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tedana A growing multi-echo fMRI ecosystem

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tedana.readthedocs.io

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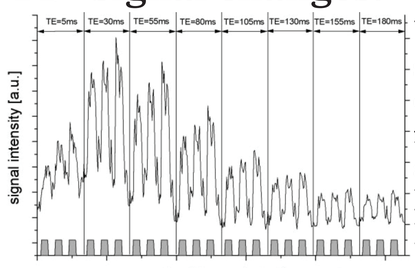
6 EPFL Neuro X Institute
7 Northwestern
8 LINC lifespan informatics & neuroimaging center Penn University of Pennsylvania
9 bcbl BASQUE CENTER ON COGNITION, BRAIN AND LANGUAGE

WHAT IS MULTI-ECHO FMRI?

The fMRI BOLD response is T2* weighted and the relative response magnitude varies with echo time (TE). Head motion and some scanner artifacts are S0-weighted and do not vary with TE.

Multi-echo fMRI involves collecting several TEs during one acqusition and the information can be used to better isolate T2* signal changes.[1,2]



When a participant does the same finger tapping task with different TEs, the response magnitude varies with TE in a predictable manner.
Image from Barth et al NMR Biomed 2001

tedana is

1. Open software to test and improve multi-echo methods with an emphasis on an ICA-based denoising method[4,5]

2. Tools to make ICA-based denoising methods adaptable & understandable

3. A *community* and resources for people interested in multi-echo fMRI whether or not they use tedana software

WAYS TO CONNECT

Multi-echo questions: https://neurostars.org with 'multi-echo' or 'tedana' tags

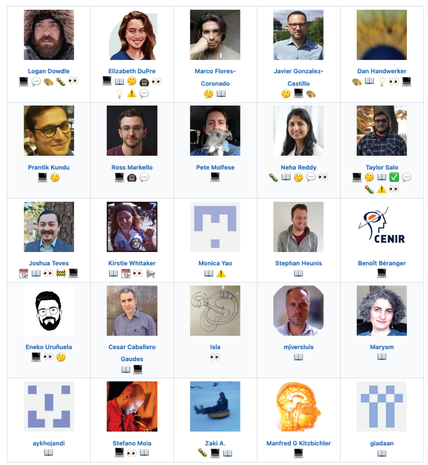
Subscribe to the tedana (low volume) newsletter: http://tinyletter.com/tedana-devs

Join the conversation: mattermost.brainhack.org/brainhack/channels/tedana

Code and resources are open source. Contribute at: https://github.com/ME-ICA/tedana

A list of multi-echo content at OHBM: https://github.com/ME-ICA/ohbm-2023-multiecho

CONTRIBUTORS



and you!

REFERENCES

Tedana publication:
DuPre, Salo et al., (2021). "TE-dependent analysis of multi-echo fMRI with tedana." Journal of Open Source Software, 6(66), 3669, https://doi.org/10.21105/joss.03669

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2. Posse, S., et al. (1999). "Enhancement of BOLD-contrast sensitivity by single-shot multi-echo functional MR imaging." Magn Reson Med 42(1): 87-97.
3. Barth, M., et al. (2001). "Characterization of BOLD activation in multi-echo fMRI data using fuzzy cluster analysis and a comparison with quantitative modeling" NMR Biomed 14:484-9.
4. Kundu, P., et al. (2012). "Differentiating BOLD and non-BOLD signals in fMRI time series using multi-echo EPI." NeuroImage 60(3): 1759-1770.
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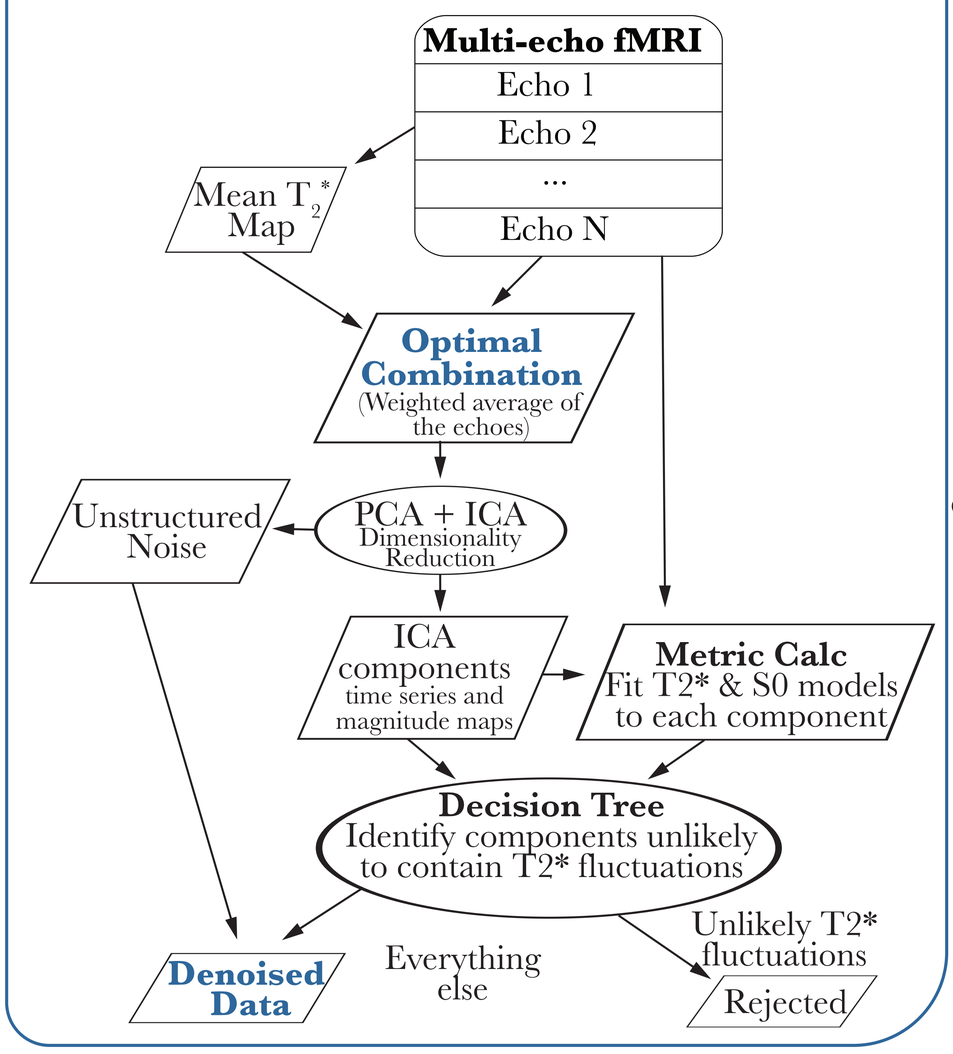
TEDANA ALGORITHM



IMPROVEMENTS DURING THE PAST YEAR

Modularized "decision tree" step where ICA components are set as accepted or rejected

Multiple decision trees can be included with tedana and users can input their own tree

Now possible to add other metrics, like head motion or respiration, into a decision tree

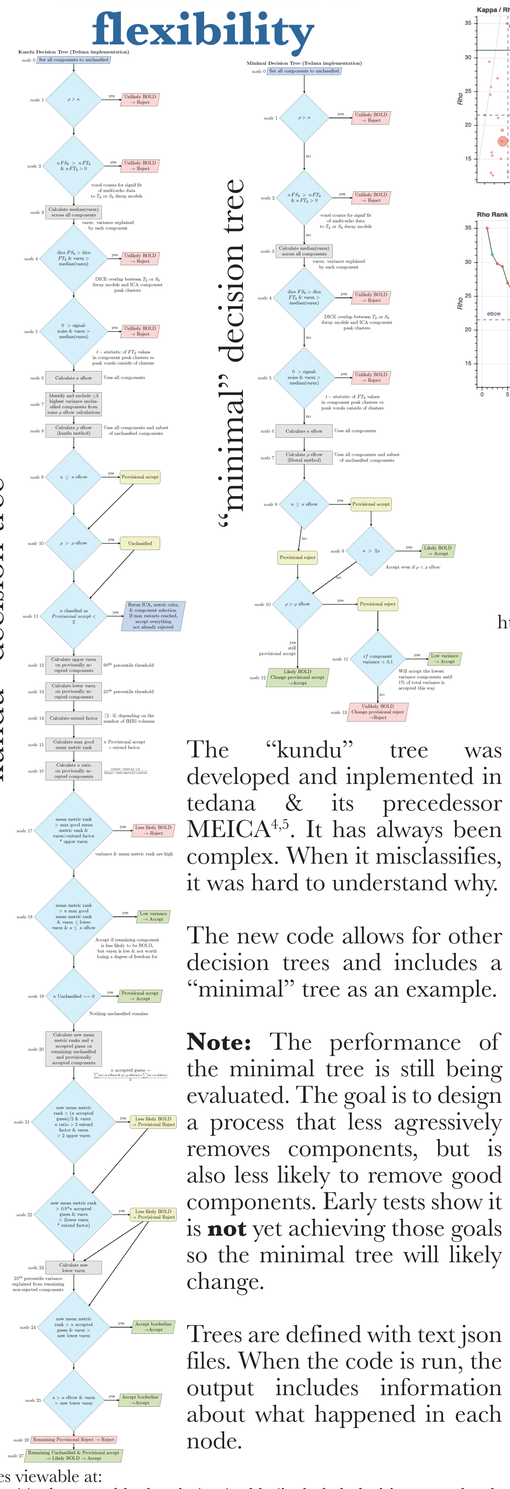
Full provenance tracking of the component classification process so that it is easier to see in which steps classifications changed.
Description of new file outputs:
https://tedana.readthedocs.io/en/stable/outputs.html

New program 'ica_reclassify' can manually change component classifications

Over 10000 new & 4000 cut lines of code

Full release notes:
https://github.com/ME-ICA/tedana/releases/tag/23.0.1

Component classification flexibility



The "kundu" tree was developed and inplemented in tedana & its precedessor MEICA[4,5]. It has always been complex. When it misclassifies, it was hard to understand why.

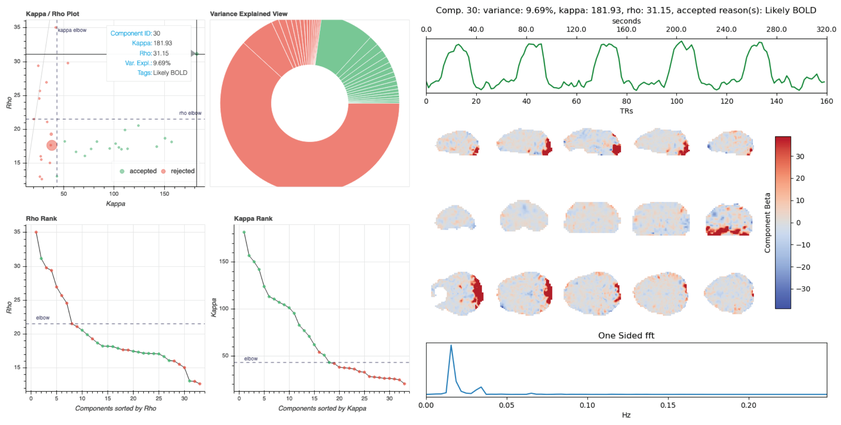
The new code allows for other decision trees and includes a "minimal" tree as an example.

Note: The performance of the minimal tree is still being evaluated. The goal is to design a process that less agressively removes components, but is also less likely to remove good components. Early tests show it is **not** yet achieving those goals so the minimal tree will likely change.

Trees are defined with text json files. When the code is run, the output includes information about what happened in each node.

Trees viewable at:
https://tedana.readthedocs.io/en/stable/included_decision_trees.html

Result reports



Interactive result reports now show lines for kappa and rho elbow thresholds. Hover text includes classification tags with descriptive language for how a component was classified.

Interactive demos for this run of a block design flashing checkerboard block design task are at:
https://me-ica.github.io/ohbm-2023-multiecho/

The demo shows output for the kundu and minimal tree and reclassifies a component using the new *ica_reclassify*

	Component	initialized classification	Node 0	Node 1	Node 2	Node 4	Node 5	Node 8	Node 9	Node 10	Node 11	Node 13
1												
2	ICA_00	unclassified	unclassified	unclassified	unclassified	unclassified	unclassified	provisionalreject	provisionalreject	provisionalreject	provisionalreject	rejected
3	ICA_01	unclassified	unclassified	unclassified	unclassified	unclassified	unclassified	provisionalreject	provisionalreject	provisionalreject	provisionalreject	rejected
4	ICA_02	unclassified	unclassified	unclassified	unclassified	unclassified	unclassified	provisionalreject	provisionalreject	provisionalreject	provisionalreject	rejected
5	ICA_03	unclassified	unclassified	unclassified	unclassified	unclassified	unclassified	provisionalaccept	accepted	accepted	accepted	accepted

New status table file shows how classifications changed during every node of the decision tree. Example at:
https://github.com/ME-ICA/ohbm-2023-multiecho/blob/main/tedana/tedana_results_minimal_five-echo/desc-ICA_status_table.tsv

Breaking changes current tedana users should know about

Manual classification changes moved from *tedana* to *ica_reclassify*

Descriptive *classification_tags* replaced *rationale* number codes

There are no more *ignored* components. Components that were previously *ignored* are now *accepted* with classification tags *low variance* or *Borderline Accept*.

Expanded documentation particularly focused on the new decision tree code at: tedana.readthedocs.io

FUTURE PLANS

Reliability of dimensionality estimation for PCA/ICA is an ongoing issue. Identify solution with general methods or methods that benefit from multi-echo information

Continue to improve documentation and educational materials

Improve interactive visualization of single-run results and full study results

Improve decision process and combine multi-echo & other metrics

Improve automated comparisons of result quality