Feedback Modality for Motor Imagery

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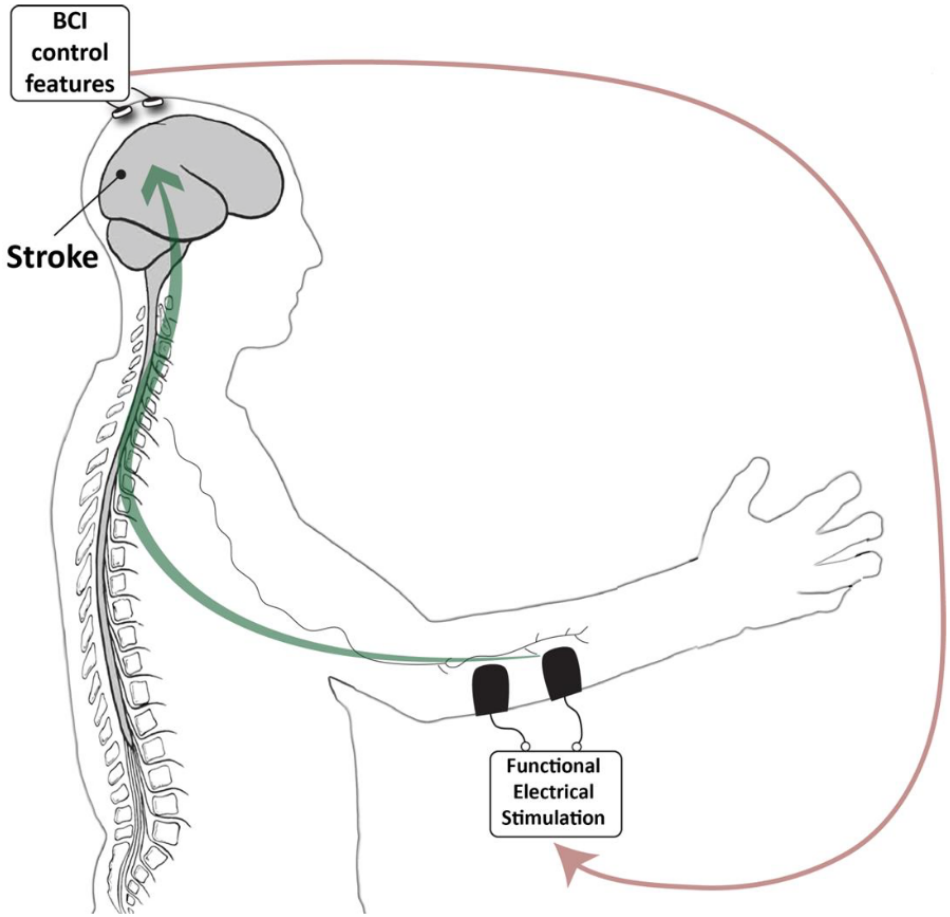
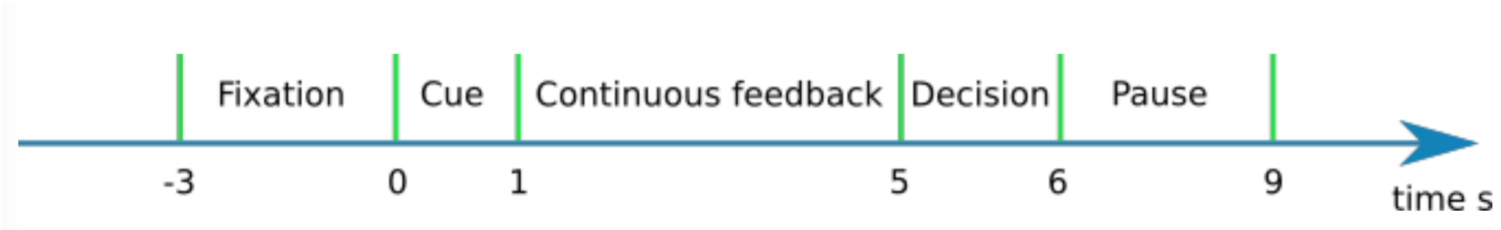
Feedback Modalities



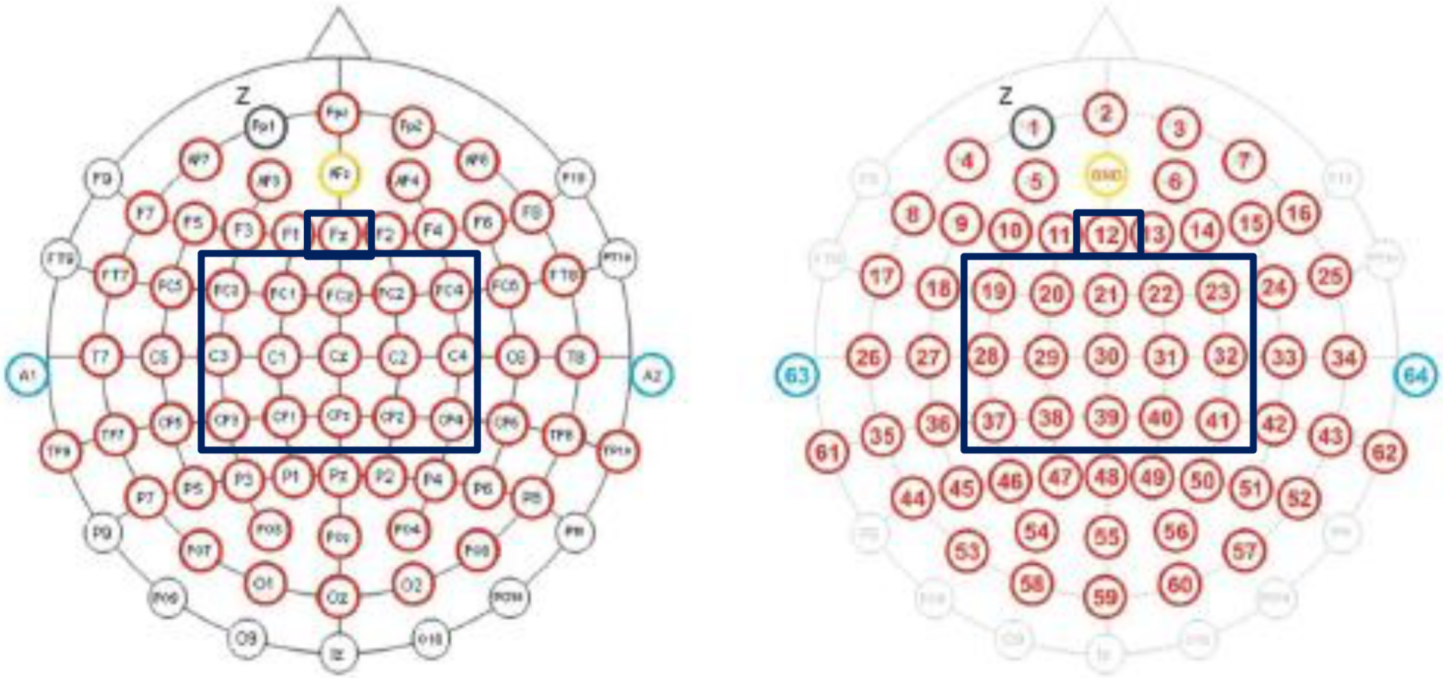
Functional Electrical Stimulation: Low energy electrical stimulation utilized in to simulate normal motor action (e.x. grasping).

Protocol



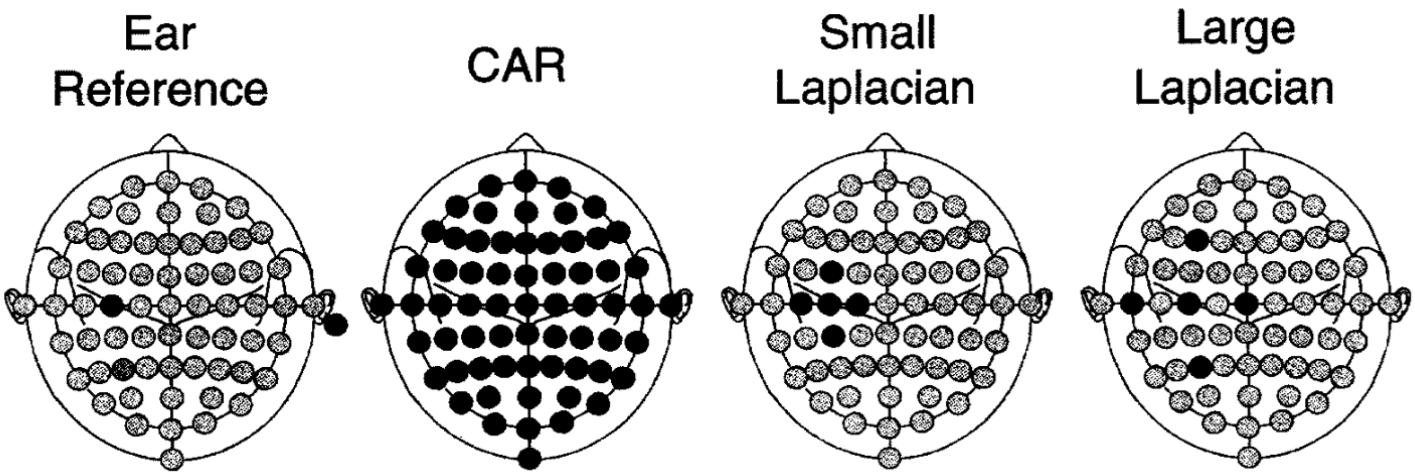
- **Fixation**: User focuses on cross on screen
- **Cue**: User informed of required action (Rest/MI)
- **Continuous Feedback**: User receives visual or electrical feedback
- **Decision**: Arrow reaches top (visual). Muscle contraction (FES)
- **Pause**: User allowed to adjust position, blink, etc.

EEG Recording



- Record from 64 electrodes, analysis on 16.
- Remove NaN and noisy channels

Filtering

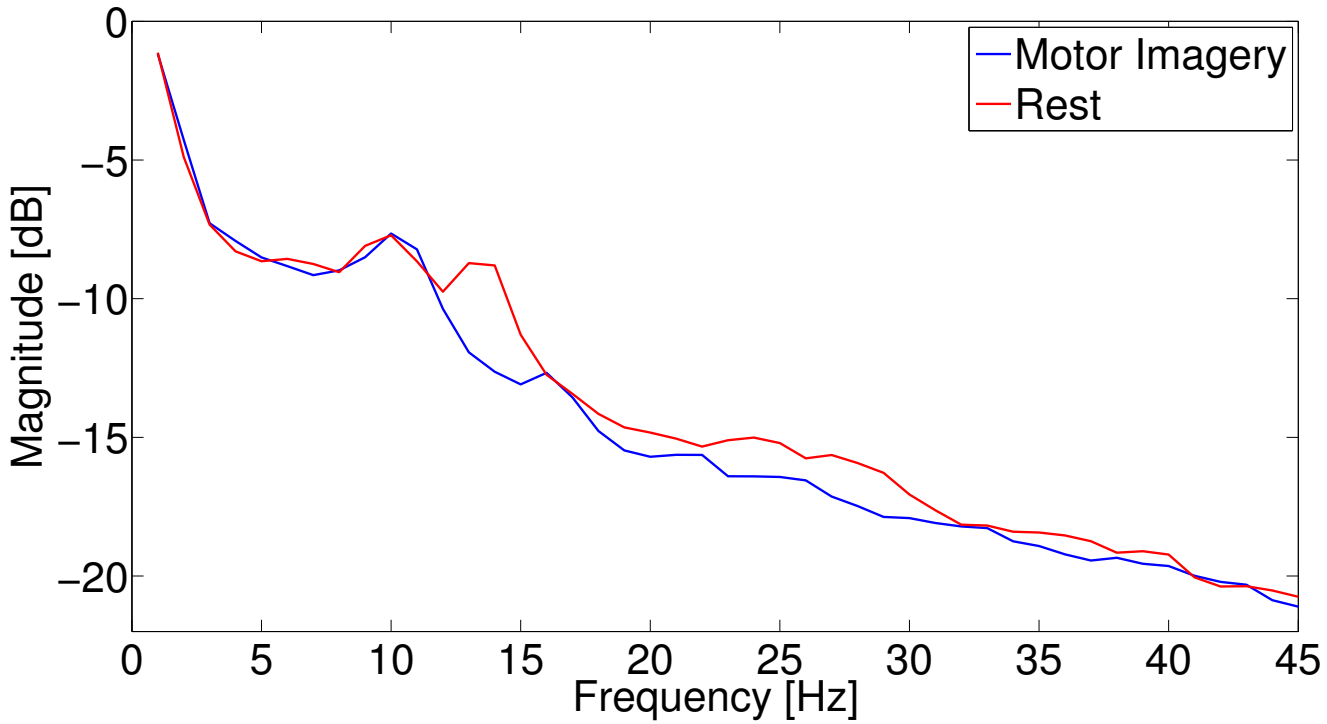


We attempted both common average reference (CAR) and small laplacian on both subjects. Our results suggest that the small laplacian filter was more effective on subject 2, whereas CAR proved best for subject 3. [McFarland, 1997]

pwelch - Visualization of ERD

pwelch parameters

1. **Window Size**: 1 sec (512 samples)
2. **Window Overlap**: 50%
3. **Frequency Band**: 0.5-45Hz



Feature Selection

In order to select features we analyzes the data utilizing a combination of statistical methods:

- R-Squared

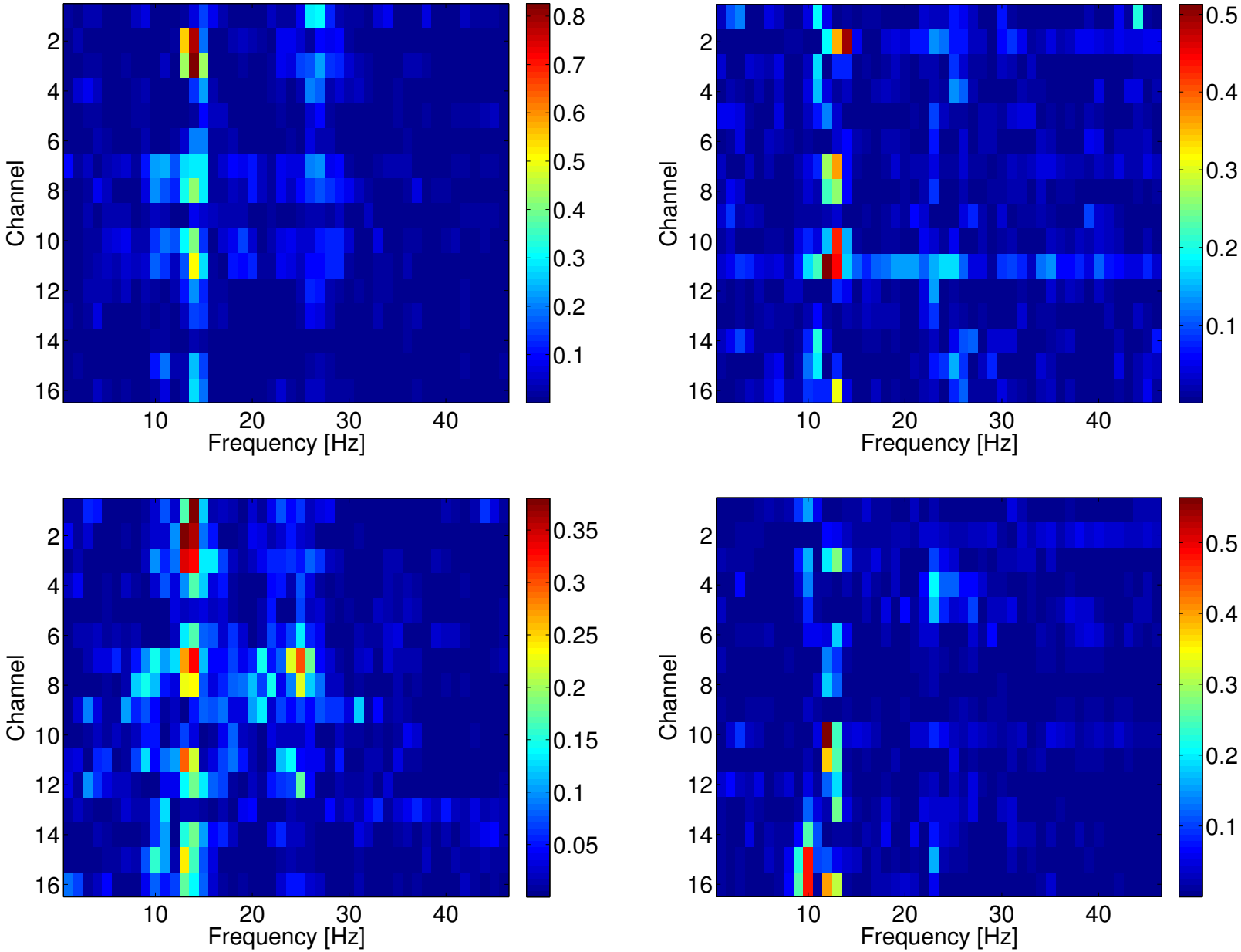
$$\rho(X, Y) = \frac{\mathbf{Cov}(X, Y)}{\sqrt{\mathbf{Var}(X)\mathbf{Var}(Y)}} \tag{1}$$

- Fisher Score

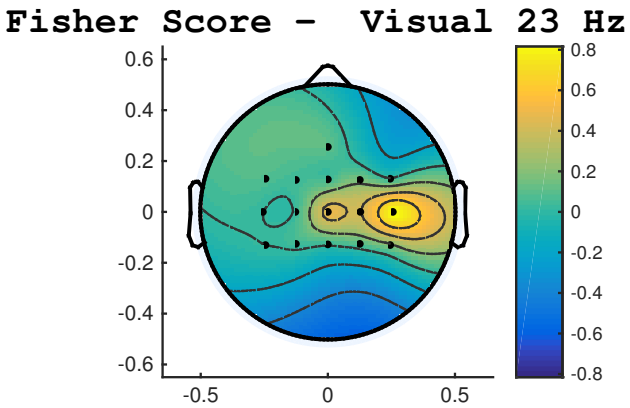
$$F_r = \frac{\sum_{i=1}^{c} n_i(\mu_i - \mu)^2}{\sum_{i=1}^{c} n_i \sigma_i^2} \tag{2}$$

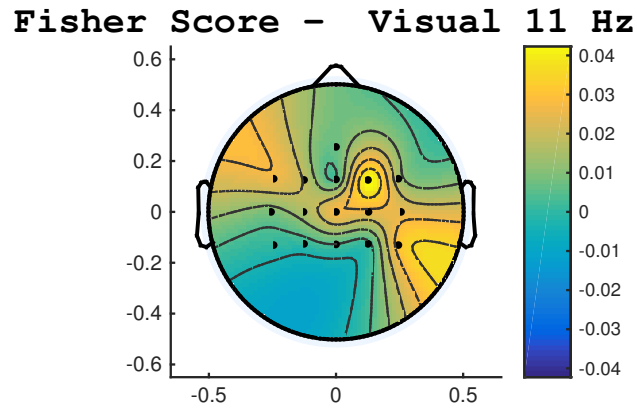
In addition we utilized both *students t-test* and *independent feature modeling*. After examining each method we found that fisher scoring [Xiaofei, 2005] was optimal for both subjects data sets.
In order to select features which were logical we limited ourselves to the μ (7.5 - 12.5 Hz) or β (16 - 31 Hz) bands due to a priori knowledge of their significance in the sensorimotor areas
[Pfurtscheller, 2006],[Pfurtscheller, 1997].

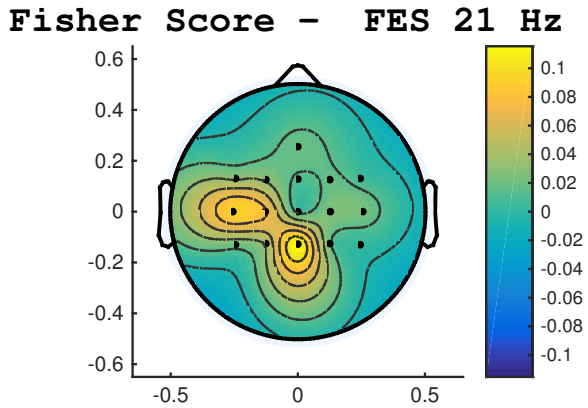
Feature Plotting

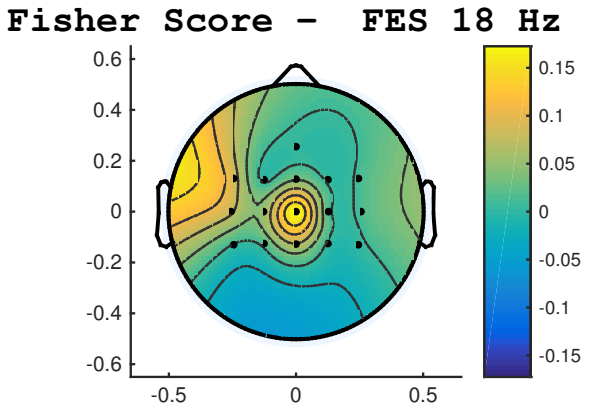


Topographic Feature Plotting

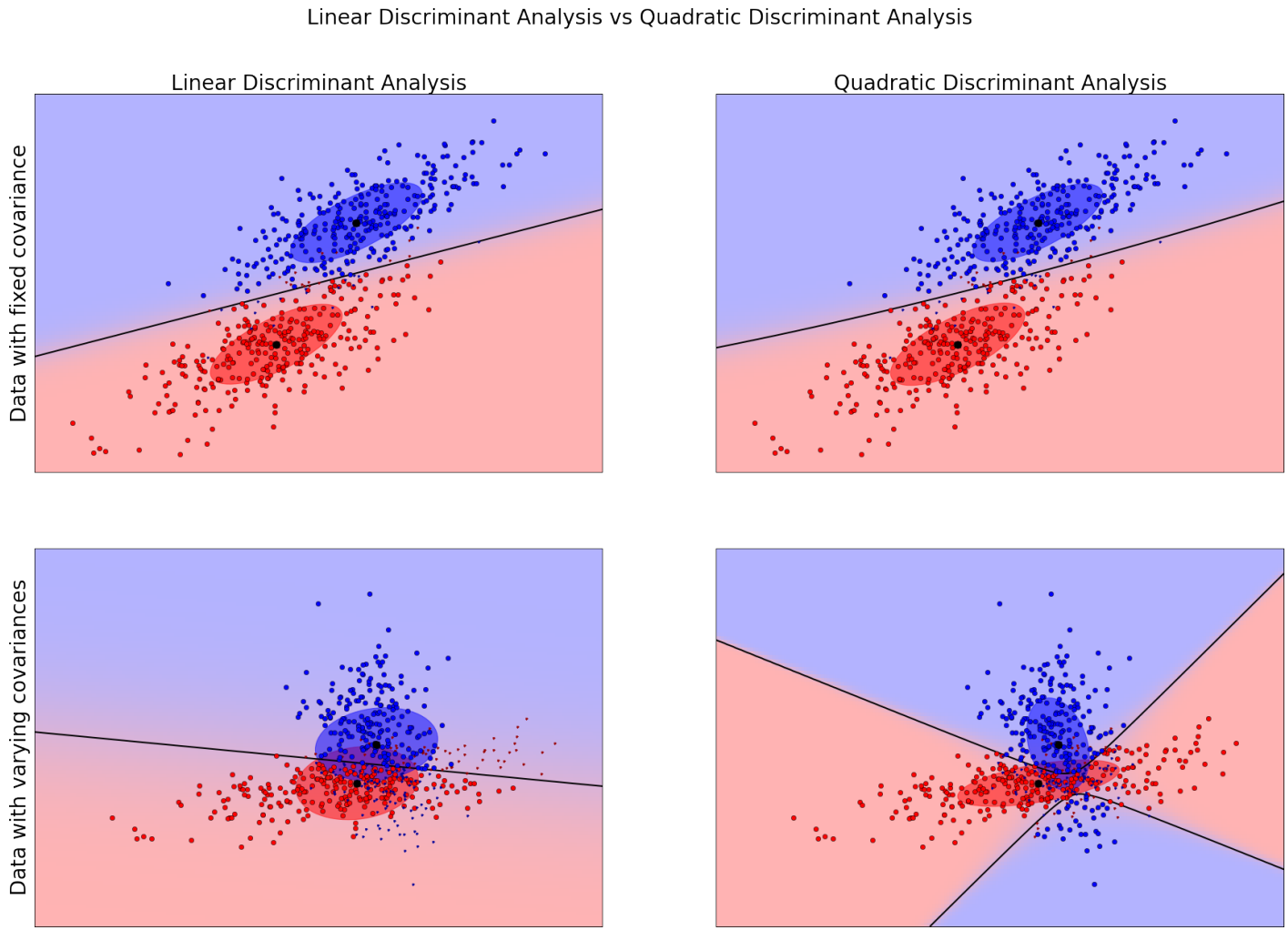






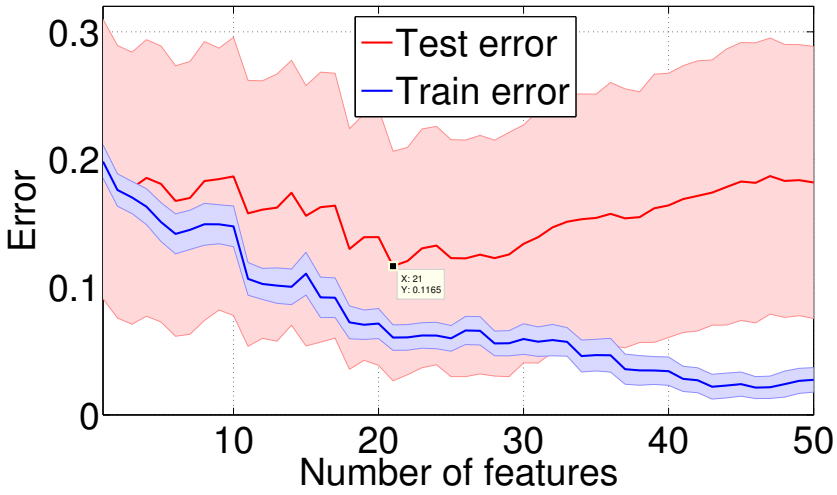


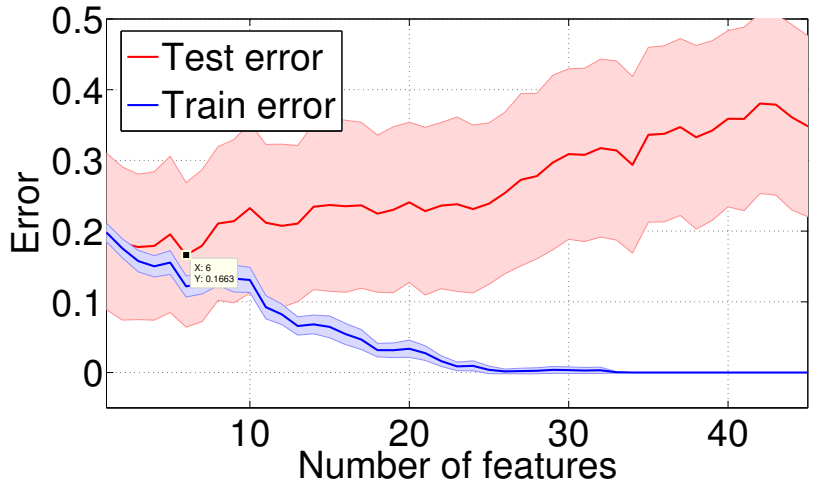
Classifiers

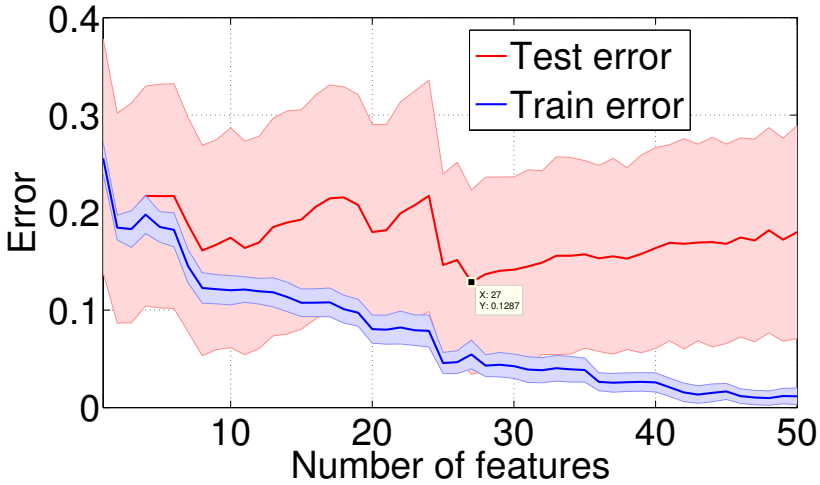


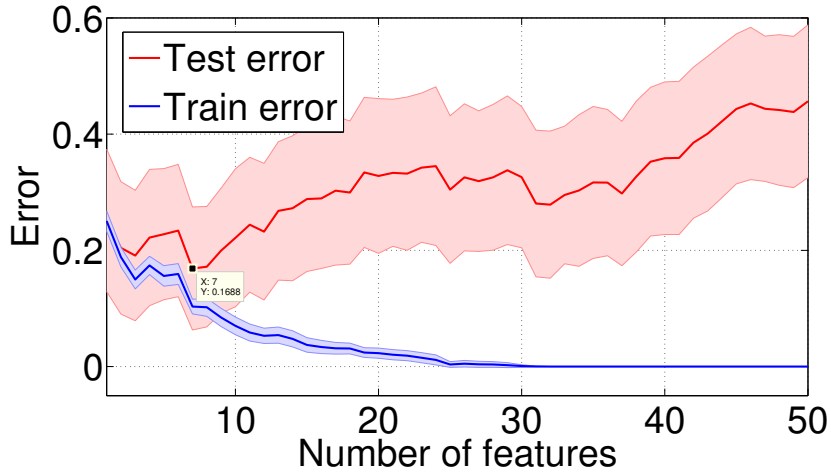
[http://machine-learning-python.kspax.io]

Classifiers: Performance of QDA vs LDA

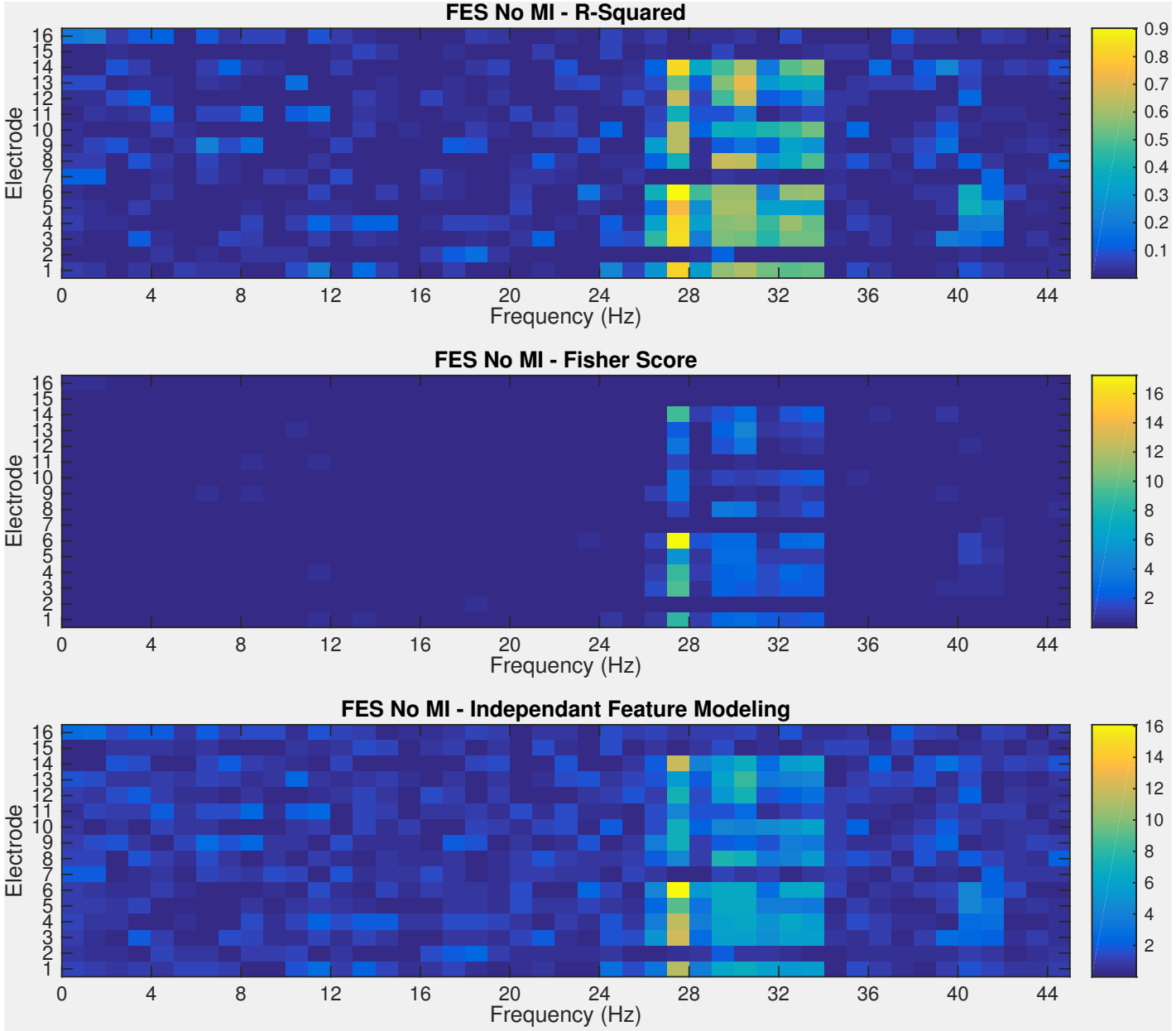




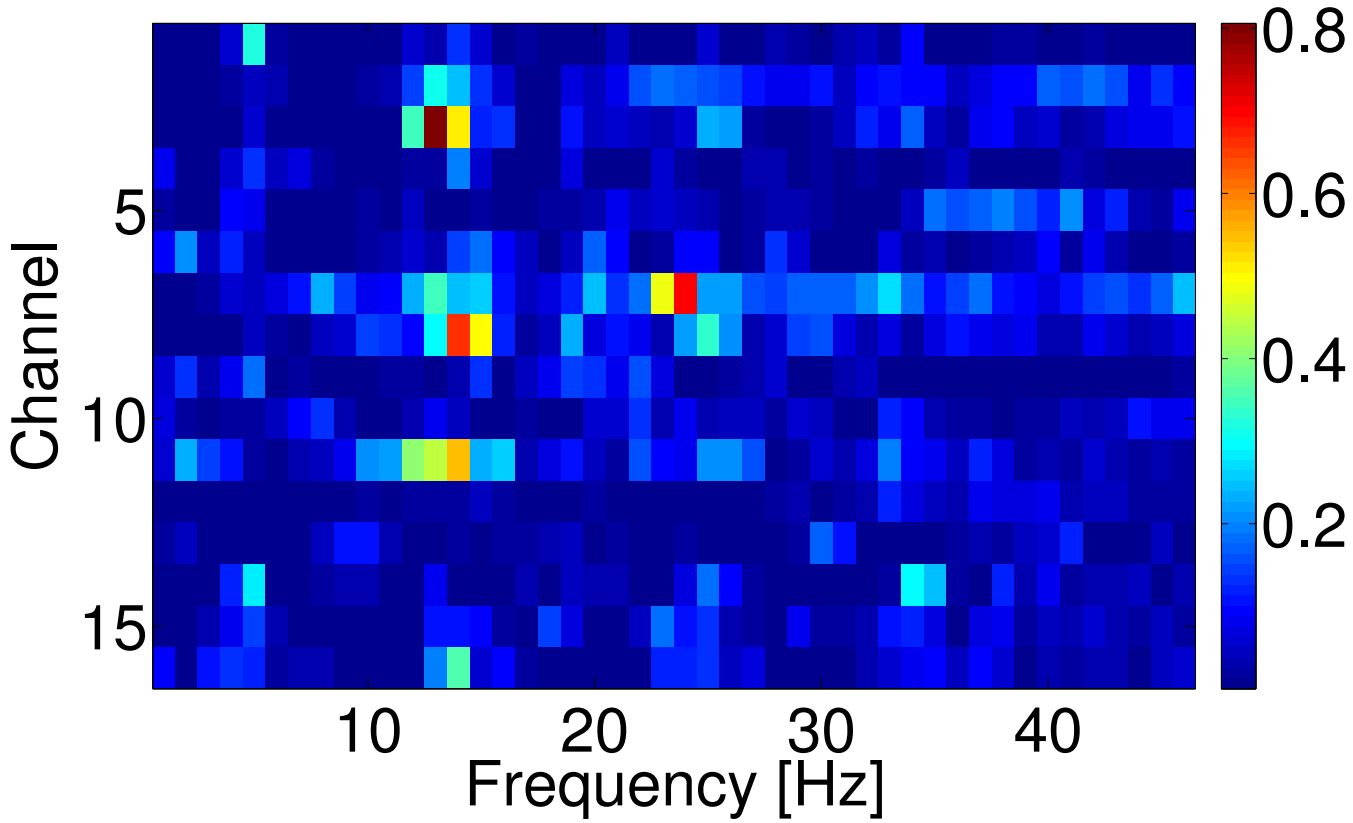




FES: Control

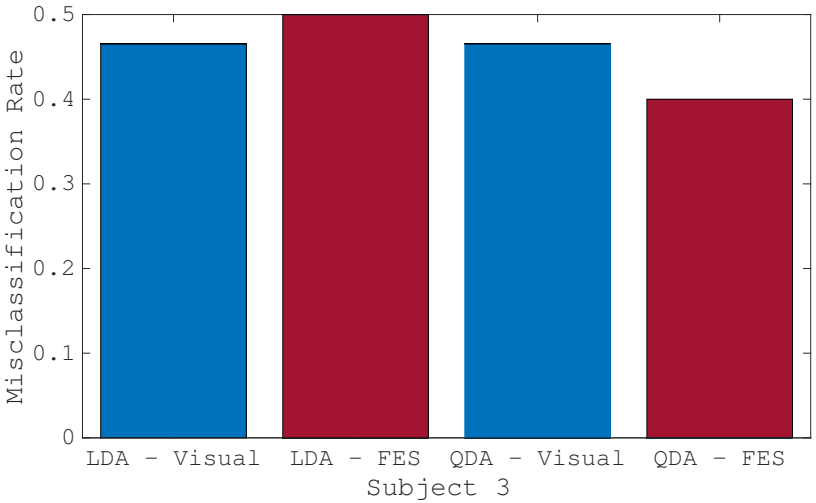

FES No MI - R-Squared
Electrode
Frequency (Hz)
FES No MI - Fisher Score
Electrode
Frequency (Hz)
FES No MI - Independant Feature Modeling
Electrode
Frequency (Hz)

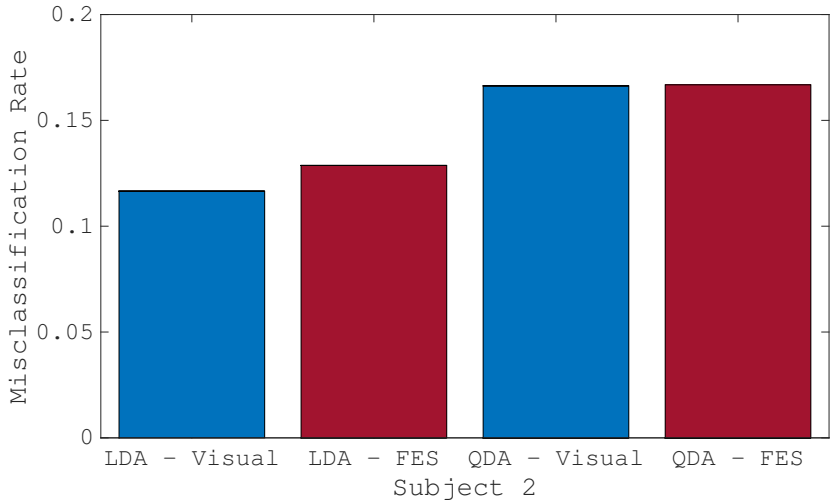
FES: Control



Fisher score of Subject 2's NoMI-FES control. Note that unlike the previous figure there are distinct features present here which overlap our features utilized for classification.

Results





Misclassification rates of LDA and QDA classifiers during session 1 for both FES and visual feedback for both subjects.

References

McFarland DJ1, McCane LM, David SV, Wolpaw JR. (1997)

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G. Pfurtscheller, C. Brunner, A. Schlo gl, and F. H. Lopes da Silva (2016)

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Xiaofei He, Deng Cai, and Partha Niyogi (2005)

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Questions