Classification As Bad Epoch Rejection (CABER): An advanced technique for “tossing” low-quality trials from EEG datasets

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INTRODUCTION

- Many techniques exist for removing overt problems in EEG data (e.g., blinks and other ocular/muscular artifacts)
- However, traditional techniques may miss more subtle effects or poor data due to e.g. participant inattention
- We developed the CABER method to reject (“toss”) such trials
- CABER uses deep multivariate pattern analysis (dMVPA), implemented via DeLINEATE, a deep learning toolbox[1]
- Requires factorial design with at least two orthogonal factors

DATASETS

Dataset 1: Perceive/Refresh

- Previous dataset examining neural correlates of refreshing[2]
- N = 37 young, healthy subjects
- Recorded with 32-channel low-impedance EEG cap
- 11,962 epochs total (3,951 Refresh; 8,011 Perceive)
- Artifact rejection: epochs rejected if peak-to-peak amplitude >150μV, or any EEG channel had flat period of >75ms
- *Perceive*: Presented with two items (faces, words, or scenes)
- *Refresh**: Think back to and visualize one of the two items

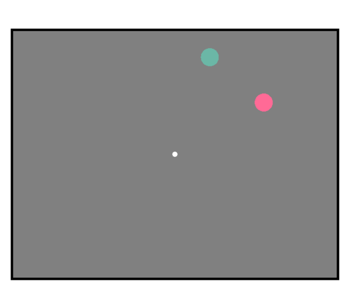
Perceive (1500ms) — Faces OR words OR scenes
Cue* (1500ms) — Refresh OR NoAct OR Act

* NoAct = do nothing. Act = button press. We analyzed only Refresh cues (up/down arrows).

Dataset 2: Visual Short-Term Memory (VSTM)

- N = 27 young, healthy subjects
- Recorded with 256-channel high-impedance EEG cap
- 4,864 epochs total
- Artifact rejection: channels manually rejected, epochs rejected if peak-to-peak amplitude >100μV
- Subset of channels converted to approximate 10/20 system
- Only encoding period of the VSTM task analyzed
- Presented with either *one or two* colored discs, both in either *left or right* hemifield, for 1000ms

Example epoch
Two items; *Right* hemifield



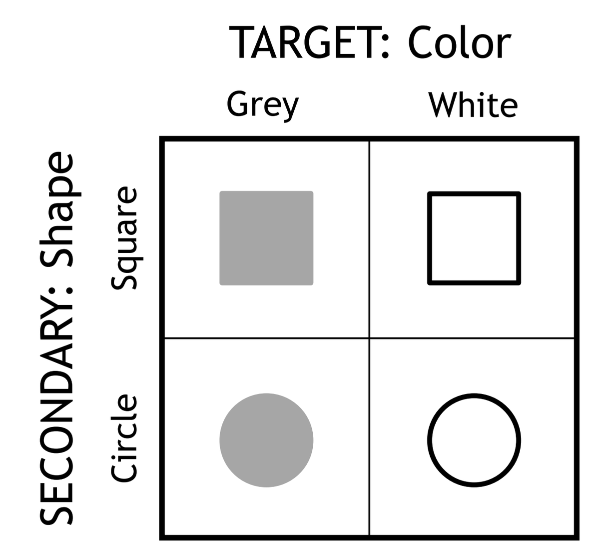
APPROACH

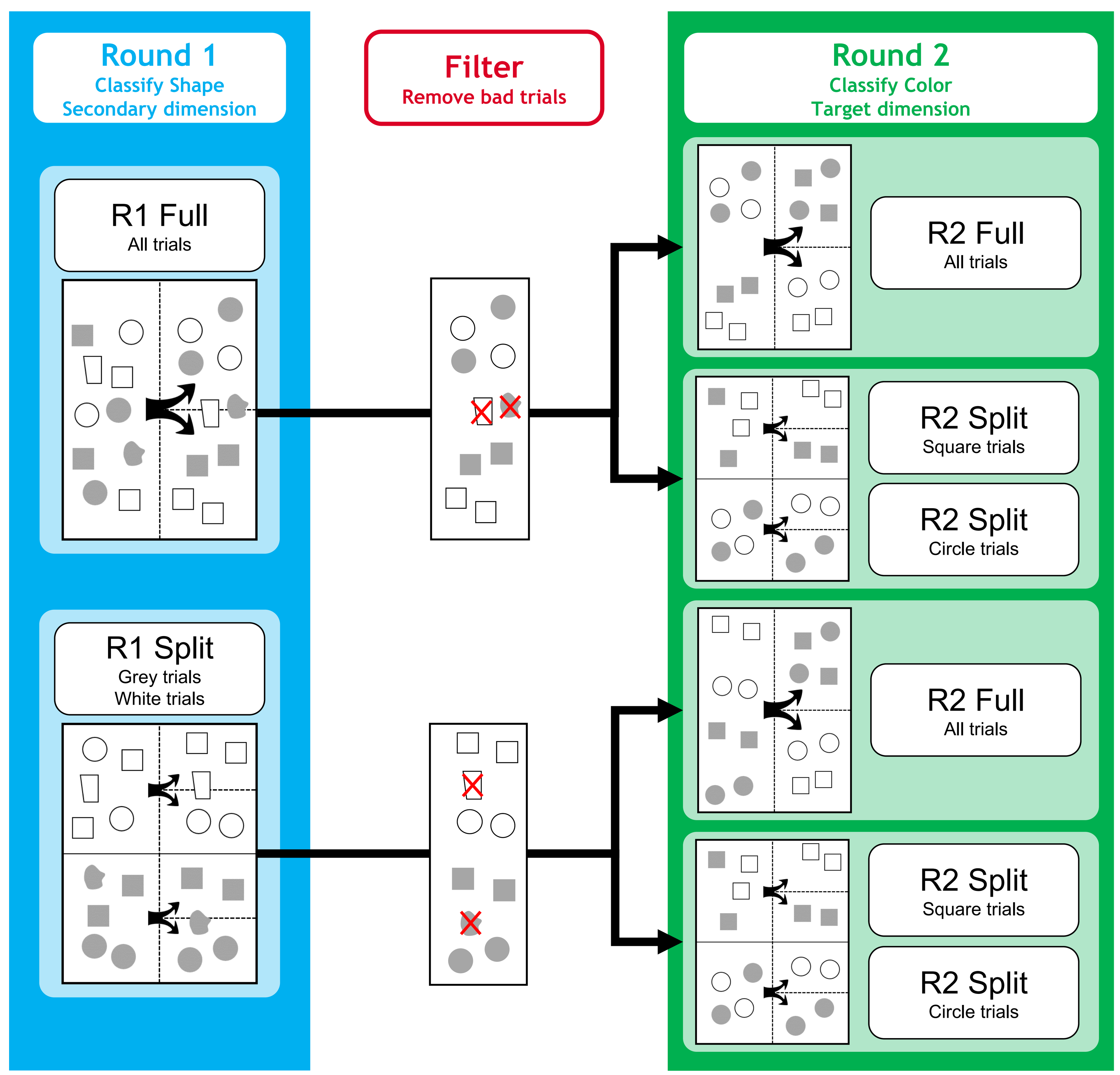
Premise of CABER tossing

If the primary classification of interest is over Dimension A, use classification accuracy over an orthogonal Dimension B to identify high/low quality trials before performing classification over Dimension A.

Conceptual example

- Dataset with two dimensions (color: grey/white; shape: circle/square)
- Color: dimension of interest, i.e. **target** dimension
- Shape: of secondary interest, i.e. **secondary** dimension
- Three steps:
  - **Round 1**: Classify trials over *secondary dimension*, e.g. shape
  - **Filter**: Remove trials with low decodability in Round 1
  - **Round 2**: Classify trials over *target dimension*, e.g. color
  - **Round 3**: Profit
- We explored two manipulations:
  - Effects of removing 10% least decodable trials, vs 20%, 30%, ... 90%
  - When classifying over one dimension, effects of splitting (**Split**) or not splitting (**Full**) the dataset according to the orthogonal dimension

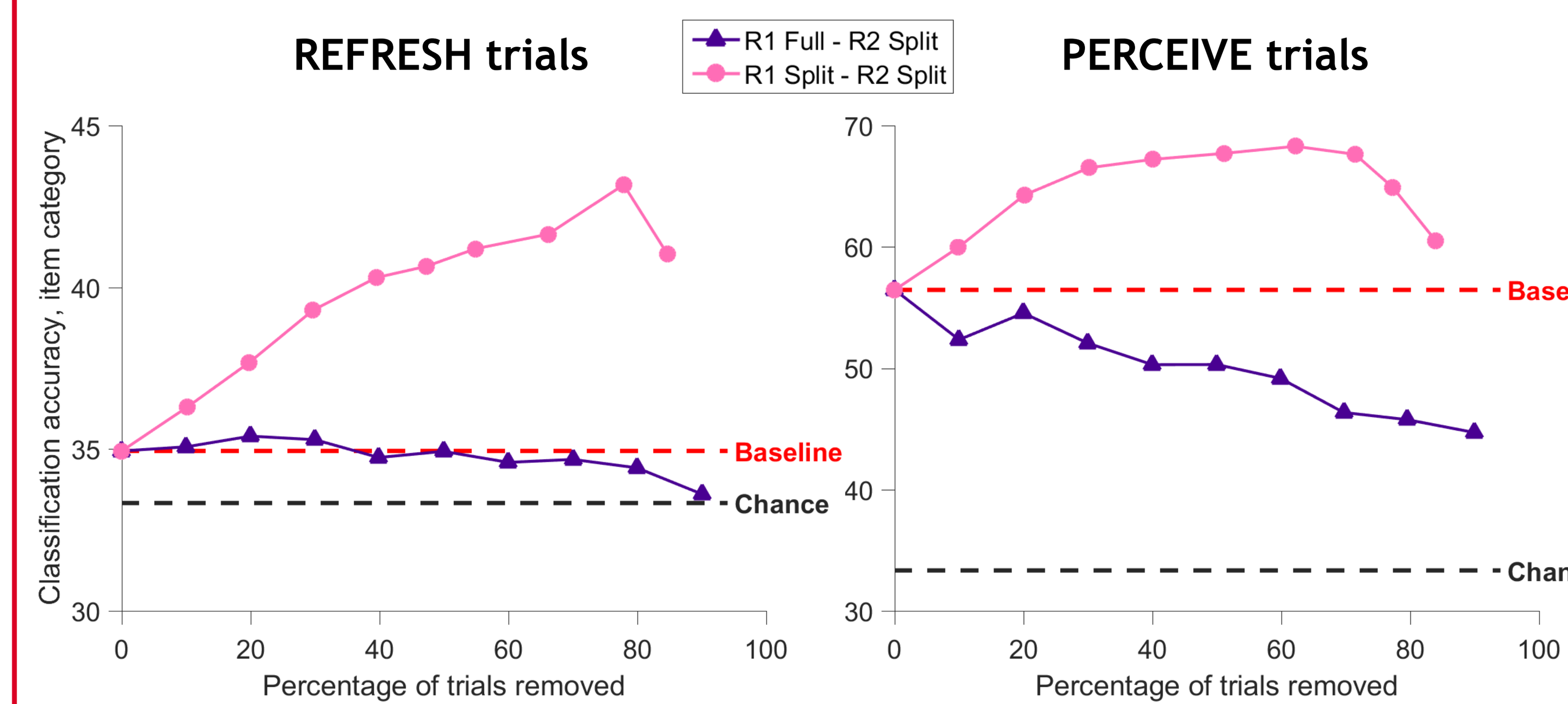




RESULTS

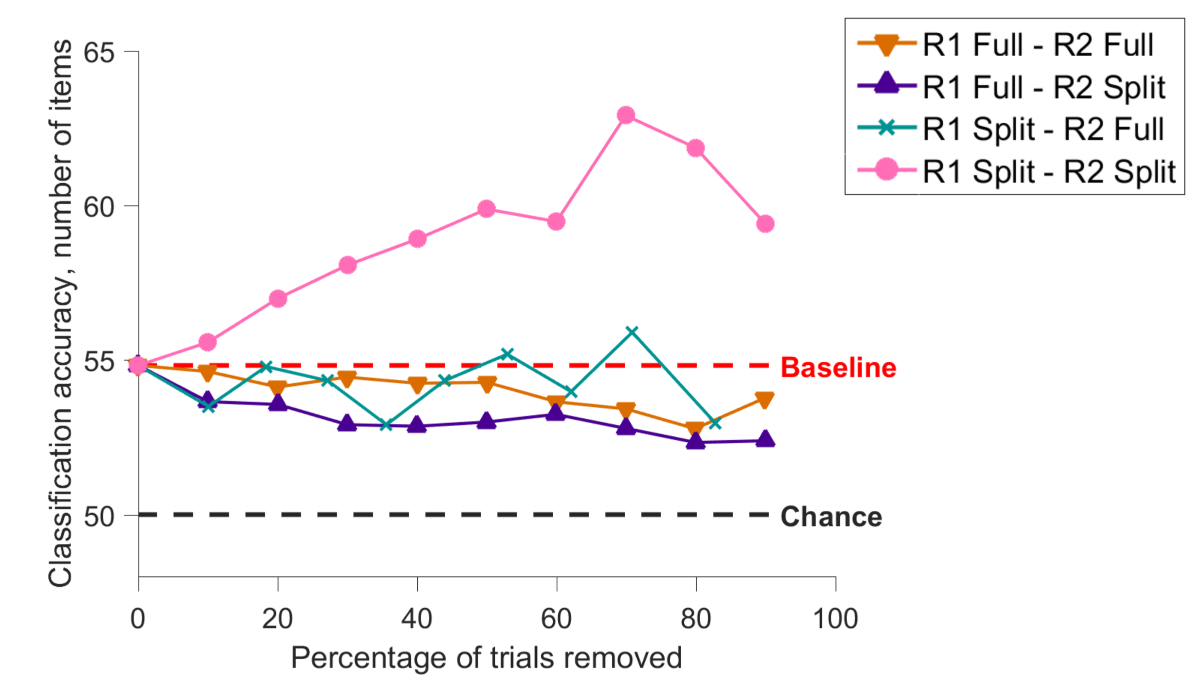
Dataset 1: Perceive/Refresh

- Target dimension: item category (face/scene/word)
- Secondary dimension: task performed (Perceive/Refresh)
- Baseline accuracy (pre-CABER, no trials removed): 56.5% Perceive, 34.9% Refresh



Dataset 2: VSTM

- Target dimension: number of items (one/two)
- Secondary dimension: hemifield (left/right)
- Baseline accuracy (pre-CABER, no trials removed): 54.2%



CONCLUSIONS

- Classification accuracy improved from baseline *only* when Rounds 1 *and* 2 were split
- Splitting both Round 1 and 2 improved accuracy regardless of how much/little data was removed
- Suggests some kind of overall data quality exists that can be indexed by decoding
- Separable from traditional artifact rejection (AR): CABERing both datasets before and after traditional AR produced same results

REFERENCES & ACKNOWLEDGEMENTS

[1]DeLINEATE: A deep learning toolbox for neuroimaging data analysis. Kuntzelman K, Williams JM, Samal A, Rao PK, Johnson MR. 2019. *Cognitive Neuroscience Society 26th Annual Meeting*, Poster B105. http://delineate.it
[2]Johnson MR, McCarthy G, Muller KA, Brudner SN, Johnson MK. 2015. *Journal of Cognitive Neuroscience*, 27: 1823-1839

Supported by NSF/EPSCoR grant #1632849 to MRJ and colleagues