Eye to eye communication

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The theory

- The intensity of the empathic activity is proportional to the ***empathy gain***
- The gain is proportional to the ***novelty*** of the signal that the observer receives, and to the ***affinity*** between observer and observed
- Novelty and affinity may move in opposite direction

Empathy Gain

- The empathy gain is the difference between the expected utility of the observer if he can observe the empathic signal and if he cannot.
- The utility only depends on the action of the observer and the state of the observed. This action is not the reproduction of the observed subject's movement.
- For example the action may be better because the observer can better predict the future action of the observed

Basic Elements

- Θ is the set of parameters that describe the observed
- X is the same set as Θ, signals to the observer
- A are the actions available to the observer
- $u : \Theta \times A \to R$ is the utility of the observer
- $P(\theta, x)$ is the joint probability of θ and x, symmetric and mixtures of independent random variables
- P^1 and P^2 are the marginal probabilties on Θ and X respectively

Empathy Gain

- The empathy gain is:

$$\sum_{x \in X} P^2(x) \left(\max_{a \in A} \sum_{\theta \in \Theta} P(\theta \mid x) u(\theta, a) - \max_{a \in A} \sum_{\theta \in \Theta} P^1(\theta) u(\theta, a) \right)$$

- When A is the set of probabilities on Θ, and the utility is the log, the Empathy gain the relative entropy of $P(\cdot \mid x)$ with respect to P.

Affinity and Novelty

For the log utility:

- The *affinity* at x is

$$\sum_{\theta} P(\theta \mid x) \log P(x \mid \theta)$$

- The *novelty* is $\log P^2(x)$

- **Theorem** The empathy gain is the sum of novelty and affinity

The experiment

- Analyze brain activity when two subjects are exchanging gazes, in different conditions

Hypothesis

- When a subject observes another one, an effort is automatically made to understand the intention of the other
- This process is a based on an empathic reproduction
- The intensity of the activation is proportional to the value of the information that can be derived from it

Prediction on the areas

- Superior Temporal Sulcus (STS) provides a visual description of the observed action
- BA44-45 code the goal of the action
- Insula, which connects both centers above to the limbic system, decodes the emotional implications of the action representation

Hypotheses

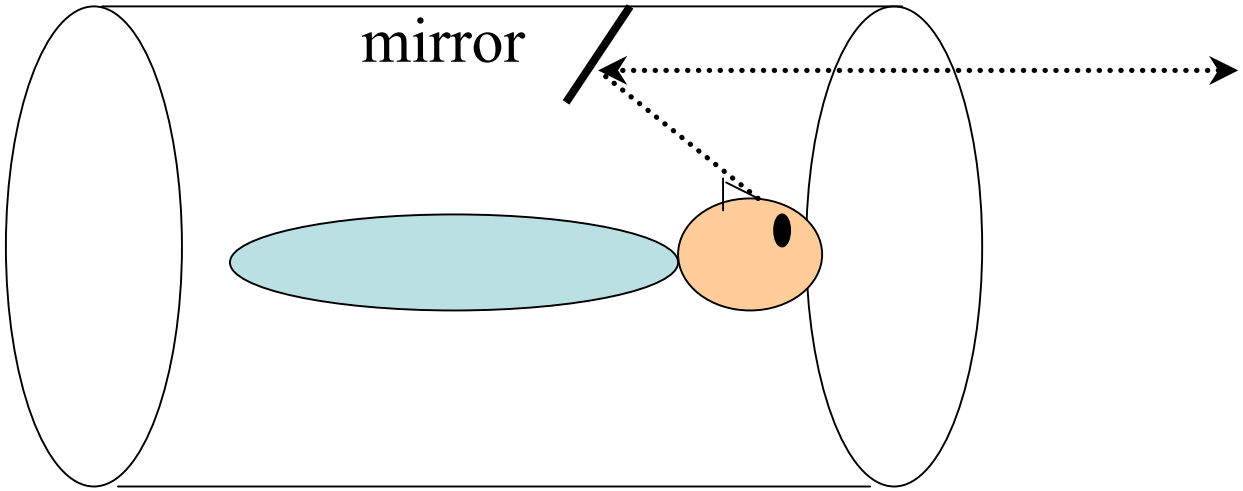
The interaction will activate areas involved in communication and empathy

Candidate regions:

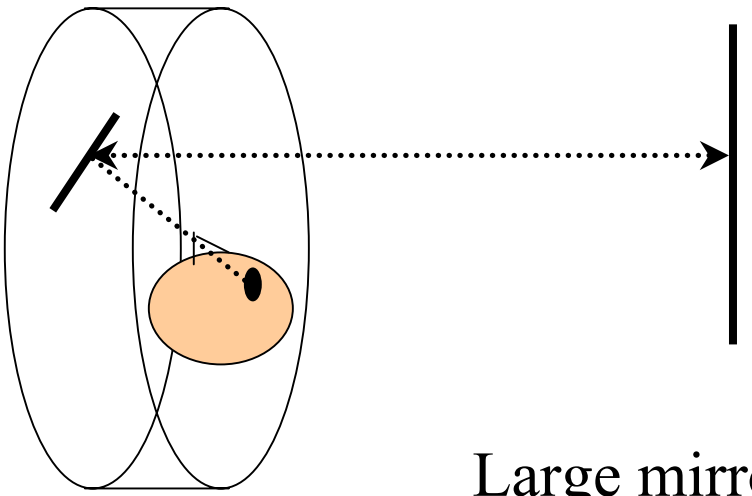
- BA44, BA45 (corresponding to Monkey's F5),
- Insula
- STS
- Ant. Cingulate
- BA6

BUT: how does the activation differ in different conditions?

Experimental Design

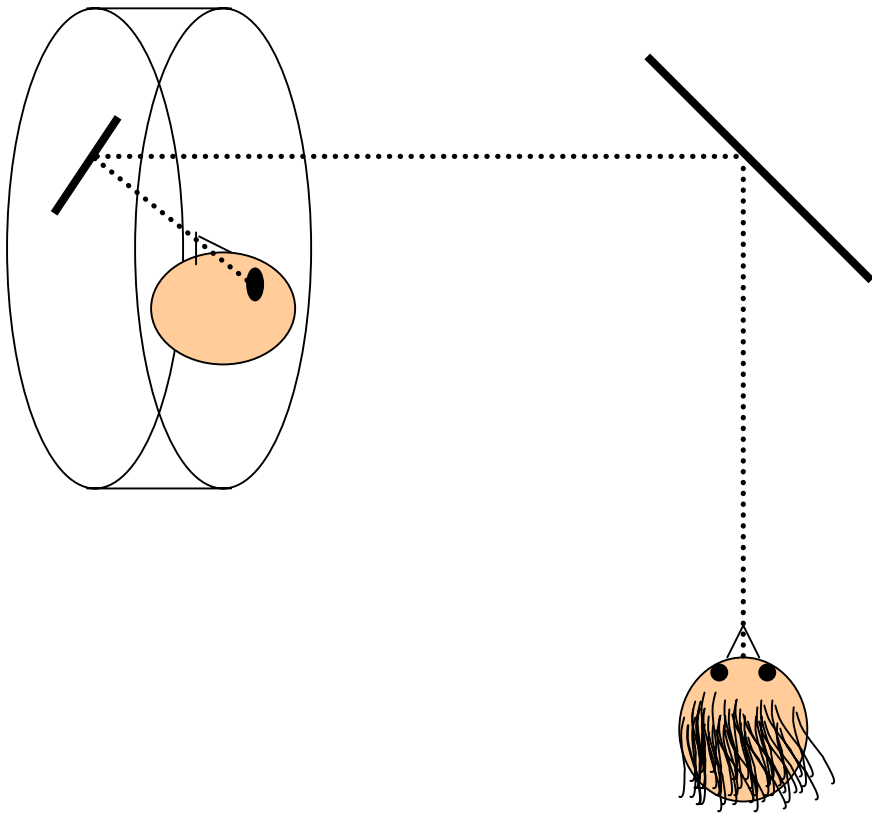

mirror

self



Large mirror

other



Face, real or photograph

Experimental design

- The subject goes through different stages, interrupted by breaks
- In each stage he looks at the experimenter, or is looked at, or he is looking at a fixed picture, or is looking at himself.
- 21 subjects, 3T MRI scanner (Siemens, at CMRR, Minneapolis)

Conditions

Each condition is described by a pair:

(What the **subject** does, what the **experimenter** does)

For example

(Look, Not Look)

(Subject, Experimenter)

describes the condition in which

- The subject is looking into the eye of the experimenter, and
- The experimenter is not looking back

Five Conditions

- Look, Look (L,L)
- Look, Not Look (L,NL)
- Not Look, Look (NL,L)
- Look at yourself (LYS)
- Look at a fix picture (LFP)
- Eyes Closed Break

Hypotheses

The activation will be stronger when communication is either active of possible for the observing subject, and the information is new.

- Strong activation in (L, L)
- The activation will be ***smaller*** when the other is not watching (L,NL)
- The activation will be ***smaller*** when the other is.. yourself (LYS)
- What when the subject is not watching, but the other is? (NL,L)

Look Look – Look at Fixed Picture

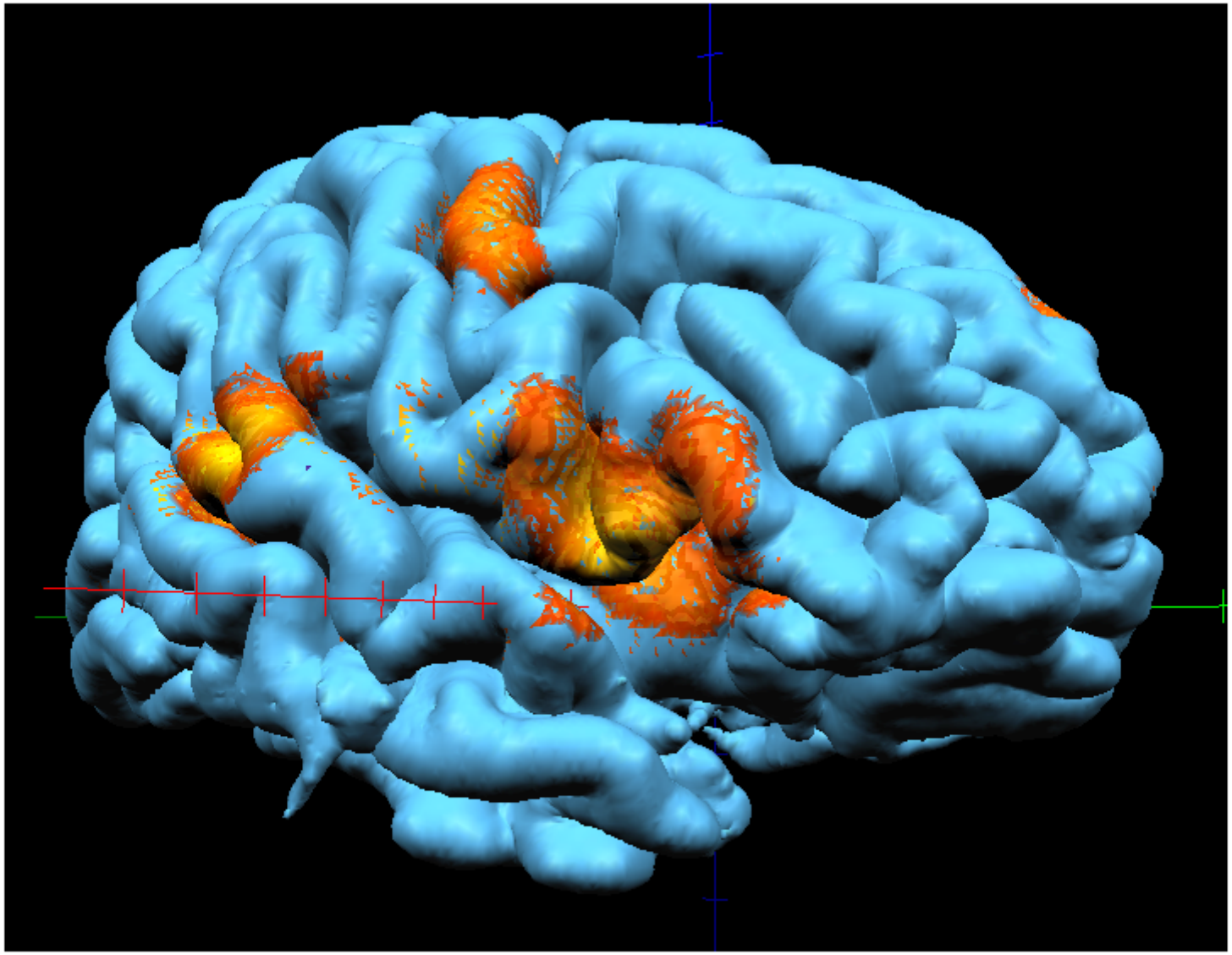
In LFP no communication possible, although the visual stimuli are similar.

Look, Look - Look Fix Picture

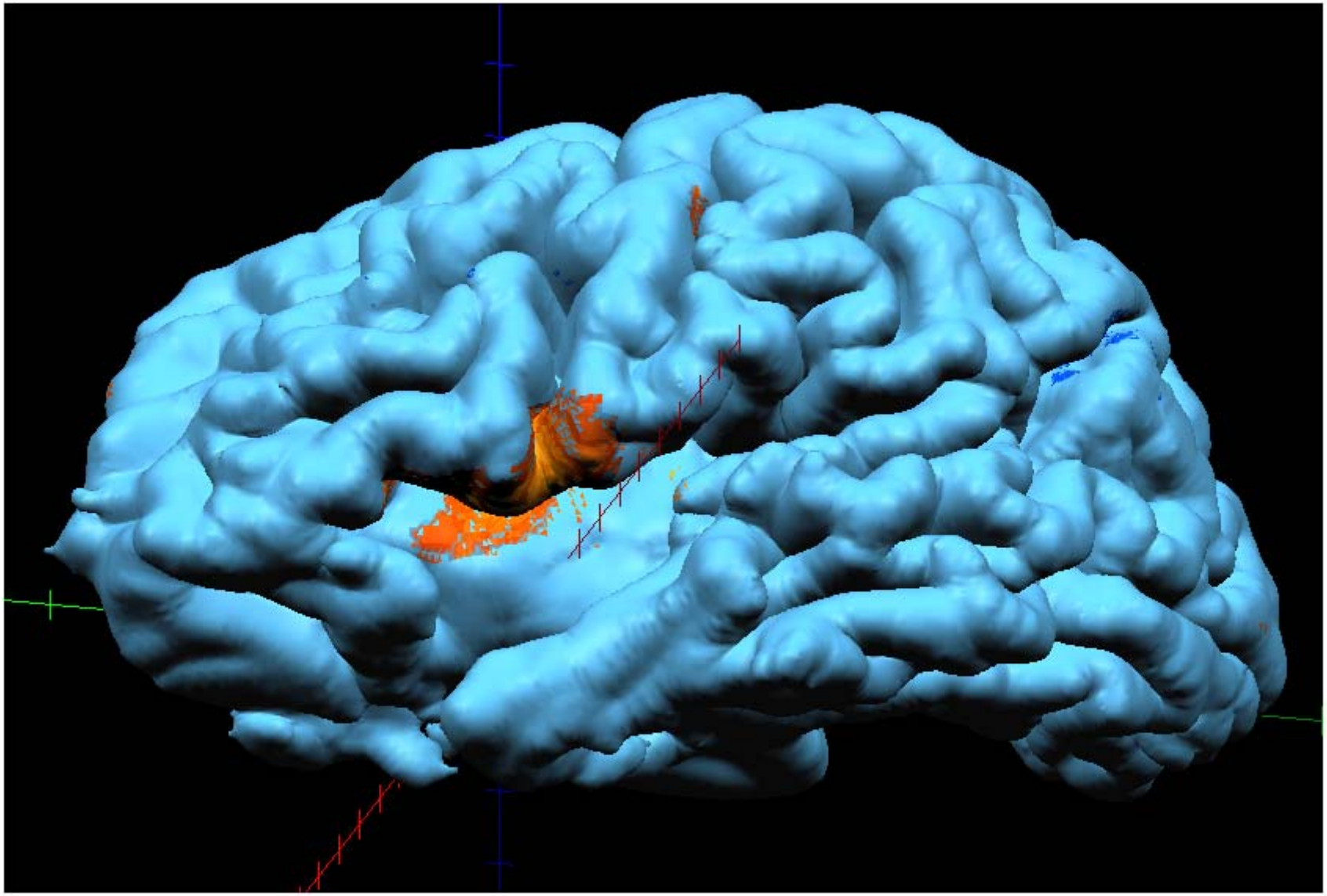
Three main clusters

- Right BA44
- Bilateral Insula
- BA6 and Cingulate Gyrus

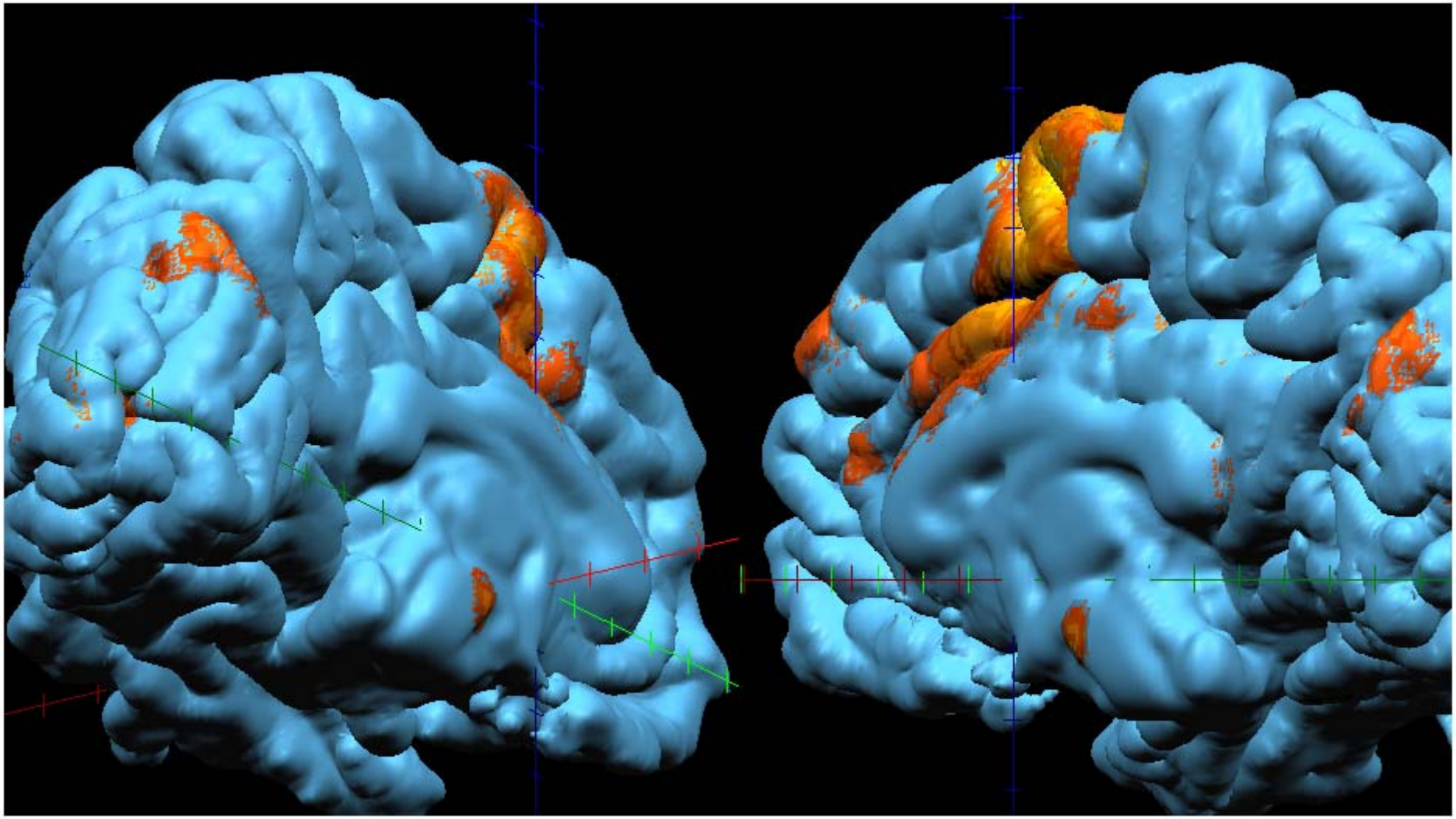
L,L-LFP, FDR=0.02, p=0.0008



LL-LFP, FDR=0.02, p=0.0008

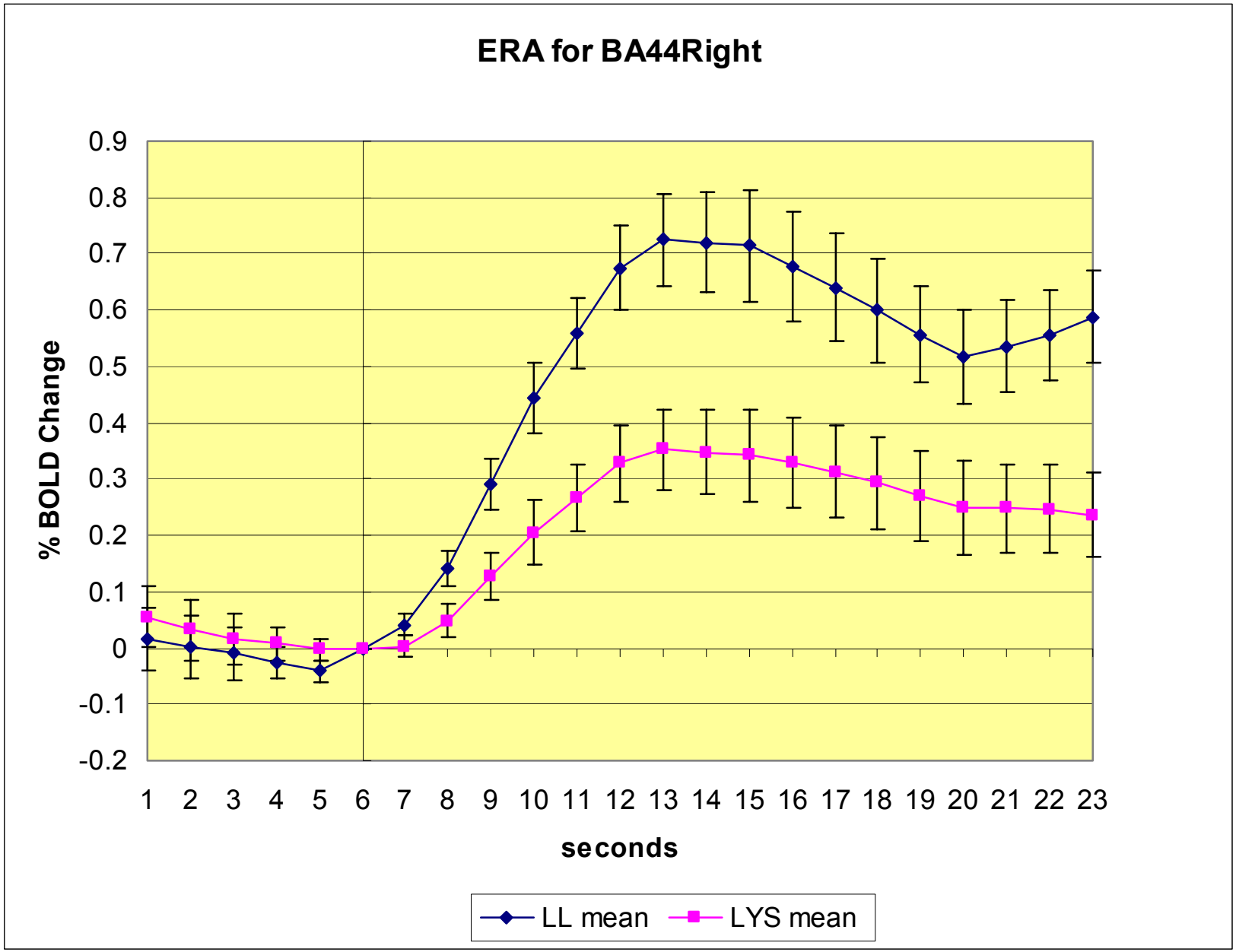


LL-LFP, FDR=0.02, p=0.0008

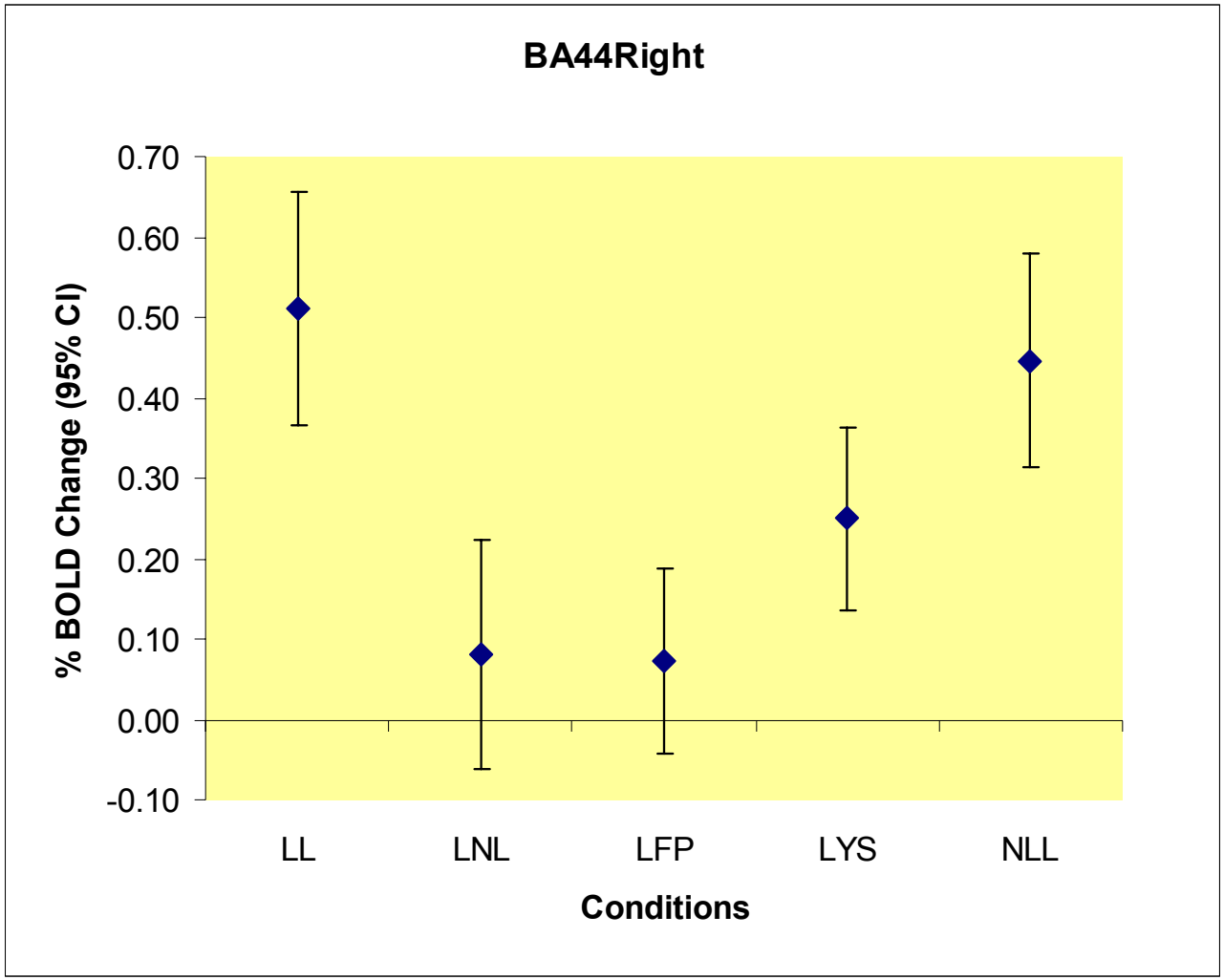


Look Look – Look Your Self

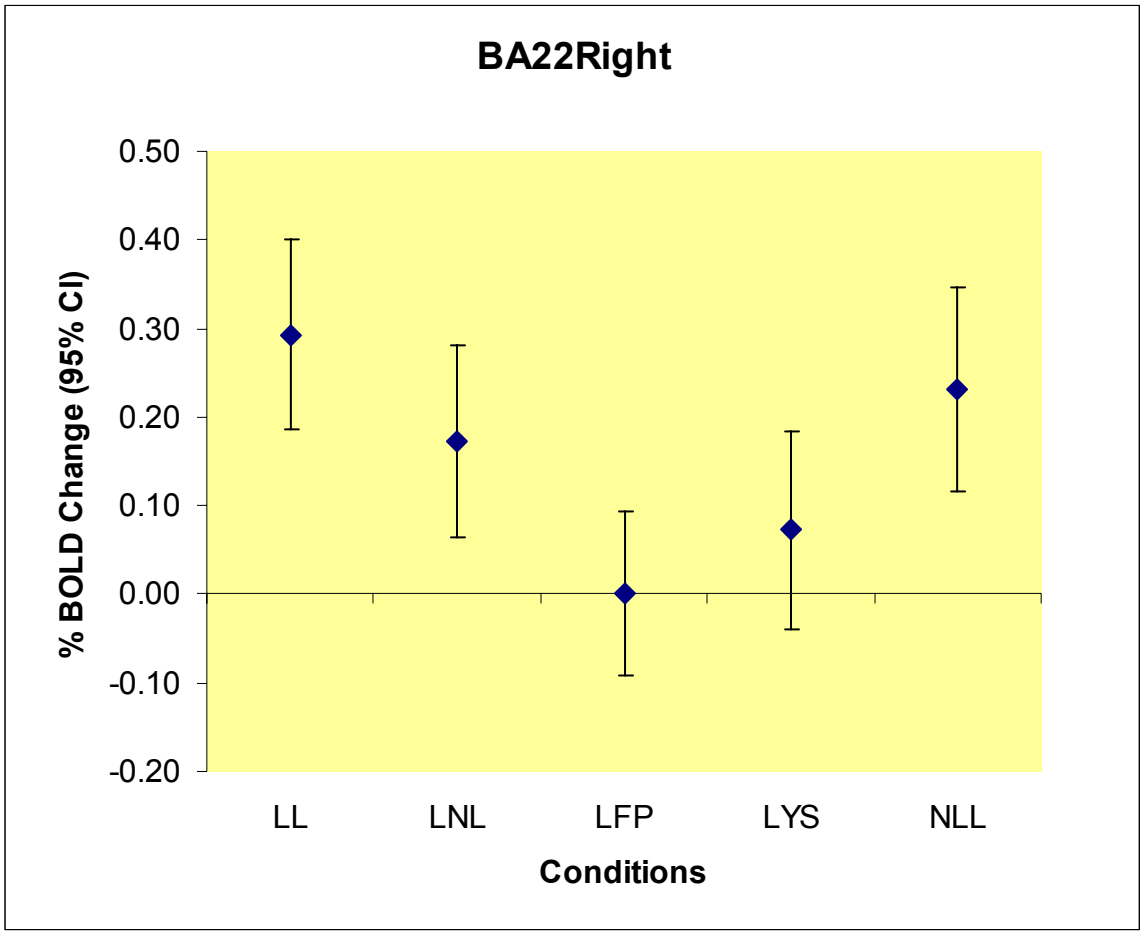
The informational value of LL is higher than LYS, so BA44 activated less in LYS


ERA for BA44Right
% BOLD Change
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
seconds
LL mean
LYS mean

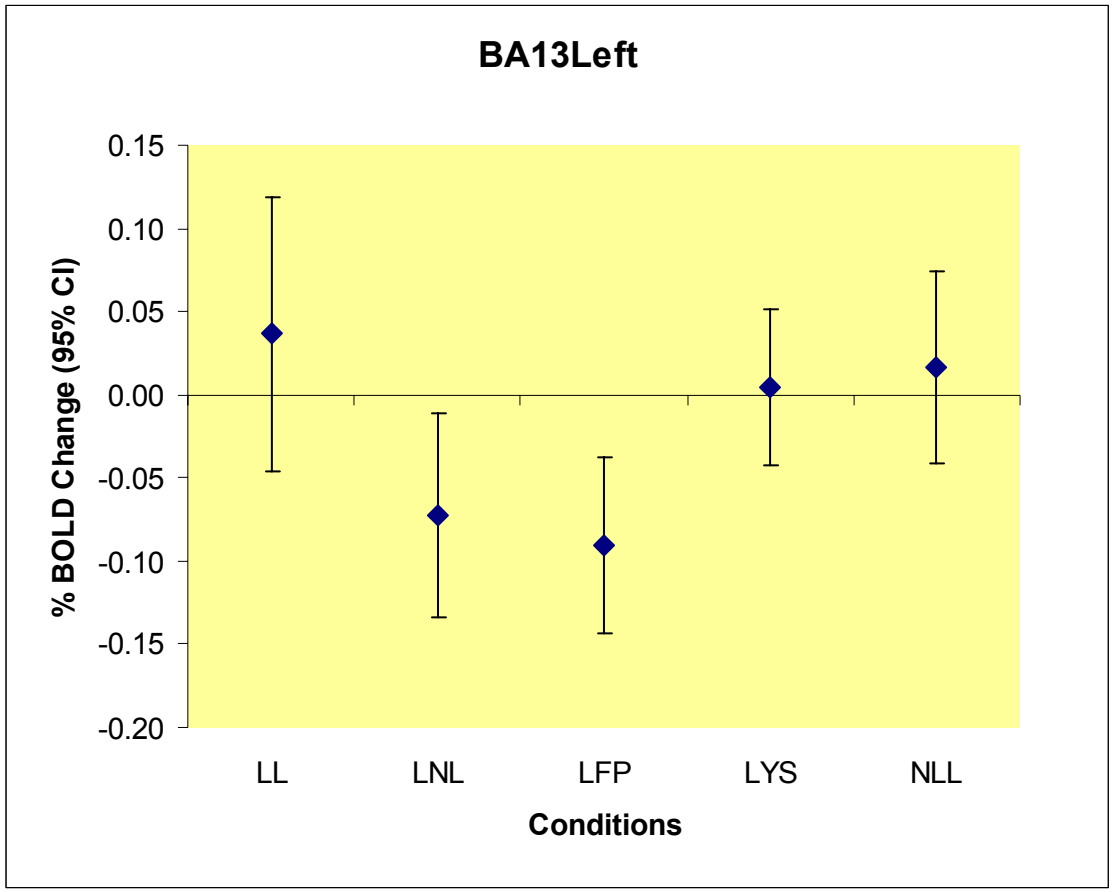
BA44 in the different conditions


BA44Right
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
% BOLD Change (95% CI)
LL
LNL
LFP
LYS
NLL
Conditions

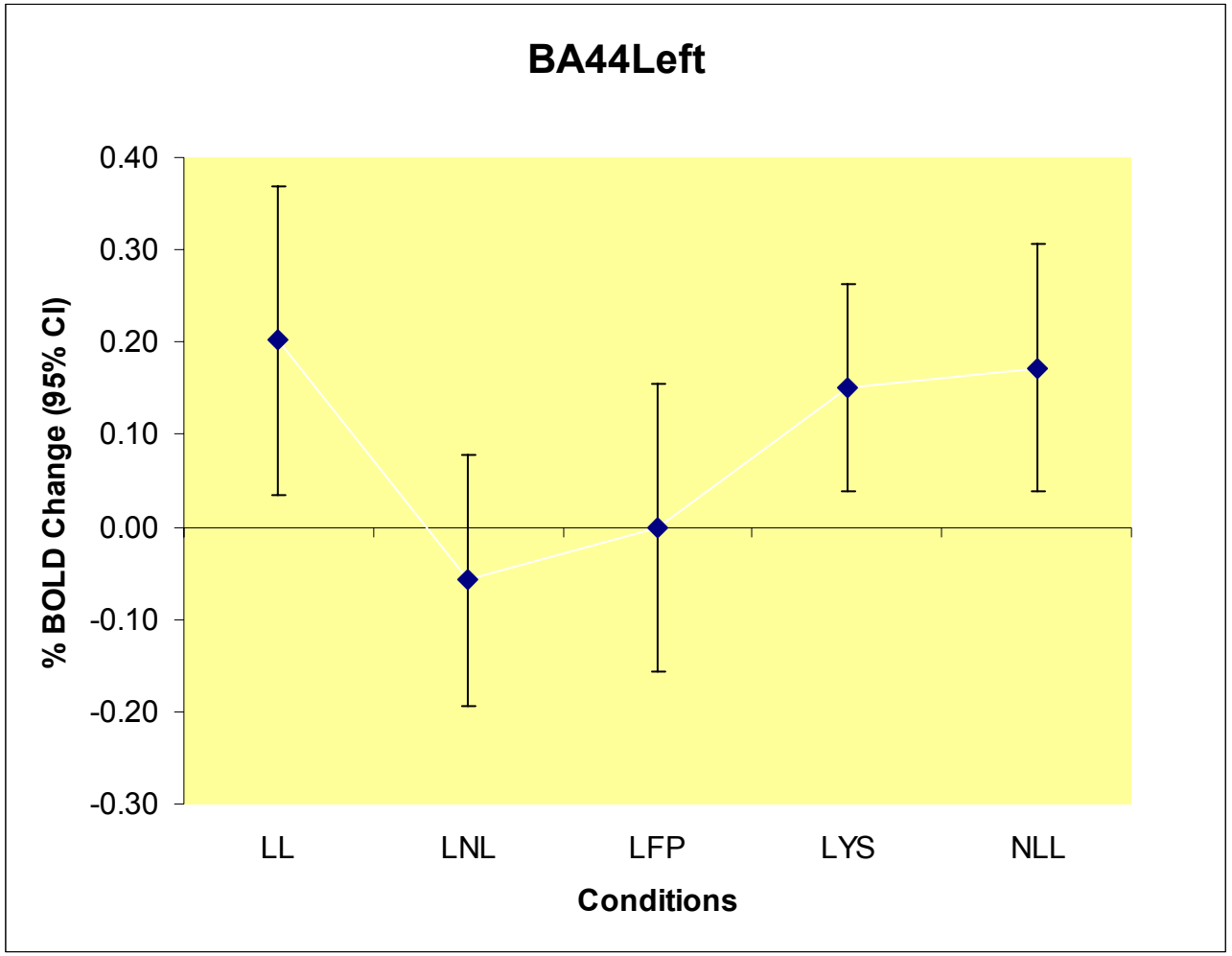
STS activation in different conditions

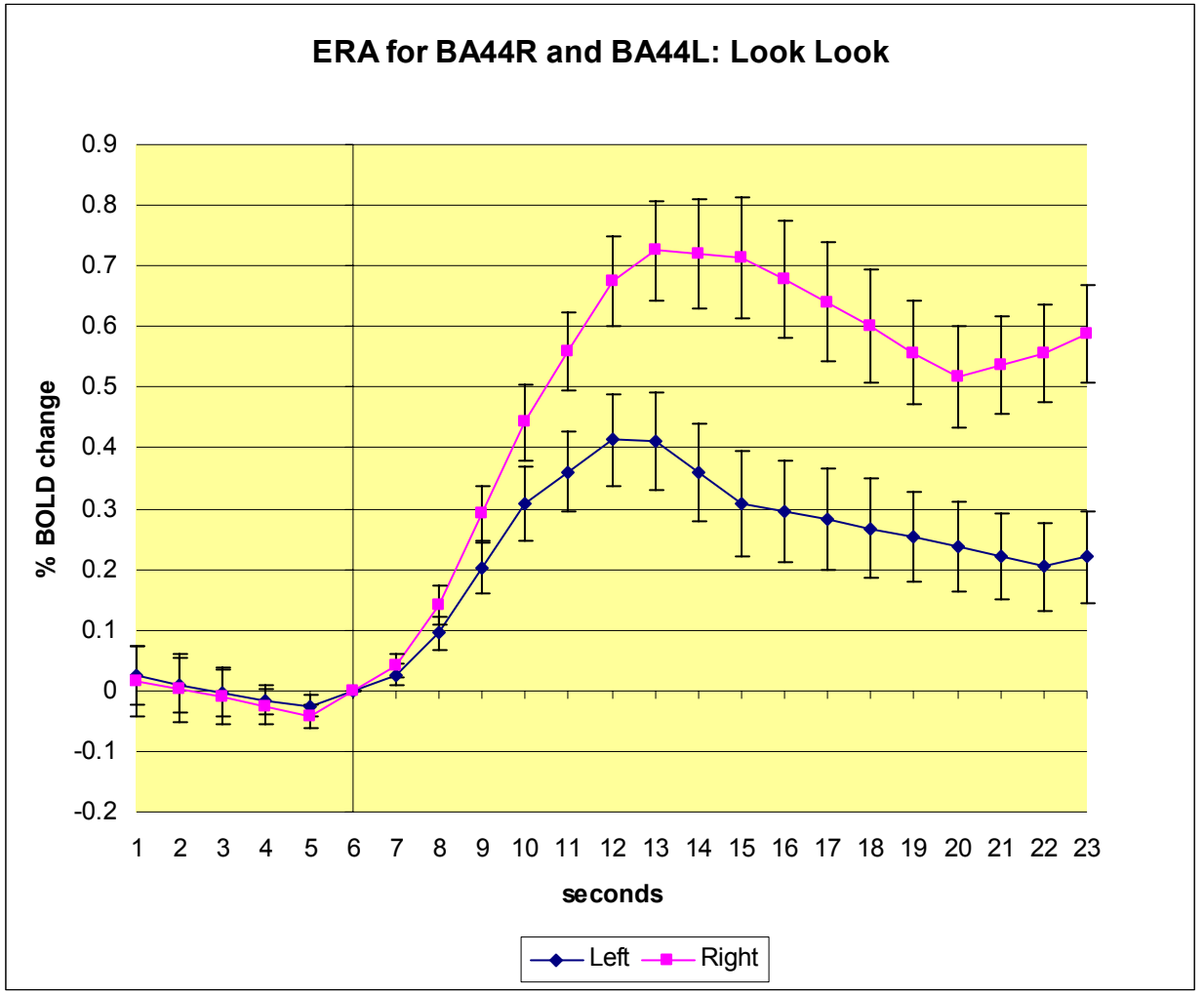

BA22Right
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
% BOLD Change (95% CI)
LL
LNL
LFP
LYS
NLL
Conditions

Insula


BA13Left
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
% BOLD Change (95% CI)
LL
LNL
LFP
LYS
NLL
Conditions

Is the Left BA44 (Broca’s Area) active?


BA44Left
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
% BOLD Change (95% CI)
LL
LNL
LFP
LYS
NLL
Conditions


ERA for BA44R and BA44L: Look Look
% BOLD change
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
seconds
Left
Right

Conclusions

- The interaction activates areas involved in communication and empathy (BA44, CG, Insula).
- The activation is stronger when communication is active or possible for the observing subject.

In particular:

- The activation is smaller when the other is not watching
- The activation is smaller when the other is yourself
- The activation is stronger when the subject is not watching and the other is, then in the symmetric situation.