# Beatboxing, is it talking?

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Plosive consonants /p, t, k/ are among the most commonly-found phonemes in the phonological inventory of the world's languages [Maddieson & Disner, 1984]. In addition to their linguistic role, they also fulfil an extralinguistic role. Syllables with plosive consonants are used in instrumental practice, for playing wind instruments and percussion. They also support vocal practice, as is the case with scat or Indian konnakol. The linguistic origin of these sounds impacts their articulation even when they are used in an extralinguistic way. Some studies have highlighted articulatory differences in the plosives used in instrumental practice depending on the player's first language [Lamkin, 2005, Heyne *et al.*, 2019].

This study focuses on Human Beatboxing (HBB) production. HBB is an emerging vocal art that relies on the human vocal instrument to produce all kinds of sound for the purpose of music making. Plosive sounds are highly exploited. HBB learning frequently begins with training on speech plosives, syllables or sentences. For instance, kicks, the sounds used to imitate the bass drum, are learned from a [p] or [b] consonant, hi-hats, which reproduce the sound of the hi-hat, stem from a [t] or [ts], or the rimshot technique, is based on a [k]. An open research question is that of the similarities and differences in the articulatory dynamics between speech and HBB. In the present study, we examine articulatory trajectories and ventilatory volumes, and compare the production of plosive consonants in speech and plosive sounds in HBB with same places of articulation.

Four French speaking beatboxers were recorded. Electromagnetic articulography (EMA) was combined with acoustic, electroglottographic and ventilatory measurements. The spoken plosives /p, t, k/ were compared to their HBB equivalent in terms of place of articulation: kick, hi-hat and rimshot. The bursts of the plosives were manually segmented and annotated from the audio recordings using Praat software [Boersma, 2006]. 3D trajectories of three flesh points of the tongue (apex/blade, middle and dorsum) and four flesh points of the lips (upper and lower, median and lateral) were extracted from the EMA recordings.

Although common features are observed especially regarding place of articulation and trajectory, the detailed analysis of acoustic, articulatory and ventilatory data shows that the production of plosive sounds in HBB is clearly different from that of plosive sounds in speech. Ventilatory volumes are engaged differently in HBB and speech sound production. The articulatory dynamics of HBB plosive sound production desplays aspects that are specific to HBB and different from that of speech. In the case of the kick compared to a bilabial voiceless plosive, the occlusion can be lateralized. This lateralization of the bilabial occlusion release is observed in some beatboxers, but not systematically. The side (left or right) of lateralization depends on the beatboxer. This labial gesture is presumably intended to better control lip tension at the occlusion release. The tongue is also very active even though the occlusion involves the lips. Articulatory speeds are often higher in HBB than in speech, especially before the burst. The lingual dynamics of the HBB plosive sounds seems to be consistent with the use of an ejective mechanism. The very active and reproducible lingual

dynamics during articulation of the bilabial plosive sounds of HBB cannot be fully explained by coarticulation. Further, all three tongue coils are recruited in almost the same way, indicating an overall movement of the tongue. Therefore, this seems to suggest a movement of the tongue in relation to the laryngeal upward movement specific to the ejective mechanism already observed in previous studies [Proctor *et al.*, 2013, De Torcy *et al.*, 2014, Sapthavee *et al.*, 2014, Blaylock *et al.*, 2017, Patil *et al.*, 2017, Dehais Underdown *et al.*, 2019] and used to increase the acoustic efficiency of the sound. The complex articulatory dynamics and a widespread use of the ejective mechanism make the study of HBB plosive sound production a promising research field, which may contribute to a broader understanding of articulatory phenomena at the lingual level.

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