Identifying computable functions and their spatiotemporal distribution in the human brain

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An important goal for cognitive neuroscience is to identify the specific computations carried out by the human brain and to relate these to specific spatio-temporal patterns of neural activity. This can be achieved by testing computationally explicit models of neural functions against spatiotemporally accurate measurements of brain activity. We report here a new approach that can search representations of neural activity, captured by combined electro- and magneto-encephalographic (EMEG) whole brain recordings, to determine the neural distribution of appropriately and rigorously defined computational functions. Focusing on speech comprehension, we show how this technique can locate computational functions relating to two very different aspects of this complex process: signal based processes related to the extraction of perceptual features (loudness and pitch) and knowledge-based processes operating on the listener's representation of words in their language. Using a combination of signal correlation techniques and a temporal moving window to search EMEG source space on a searchlight basis, we are able to identify a loudness process running in L and R planum temporale at lags of 65-70 ms and 75 ms, a pitch process close to L Heschl's gyrus at 65 ms and R planum temporale at 85 ms, and a primary set of word-recognition processes running in L and R temporal lobes at 235-250 ms. These successful applications of the technique demonstrate its potential to map out the computational functions underpinning complex neurocognitive capacities.