Study of normal and pathological brain activity and connectivity with MEG

Experiment

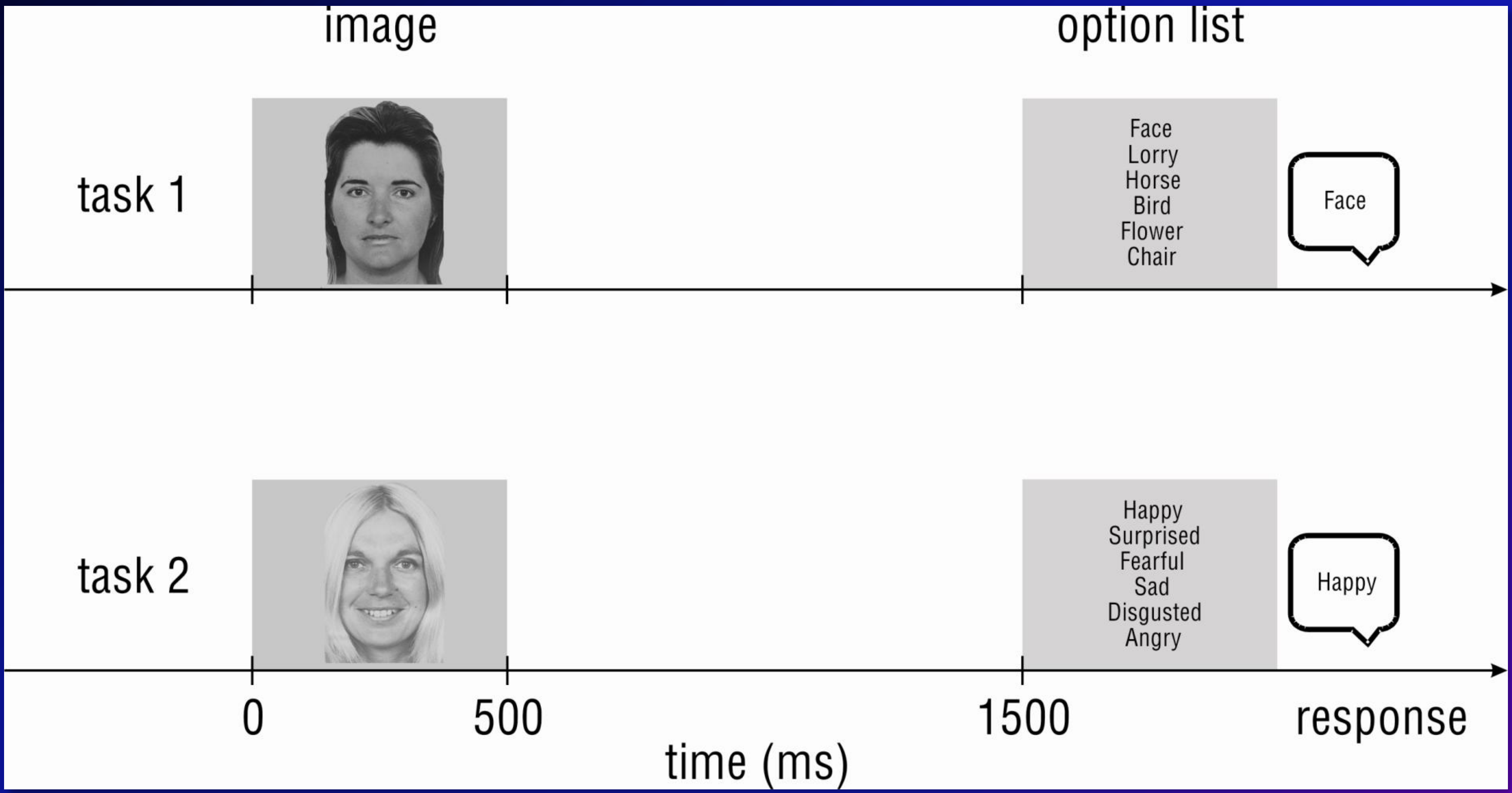
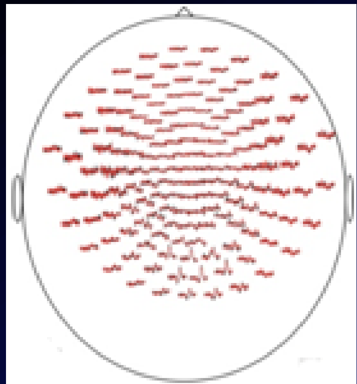


image
option list
task 1
Face
Lorry
Horse
Bird
Flower
Chair
Face
task 2
Happy
Surprised
Fearful
Sad
Disgusted
Angry
Happy
0
500
1500
response
time (ms)



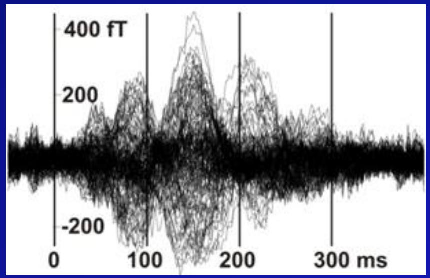
Recorded MEG signals

Pre-processing

High-pass filter (1 Hz)

Elimination of noisy channels and trials

Artifact removal (ICA)



Processed MEG signals

Source analysis

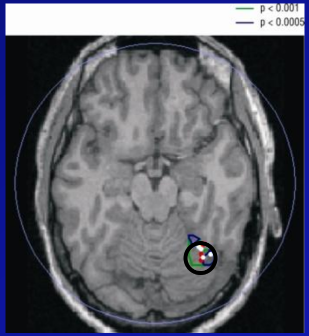
Magnetic field tomography (MFT)

MFT solutions (current density)

SPM

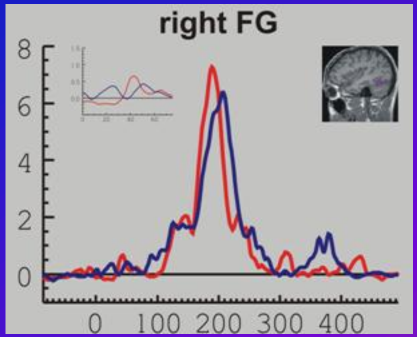
Post- vs. pre-stimulus

Emotional vs. neutral



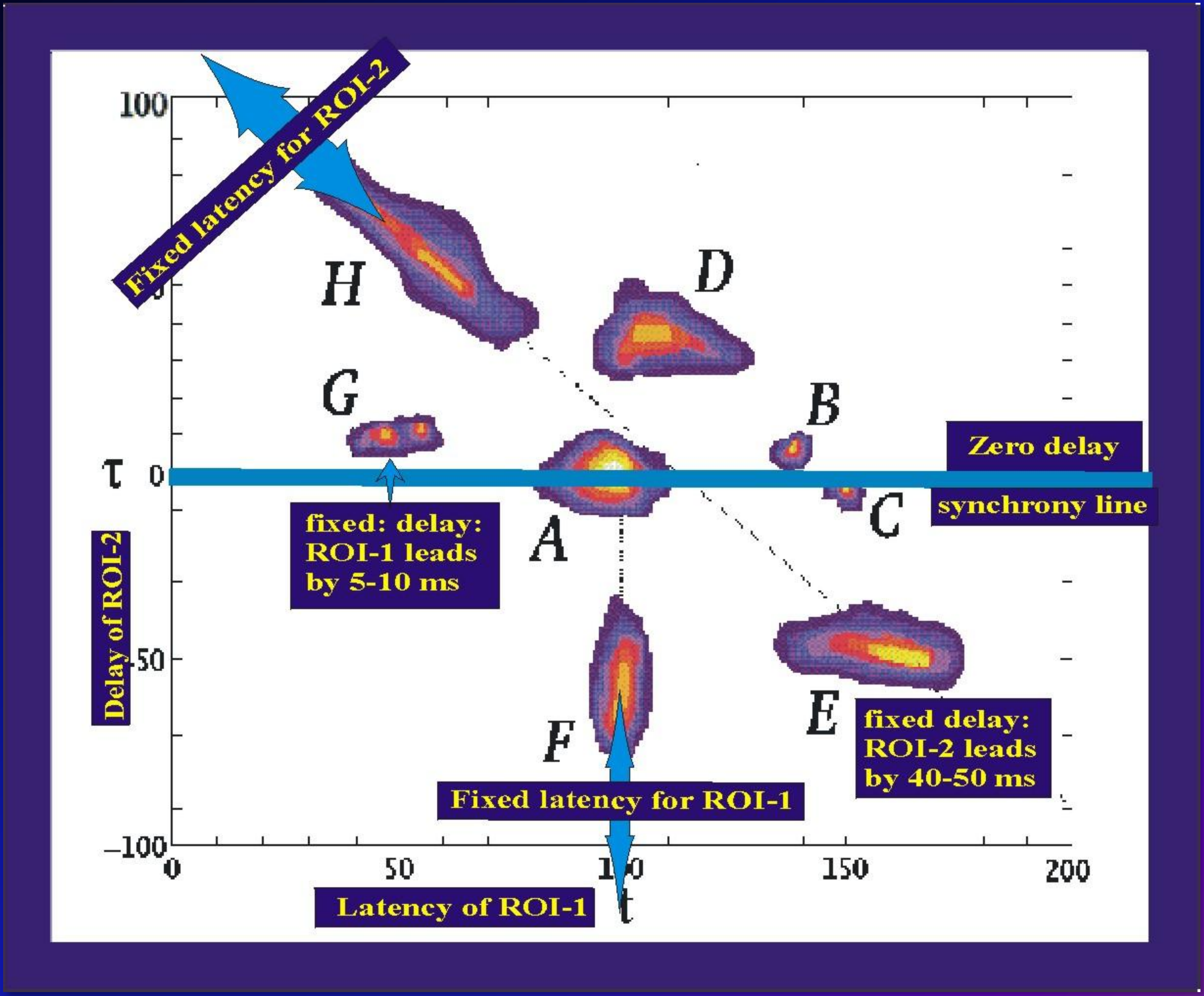
SPM

Regional activation curve generation

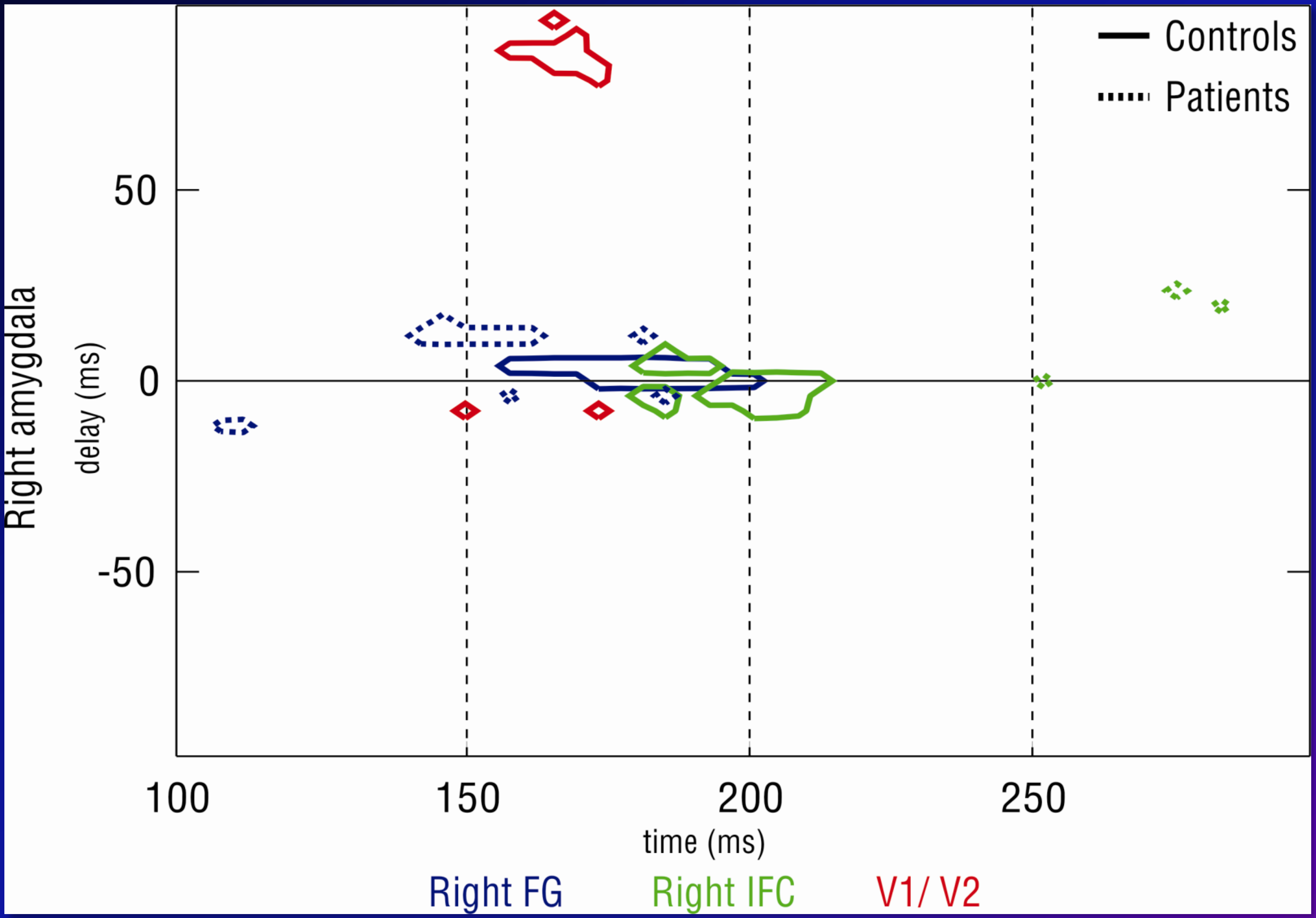


Activation curve

Mutual information map

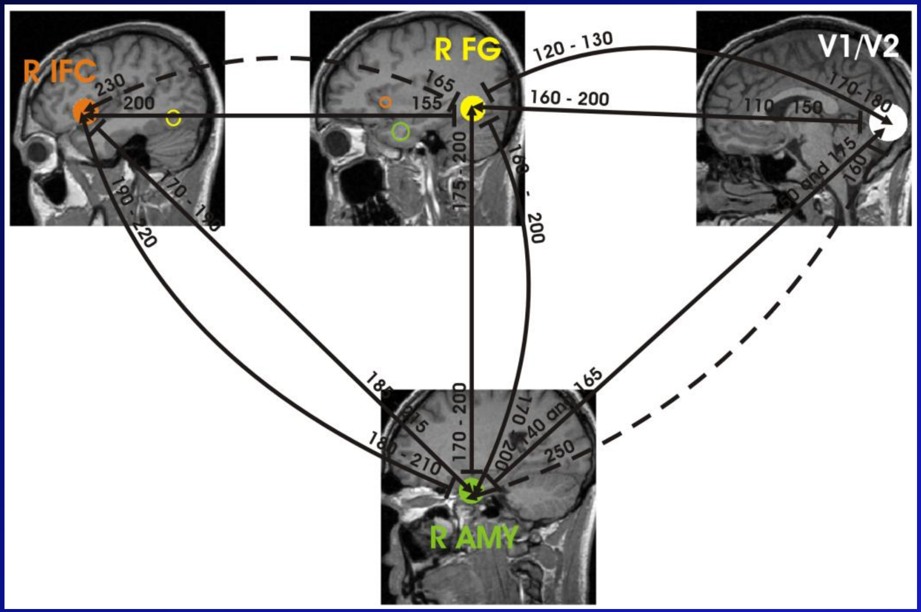


Example MI map with several areas

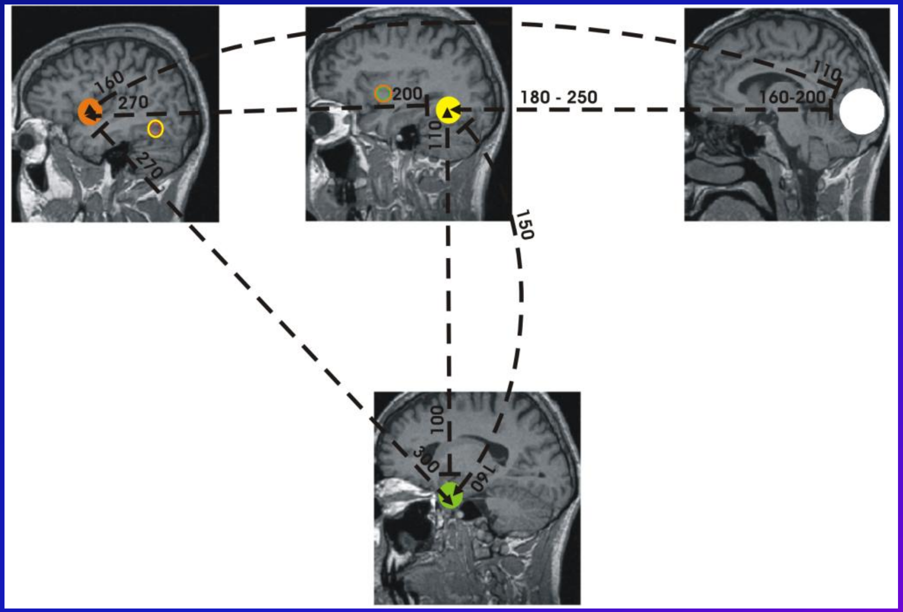


Influence diagram

Controls

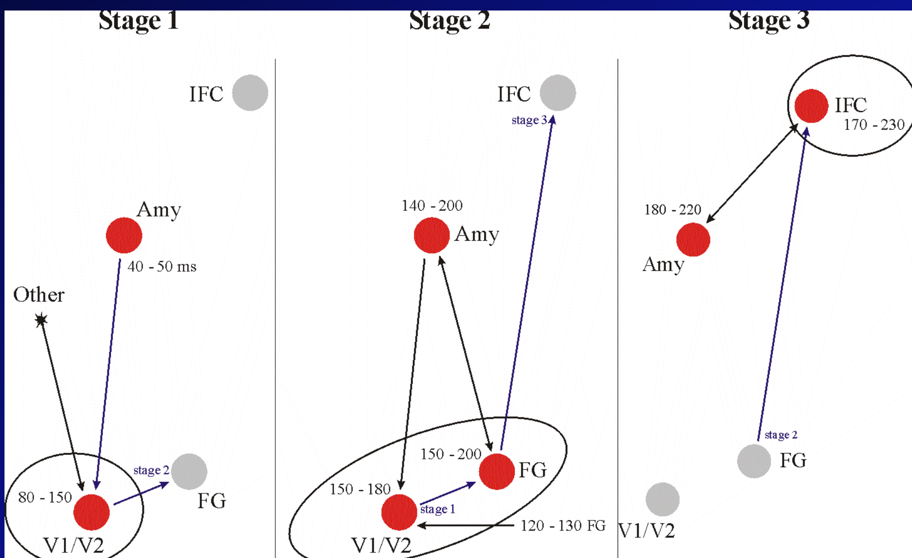


Patients

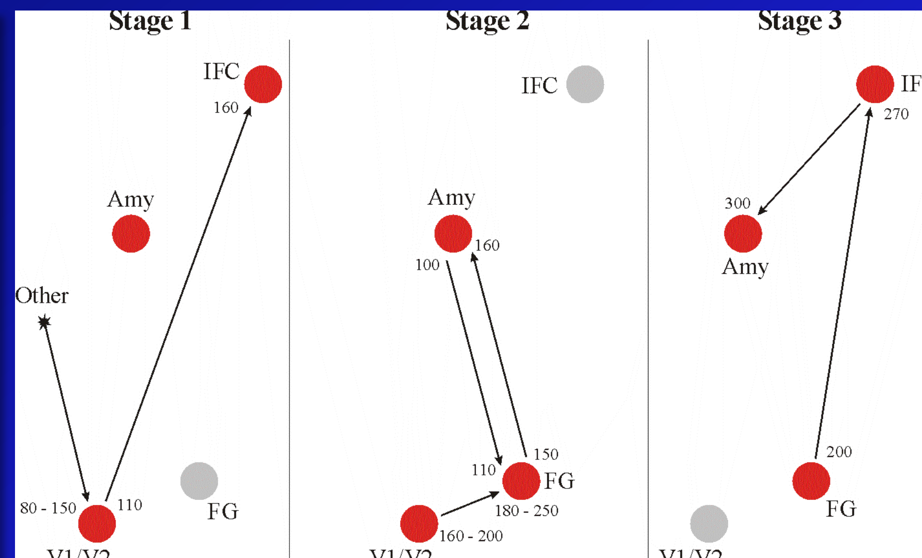


Processing stages

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 X1 and X2 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:

$$\boxed{I(X_1, X_2) = H_S(X_1) + H_S(X_2) - H_S(X_1, X_2)}$$

$$\boxed{I(X_1, X_2) \geq 0}$$

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

$$\boxed{I(X_1, X_2; \tau) = H_S(X_1) + H_S(X_2; \tau) - H_S(X_1, X_2; \tau)}$$

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:

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