Brain electrical activity obeys Benford's law.

Abstract:
Monitoring and automated online analysis of brain electrical activity are frequently used for verifying brain diseases and for estimating anesthetic depth in subjects undergoing surgery. However, false diagnosis with potentially catastrophic consequences for patients such as intraoperative awareness may result from unnoticed irregularities in the process of signal analysis. Here we ask whether Benford's Law can be applied to detect accidental or intended modulation of neurophysiologic signals. This law states that the first digits of many datasets such as atomic weights or river lengths are distributed logarithmically and not equally. In particular, we tested whether data obtained from electrophysiological recordings of human patients representing global activity and organotypic slice cultures representing pure cortical activity follow the predictions of Benford's Law in the absence and in the presence of an anesthetic drug. Electroencephalographic (EEG) recordings from human subjects and local field potential recordings from cultured cortical brain slices were obtained before and after administration of sevoflurane. The first digit distribution of the datasets was compared with the Benford distribution. All datasets showed a Benford-like distribution. Nevertheless, distributions belonging to different anesthetic levels could be distinguished in vitro and in human
EEGs. With sevoflurane, the first digit distribution of the in vitro data becomes steeper, while it flattens for EEG data. In the presence of high frequency noise, the Benford distribution falls apart. In vitro and EEG data show a Benford-like distribution which is altered by sevoflurane or destroyed by noise used to simulate artefacts. These findings suggest that algorithms based on Benford's Law can be successfully used to detect sevoflurane-induced signal modulations in electrophysiological recordings.