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# Integrating EEG and MEG information to enhance motor-imagery classification in brain-computer interface

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Brain-computer interface (BCI) is a potential tool for rehabilitation and communication that mainly relies on the electroencephalography (EEG). Despite its clinical applications, BCI faces to both engineering and user-oriented challenges to improve its spreading. In this work, we assess the possibility of integrating electroencephalographic (EEG) and magnetoencephalographic (MEG) signals to enhance the classification performance in motor imagery-based BCI. By adopting a matching-score fusion approach (in an offline fashion) that optimizes the choice of the features in each individual, we reached an average classification improvement of 12.8 % as compared to separate EEG and MEG classifiers. These results could promote multimodal BCIs development.

## Methods

### BCI protocol

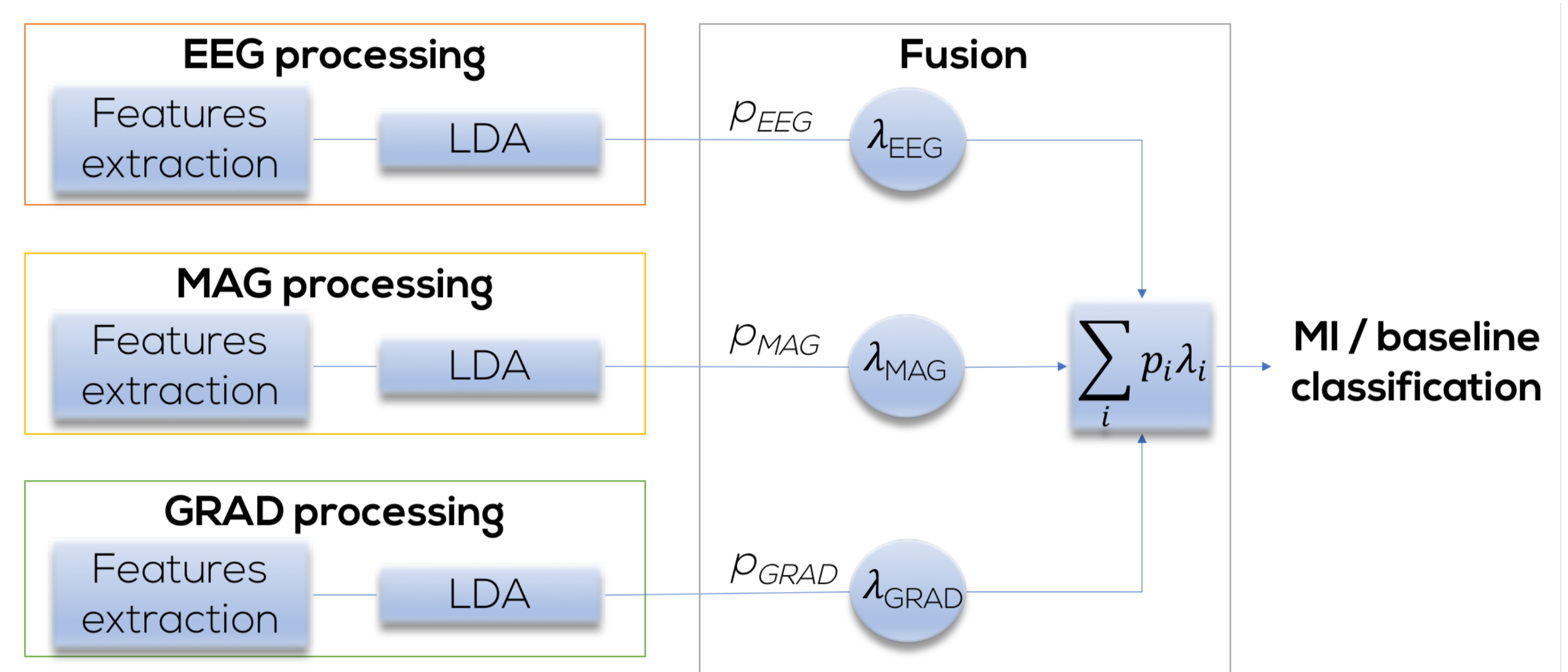
Fifteen healthy subjects (aged  $28.13 \pm 4.10$  years, seven women) participated to the protocol



**Fig. 1:** BCI experiments performed at the CENIR. MEG and EEG are simultaneously recorded with, respectively: an Elekta Neuromag TRIUX machine® (204 planar gradiometers and 102 magnetometers) and a 74 EEG-channel system. The task consists in a 1D, 2-target, right-justified box task where the subject performs a sustained MI (grasping) of the right hand to hit up-targets, while remaining at rest to hit down-targets.

### Fusion approach

No artifact removal method applied here to simulate online scenarios.



**Fig. 2:** Classifier fusion approach for a given frequency bin. The variables  $p_i$  and  $\lambda_i$  stand for the posterior probability and the weight parameter associated with the modality  $i$ .

Semi-automatic procedure to extract features:

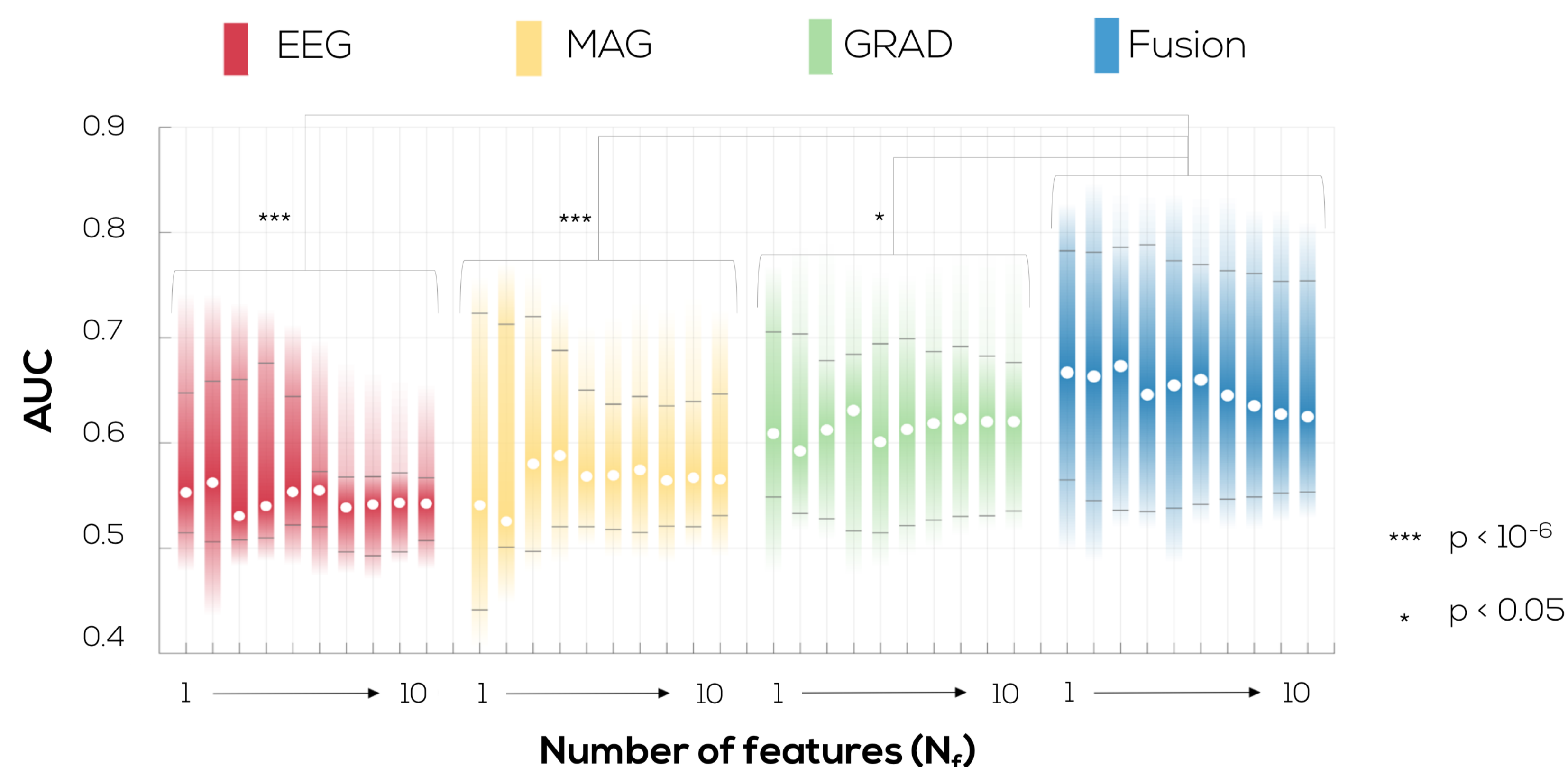
Focus on motor area contralateral to the imagined movement

Nonparametric cluster-based permutation t-test between power spectra of MI and rest epochs

Extraction of the  $N_f$  most discriminant features within the standard frequency bands

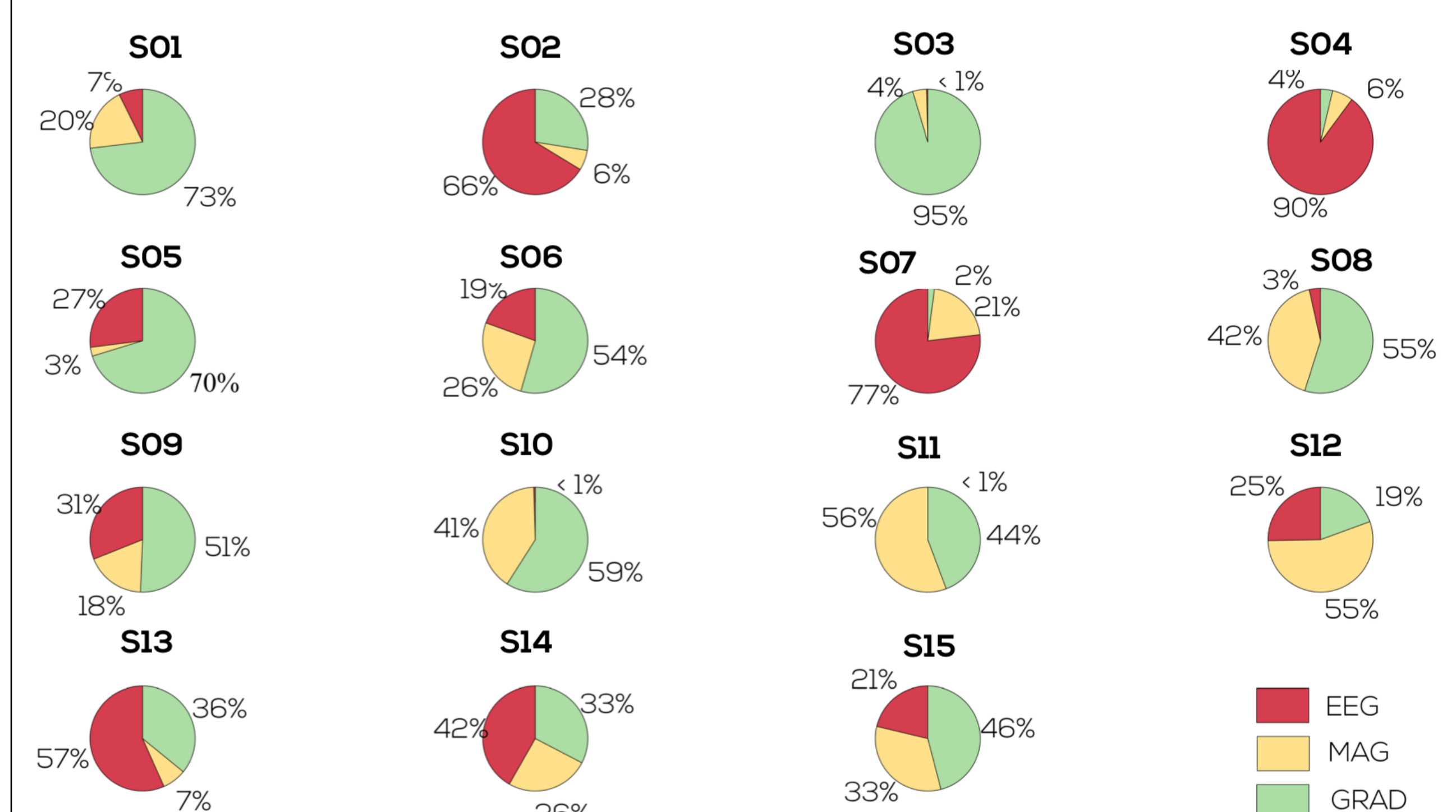
## Results

### Classification fusion enables a significant performance improvement



**Fig. 3:** AUC distributions across the 15 subjects, for all the modalities, and for different numbers of features within the alpha-band. White circles correspond to the median values. In all frequency bands, the type of modality significantly affected the AUC values (ANOVA,  $p < 10^{-3}$ ), whereas the number of features did not have a significant impact ( $p > 0.05$ ).

### Inter-subject variability: attributed weights



**Fig. 4:** Contribution of different modalities to the individual performance. Pie-diagrams show the  $i$  values (in percentage) obtained for each modality via the fusion approach.

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