MODELLING MOTOR CONTROL IN SPEECH PRODUCTION

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Humans produce speech by controlling a complex mechanical apparatus in order to achieve desired speech sounds. The ways in which the speaker exploits this apparatus and the ways in which the apparatus determines the form of speech outputs is a fundamental problem for speech research but one that is as yet poorly understood. A motor command that is successful in achieving a desired output in one context may be inappropriate under slightly different mechanical conditions. Thus complexity of control may depend on the extent to which the mechanical behavior of the system varies with factors such as movement direction, speed, and position in the workspace.

In this lecture, a short review of the neurophysiological control of human movements will be presented, with a particular emphasis on how those principles can account for some phenomena observed in speech production. The Equilibrium Point Hypothesis will be presented and discussed in the context of empirical and modelling studies in which the complexity of the underlying motor commands have been investigated (Gomi & Kawato, 1996, Gribble et al., 1998). We will show why a better knowledge of the biomechanical and neurophysiological apparatus can help to understand the sensorimotor emergence of the central commands.

We will also show how kinematic variability in speech may be influenced by patterns of articulators stiffness. Empirical studies using a robotic device were used to deliver mechanical perturbations to the jaw to quantify its stiffness in the mid-sagittal plane (Shiller et. al., 2002). These studies support the idea that the pattern of jaw stiffness is affected by musculo-skeletal geometry and muscle-force-generating abilities and have a direct relationship with the variability of the jaw protrusion/rotation configurations observed in different vowels.

Finally, recent studies have demonstrated the ability of subjects to adjust the control of limb movements to counteract the effects of self-generated loads. The degree to which subjects change control signals to compensate for these loads is a reflection of the extent to which forces affecting movement are represented in motion planning. We will briefly present the results empirical and modelling studies to examine whether the nervous system compensates for loads acting on the jaw during speech production, appearing during walking and changes in body orientation (Shiller et al. 2001).