Title: “The emergence of the arrow of time in whole-brain dynamics”

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Abstract:

Living organisms operate far from the thermodynamic equilibrium. By consuming and dissipating internal energy, they break the detailed balance of the transitions between the underlying microscopic states, giving rise to irreversible dynamics, i.e an “arrow of time”. While these nonequilibrium phenomena have been studied on the microscopic scale, it is still unclear how these dynamics emerge at larger scales. In this work, we characterize the emergence of the arrow of time in the human brain at the large scale. Specifically, we use whole-brain neuroimaging data from HCP during rest and cognitive tasks, and we compute a decomposition of the irreversibility into the dynamics of the individual elements, and a series of contributions of the correlations among pairs, triplets, and higher-order interactions. Our results show that the pairwise dynamics account for more of the local irreversibility than higher-order dynamics. Previous studies showed that groups of neurons break the detailed balance in a pairwise way. Taken together, these results suggest that this hierarchy in which the interaction of pairs of elements drives the irreversible dynamics is a scale-free phenomenon in the brain.