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Canonical decomposition of ictal EEG reliably detects the seizure onset zone.

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Rationale: The aim of this study was to develop and validate an ictal source localisation algorithm based on the extraction of the potential distribution of the ictal atom from electroencephalograms (EEG) using the higher-order Canonical Decomposition method, also referred to as the CP model.
Methods: After wavelet-transformation of all EEG channels, a three-way tensor was obtained with dimensions (channel x time x frequency).
The CP model decomposes in a unique way a higher-order tensor in a minimal sum of rank-1 'atoms'. Each atom was the outer product of a spatial, a temporal and a frequency component. The potential distribution of the epileptic activity is given by the spatial component of the epileptic atom. This epileptic atom can be visually determined or automatically detected when seizure activity can be seen in the EEG.
Thirty-seven ictal EEG recordings from patients with refractory partial epilepsy who underwent a full presurgical evaluation were included. Seizure semeiology, structural MRI, interictal EEG, subtraction ictal SPECT co-registered with MRI (SISCOM) and neuropsychological assessment were concordant, and reliably defined the epileptogenic zone in all patients. Ictal EEG findings were not an inclusion criterion. SISCOM was used as the golden standard for ictal source localisation. The results of this automatic method were compared with human reading: the ictal EEGs were presented to a clinical neurophysiologist/epileptologist who was blinded to all other clinical and localising data.
Results: The newly proposed method correctly localised the seizure onset zone in 34 of 37 cases (92%), and outperformed the human reader, who correctly localized 21 of 37 cases (57%) ($p = 0.00024$). Muscle artifacts did not influence the results of the CP decomposition. The computation of the decomposition only takes a few seconds.
Conclusion: Canonical decomposition of ictal EEG is a new, very sensitive, fast and easy to implement method to define the seizure onset zone. It is highly insensitive to muscle artifacts, approaches the sensitivity of early ictal SPECT and significantly outperforms human visual analysis of ictal EEG.

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