# Uncovering low-dimensional structures in high-dimensional electrophysiological recordings of epilepsy

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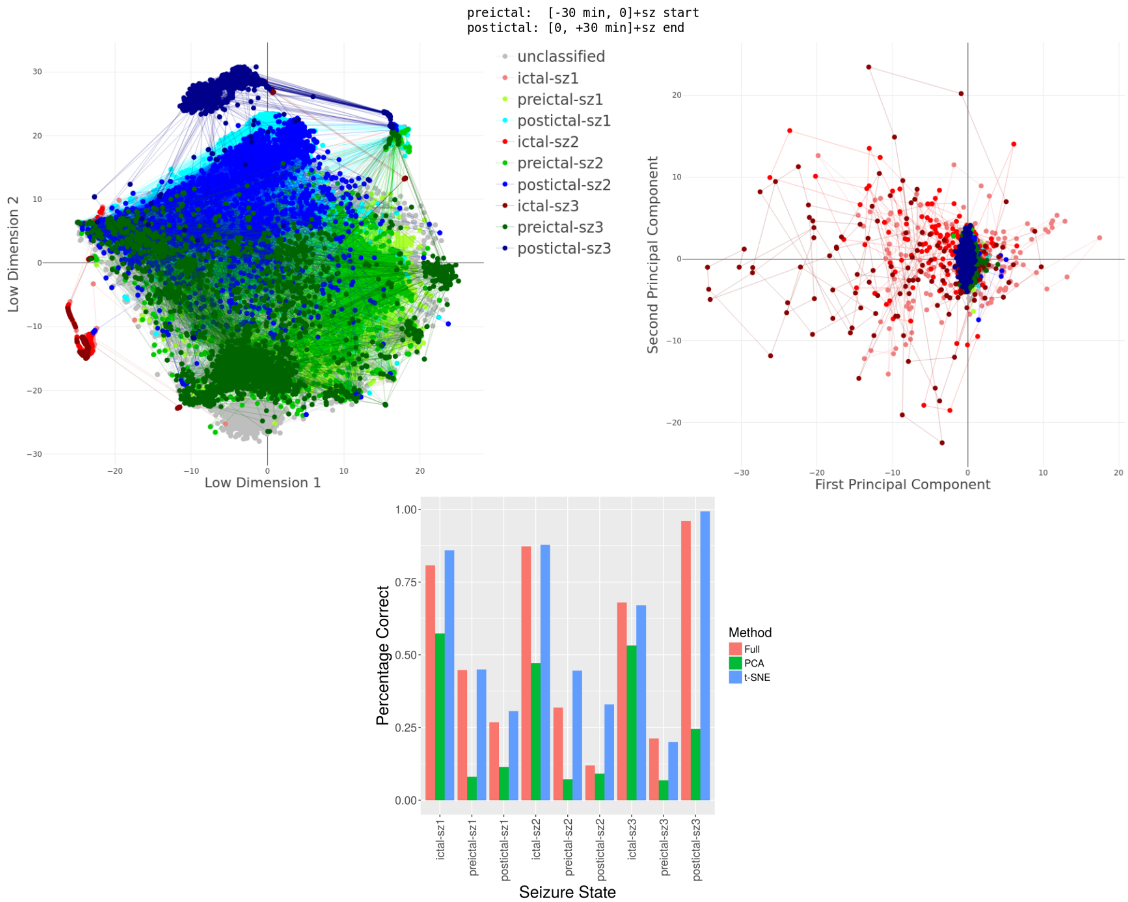
**Abstract**

Advances in neural recording technology and signal processing now yield very high-dimensional descriptors of brain activity. However, the essential process of visual inspection in a high-dimensional space can become too challenging. Thus, it is useful to derive low-dimensional representations, especially in applications to neurological disorders. We are evaluating methods for such representations; e.g., t-distributed stochastic nonlinear embedding (t-SNE), hidden Markov models, principal components analysis (PCA). Here, we focus on t-SNE. Recordings from a 10x10 (4x4 $mm^2$) microelectrode array, intracortically implanted in a patient with focal epilepsy, were segmented in 1 s time windows, represented in a high-dimensional space (2,072 features related to LFP power spectra, multi-unit activity (MUA) counts and their correlation matrix), and projected to low-dimensional spaces via t-SNE and PCA. Coordinates of points in Fig. 1a are t-SNE features from a recording segment including three "spike-and-wave" seizures (colors indicate preictal, ictal, and postictal states; shades mark different seizures; lines connect temporally adjacent time windows). Qualitatively, different states appear well separated, transitions between states are not gradual but abrupt, and ictal features are highly stereotypical (i.e., different from non-ictal ones and similar across seizures). In contrast, PCA failed to separate non-ictal features (Fig. 1b). We quantified the quality of low-dimensional representations by classifying (k-nearest-neighbors) time windows from a given seizure and state (e.g., ictal windows from seizure 1) using labeled data from all the other seizures and states. In all cases, t-SNE performed better than PCA. Classification accuracy using t-SNE was comparable to, and sometimes better than, that using the full high-dimensional representation (Fig. 1c). Hence, t-SNE low-dimensional representations appear useful for visualizing and classifying high-dimensional epileptic recordings, preserving relevant information and possibly eliminating noise.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