A Topological Classifier for Neural Data

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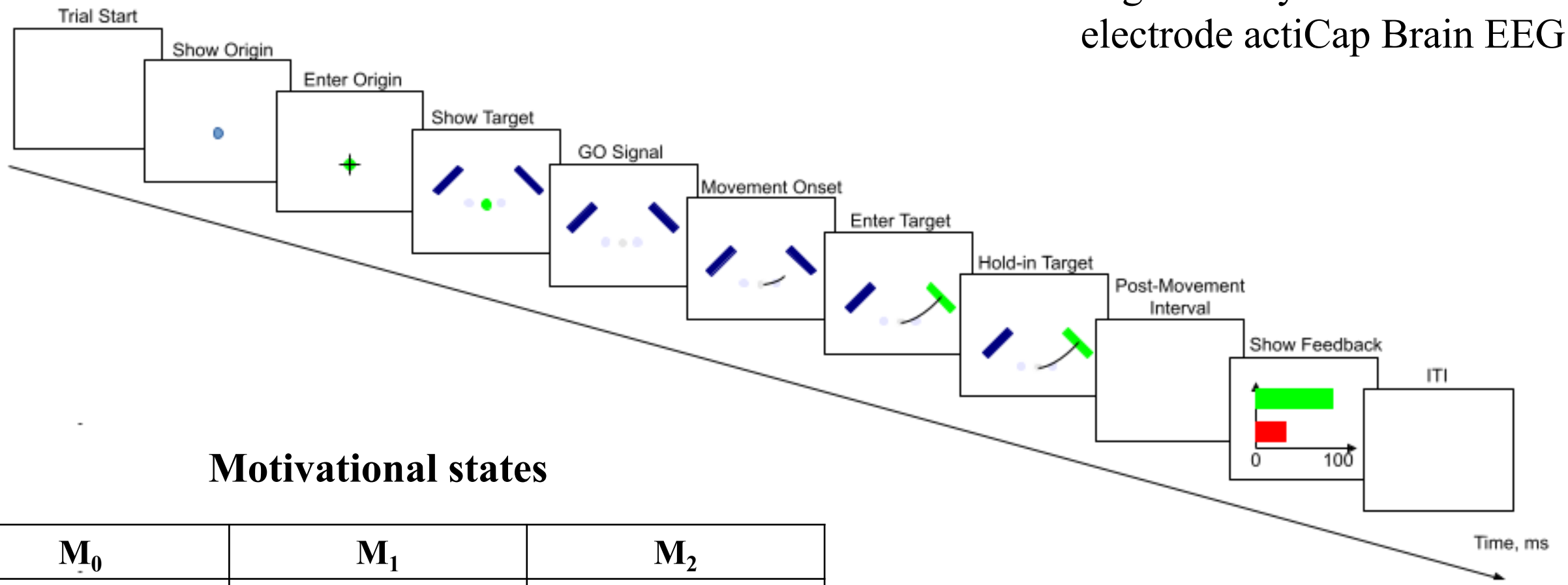
Outline of presentation

- Experimental setup
- Persistent homology
  - Diagram
  - Descriptors
  - Landscape
  - Silhouette
- TDA pipeline for classifying neural data
- Results

Experimental setup

Recorded data:
High-density 64 active electrode actiCap Brain EEG

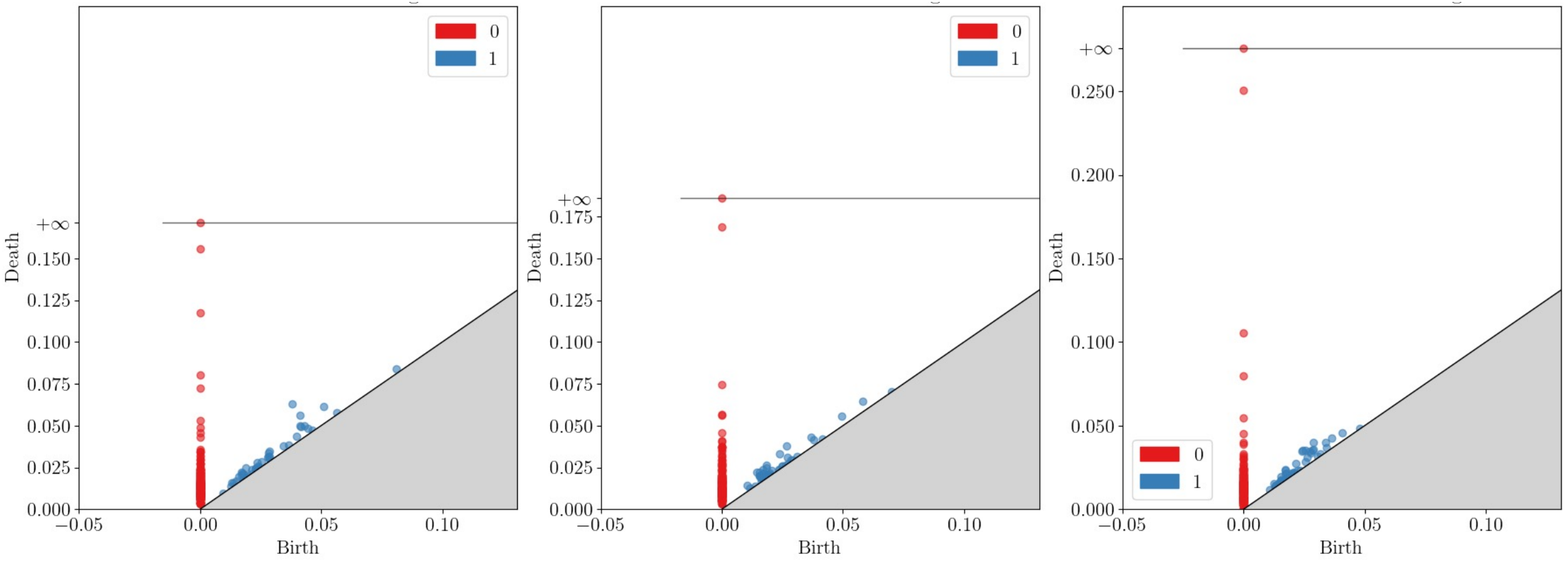


Motivational states

M_0	M_1	M_2
Play alone	Play against a low-performance opponent	Play against a high-performance opponent

Cos et al., submitted

Topological features: Persistent diagrams



F. Nobbe Fisas 2021

Topological features: descriptors

Persistent descriptor: numerical or vectorised summary of a persistent diagram

V_1 V_0

$[\ ]$ $[\ ]$

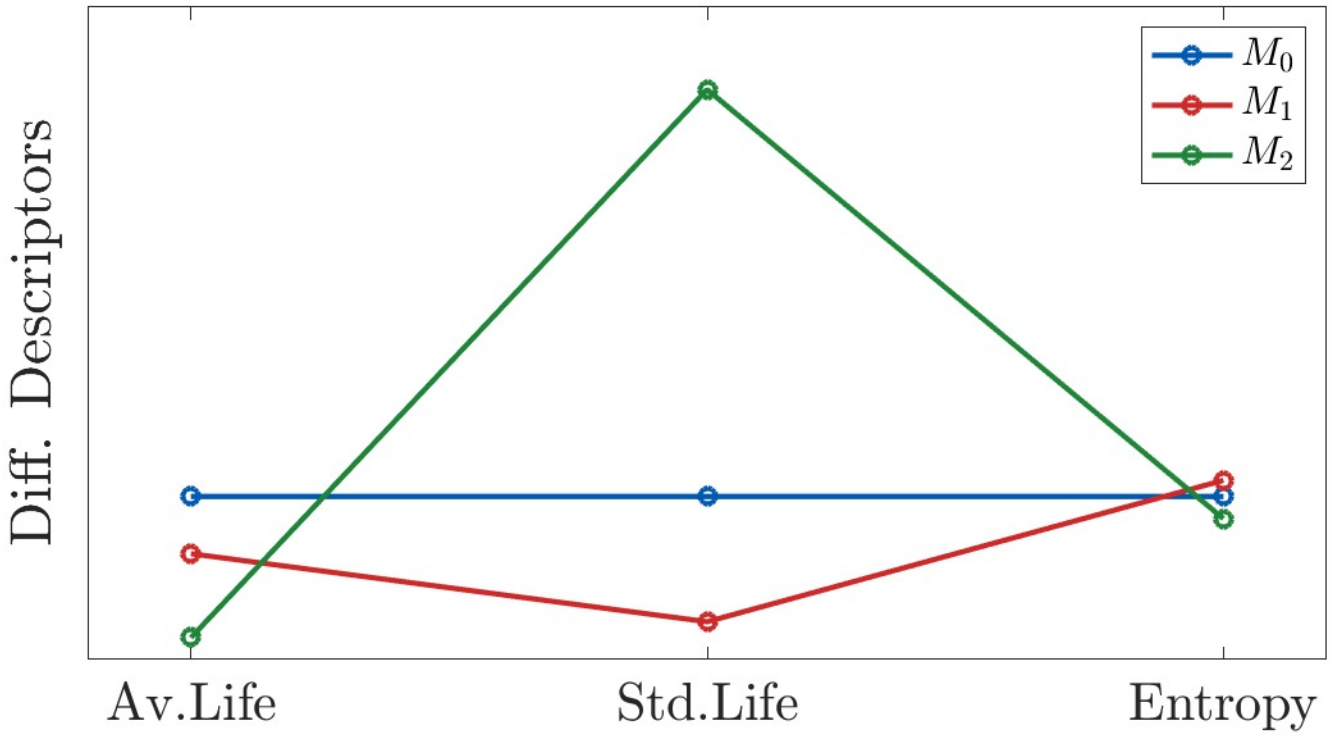
- Entropy
- Average and standard deviation of life [death – birth]

} 0-dim features

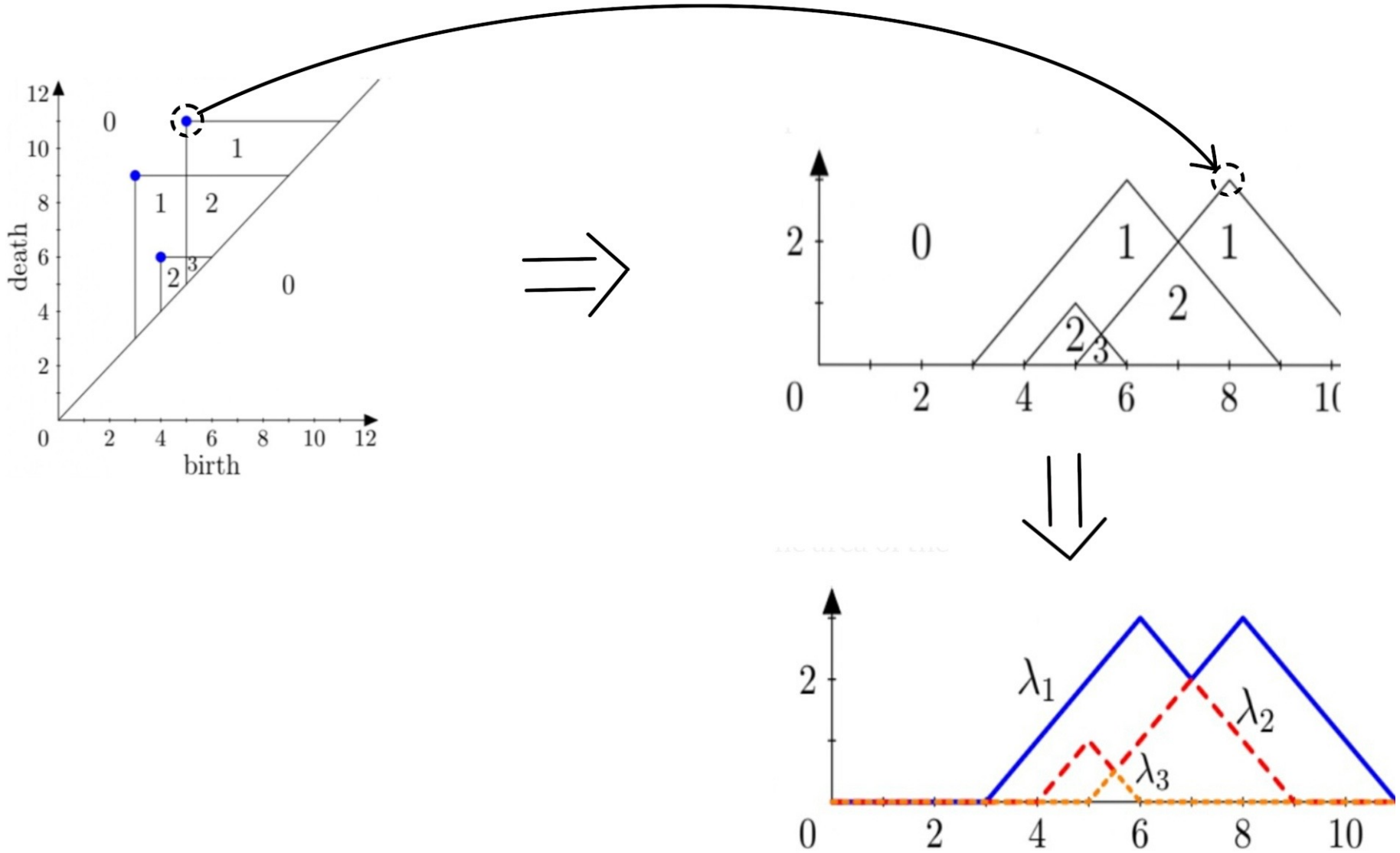
- Average and standard deviation of birth
- Average and standard deviation of death
- Average and standard deviation of mid-life [(death + birth)/2]

} 1-dim features

Topological features: 0-dim descriptors



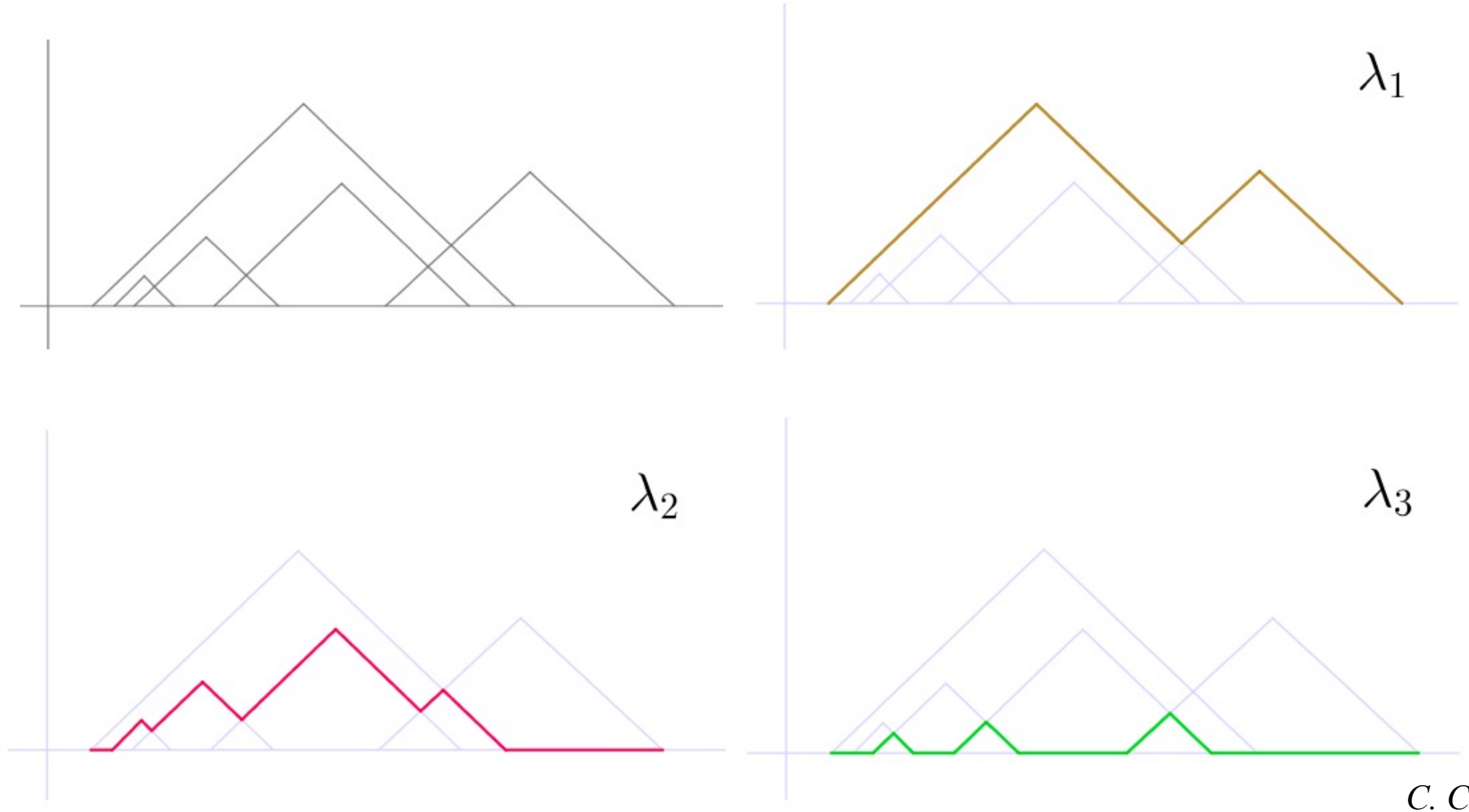
Topological features: from persistent diagram to landscape



Bubenik et al. 2015

Topological features: landscapes

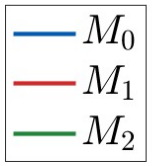
In our case we only consider the first 5 landscapes



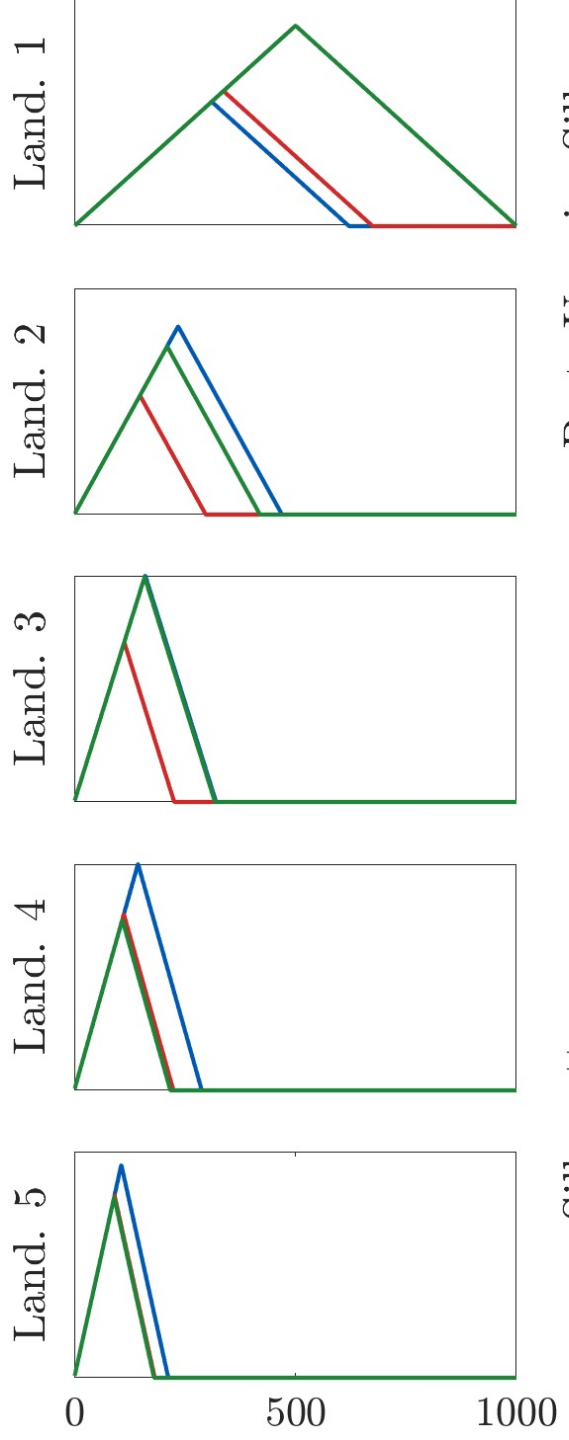
Topological features: Silhouette

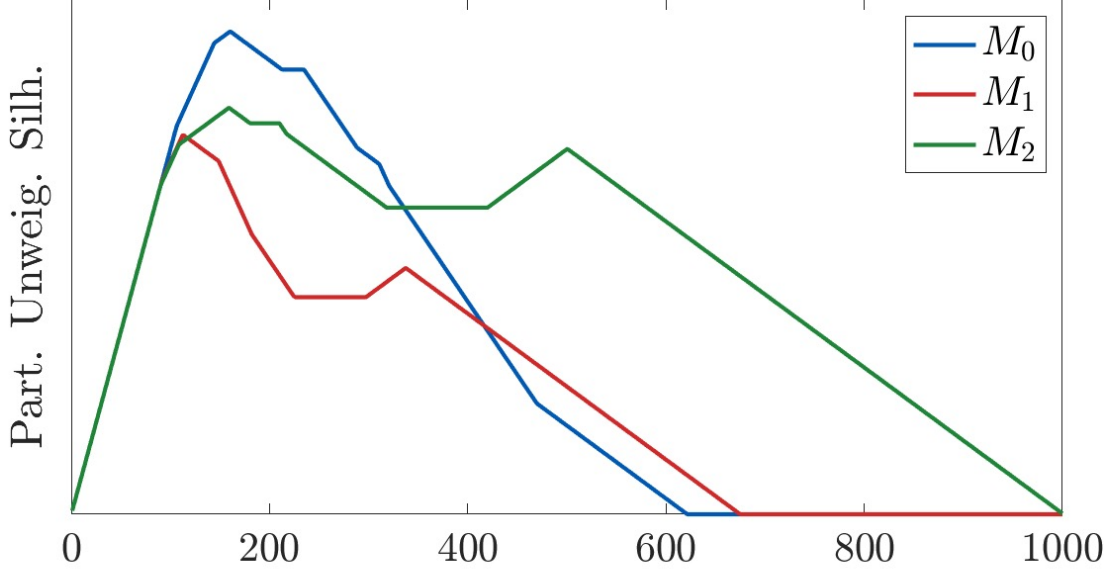
Silhouette:
weighted average of landscapes

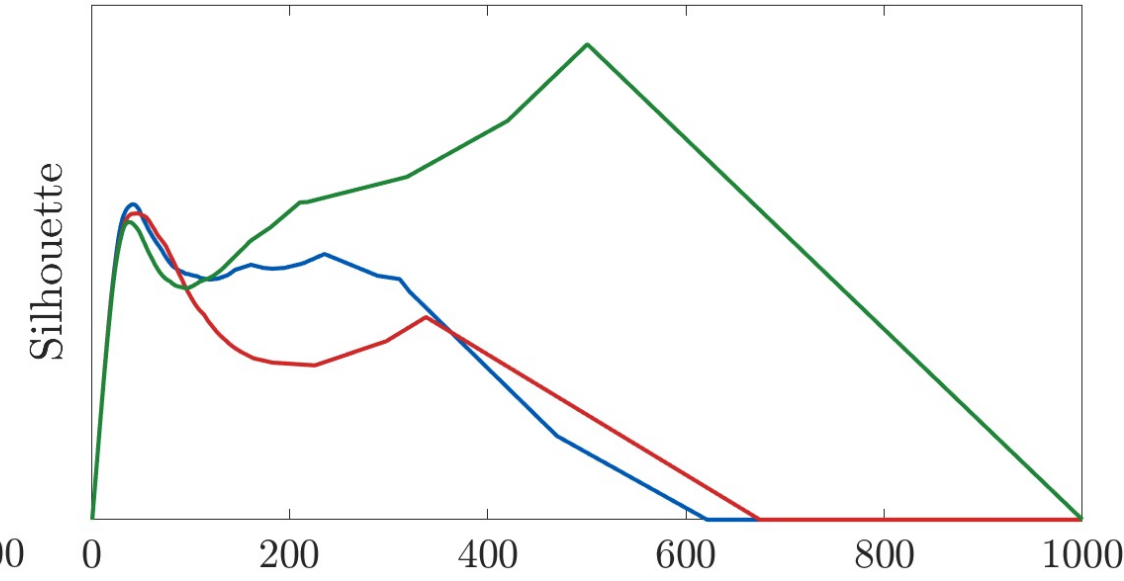
In our case we use the life as weight



Motivational states

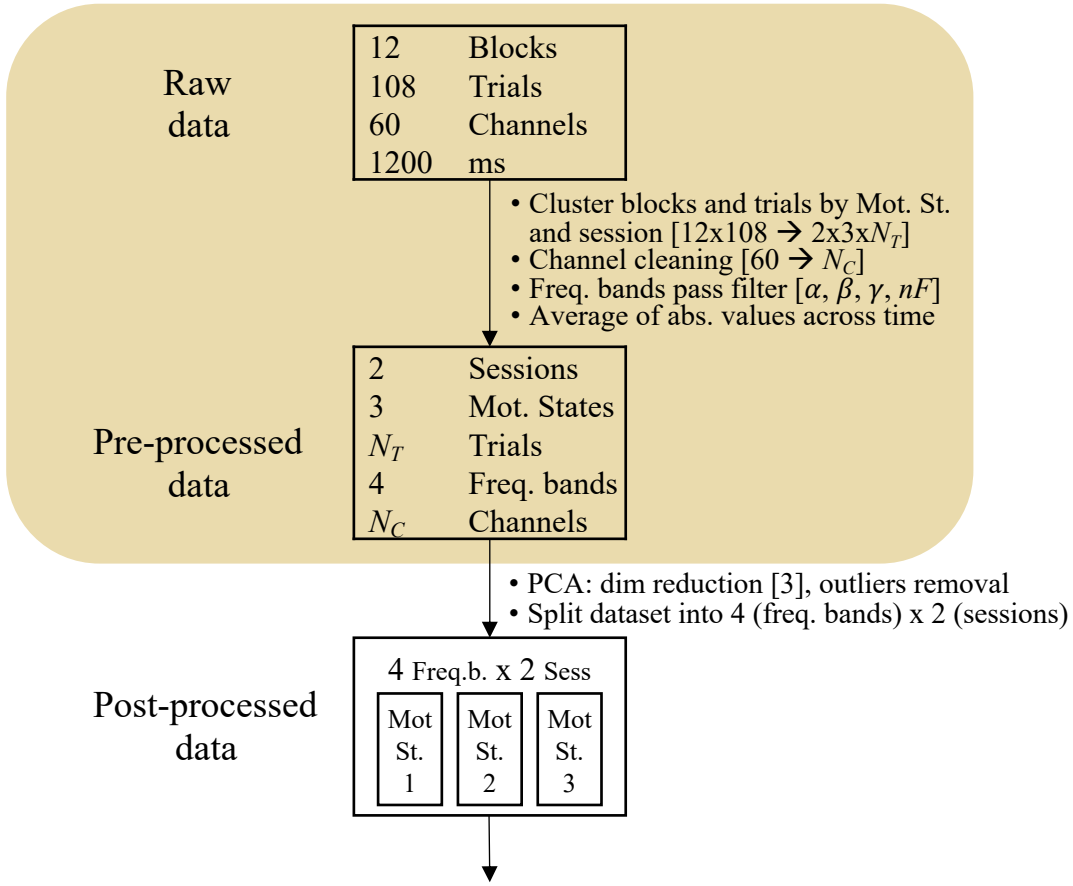




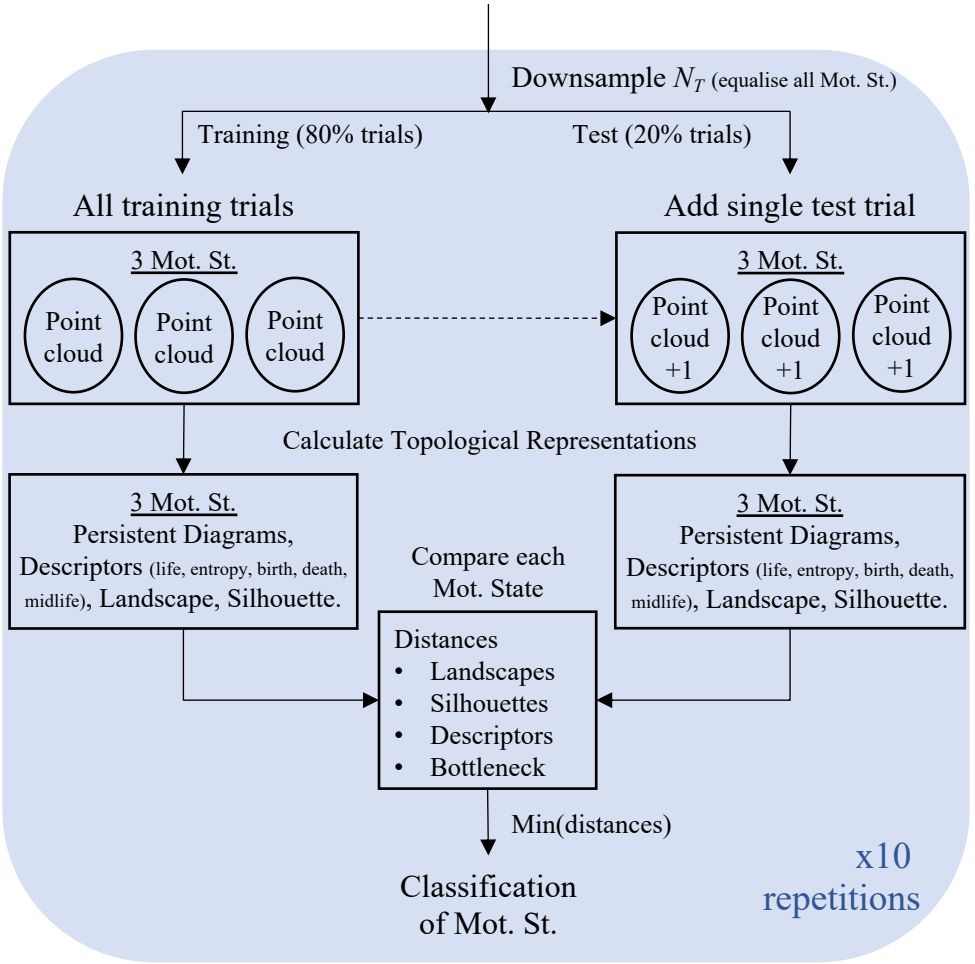


Analysis pipeline

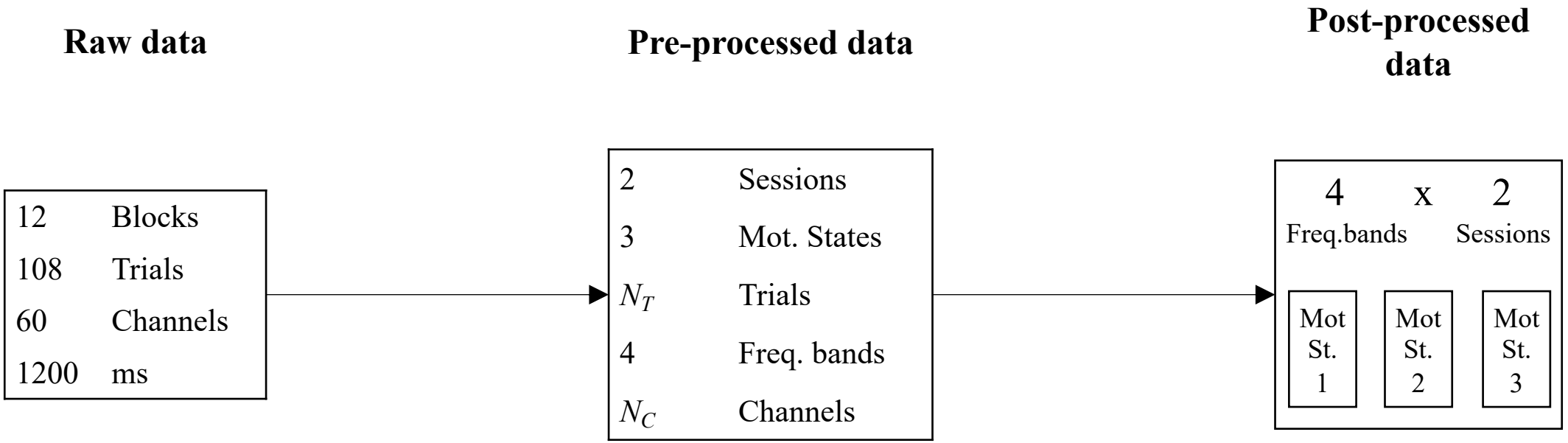
Data pre-processing



Classification



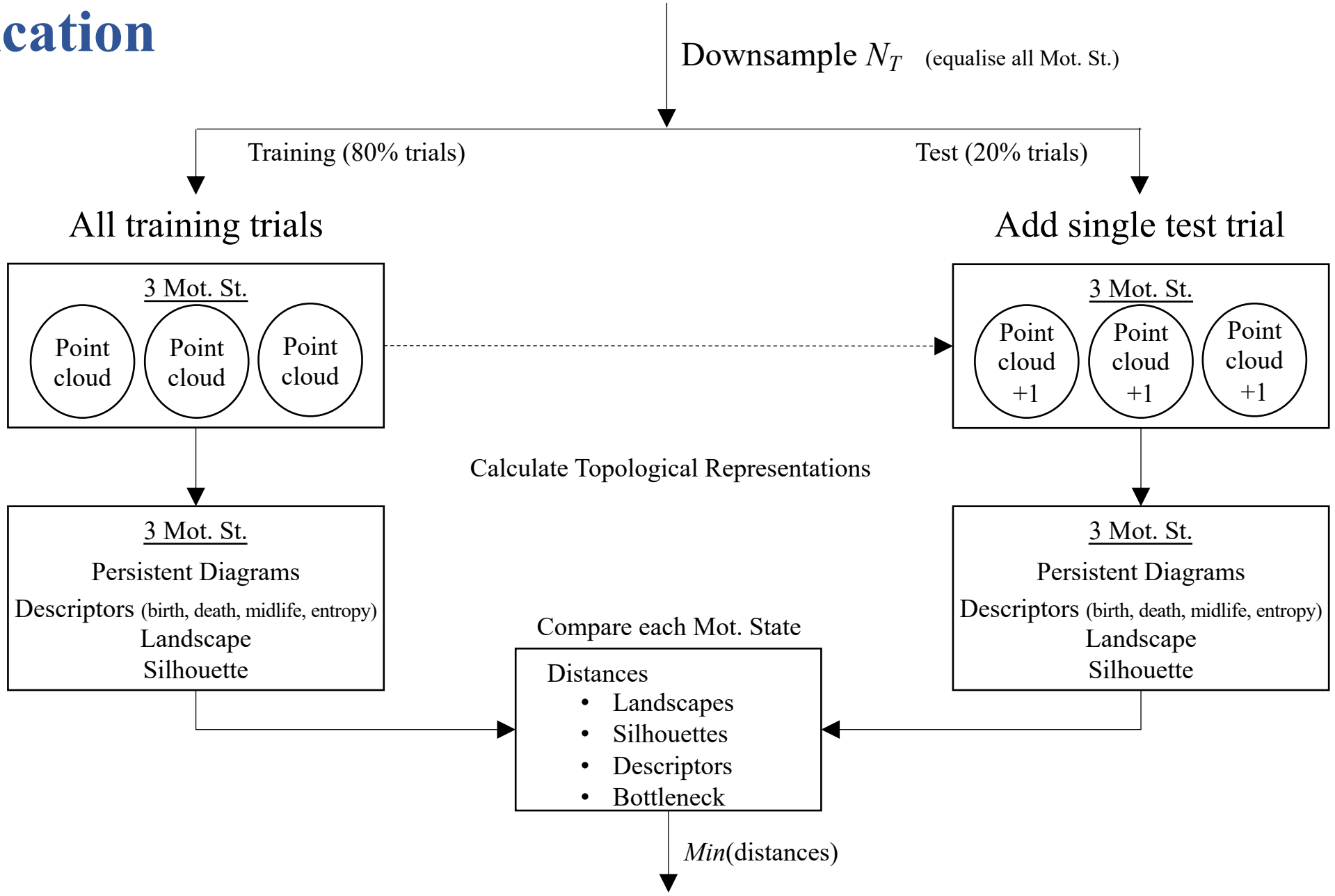
Data pre-processing



- Cluster blocks and trials by motivational state and session [12x108 → 2x3xN_T]
- Channel cleaning [60 → N_C]
- Frequency bands pass filter [α, β, γ, nF]
- Average of abs. values across time

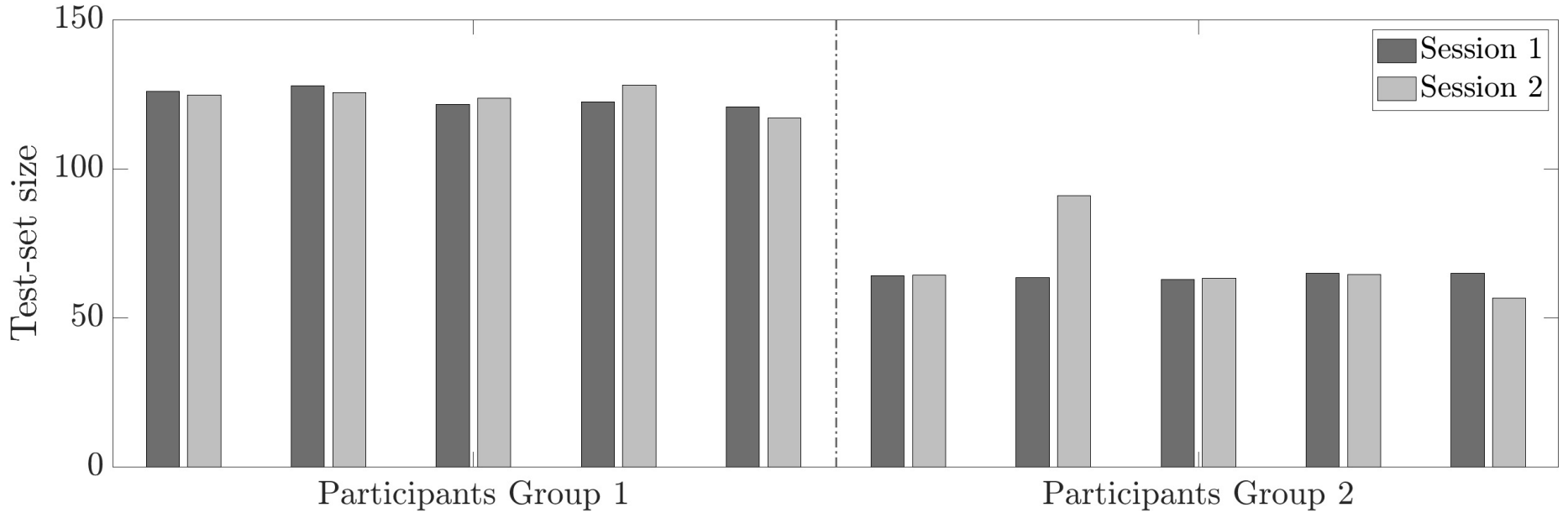
- PCA: dim reduction [3]
  outliers removal
- Split dataset into: 4 freq. bands
  2 sessions

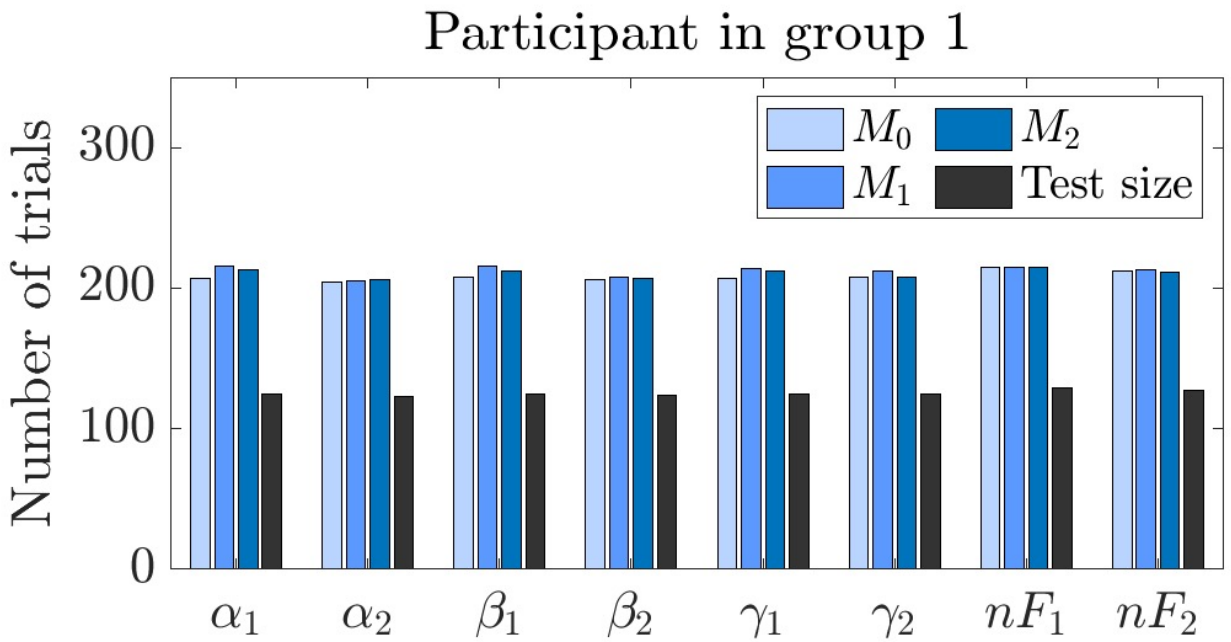
Classification

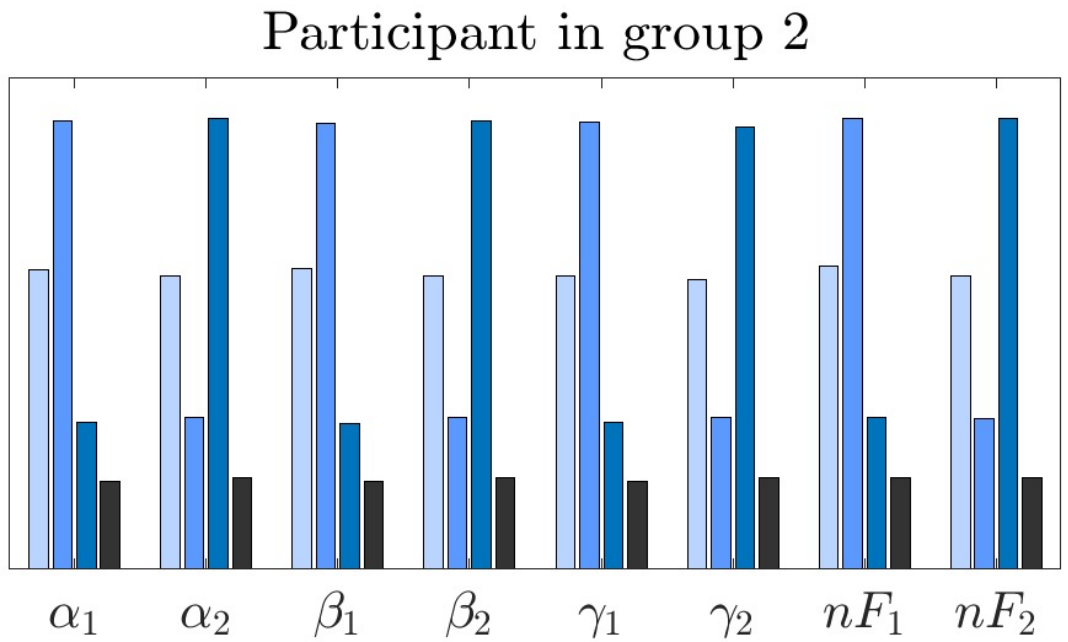


x10 repetitions

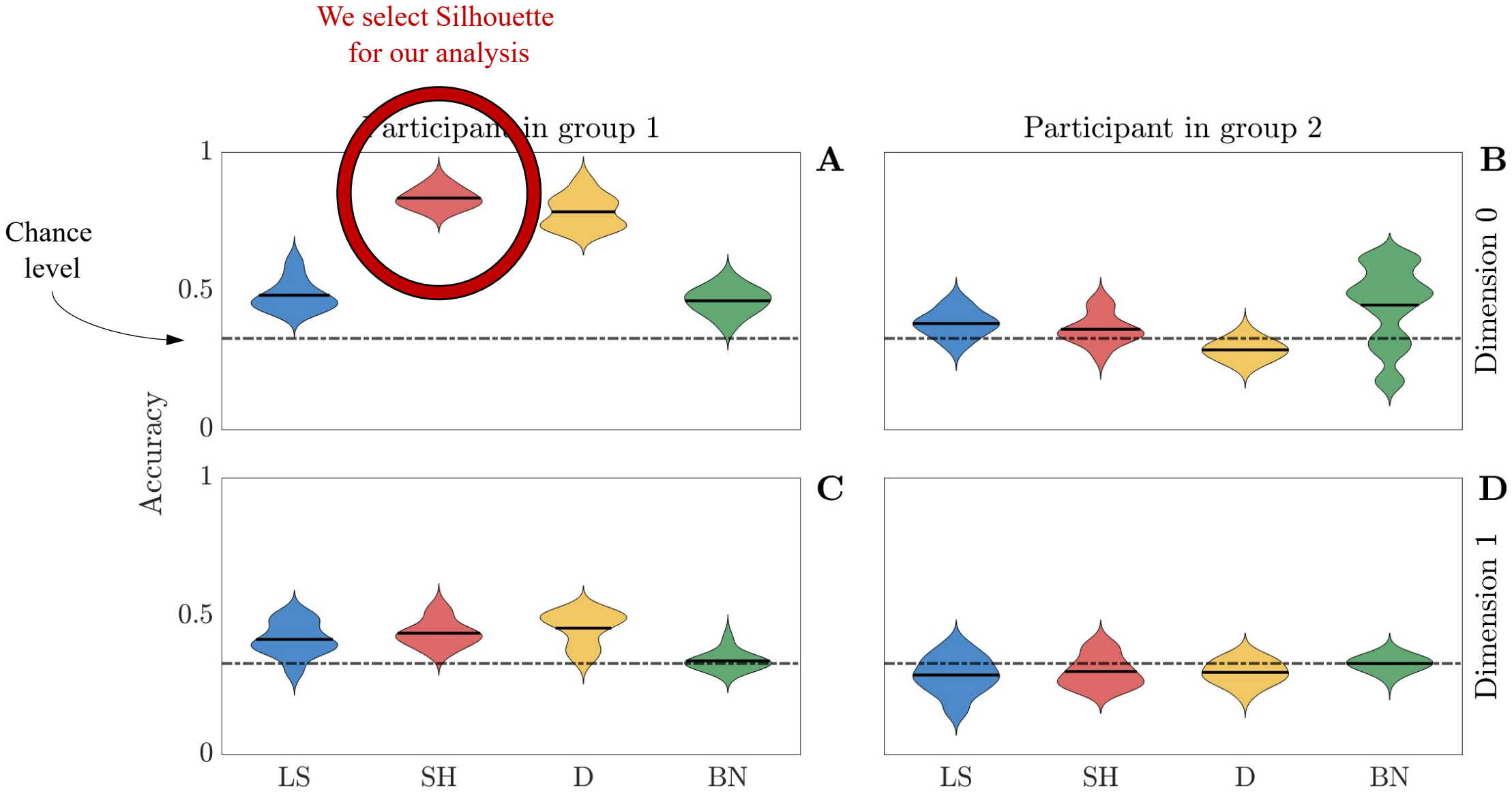
Results: Dataset size



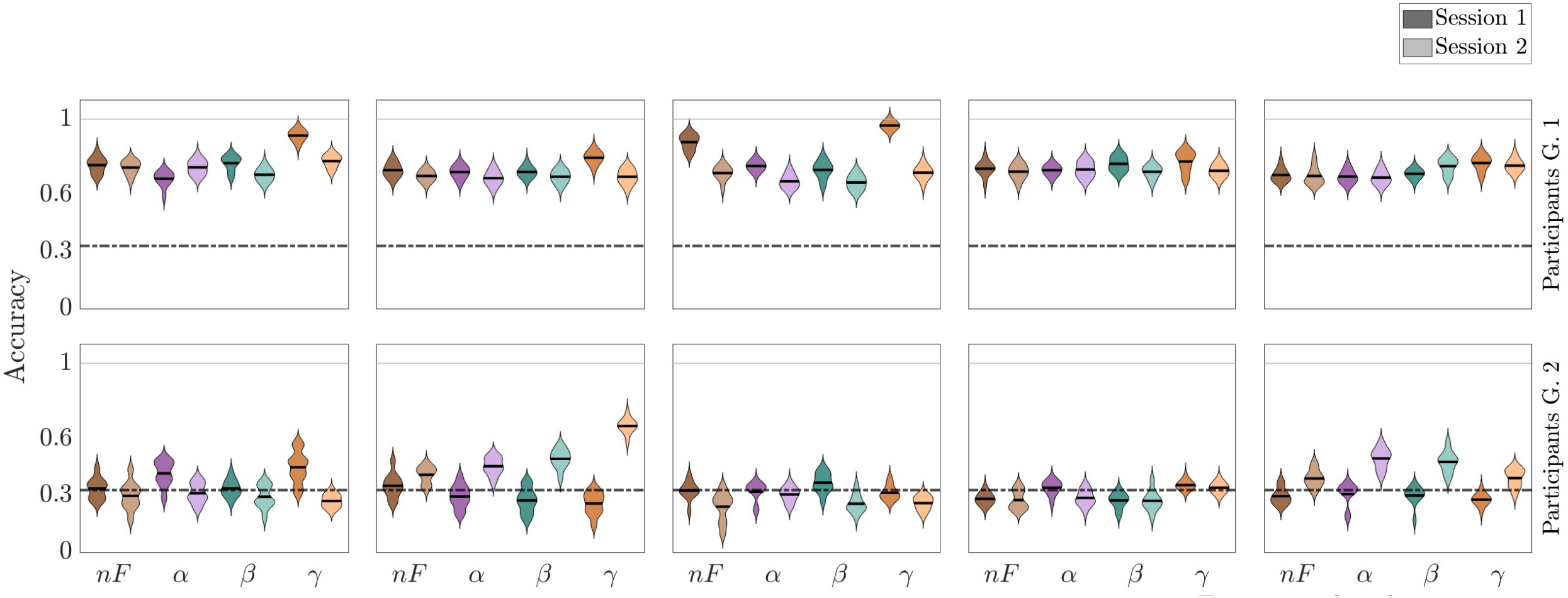




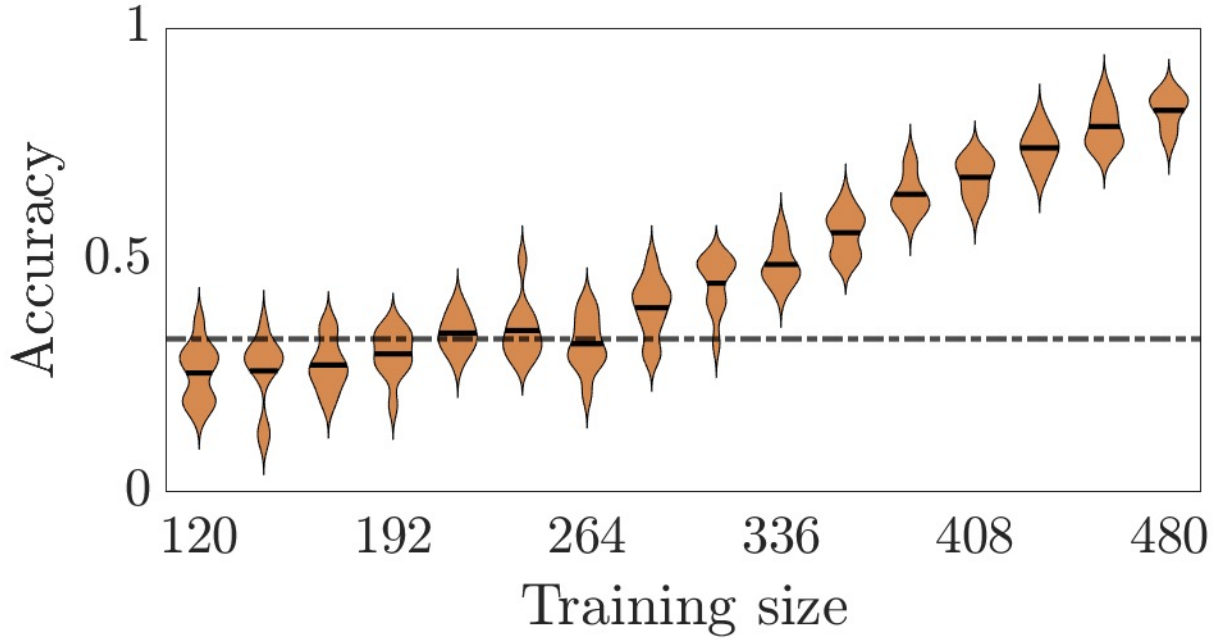
Results: Accuracies for different metrics



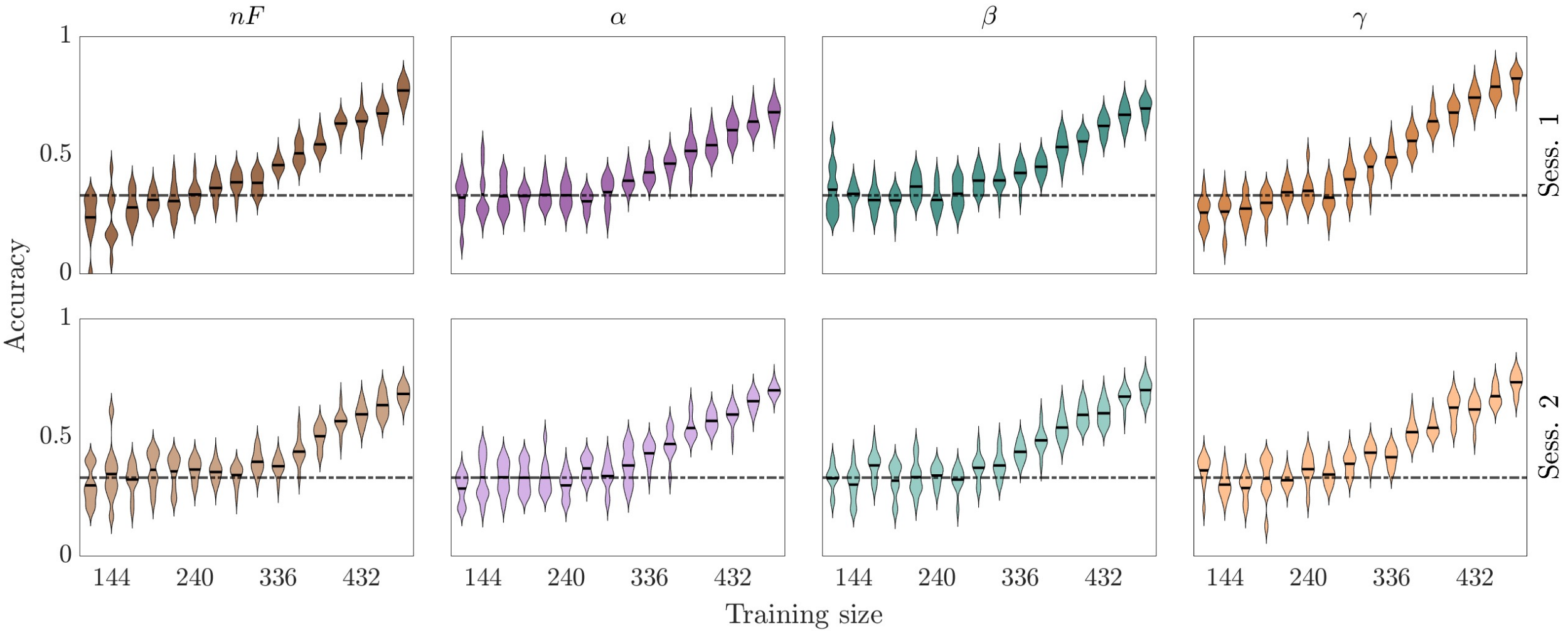
Results:
Classification accuracies for Silhouette



Results:
Accuracy depends on training size



Results:
Accuracy depends on training size



Conclusions

- We developed a TDA based classifier which outperforms the use of simple topological representations;
- Classification accuracy is strongly dependent on dataset size;
- γ band signal yields to the highest classification accuracy (in agreement with previous studies);
- Silhouette is the best informative topological summary.

Thanks for your attention!

Acknowledgment:

- Fritz-Pere Nobbe Fisas
- Carles Casacuberta
- Ignasi Cos
- Michael DePass

This project has received funding from European Union's Horizon 2020 Framework Programme for Research and Innovation under the Specific Grant Agreements No. 945539 (Human Brain Project SGA3)

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