative, and qualitative methodology.