The neurophysiology of developmental stuttering and models of speech motor control

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Developmental Stuttering (DS) is a disturbance in the rhythm of speech. DS is characterized by abnormal activations of brain regions related to motor/speech function, as well as by abnormal white matter integrity, especially in left hemisphere motor/speech areas. Neuroimaging research allowed to obtain a consensus of view about some of the most involved neural networks in DS. In this context, our group was able to contribute in the understanding of the role of intracortical motor networks in DS, especially of the left hemisphere (the right hemisphere seems more involved in stuttering compensation), by means of Transcranial Magnetic Stimulation (TMS). This has been realized both on speech and not strictly speech related motor effectors, such as tongue and hand muscles. However, one of the most involved pathway is the cortico-basal-thalamo-cortical network, where supplementary motor area (SMA) plays a crucial role. Thus, we also investigated the effect of TMS on SMA and neural dynamics in DS, while registering electroencephalogram (EEG), starting from a “default” condition (participants were asked to stay at rest, with closed eyes). We evaluated TMS-evoked potentials and source localization. Resting state EEG, recorded before stimulation, was also evaluated. Findings suggest different neural dynamics between groups: normal speakers showed a stronger activation of motor/speech regions of the left hemisphere (inferior frontal regions) in a time window comprised between 65-250 ms after TMS delivery. Stutterers reacted to this “lacking” of activation by recruiting fronto-temporal (likely homologue) regions of the right hemisphere, starting from about 150 ms after TMS. Resting state EEG suggested, in DS, the presence of lower relative power of beta rhythms in sensorimotor regions, as well as higher functional connectivity between left and right frontal regions. An analysis of effective connectivity suggested that neural information flows from left hemisphere regions toward the right ones, in DS. Findings suggest that motor preparation networks (stimulated by SMA activation) are functionally abnormal in DS. SMA plays a role in demanding voluntary movements (such as speech). It is also very interesting try to combine present findings with respect to a series of theories and models of speech motor control that consider fluent speech production as well as stuttered speech. More specifically, compatibly with our TMS/EEG findings, different basal ganglia and cortical motor circuits need to exchange neural information in a continuous way, in order to produce fluent speech. Finally, findings may be useful for new treatment solutions for PDS, ranging from neuromodulation to neurofeedback.