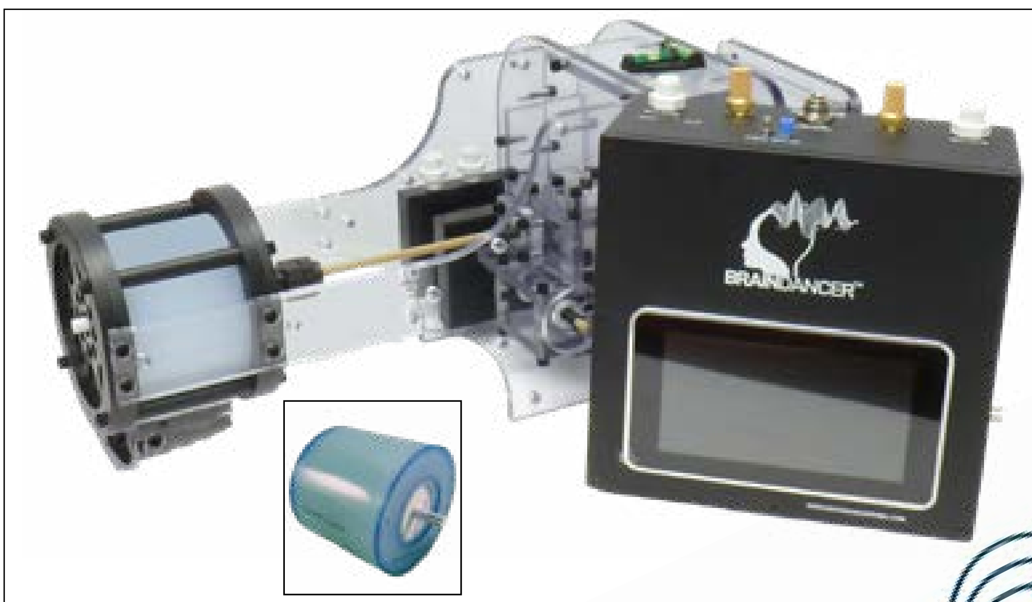
BRAINDANCER™

fMRI Dynamic Phantom for Resting-State Brain Networks

BRAINDANCER™

Improving Signal to Noise Ratio during fMRI studies

- Cleaner signal
- Stronger results
- Better integration of fMRI data across scanners and sites



ALA Scientific Instruments

BRAINDANCER™

fMRI Dynamic Phantom for Resting-State Brain Networks

The ability to minimize and correct for scanner-induced distortion is a fundamental unmet need in modern task-free ("resting-state") fMRI. For task-based fMRI, subtracting noise from signal is straightforward, since a task activates the brain reliably more under one condition (signal) than another (noise). However, for taskfree analyses, the 'baseline' fluctuations themselves also include the 'signal'.

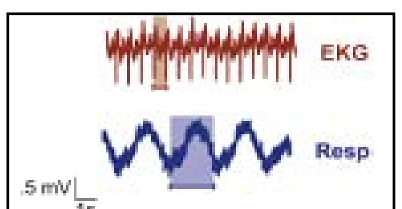
The BrainDancerTM is a commercial-grade dynamic phantom, designed to identify and correct systematic scanner-induced noise using our deep learning algorithm, NoiseNetTM. The BrainDancerTM dynamic phantom not only improves the signal-to-noise ratio, but can also be used for standardization of protocols and normalization between scanners The BrainDancerTM is a commercial-grade dynamic phantom, designed to identify and correct systematic scanner-induced noise using our deep learning algorithm, (available as freeware). The Braindancer not only improved the signal-to-noise ratio, but can also be used for standardization of protocols and harmonization across scanners.

- Pneumatically controlled movement
- Rotating inner cylinder to produce T2* changes within voxels
- Imitates BOLD amplitudes of human brains
- Externally triggered programmable sequence
- Deep learning algorithm available for temporal noise estimation

BrainDancer w/Cartridge and Controller

Sources of First Level Noise in fMRI Data

1. **Physiological Noise** (cardiac and respiratory effects causing changes in blood flow, affecting T1 and T2*).



Ground-Truth Measurements Available

2. **Subject Head Motion** (causes temporally correlated-non-stationary noise and induces spurious correlations).

Motion Estimation Using Image Registration

3. **Scanner Induced Noise** (affects detection sensitivity of resting-state networks).

No Ground-Truth Measurements Available

Why is fMRI not used as a neurodiagnostic tool?

1. A critical rate-limiting factor for use of fMRI in clinical practice is fMRI's poor signal-to-noise (SNR) profile, hence limited sensitivity, for single-subject level analysis.
2. Traditional reliance on using group-level statistical analysis for inference and prediction.

Types of Scanner induced

1. Thermal Noise

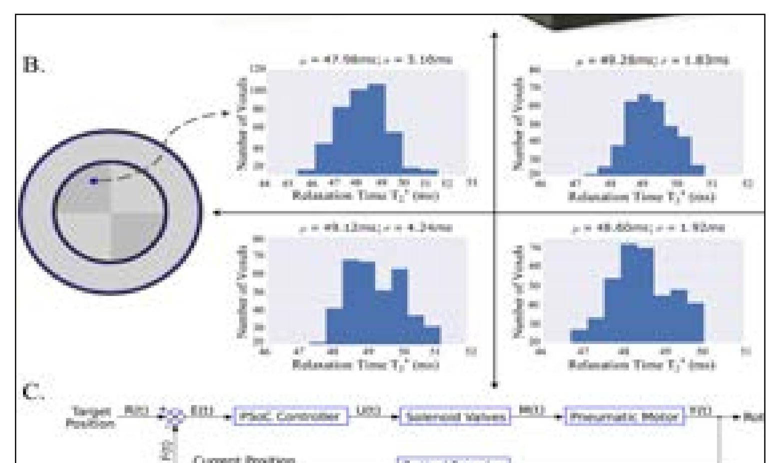
- Independent of MR image intensity; Additive noise.
- Arise due to a random process like Brownian motion of ions in MR electronics or the human subject, external RF noise sources in the scanner room, RF spikes due to intermittent contact between metallic components.

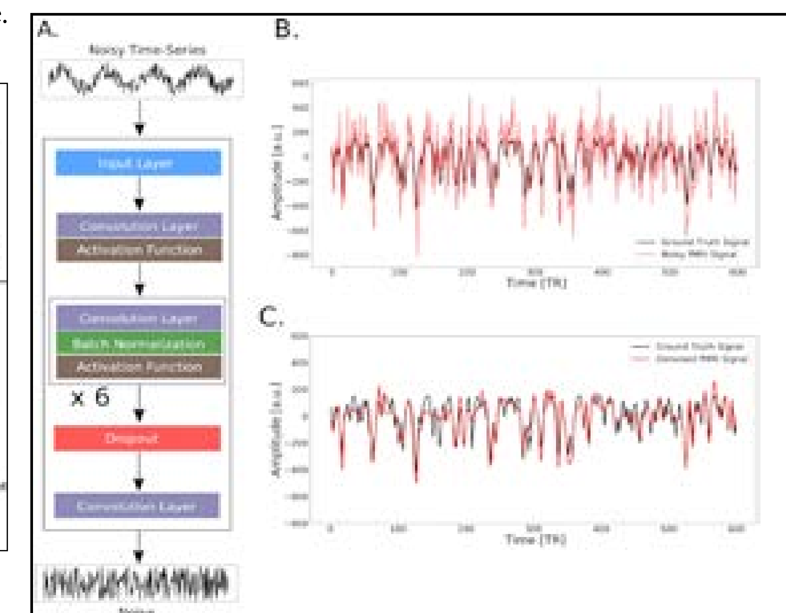
2. Multiplicative Noise (Scanner Instability)

- Proportional to MR image intensity/Signal-dependent noise.
- Time-varying gradients in fast imaging methods, such as interleaved echo-planar imaging (EPI), require high-gradient amplitudes and slew-rates, pushing the scanner to its limits and causes image artifacts due to k-space trajectory deviations.
- Scanner instabilities may be caused by variation in flip angle over time, imperfections in gradient system, time-varying eddy current effects, or gain changes in transmit and receive chains.

Solution:

- Using ground truth brain-like dynamic signals, we quantified a Standardized Signal-to-Noise Ratio (ST-SNR) and Dynamic Fidelity; these demonstrated wide variance across scanners, even for the "best case scenario" of high-performance scanners utilizing acquisition parameters individually optimized by a highly experienced MR physicist.
- Using the dynamic phantom generated ground-truth, we quantified the ratio of scanner instability to background noise in fMRI time-series, thereby identifying multiplicative versus thermal noise components.
- Using the dynamic phantom generated ground-truth, we quantified scanner-induced non-linearity in fMRI response.
- Using the dynamic phantom generated ground-truth, we evaluated the efficacy of applying random matrix theory to remove scanner-induced noise; thereby, demonstrating the utility of the dynamic phantom for comparing retrospective denoising techniques against a ground-truth.
- We designed a data-driven temporal filter and observed robust increases in ST-SNR and Dynamic Fidelity of fMRI time-series after denoising.
- Removing scanner-induced variance from human fMRI data increased the detection sensitivity of brain networks, visible even at the single-subject level.





Scientific Instruments

Furthering Life Science through Innovative Instrumentations

BRAINDANCER™

BrainDancer Specifications	
Dimension & Weight	58.5cm x 27.5cm x 23.5cm , 13.8 lbs (WOA: 13.8 lbs)
Cartridge & Coil Weight	Cartidge: 3.2 lbs , Coil Load(Gel): 1.58 lbs
Head Coil Fit & Air Tube	Min Fit: 16cm x 15.2cm , Tube: 7.6cm (Max: 15.2cm)
Fiber Optic	10m
Controller Specifications	
Dimensions & Weight	25.5cm x 25.5cm x 11.5cm , 7.6 lbs
Touch Screen	7” color display
Power & Input	Universal power supply (brick) , 24V 6A DC input
Connectivity	USB , Ethernet , TTL trigger in , USB Flash Drive
Air Input	70-90 PSI (4.83-6.21 Bar)

Latest BrainDancer References

https://doi.org/10.1016/j.neuroimage.2020.117584

https://doi.org/10.1162/imag_a_00309

https://doi.org/10.1073/pnas.2416433122