THE LACK OF TEMPORAL BRAIN DYNAMICS ASYMMETRY AS A SIGNATURE OF IMPAIRED CONSCIOUSNESS STATES

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Life is a constant battle against equilibrium. From the cellular level to the macroscopic scale, living organisms as dissipative systems require the violation of their detailed balance, i.e. metabolic enzymatic reactions, in order to survive. We present a framework based on temporal asymmetry as a measure of non-equilibrium. By means of statistical physics, it was discovered that temporal asymmetries establish an arrow of time useful for assessing the reversibility in human brain time series. Previous studies in human and non-human primates have shown that decreased consciousness states, such as sleep and anaesthesia, result in brain dynamics closer to equilibrium. Furthermore, there is a growing interest in the analysis of brain symmetry based on neuroimaging recordings, and since it is a non-invasive technique, it can be extended to different brain imaging modalities and applied at different temporo-spatial scales. In the present study, we assess the degree of non-reversibility or the arrow of time by comparing pairwise time series of both the original and artificially generated time-reversed version. The degree of asymmetry between the two series, original and reversed version, is calculated through the time-shifted Pearson's correlation. For the first time, we conduct a reversibility analysis in human functional magnetic resonance imaging data in patients suffering from disorder of consciousness. Our findings indicate that decreased consciousness states result in brain dynamics closer to equilibrium, with a decrease in asymmetry and non-stationarity of brain signals. Our results in impaired consciousness states verify the tendency of reversible brain dynamics previously demonstrated in healthy lowered levels of consciousness. We expect that this work opens the way for assessing biomarkers for patients' improvement and classification, as well as motivating further research on the mechanistic understanding underlying states of impaired consciousness.