During auditory processing, sensory information enters primary auditory cortex (ACx) through thalamus; auditory cortices then project intratelencephalically (including onto each other) and to a number of subcortical targets, such as thalamus and inferior colliculus. The contribution of the specific elements of neural circuits in this long-range functional connectivity is poorly understood. Pyramidal neurons of layer 5 are the major neural output class of the neocortex and can be classified based on their projection targets, morphology, and firing type. Regular spiking (RS) neurons have slender dendrites and project intratelencephalically. Intrinsic bursting (IB) neurons have thick-tufted, heavily arborizing dendrites and project to subcortical areas. To investigate the synaptic physiology of long-range afferents onto these neuronal classes (each labeled by retrograde tracers injected into their projection targets), we expressed light-activated membrane protein, channelrhodopsin, in the fibers arriving from the contralateral ACx and ipsilateral thalamus.

We discovered that RS and IB neurons receive significantly different levels of monosynaptic excitatory input from both thalamic and callosal fibers. It was shown that the callosal input “gates” current-evoked action potentials by inhibiting them in RS but not IB neurons. We also discovered that the layer-5 RS neurons receive input comparable in strength and latency to those to layer-4 neurons (traditionally thought of as the primary target of thalamic input) and greater than those to layer-2/3 and layer-5 IB neurons. These data provide novel insight into the local cortical circuitry involved in linking the long-range colossal and thalamic afferents to intratelencephallic vs. subcortical efferents of ACx.