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BOLD Noise Assumptions in fMRI

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Abstract

This paper discusses the assumption of Gaussian noise in the blood-oxygenation-dependent (BOLD) contrast for functional MRI (fMRI). In principle, magnitudes in MRI images follow a Rice distribution. We start by reviewing differences between Rician and Gaussian noise. An analytic expression is derived for the null (resting-state) distribution of the difference between two Rician distributed images. This distribution is shown to be symmetric, and an exact expression for its standard deviation is derived. This distribution can be well approximated by a Gaussian, with very high precision for high SNR, and high precision for lower SNR. Tests on simulated and real MR images show that subtracting the time-series mean in fMRI yields asymmetrically distributed temporal noise. Subtracting a resting-state time series from the first results in symmetric and nearly Gaussian noise. This has important consequences for fMRI analyses using standard statistical tests.