Optimal Denoising for Naturalistic fMRI Data

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BACKGROUND

- A growing trend in neuroscience is to use movies, television shows, video games, or audiobooks to study the human brain in more ecologically valid and naturalistic settings.
- Naturalistic stimuli, like movies, draw viewers into a shared experience, such that in neurotypical individuals we can observe synchronization of the fMRI signal fluctuations across subjects engaged with the same stimulus – this is often referred to as inter-subject correlation (ISC)[1]

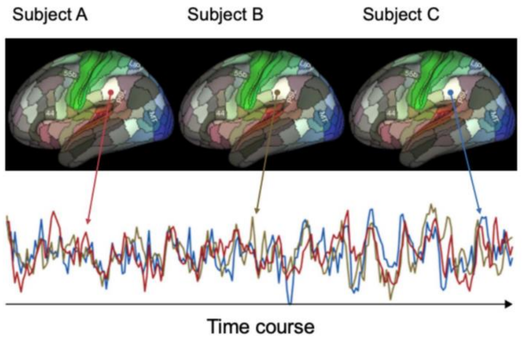


Figure 1. A representative image demonstrating inter-subject correlation across three hypothetical subjects.

- It is possible we may be able to use such techniques to examine neural abnormalities in. most common neurological disorders, like epilepsy.
- Little is known currently about optimal methods for preprocessing naturalistic fMRI data
- Here, we investigated removal of motion artefacts from naturalistic fMRI data using Independent Components Analysis-based Automated Removal of Motion Artefacts (ICA-AROMA)[2] along with various sets of motion regressors of increased complexity

METHODS

- Data collected through the EpLink program of the Ontario Brain Institute

- Patients (n=18) and controls (n=24) were scanned while watching an edited clip of Alfred Hitchcock's 1961 TV episode "Bang! You're Dead"

Figure 2. The movie used for the study.

- Data were preprocessed using the *fMRIprep* pipeline
- Data were denoised seven ways using a general-linear model, which included a number of motion regressors (see **Table 1**)
- Glasser parcellation[3] divided each cortical hemisphere into 180 regions. ISC was calculated and patterns were examined at whole brain and regional levels[4]

Table 1. The motion regressors contained within each set used to denoise fMRI data. Set 3 contains the fewest amount of motion regressors while Set 5 is the most complex with the highest amount of motion regressors. Colour denotes the presence of a regressor, whereas white denotes the absence of one.

	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7
fMRI pre-processing							
ICA-AROMA							
csf, white matter, x, y, z, pitch, roll, yaw							
Derivatives, power, and derivatives of power of csf, white matter, x, y, z, pitch, roll, yaw							
Global signal (and derivatives, power, and derivatives of power)							
Framewise displacement, rmsd, dvars (and standard deviation dvars)							

RESULTS

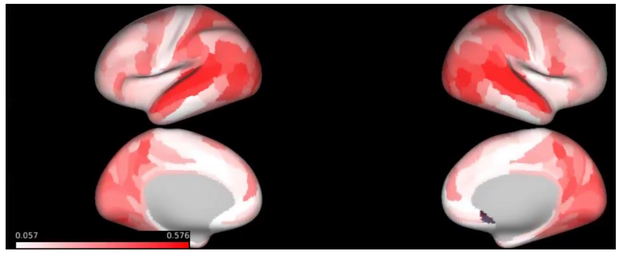
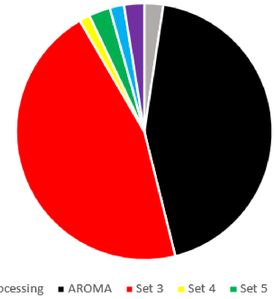


Figure 3. ISC levels within the brain, averaged across patients and controls. Red indicates higher correlation values, and white indicates lower correlation values

- Denoising with Sets 2 and 3 produced significantly greater ISC values
- Significant drop in ISC values with other sets and without AROMA



- ISC levels were found to be the highest in the auditory cortex
- This is consistent with previous literature[5, 6]

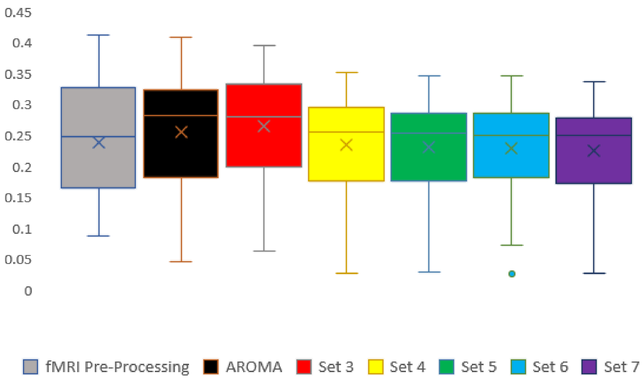


Figure 4. Boxplots of the various sets of motion regressors applied to the data and the average ISC levels for each set

- Regional ISC analysis revealed that AROMA and Set 3 produced the most maximum ISC values across regions
- Both patients and controls displayed this pattern

DISCUSSION

- To maximize sensitivity to signal, naturalistic fMRI data should be denoised with ICA-AROMA, with possible addition of only basic motion regressors (csf, white matter, motion confounds)
- The addition of more complex motion regressors may reduce signal and would thus be less optimal for use
- This study is important to suggest the use of certain motion regressors for optimal clinical use in epilepsy assessment
- To assess further clinical utility, future studies should be conducted on naturalistic fMRI in order to determine any potential alternate optimal denoising methods

REFERENCES

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SUPPORT This project is supported by a CIHR grant, BrainsCAN and NSERC awarded to IJ