The Importance of Applying Physiological Regression to rsfMRI

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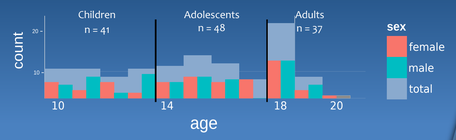
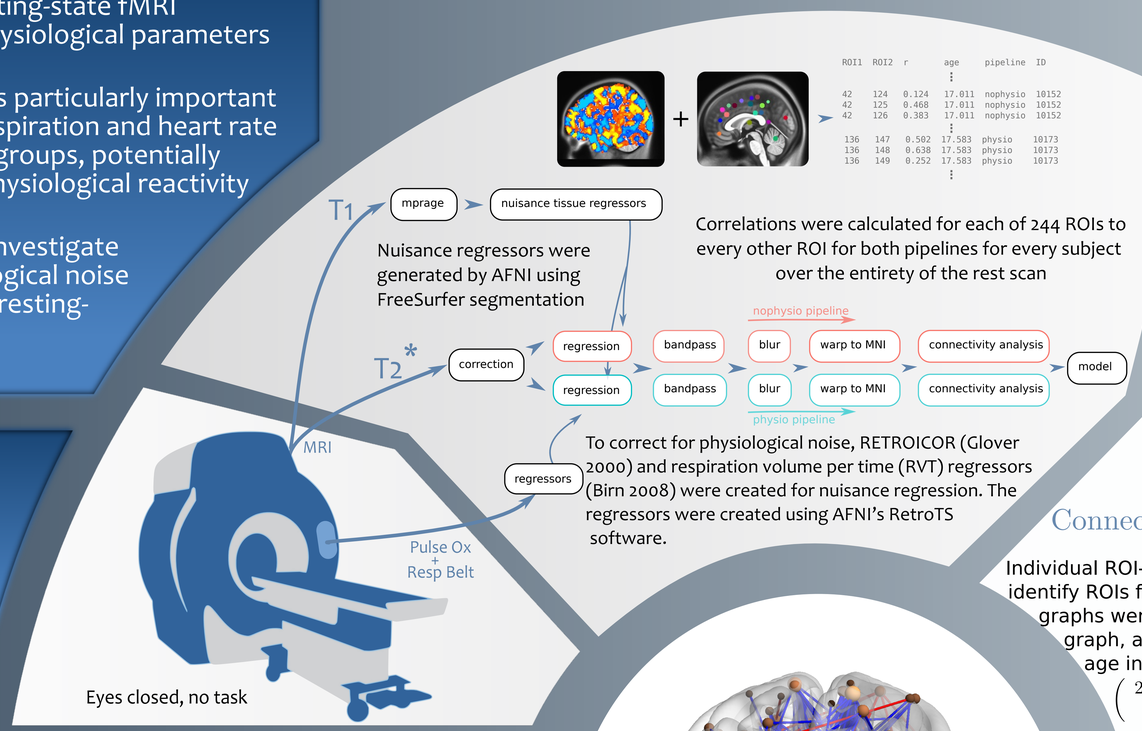
Intro

- Existing evidence suggests that resting-state fMRI connectivity can be confounded by physiological parameters (Birn et al., 2008; Chang et al., 2009).
- Controlling for physiological noise is particularly important for developmental studies because respiration and heart rate could systematically differ across age groups, potentially reflecting age-related differences in physiological reactivity to the MR environment.
- The goal of the current study is to investigate whether or not correcting for physiological noise could alter developmental changes in resting-state correlations.

Participants



n=126 from 10 to 20 yro ($\bar{x}$=15.45)



Change to developmental differences in connectivity estimates were explored with physio and nophysio pipelines in a mixed effects model for every ROI-ROI pair using centered inverse age and pipelines as predictors. The R packaged lme4 was used.

$$\text{Connectivity} = \text{Pipeline} * (\text{age} - \overline{\text{age}})^{-1}$$

Individual ROI-ROI model results were concatenated to identify ROIs frequently affected by physiology. Two separate graphs were created: an unthresholded a priori ROIs graph, and a graph comprised of all significant physio-age interacting connections in the $\binom{244}{2}$ models

Results and Conclusions

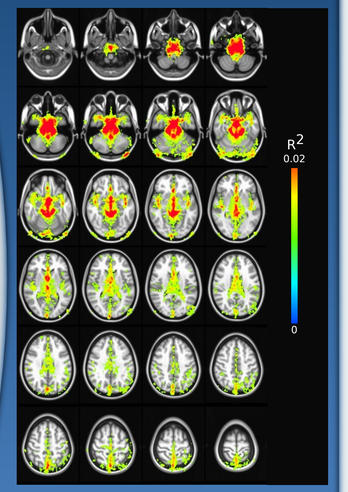
1. Physiological noise is most prominent in subcortical,cerebellar, and midline structures, explaining up to 2% of signal variance

2.However, including physiological regressors into the regression model significantly alters developmental conclusions of age-related changes in rsfMRI connectivity

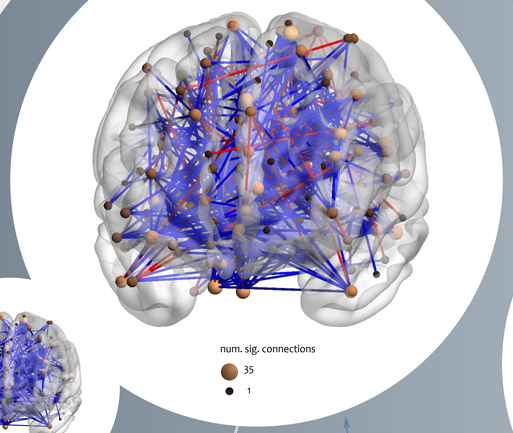
3. Cerebellar-cortical,subcortical-cortical connections are most affected. Including connections with important ROIs such as the cerebellum, the putamen, the thalamus, midline structures, and multiple frontal regions.

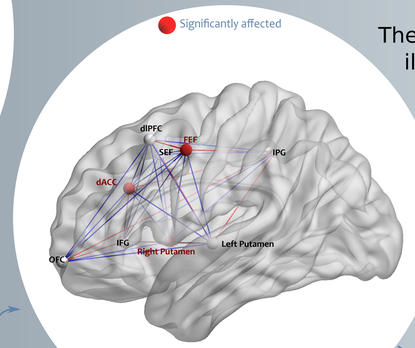
4. Including physiological regressors could reduce false age-related decrease in functional connectivity, or increase sensitivity in finding age effects.

Physiological noise is most prominent in brain stem, subcortical, cerebellar, and midline structures



2% of the variance in rsfMRI signal is explained by physiological parameters. There is no developmental change in the singal explained by physiological paremeters across age groups





The a priori ROI graph illustrates the effect of accounting for respiration and cardiac measures has on modeling connectivity over development

All ROIs

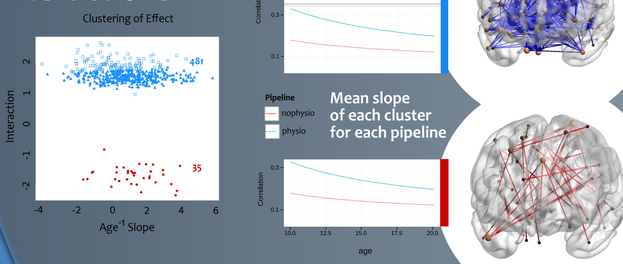
a priori ROIs only

+/- interaction

Physiologically significant ROIs

Significant Interactions

Negative and Positive interactions



Physiological Recordings

Respiration and heartbeat were continuously recorded using a respiration belt and a pulse oximeter attached to the left index finger.

Regressors

- 5 RVT regressors, time shifted versions of one another (Birn et al., 2008)
- 8 Retroicor, 2 sine and 2 cosine for each card and resp (Glover et al., 2000)

Regions of Interest

ROIs for full brain coverage

5mm radius around 244 coordinates adapted from Power et al. (2011)

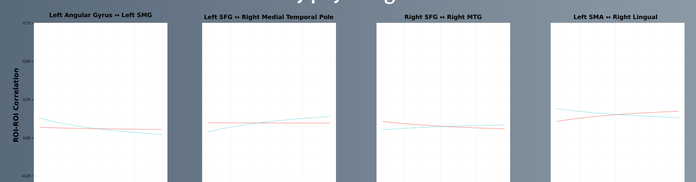
A priori ROIs

Subset of ROIs preselected with expectation of correlation changes along developmental

	x	y	z
dlPFC	-35	20	51
FEF	-44	2	46
IPG	49	-42	45
SEF	-1	15	44
dACC	0	30	27
R Putamen	23	10	1
L Putamen	-31	-11	0
IFG	53	33	1
OFC	-18	63	-9

ROIs with connectivity most affected by physiological noise

Findings of developmental changes in functional connectivity altered by physiological noise

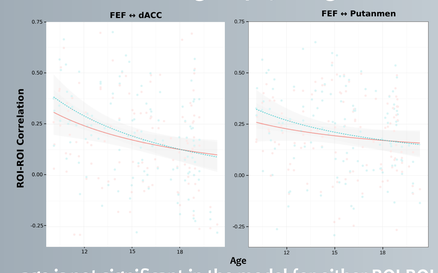


Pipeline

nophysio

physio

Developmental changes in connectivity found after correcting for physiological noise



age is not significant in the model for either ROI-ROI

Future Directions

- ☐ Test the effectiveness of using physiological signal estimation software (PESTICA) in absence of real physiological signal recordings
- ☐ Test if physiological noise removal alters graph theory metrics

References

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Support NIMH MH080243

Source Code
https://github.com/WillForan/physioCompare