# Common Spatial Patterns for Detecting Motor Imagery in Disorders of Consciousness

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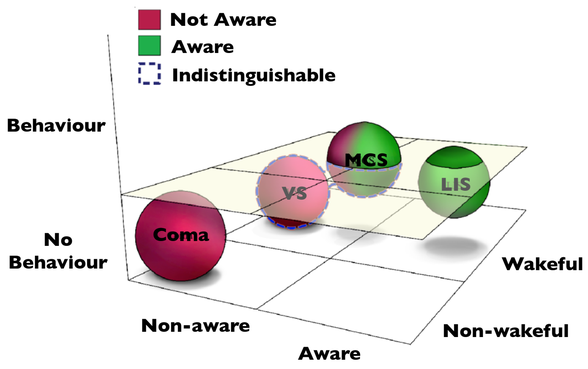
## A THE CHALLENGE

***How can we accurately detect whether a vegetative patient can imagine motor movements to demonstrate conscious awareness?***

### Disorders of Consciousness

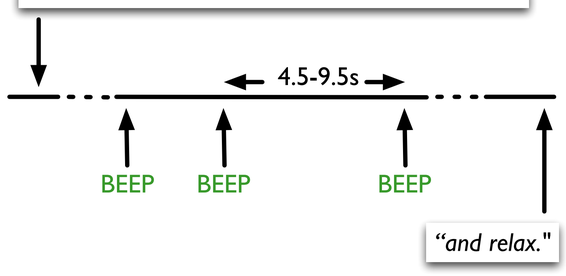
*Vegetative and Minimally Conscious States*




### Motor Imagery[1]

*Right Hand vs. Toes*

"*Every time you hear a beep, imagine that you are **squeezing your right-hand into a fist** // **wiggling all of your toes***"




## B THE METHOD

### Common Spatial Patterns Analysis[2]

***What is it?***

**Improves spatial resolution of EEG signals**

*Counteracts volume conduction of skull & scalp*

**Spatially filters single EEG trials**

*Highlights weak sources of sensorimotor rhythms*

**Data-driven class separation technique**

*Pulls Right Hand and Toes classes apart*

**From many electrodes to few spatial filters**

*Reduces feature dimensionality for better classification*

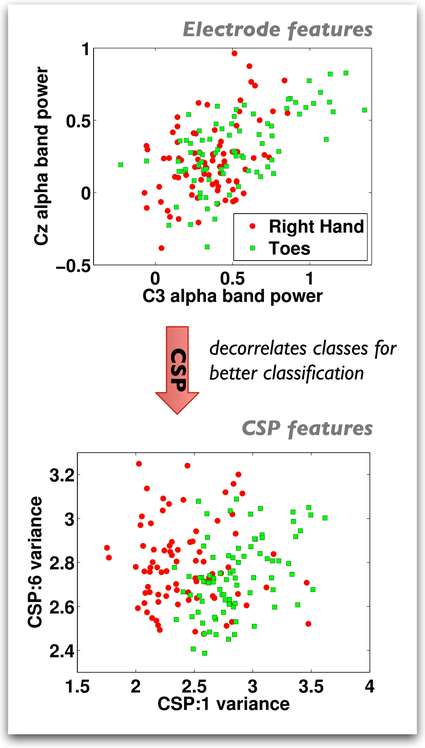
**Ideal spatial filters**

*Maximise signal variance in one condition*

*Minimise it in the other condition*

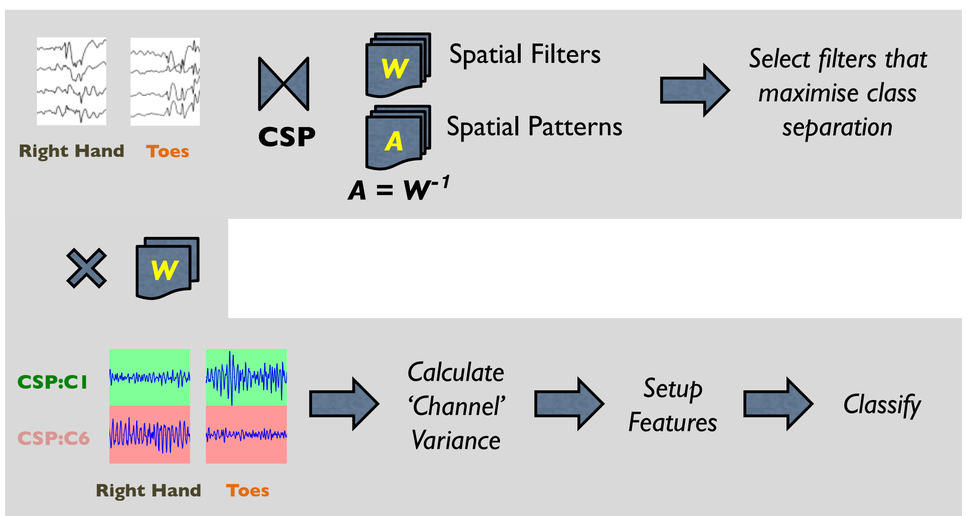
**Mathematical Basis**

*Eigenvalue decomposition of EEG data*




***How does it work?***

***Calculate spatial filters and train classifier on training trial set***




***Apply spatial filters and test classifier on test trial set***

***How does one select the best spatial filters?***

**Filters can be scored by their 'value'**

*Score reflects how well a filter separates the two classes*

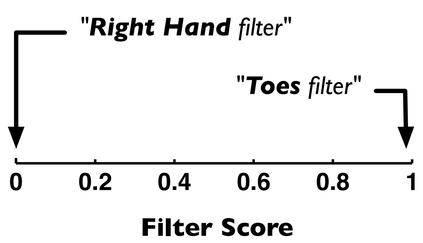
**Filters that**

*maximise variance for **Right Hand** get scores near **0***

*maximise variance for **Toes** get scores near **1***

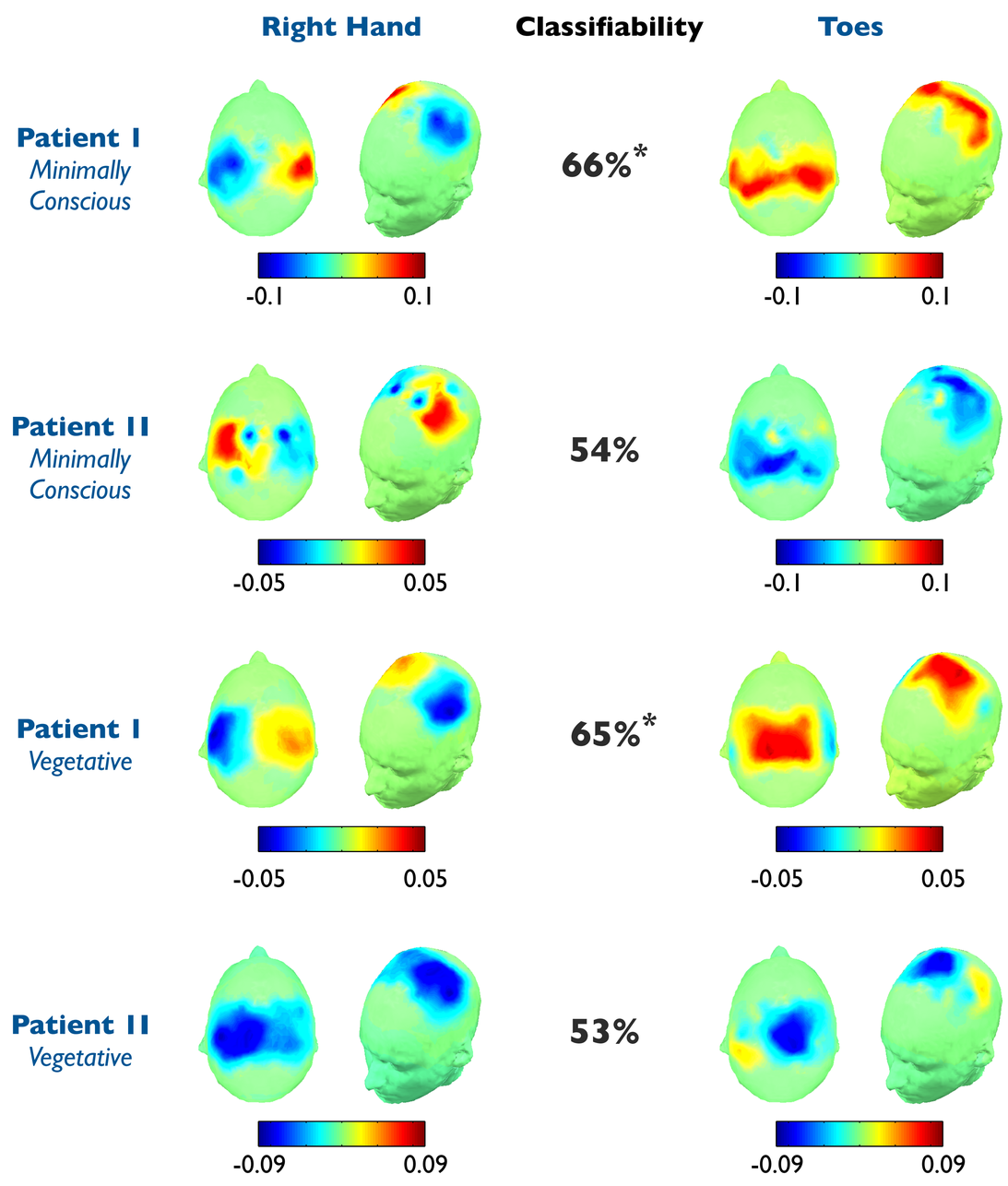
**Semi-automated filter selection**

*select neurophysiologically plausible filters near **0** and **1***

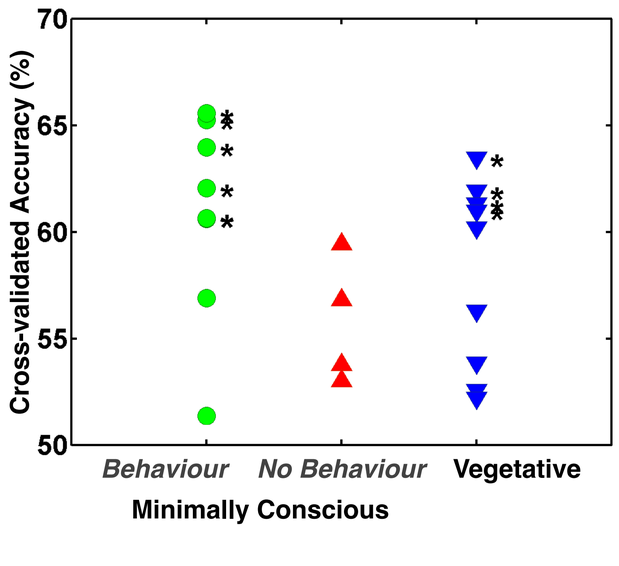



## C THE RESULTS

### Sample CSP Maps




### Cross-validated Classification




*Subset of patients get significant cross-validated classification accuracies*

***Significant at p=0.01 with randomisation testing**

## D CONCLUSIONS & DIRECTIONS

**CSP analysis can detect volitional motor imagery in some DoC patients**

*Increased physiological noise in patient data adversely affects accuracies*

**Neurophysiogically plausible spatial filters produce significant accuracies**

*CSP maps highlight significant variability among spatial filters in patients*

**Future Work: ask questions - by mapping *Right Hand* to "Yes" and *Toes* to "No"**

*This will be the litmus test for generalisability of patient CSP maps*

## References

1. Cruse et al. **Bedside detection of awareness in the vegetative state**, *Lancet*, 2011
2. Blankertz et al. **Optimizing spatial filters for robust EEG single-trial analysis**, *IEEE Signal Processing Magazine*, 2008

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