

Specialized cortical-subcortical white matter connections support lateralized blood flow patterns during speech production

John J. Sidtis¹, Muhammed Asim Mubeen¹, Diana Sidtis^{1,2}, Babak Ardekani³

¹. Brain and Behavior Laboratory, Geriatrics Division, NKI

². Department of Communicative Disorders and Sciences, NYU Steinhardt School

³. Center for Biomedical Imaging and Neuromodulation, NKI

The specialization of the left cerebral hemisphere for speech and language became a cornerstone of functional localization in the brain following the observations of Broca and Wernicke, but interest in the effects of focal brain damage waned with the growth of functional imaging. However, brain maps derived from imaging have not always been consistent with lesion studies. Specifically, the strong left-hemisphere lateralization of speech and language has not been reflected in the bilaterality of brain activation in functional imaging. We have previously shown that despite bilateral activation during speech tasks, performance can be predicted by a combination of an increase in blood flow in the left inferior frontal region and decrease in the right caudate. In the present study, we examined the structural connections between the inferior frontal regions and the caudate nuclei using diffusion tensor imaging in normal volunteer subjects ($n = 25$) and assessed the relationships between the measures of white matter connections and speech characteristics obtained from acoustic analysis of speech samples obtained at a separate evaluation. Probabilistic tractography was used to estimate the strength of the connections between the head of the caudate nucleus (the seed) and the inferior frontal region (the target), both ipsilaterally and contralaterally. After the probabilistic connections were established for each subject, the fractional anisotropy (FA) was measured for these tracts. The probabilistic tractography demonstrated that the majority of fiber connections were ipsilateral, but contralateral connections were present as well. The inter-subject variability in the relative number of connections between the right caudate and the left inferior frontal region was significantly associated with the inter-subject variability in the acoustic measures of stability for frequency (Spearman's coefficients for the repetition of the syllables /pa/ = 0.46; /ta/ = 0.5; /ka/ = 0.46; /pataka/ = 0.52) and amplitude (Spearman's coefficients for the repetition of the syllables /pa/ = 0.43; /ta/ = 0.5; /ka/ = 0.49; /pataka/ = 0.49) in the speech signals, echoing the significant relationship in blood flow in these regions during speech. A similar pattern was found for FA. No other cortical-striatal connections demonstrated these relationships with speech characteristics. These results suggest that white matter connections may share some degree of functional specialization with the structures that they connect.