Study of normal and pathological brain activity and connectivity with MEG
Experiment

- **Task 1**: Image of a person with the option list containing items such as Face, Lorry, Horse, Bird, Flower, Chair. The response is indicated by a speech bubble with the word "Face".

- **Task 2**: Image of a person with a smiling face with the option list containing items such as Happy, Surprised, Fearful, Sad, Disgusted, Angry. The response is indicated by a speech bubble with the word "Happy".

*Time (ms)*: 0, 500, 1500.
Pre-processing

High-pass filter (1 Hz)
Elimination of noisy channels and trials
Artifact removal (ICA)

Processed MEG signals

Source analysis
Magnetic field tomography (MFT)

MFT solutions (current density)

Regional activation curve generation

SPM
Post- vs. pre-stimulus
Emotional vs. neutral

Activation curve
Example MI map with several areas
Influence diagram

Controls

Patients
Processing stages

Controls

Patients
Shannon Entropy

Let $X$ be a system under study. If we perform a measurement, we obtain the result that the system is in state “I” with a certain probability $p(I)$. The average amount of information from such a measurement can be quantified in terms of Shannon entropy:

$$H_S(X) = - \sum_i p(i) \ln p(i)$$

If we measure simultaneously two subsystems $X_1$ and $X_2$ then the joint entropy of the combined system equals

$$H_S(X_1, X_2) = - \sum_{i,j} p(i, j) \ln p(i, j)$$
Mutual Information

Mutual Information evaluates the amount of information about one of the subsystems resulting from a measurement of the other and can be expressed in terms of entropy:

\[ I(X_1, X_2) = H_s(X_1) + H_s(X_2) - H_s(X_1, X_2) \]

\[ I(X_1, X_2) \geq 0 \]

Information transport may lead to time-delayed effects in the synchronization of correlations. Such effects can easily be quantified by calculating the time-delayed MI:

\[ I(X_1, X_2; \tau) = H_s(X_1) + H_s(X_2; \tau) - H_s(X_1, X_2; \tau) \]
Generalized version of the MI

There exist a generalization of the information entropy:

$$H_q(X) = \frac{1}{1-q} \ln \sum_i p^q(i)$$

For $q = 1$ this equation yields the standard Shannon entropy. The main property of $q$-entropy is that with increasing $q$ a higher weight is given to the largest components of set $\{p(I)\}$.

We may generalize the concept of mutual information:

$$I_q(X_1, X_2; \tau) = H_q(X_1) + H_q(X_2; \tau) - H_q(X_1, X_2; \tau)$$