

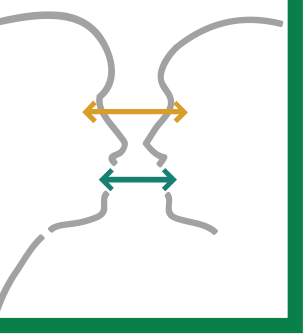
# Multiverse Analysis of Longitudinal Changes in Sensorimotor Functional Connectivity during Brain-Computer Interface Training

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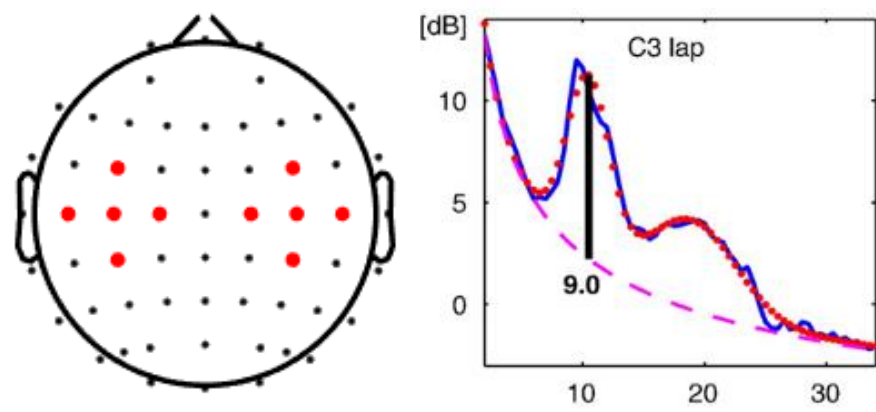
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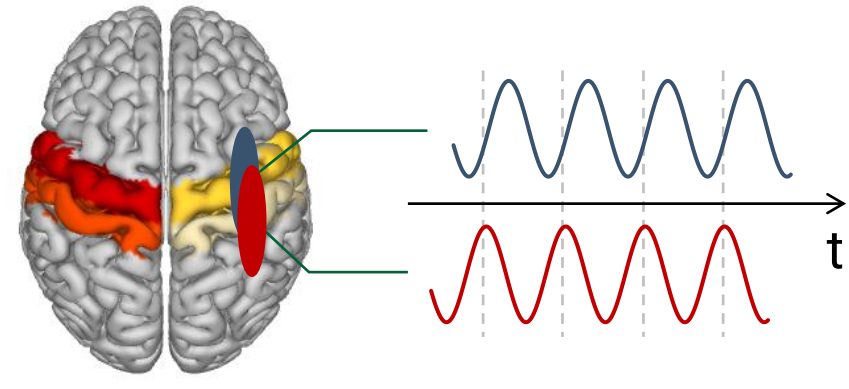
## Background

On average, around 20% of participants are unable to learn to control a brain-computer interface (BCI). Previous studies have identified several neurophysiological predictors of BCI performance, and among them are:

Signal-to-noise Ratio (SNR)  
averaged over C3- and C4-Laplace  
(Blankertz et al., NeuroImage, 2010)



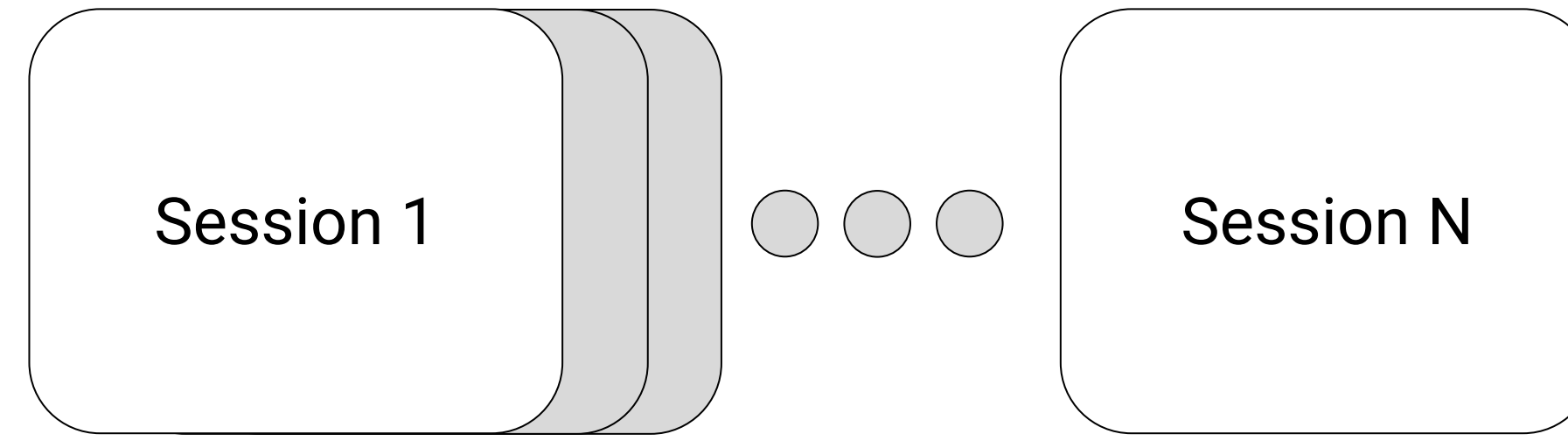
Functional Connectivity  
phase synchronization  
between sensorimotor areas  
(Vidaurre et al., Front. Neurosci., 2020)



## Research Questions

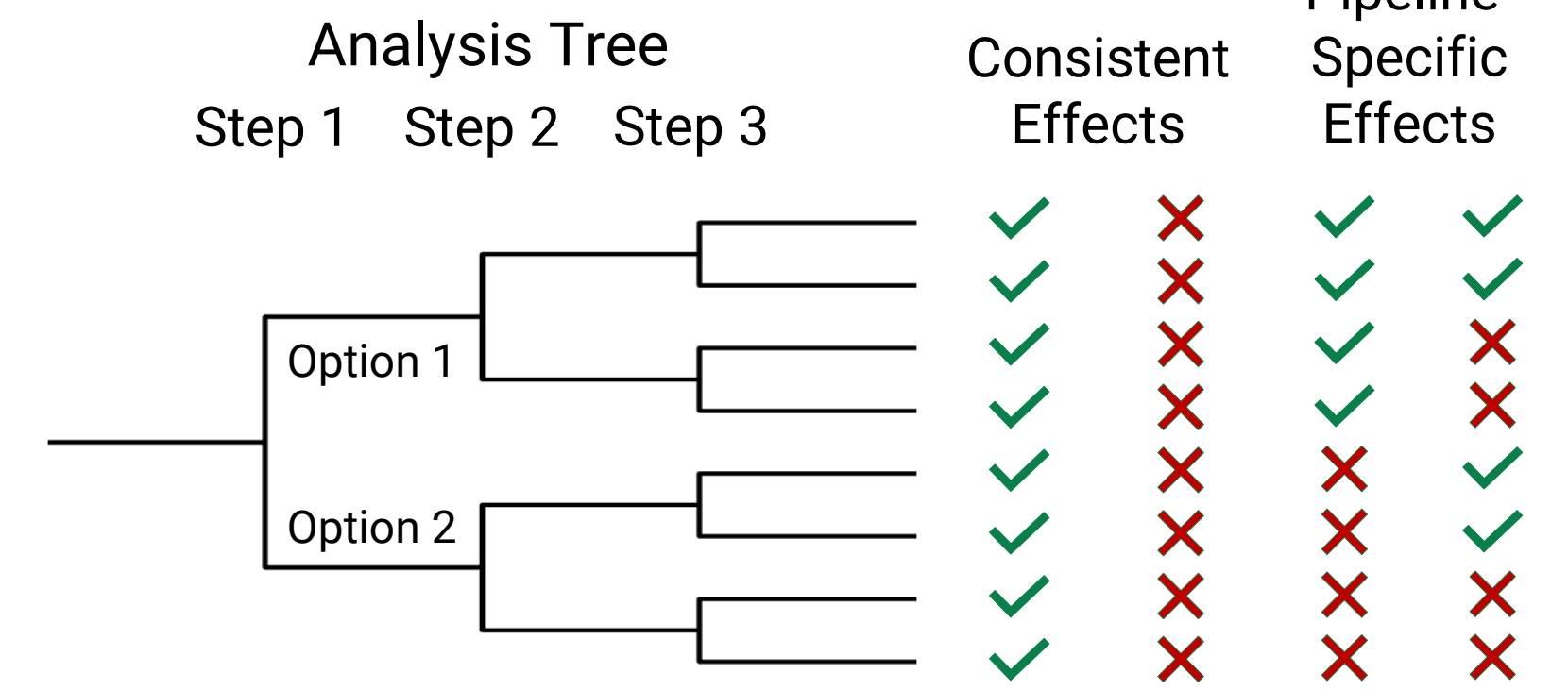
- Do SNR and connectivity predict performance not only in a single, but in multiple sessions for the same participant?
- Is SNR a static participant-specific feature or does it also change over time?
- Does connectivity change over time and can these changes reflect reorganization of the neuronal network?

Our approach: use a longitudinal dataset of BCI training



- How robust are the observed effects to the selection of the processing steps?

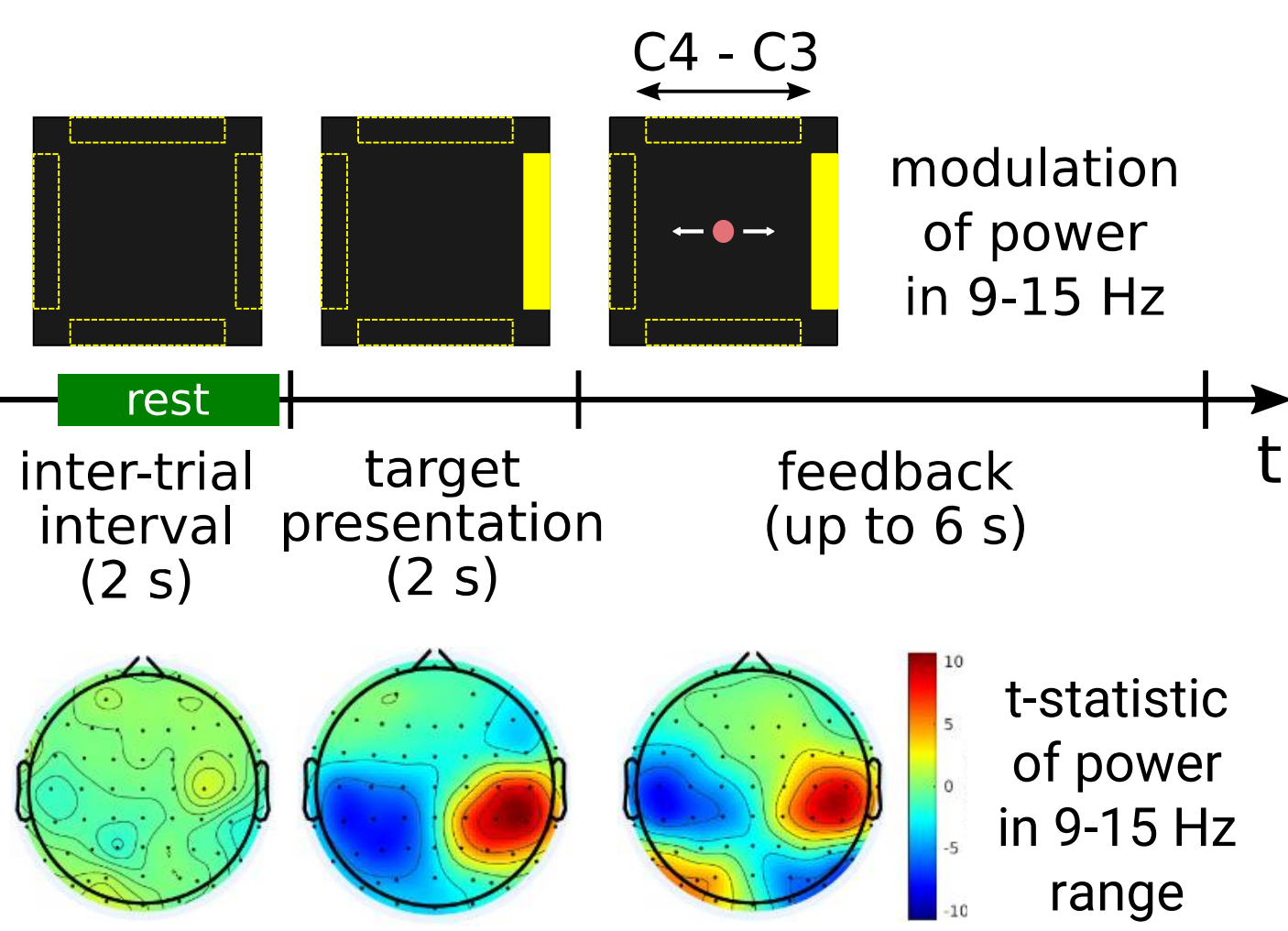
Our approach: consider several combinations of processing steps and run a multiverse analysis



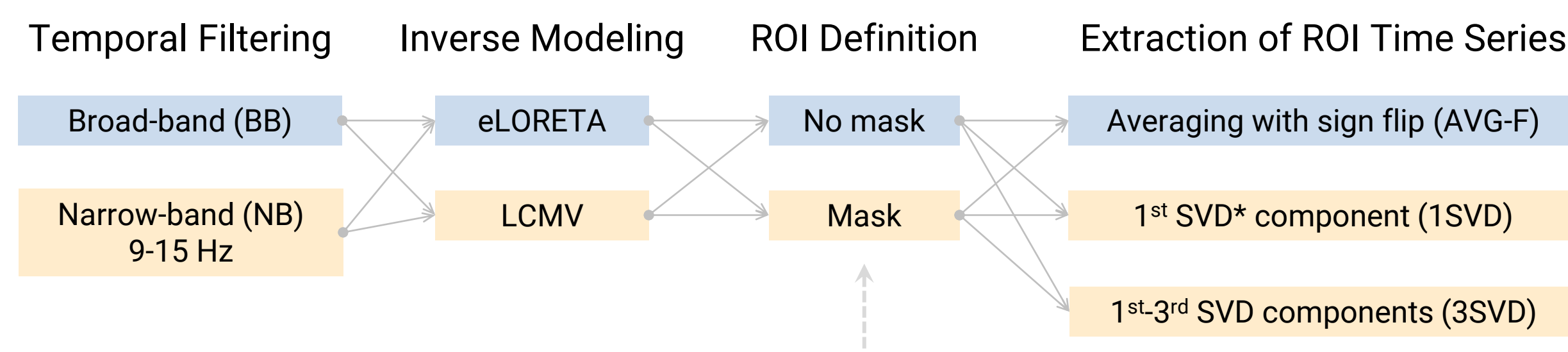
## Data & Methods

### Preprocessed EEG Data

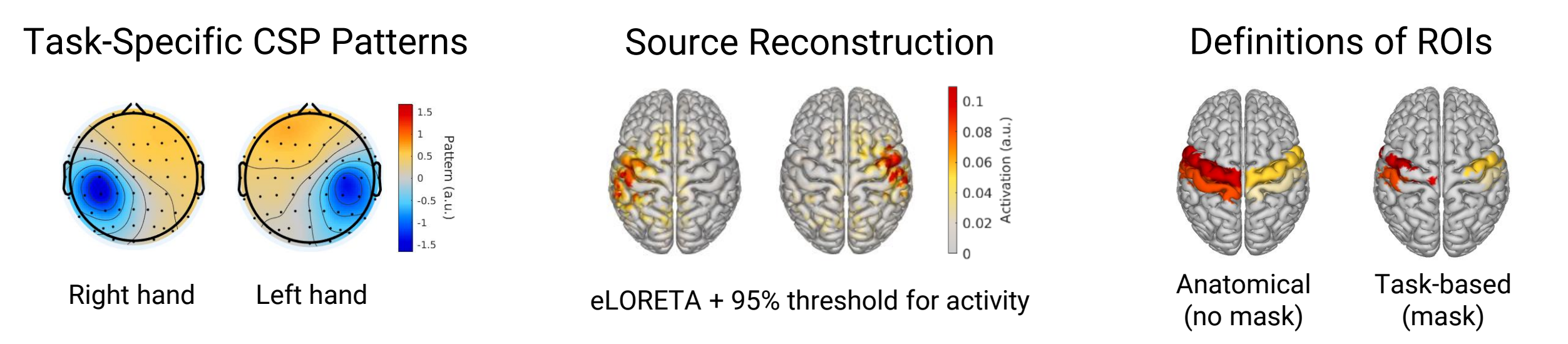
62 participants, 7-11 sessions of cursor control based on imaginary movement of left and right hands



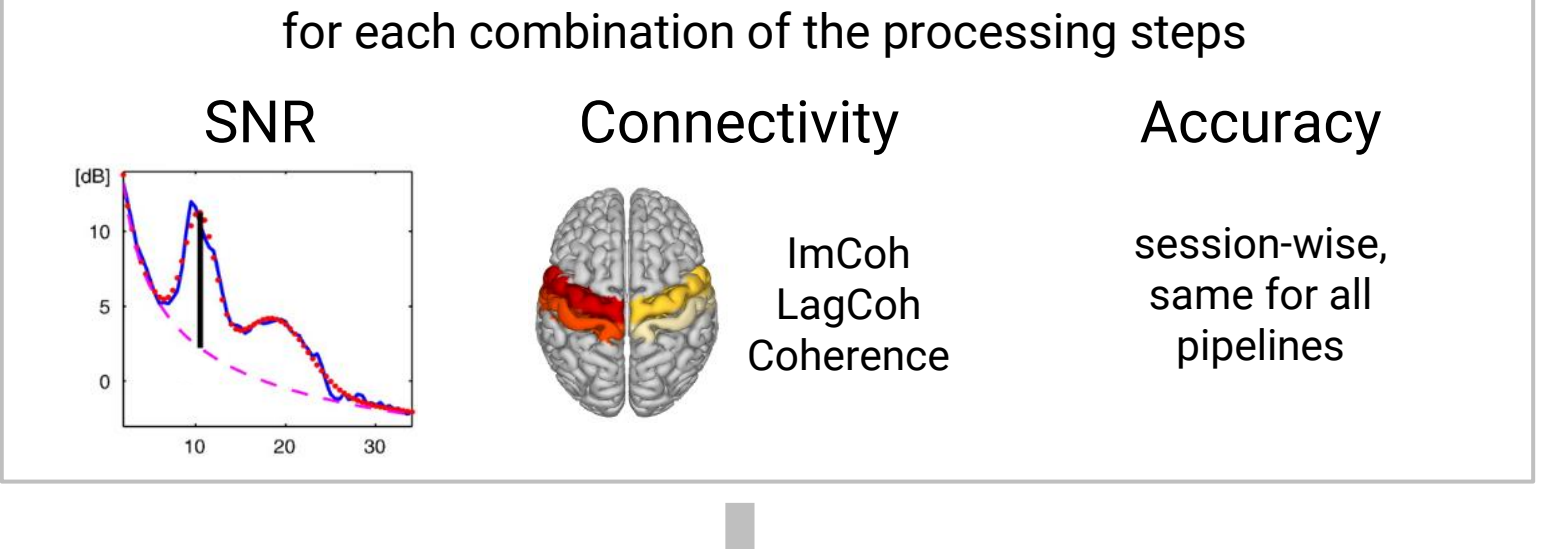
### Source Space Analysis



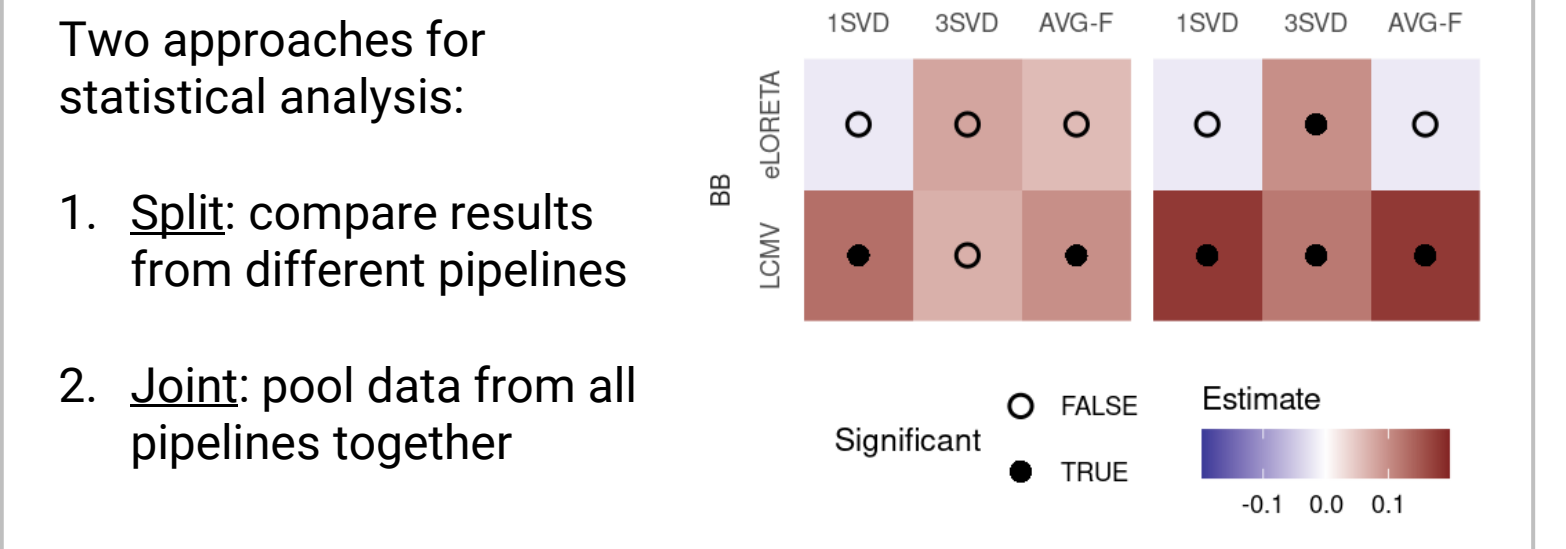
### Identification of Task-Relevant Sources



### Multiverse Analysis

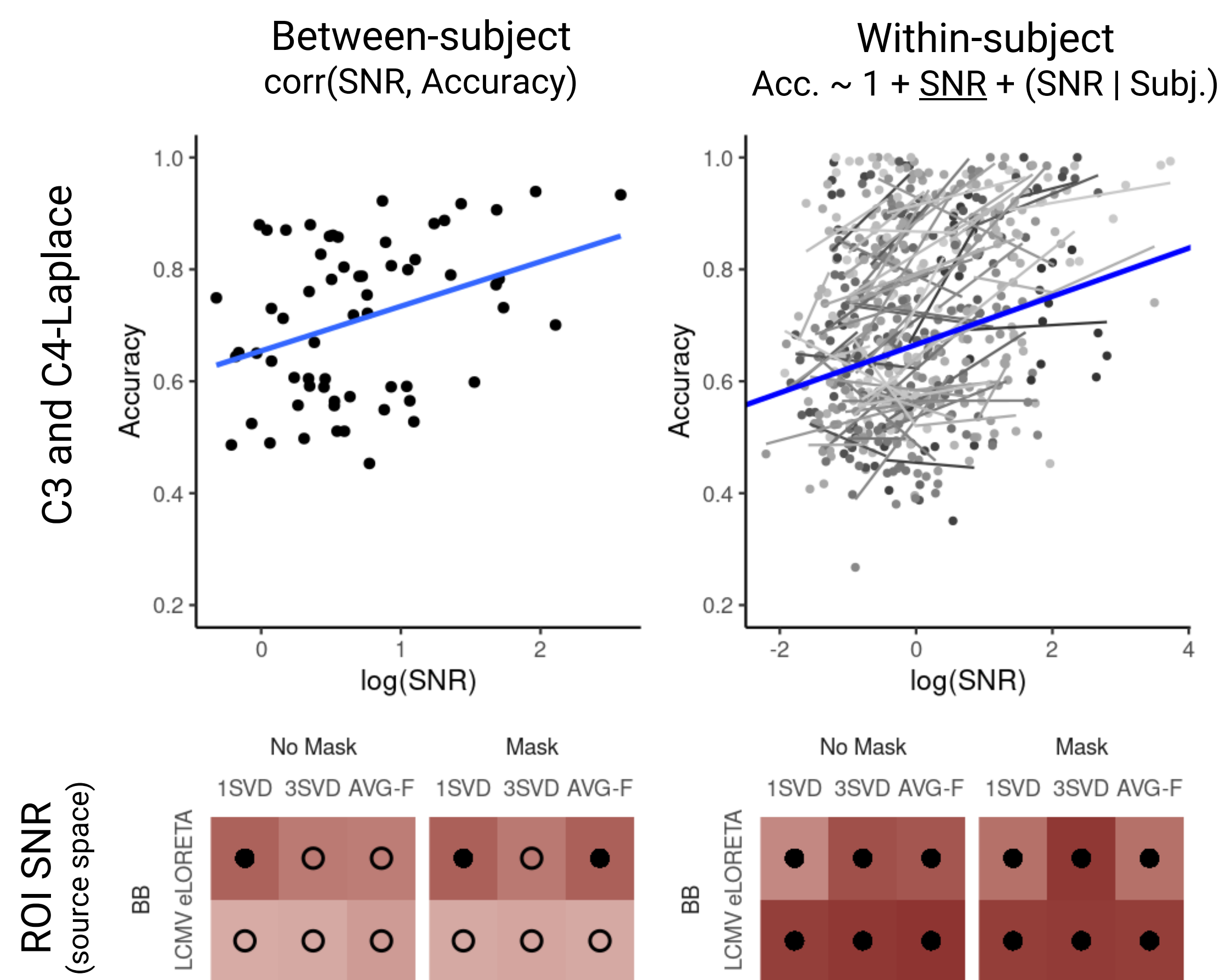


### Linear Mixed-Effects Models



## Results & Conclusions

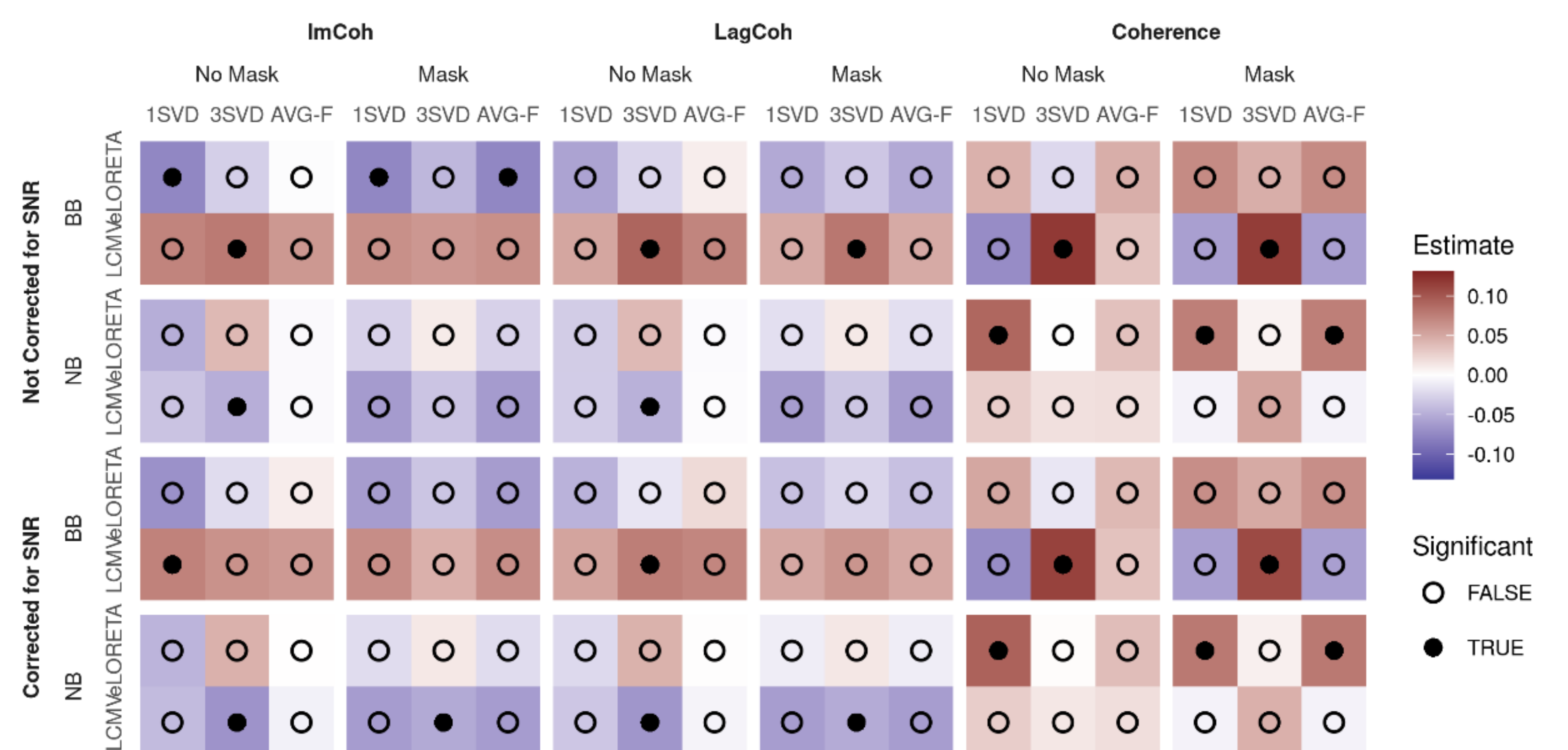
### 1 SNR predicts BCI performance in multiple sessions



Participants with higher SNR perform better on average, but also **the same participant performs better** on the days when SNR is higher

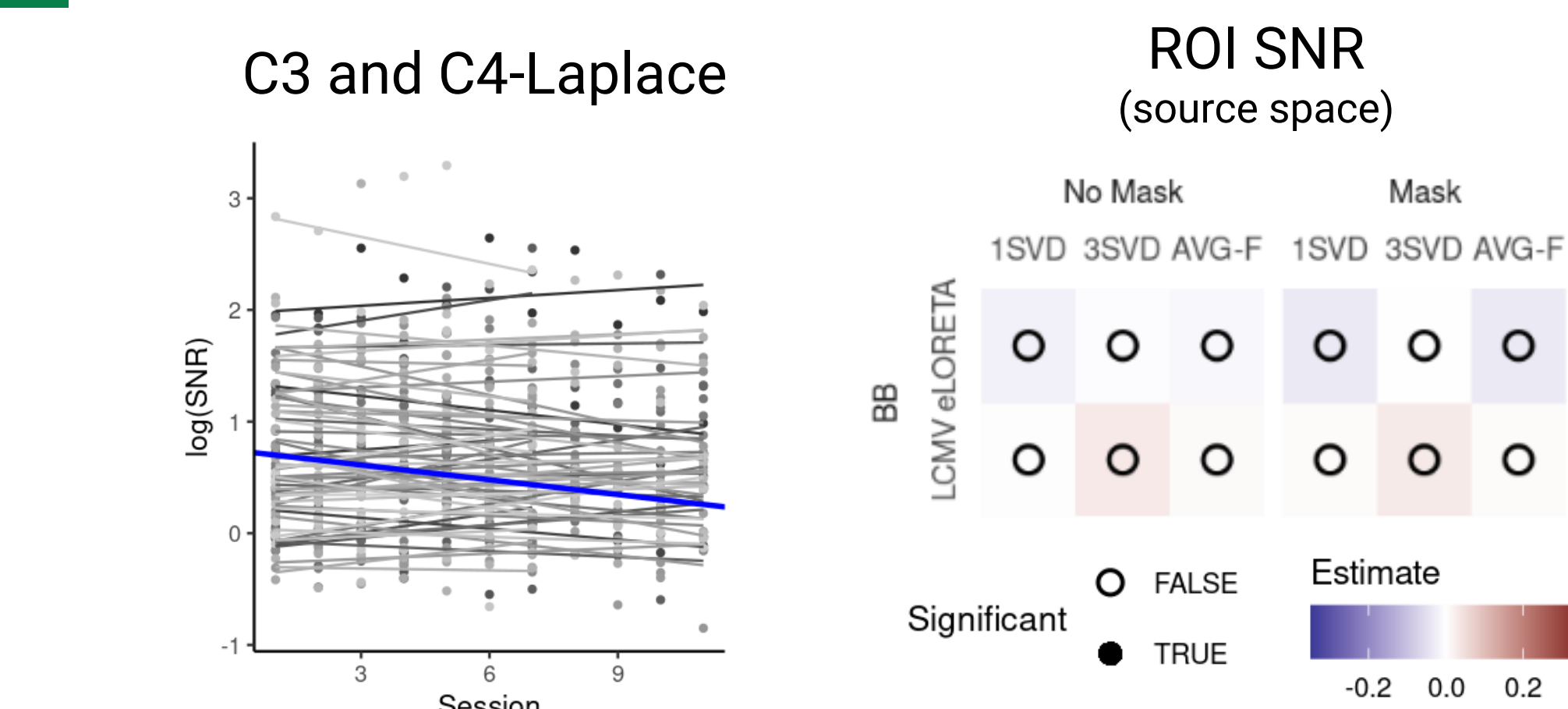
### 3 Effects of connectivity on BCI performance and changes over time are not robust in the multiverse analysis before and after correction for SNR

An exemplary plot for longitudinal changes in connectivity across hemispheres: Connectivity ~ 1 + Session + (Session | Subj.)  
Similar pattern was observed for effects of connectivity on performance: Accuracy ~ 1 + Connectivity + (Connectivity | Subj.)



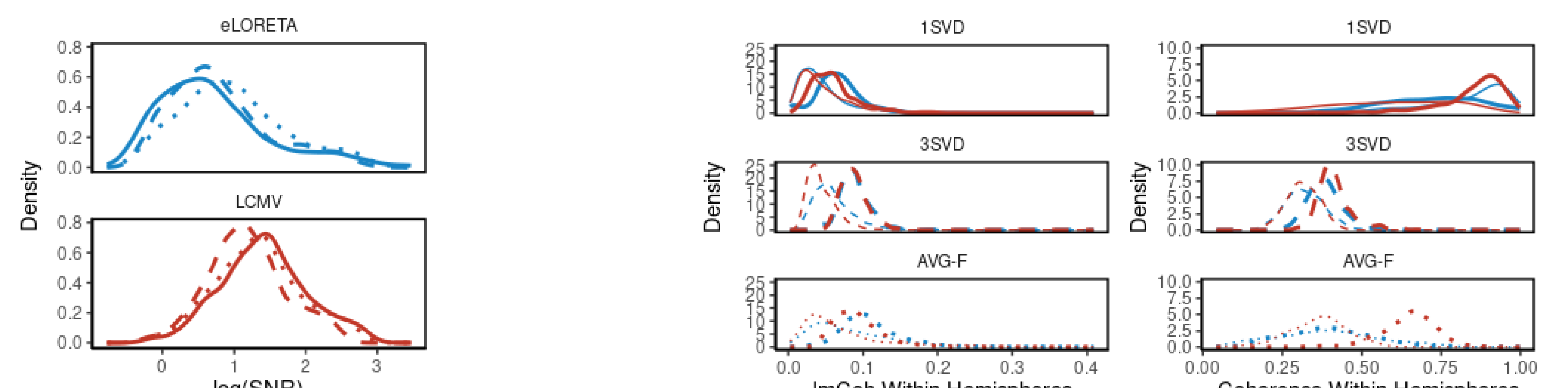
Effects of **connectivity** on performance and changes over time are **mostly not significant** after controlling for SNR, although **certain combinations** of processing steps lead to **significant** results

### 2 SNR does not change systematically over time



No significant changes in SNR over time were observed

### 4 Estimated values of SNR and connectivity are significantly affected by the selection of processing steps



SNR is higher for LCMV than eLORETA

First SVD component captures the effects of volume conduction