The relationship between sonority and glottal vibration

Sonority has been an important principle underlying explanations for various phonological phenomena (e.g., assimilation, phonotactics of syllable structure). Adequate characterization of its physical manifestation, and quantification thereof, is currently debated, but so far does not make a connection to source-filter dependencies beyond ascribing some role to voicing in general (Parker 2002). Other attempts to forge a link between sonority and articulatory factors have divorced glottal state (source) from aperture/constriction (filter) (e.g., Miller 2012). In the present experimental study, we ask whether effects of source-filter interactions distinguish among voiced consonants and vowels of varying degrees and types of vocal tract constrictions, along lines suggested by Stevens (2000). We rely on the contact quotient (the proportion of a complete vibratory cycle for which vocal fold contact area is greater than a specified threshold) from EGG signals and a Strength of glottal Excitation measure (the instant of significant excitation of the vocal-tract system during production of speech, therefore representing the relative amplitude of impulse-like excitation) (Murty and Yegnanarayana 2008) as dependent measures of glottal state during vocal tract constrictions. A lower Contact Quotient (CQ) indicates a more spread glottis (breathier voicing), and a lower Strength of Excitation (SoE) indicates less acoustic energy from voicing. This investigation allows us to explore in greater detail implications for an articulatory basis of sonority.

In a replication and extension of (Mittal et al. 2014), we recorded and took acoustic and glottal measurements from fourteen consonants representing the span of the sonority hierarchy: (1) Approximants ([j, w, l, ɹ]); (2) trill and tap ([r,ɾ]); (3) nasal ([n]); (4) fricatives ([ð, ɣ, ʁ, z]); and (5) affricates and stop ([ʤ, gɣ, d]). Affricates were segmented as stop closure (cl) and fricative release (rel). In a second task, we recorded and measured seven vowels: (1) front unrounded ([i, e, a]); (2) front rounded ([y,ø]); and (3) back rounded ([o,u]). Data collection was performed using a Glottal Enterprises EG2-PCX electroglottograph to record an EGG signal, and a high-quality B&K microphone to record the simultaneous audio signal, both at 22kHz. Consonants and vowels were repeated three times each in [aCa] and [wV] frames respectively. All fourteen study participants were trained phoneticians and fluent speakers of English.

Hand-aligned Praat TextGrids were created by identifying intervals in which at least three glottal pulses of voicing was maintained throughout the target constriction. After eliminating mispronounced and insufficiently voiced tokens, a total of 774 tokens were analyzed. Acoustic and glottal measurements were extracted automatically from the segmented speech and EGG signals using VoiceSauce (Shue et al. 2011) and EggWorks (Tehrani 2012) software.

Our null hypothesis states that there should be no difference in CQ or SoE across voiced consonantal segments compared to vowels, with the exception of voiced fricatives; the glottis during voiced fricatives is more spread due to increased airflow requirements and a lower CQ is expected. Results indicate that this is the case; but other consonant categories also vary in CQ in ways suggestive of sonority, with constricted vowels having the highest CQ values. SoE also distinguishes the segment categories, with voiced stop closures having the lowest values, but it makes additional distinctions among the vowels, liquids, and glides, The figure on the next page illustrates the distinctions among segments on these two measures. We will discuss how these and additional segment-level results are related to traditional sonority distinctions.

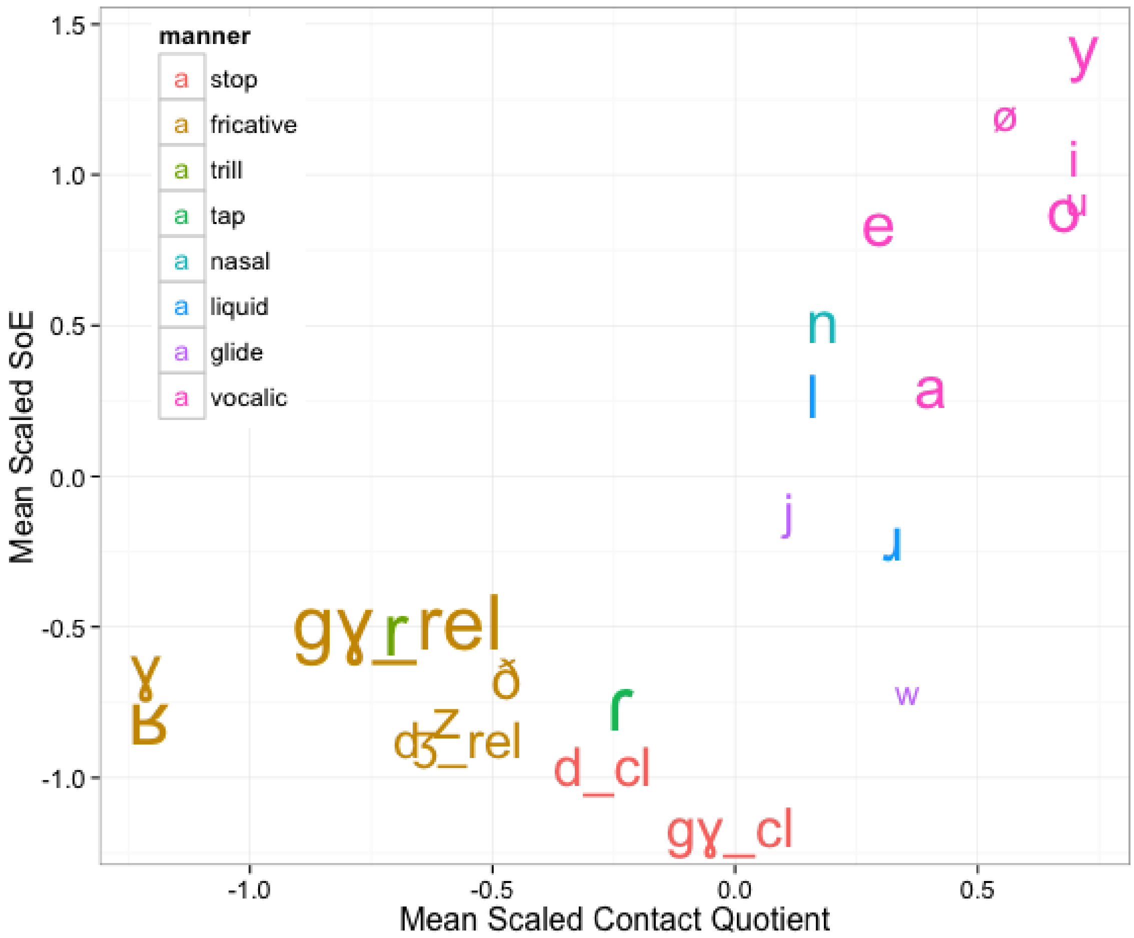

Figure 1: CQ versus SoE. Size of label indicates standard deviation.

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