MASTER Sciences Cognitives - 2019-2020

Impact of bone conduction on the perception of own speech: experiments and modeling

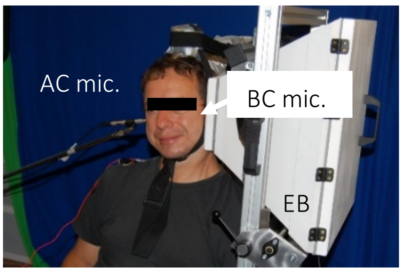
Context

Speech production is constantly guided by the auditory feedback. It is obvious in the babbling toddler, who explores thus repeatedly the relation between articulatory commands and acoustical result. But some plasticity of this sensorimotor loop is maintained in the adult: perturbing speech by introducing a sensory delay, or shifting frequency bands leads to a rapid adaptation of vocal production (see e.g. Rochet-Capellan et al. 2011). Speech is thus a feedback system in which auditory signals are used in real-time (modulo conduction and processing delays). It is also a sensorimotor system for which the sensory inflows are incompletely characterized. We know that bone conduction accounts for around half of the acoustical signal arriving on the cochlea (von Békésy 1949); yet, most research on speech has only considered the aerial feedback —the communicative signal the talker is sending. Everybody can recall the experience of hearing for the first time the difference between his/her own voice and a recording of it, but the impact of this difference on speech production is unclear. Our preliminary results hint at interesting complementarities between aerial and bone conduction signals. This project aims at furthering this understanding between speech production and acoustical feedback. In particular, we plan to test to what extent one can predict a person's full auditory feedback from the aerial signal alone, and to evaluate the impact of bone conduction on speech plasticity.

Work program

a) Data acquisition

Part of the acoustical signal conducted by the bony structure is radiated by the tympanic membrane. We will make use of a specially developed experimental setup to record this tiny signal with a probe microphone inserted into the subject's ear. An « earbox » isolates the aerial (AC) and bone (BC) components of the acoustical transmission (see Figure). The intern will first have to rigorously master this setup in order to acquire a set of joint AC/BC recordings of phonemes, syllables and of a speech corpus on a group of speakers.



Experimental setup isolating the aerial component of speech (AC mic, close to right ear) from the bone conduction component (BC mic, inserted in the subject's left ear, acoustically isolated by the earbox EB).

b) Modeling

Once these data acquired, we will strive to understand the transformations between aerial- and bone-conducted voice by developing a statistical model of their relationships. To this aim, we will repurpose a well-known technique called « voice conversion » in order to evaluate the information that is unique to each signal, and to test to what extent one can predict the bone signal from the aerial signal, in other words, guess from the outside the full auditory feedback of a speaker. Furthermore, we will explore the discriminability of phonemes in the bone-conducted signal compared to the aerial signal. Last, we will also probe the inter-subject variability of the model, i.e. to what extent it depends on the speaker's morphological features.

c) Experimental validation

We will test whether the adaptation to an auditory perturbation depends on the information comprised in the bone-conducted part of the signal. We expect that adaptation to a transformation between phonemes P1 and P2 introduced with headphones will be maximal if P1 and P2 are weakly distinguishable in the bone-conducted signal (in other terms, if bone and aerial signals are not markedly incongruent), and conversely.

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CondOss project.

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