

Riemannian Geometry for fNIRS-BCIs and other clinical applications

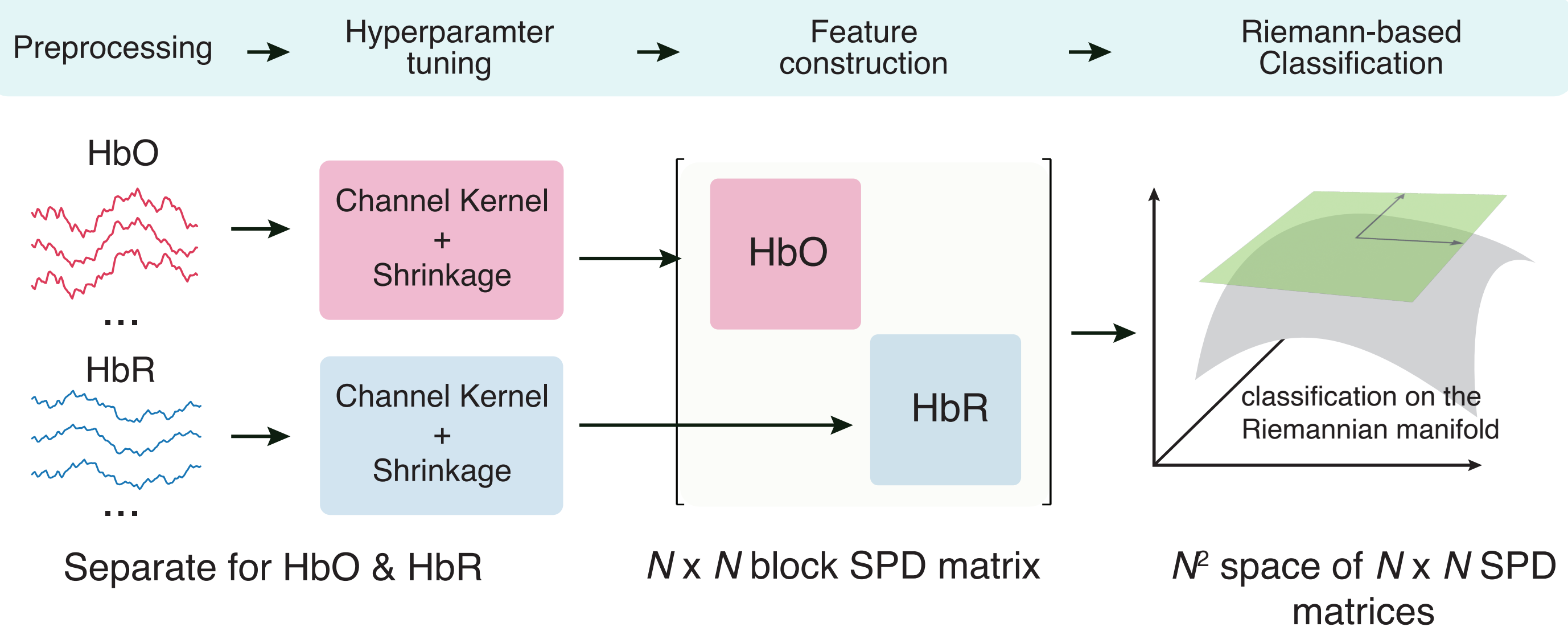
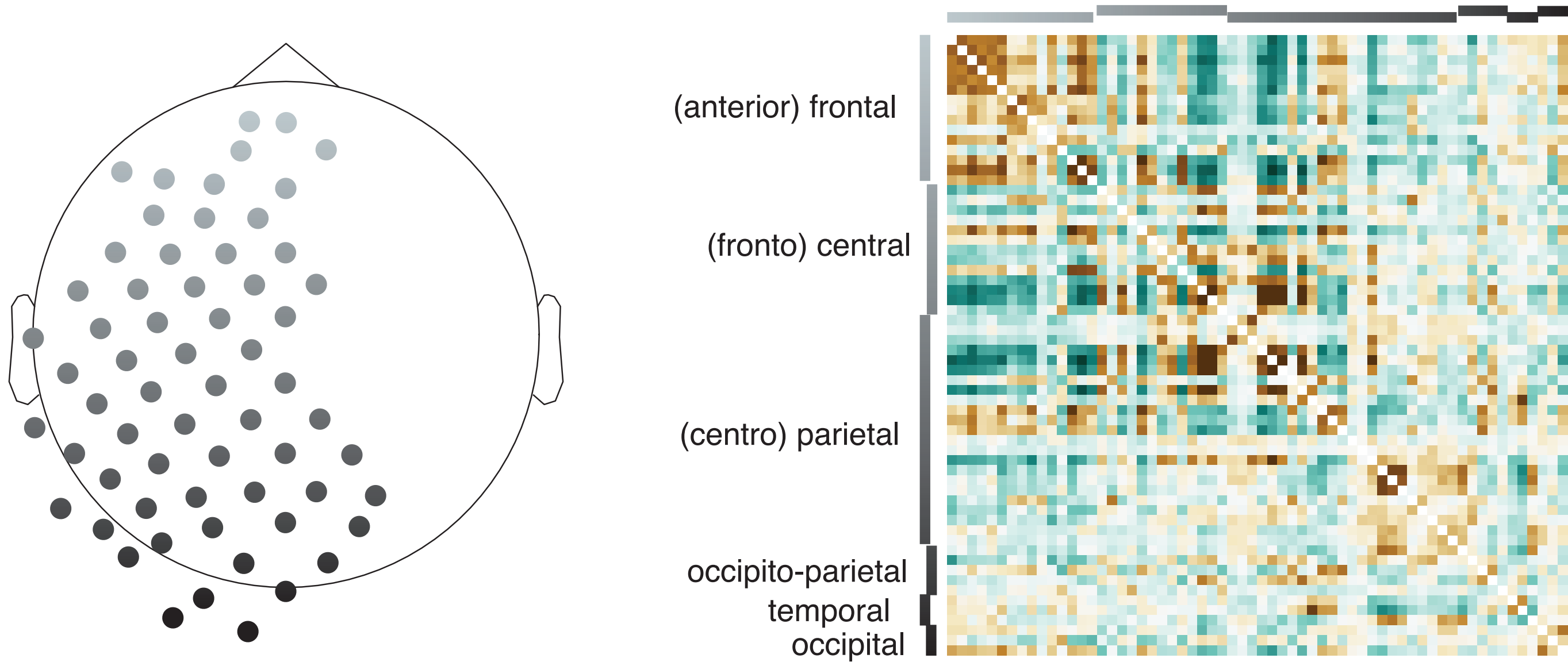
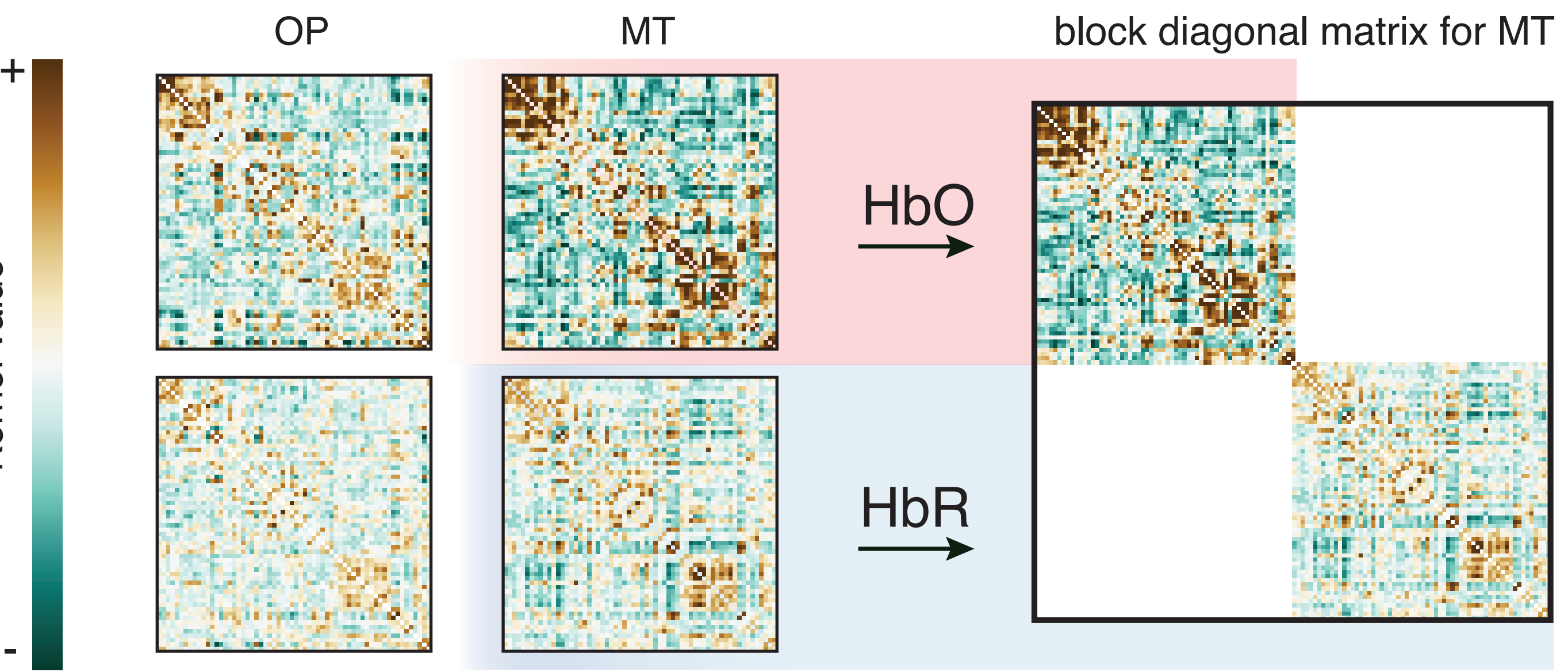
Tim Näher^{1,2,3}, Lisa Bastian^{4,5}, Anna Vorreuther⁶, Pascal Fries^{1,3}, Rainer Goebel⁷ & Bettina Sorger⁷

1 Max Planck Institute for Biological Cybernetics, Tübingen, Germany
2 Ernst Strüngmann Institute for Neuroscience in Cooperation with Max Planck Society, Frankfurt, Germany
3 Donders Centre for Cognitive Neuroimaging, Radboud University Nijmegen, Nijmegen, The Netherlands
4 University of Tübingen, Institute of Medical Psychology and Behavioral Neurobiology, Tübingen, Germany
5 International Max Planck Research School, Graduate Training Centre of Neuroscience, Tübingen, Germany
6 Applied Neurocognitive Systems, Institute of Human Factors and Technology Management (IAT), University of Stuttgart, Stuttgart, Germany
7 Maastricht University, Department of Cognitive Neuroscience, Maastricht, The Netherlands

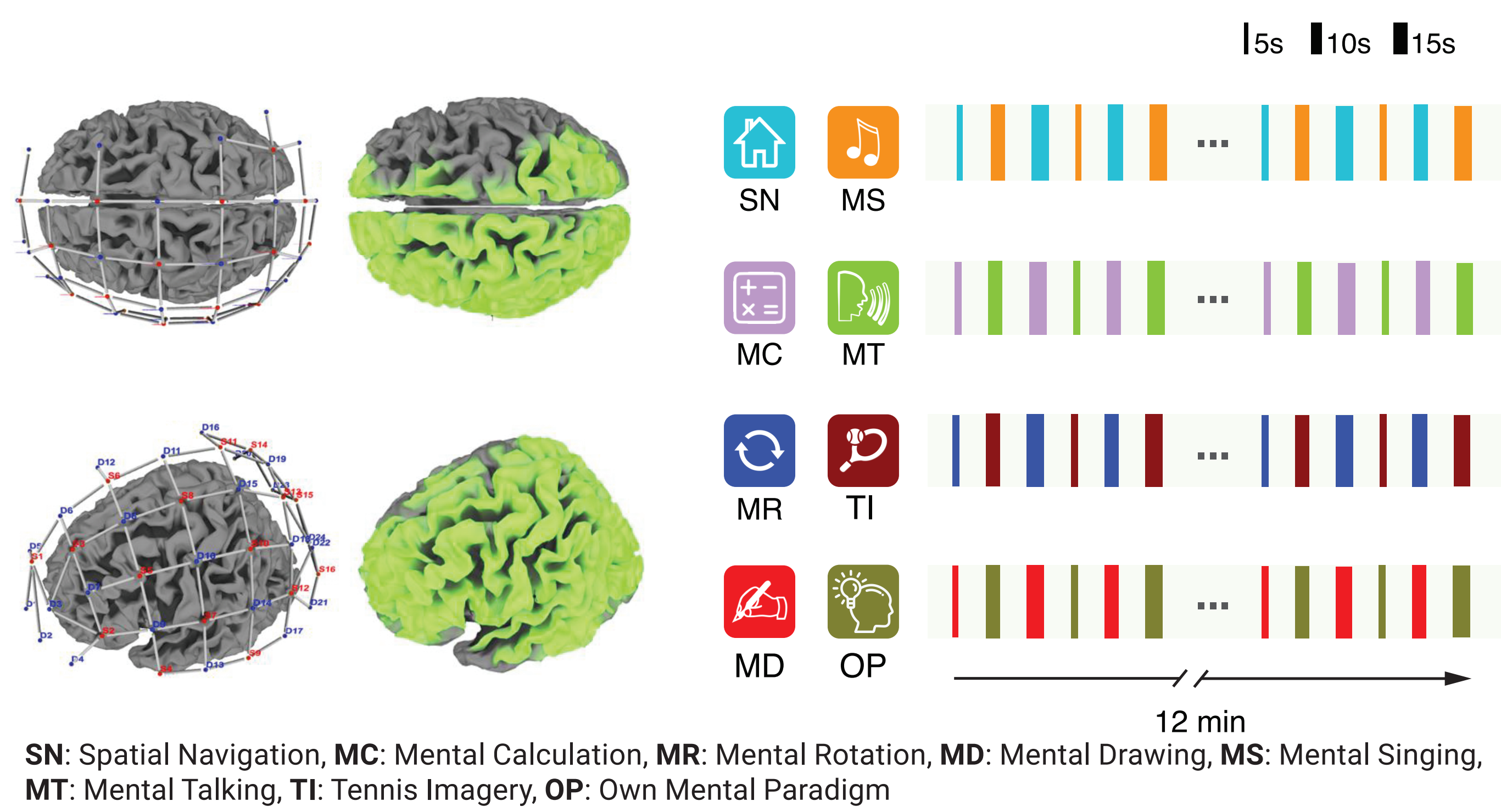
INTRODUCTION

Functional near-infrared spectroscopy (fNIRS) has become a popular tool for brain-state assessment due to its portability, non-invasive nature, and resilience to movement^{1,2,3}. However, compared to functional magnetic resonant imaging (fMRI), fNIRS has limitations in terms of brain coverage and sensitivity to deeper brain activity. Additionally, advancements in fNIRS-based classification methods have not received as much attention as in fMRI, resulting in limited performances. In this study, we present a classification approach leveraging Riemannian geometry to enhance the accuracy of brain-state classification with eight different mental-imagery tasks. We also successfully applied this framework to a proof-of-concept clinical command-following paradigm aimed at diagnosing remaining awareness in patients with disorders of consciousness (DoC).

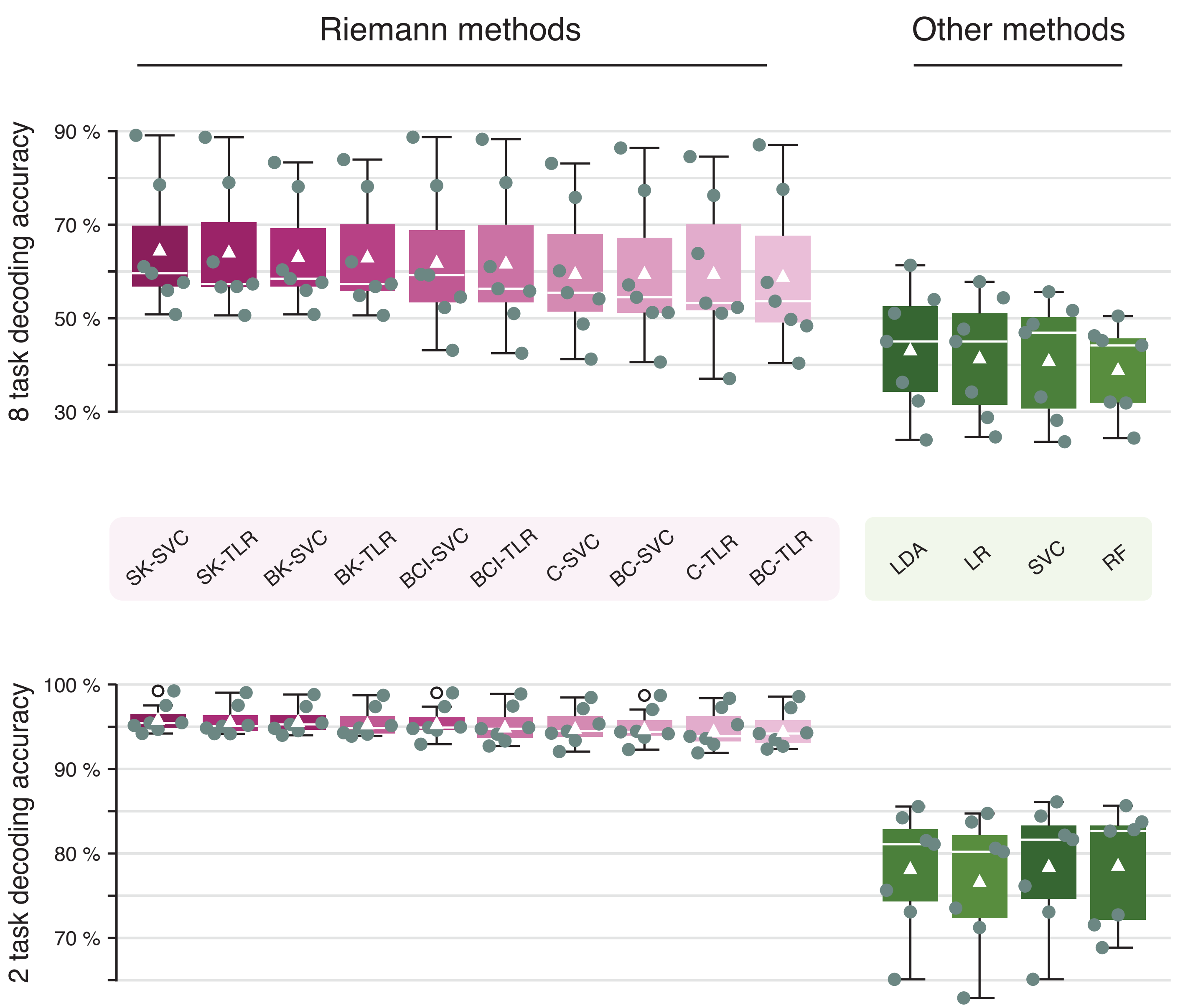
MODEL & KERNEL MATRICES



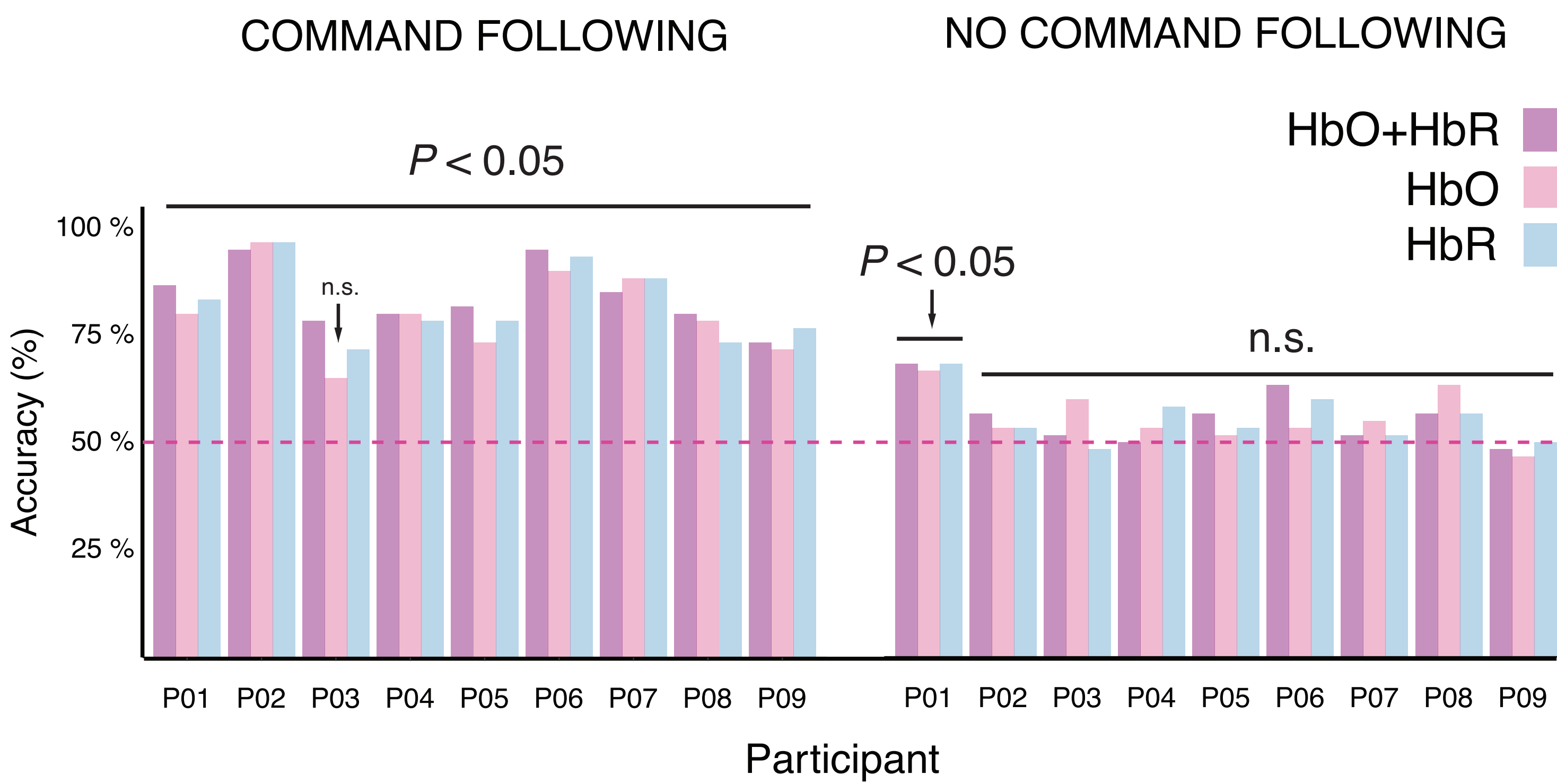
EXPERIMENTAL PARADIGM



CLASSIFICATION RESULTS



CLINICAL APPLICATION



References

1 F. Klein, S. H. Kohl, M. Lührs, et al., "From Lab to Life: Challenges and Perspectives of fNIRS for Hemodynamic Neurofeedback in Real-World Environments," (2023)

2 S. H. Kohl, D. M. A. Mehler, M. Lührs, et al., "The Potential of Functional Near-Infrared Spectroscopy-Based Neurofeedback—A Systematic Review and Recommendations for Best Practice," *Frontiers in Neuroscience* 14, 594 (2020)

3 S. R. Soekadar, S. H. Kohl, M. Mihara, et al., "Optical brain imaging and its application to neurofeedback," *NeuroImage: Clinical* 30, 102577 (2021).

PREPRINT

