Master thesis with available Ph.D scholarship:

Efforts and coordination of speech gestures

Disciplines: Acoustic phonetics, Biomechanics, Physiology, Cognition

Laboratory: GIPSA-lab, Grenoble

Supervision: Maëva Garnier, Pascal Perrier, Franck Quaine

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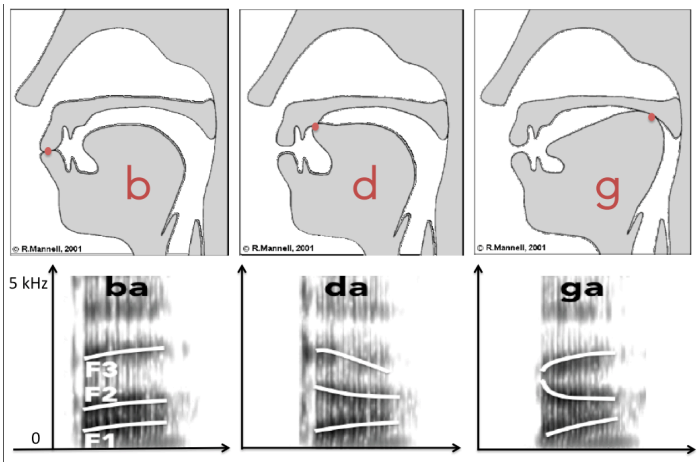
Context: This Master thesis and its possible continuation in Ph.D thesis, take part to the ANR project StopNCo, dealing with the characterization and understanding of the physiological efforts and the gesture coordination in speech production[1]. Stop consonants (/p/, /t/, /k/, /b/, /d/ or /g/) are of particular interest for the study of speech motor control, as they require a precise coordination of breathing, laryngeal and articulatory gestures in their force and timing.

General questions: Stop consonants are created by an occlusion of the vocal tract that can occur at 3 different "places of articulation" in French: at lips (for /p/ and /b/), just behind the teeth (for /t/ and /d/) or at the back of the palate (for /k/ and /g/) (see Figure). The release of this occlusion creates a short explosion noise (or "burst") and a quick variation in frequency of the vocal tract resonances ("formant transients"). These acoustic features differ significantly between the 3 places of articulation



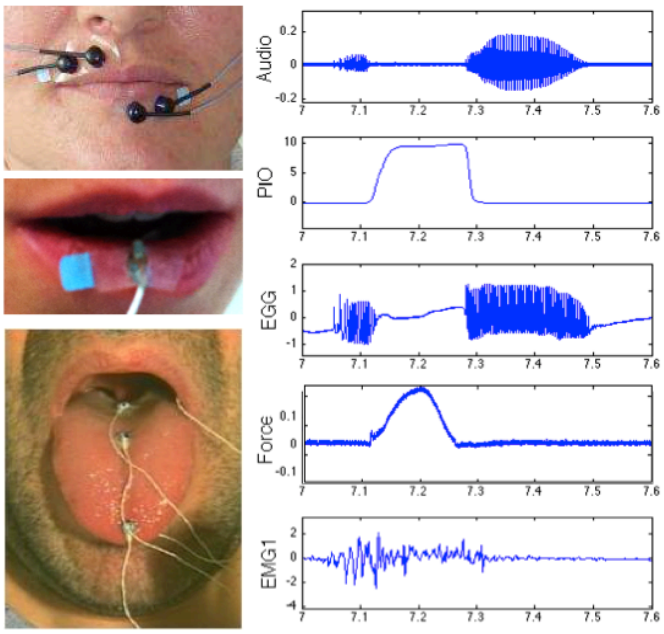
The objectives of the project are to characterize and to model:

1. by which coordination of breathing and articulatory gestures we control the finer variation of these acoustic cues (burst spectrum and formant transients)?
2. how these cues are modified when speakers speak more clearly and try to enhance the perceptual contrast between these 3 places of articulation?
3. how this control develops in children and can dysfunction in some of them?
4. how this control can vary in efficiency, i.e. in the ratio between the acoustic outcomes and the physiological efforts?

Master project: Development and test of methodologies to measure lip and tongue articulation efforts

The first step of the project will consist in implementing new methodologies to measure lip and tongue articulation efforts, using surface electromyography (EMG), force sensors and electromagnetic articulography (EMA) (see next figure).

[1] see http://www.agence-nationale-recherche.fr/en/anr-funded-project/?tx_lwmsuivibilan_pi2%5BCODE%5D=ANR-14-CE30-0017



Multiple EMG electrodes will be placed around the lips to characterize the muscle activity in different speech movements and to find global descriptors of the degree of articulation effort and fatigue.
Force sensors will be used, searching their optimal number and position on the lips and palate. We will also try to characterize the tongue and lips stiffness in order to take account of it in the calibration of the force measurements.
Finally, the articulation force estimated by these two methodologies will be confronted to the velocity peaks of tongue and lip movements measured with EMA, as well as to the perceptual self-evaluation of the effort spent by the subject.

Possible continuation in Ph.D

The Ph.D thesis will base on these methodologies to characterize the coordination of breathing, laryngeal and articulatory gestures in the production of stop consonants in healthy adult speakers. A large database will be recorded with synchronous physiological and acoustical signals, on several speakers, in controlled laboratory conditions, and for a variety of voice qualities and efforts (whisper to shout, slow to fast speech rate, etc.). Using statistical data processing and mapping techniques, you will establish a functional model able to predict the variation of acoustical outcomes from the co-variation of physiological parameters.
In a second step, a second experiment will be conducted in a more realistic and interactive situation of face-to-face communication. You will explore how speakers modify their production of stop consonants when they communicate in noisy or reverberant environments, and how they consequently modify the coordination and the effort of their speech gestures, in comparison to casual speech.

Collaborations

The project will take place at GIPSA-lab in Grenoble, under the co-supervision of Maëva Garnier (Expert in speech and cognition), Pascal Perrier (Expert in Speech motor control) and Franck Quaine (Expert in biomechanics and EMG signals), in close relationship with the medical field (a dentist and a maxillofacial surgeon).
The Master and Ph.D thesis will belong to a larger project, involving a second team that works on laryngeal efforts (including a ENT specialist), and a third team working on the development of this coordination in children (including speech therapists from Grenoble's hospital). These two teams will use the methodologies developed during the master thesis and the beginning of the Ph.D. thesis, and will bring complementary information to the functional model of stop consonants production.
During the Ph.D. thesis, we envisage to send the Ph.D candidate for about 3 months in Italy for a collaboration on high-density EMG matrices.

Skills: We are looking for an open-minded student with a main expertise in engineering (biomechanics, signal processing and/or acoustics) but with a strong interest in human-related questions (physiology, cognition, speech sciences). Programming skills (Matlab) will be appreciated, as well as an experimental approach.

Indemnities: 400 € per month during the 6 months of Master thesis.
~1400 € per month during the 3 years of Ph.D fellowship.