Functional connections in the human temporal cortex revealed by Granger analysis of near-field auditory evoked potentials

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The Granger method defines causal influences in terms of stochastic processes: one stochastic process is causal to another if at a given time point the autoregressive predictability of the other process is improved by including measurements from the immediate past of the first one (Granger, 1969). Previous investigators have used the GC to reveal directional interactions in the brain in a variety of experimental settings (Baccala and Sameshima, 2001; Brovelli et al, 2004; Hesse et al., 2003). Here, we used the GC analytical method to evaluate the patterns of directional influence between two different regions of human auditory cortex: the primary (Heschl's gyrus, HG) and association (posterior lateral superior temporal gyrus, PLST) areas during passive listening. Patients undergoing diagnostic epileptic surgery were chronically implanted with depth electrodes in their HG on the non-dominant side, and surface electrodes over the nearby PLST area. AEPs to repetitive acoustic stimulations (click, tone, noise and voice sounds) were collected simultaneously during postoperative period with patients in the awake state. Preprocessing for stationarity was achieved by high-pass filtering the single trial AEP at 15 Hz followed by normalization of variance. Granger causality profiles were computed on based on single trial auditory evoked potential (AEP) between two recording sites. The averaged GC results were pooled across patients and sound stimuli. Statistically significant changes in directional causality were found: large incremental drives appeared in the direction from HG to PLST, and smaller decremental drives appeared in the opposite direction. These results revealed for the first time the neural interactions within the human superior temporal gyrus during passive listening. Results were taken as evidence for a hierarchical system in the neural processing of sounds, with mainly incremental feed-forward influences from primary to association auditory areas.

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