

**Physiological Self-Regulation of
Anterior Cingulate Cortex Brain
Activity Using fMRI: implications for
Ambiguity Processing in Sentence
Interpretation.**

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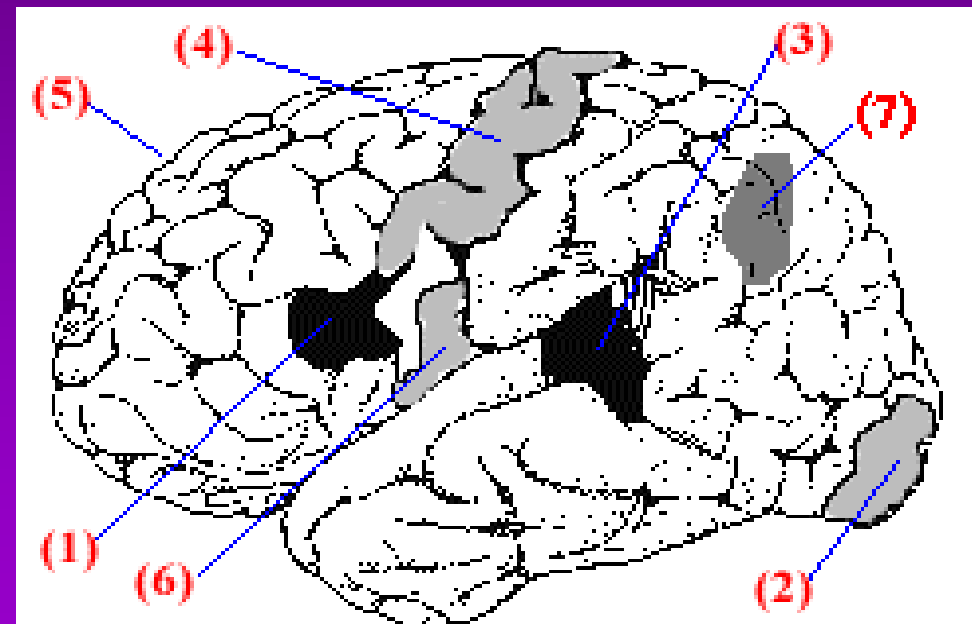
● Outline:

1. The most famous language areas
2. The Anterior Cingulate Cortex: the area of interest
3. Introduction to functional Magnetic Resonance Imaging
4. Biofeedback methodology
5. The Turbo Brain Voyager: fMRI biofeedback
6. The previous pilot study (Weiskopf and Veit, 2003)
7. Method and materials
8. Hypothesis
9. Experimental design
10. Assessments
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1. The Most Famous Brain Areas: Broca's and Wernicke's Area

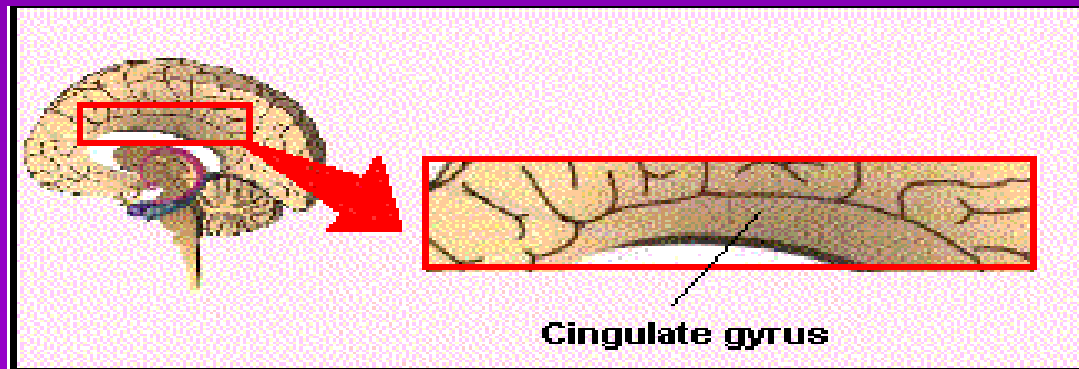
● Left hemisphere:

1. Broca's area
2. Visual cortex
3. Wernicke's area
4. Motor cortex
5. Cerebral cortex
6. Auditory cortex
7. Angular Gyrus



2. The Anterior Cingulate Cortex:

The Anterior Cingulate Cortex (ACC) comprises Brodmann's areas 24, 25 and 32. The ACC seems to be a very heterogeneous region in terms of cytoarchitecture, connectivity and functions. Recent studies suggest an involvement in language processing, specifically for conflicting data interpretation (Thompson- Schill, 1997).



3. Introduction to fMRI:

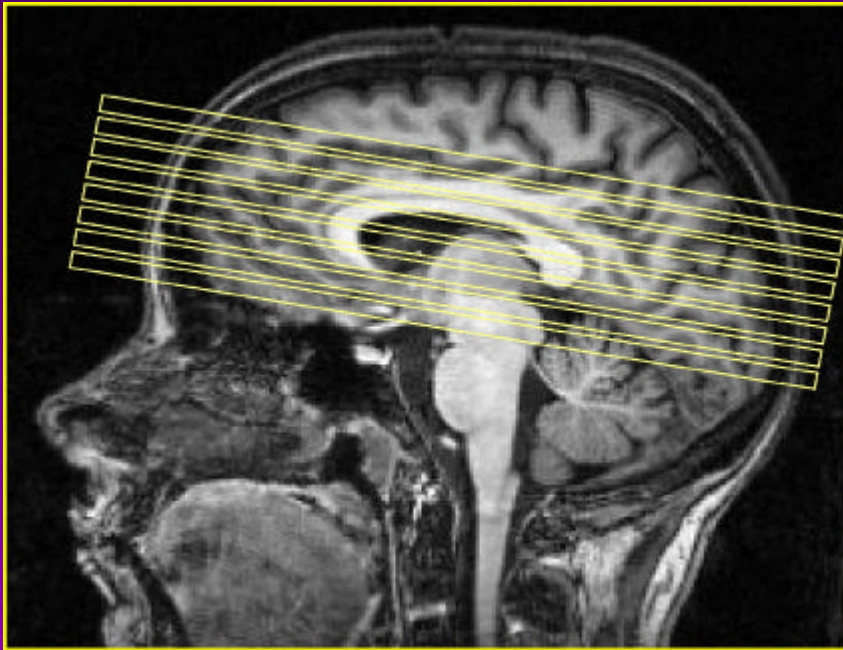
The conventional fMRI unit is a cylindrical magnet in which the subject must lie totally still for several seconds at a time.

The simple steps of a fMRI examination are the following:

- a) the subject is placed in a magnet;
- b) a radio wave is sent in;
- c) the radio wave is turned off;
- d) the subject emits a signal which is recorded;
- e) reconstruction of the picture.



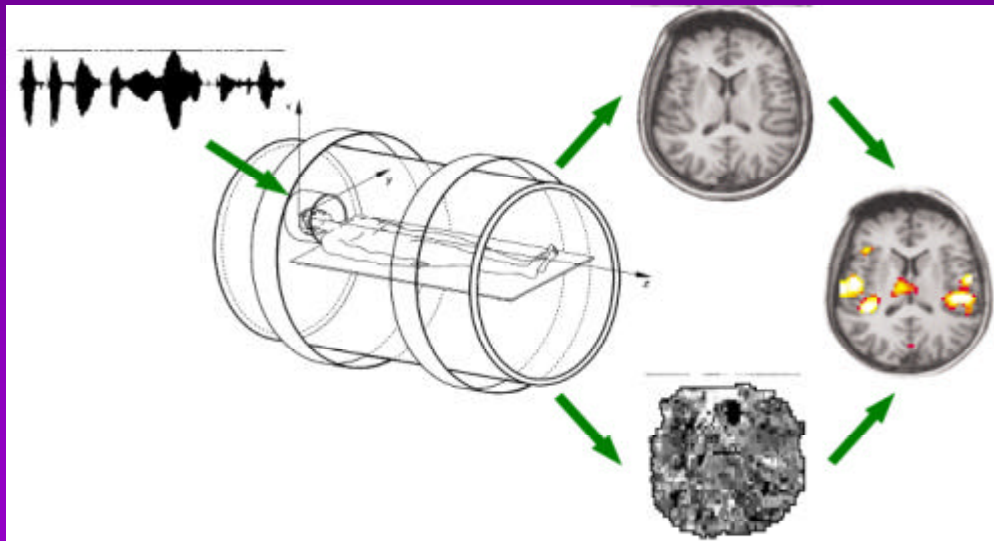
When a subject is placed in a magnet, the protons align with the external magnetic field. The protons precess along the field lines of the magnetic field. The precession frequency is higher in stronger magnetic fields. A radiofrequency pulse with the same precession frequency is sent in. The protons pick up energy, they start precessing in phase and they create a new transverse magnetization. When the pulse is switched off protons lose phase coherence and realign to their original position. By doing so measurable energy is released.



Magnetic gradient fields are superimposed on the field of the MR magnet. Therefore there are magnetic fields of different strength for the various body sections. The selection of a certain pulse frequency allows to determine the location of the slice to analyse.

The horizontal slices across the image indicate the various levels at which the scanner can display the image.

fMRI is based on the increase in blood flow to the local vasculature, which correlates with neural activity. MRI scanning works by aligning the hydrogen atoms of each water molecule in the brain using their inherent magnetic properties.



An active area has a higher concentration of oxygenated blood, which is the direct effect of its activity.

4. Biofeedback Methodology:

- The word “biofeedback” was coined in the 1960’s to describe laboratory procedures used to train subjects to self-regulate physiological functions, which are normally not voluntarily controlled, like, for instance, blood pressure and heart rate.

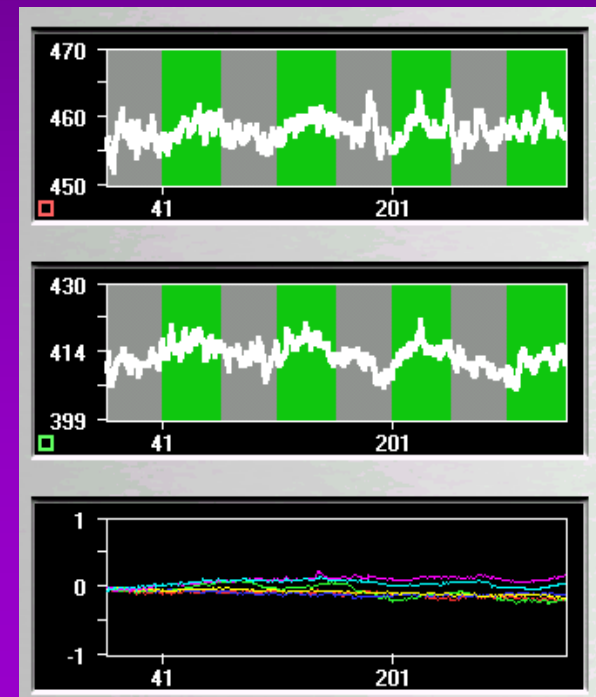
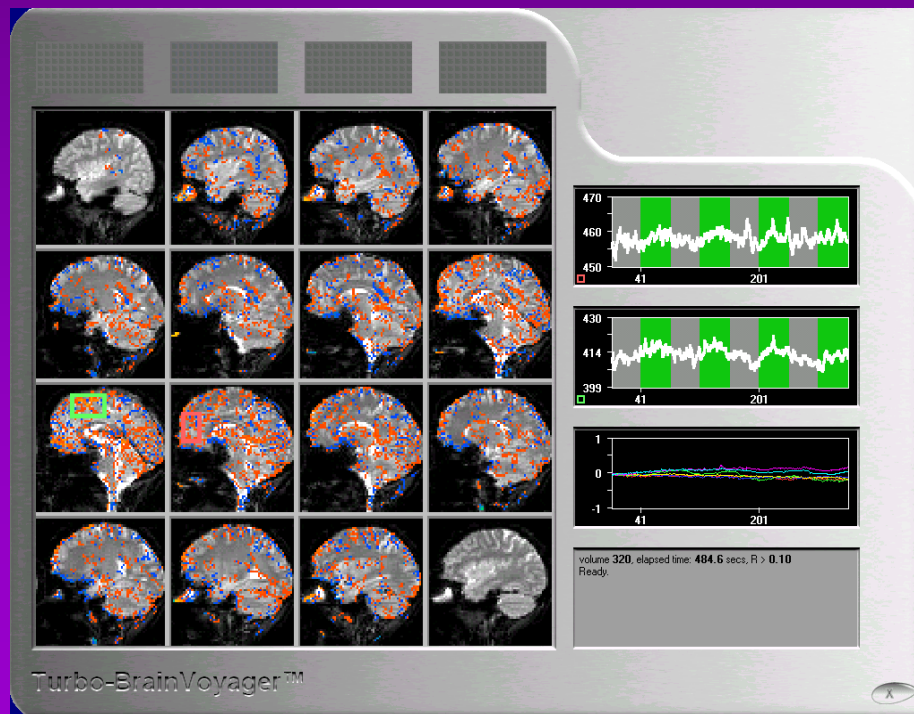
- Neurofeedback is a learning strategy that allows the self-regulation of brain activity.

The subject receives on-line information about a specific physiological function: he can see or hear a signal which changes according to the self-regulation performed.

- Up to now there has been a lack of research about biofeedback based on the “BOLD” signal measured using fMRI. This lack is due to methodological problems in the implementation of a real-time feedback. It is necessary to process the signal for many seconds (up to 12) in order to have a feedback to send back to the subject.

5. The Turbo-Brain Voyager: fMRI Biofeedback

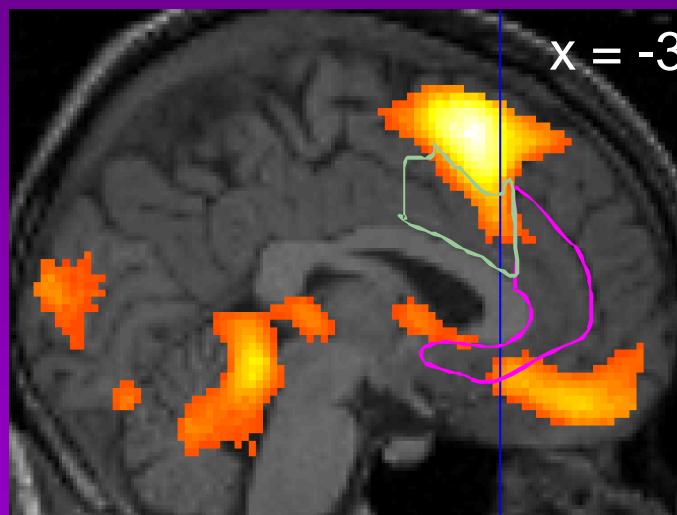
The “Turbo Brain Voyager” (Goebel, 2002) is a software which allows a real-time fMRI analysis (only two seconds of delay between data acquisition and feedback input).



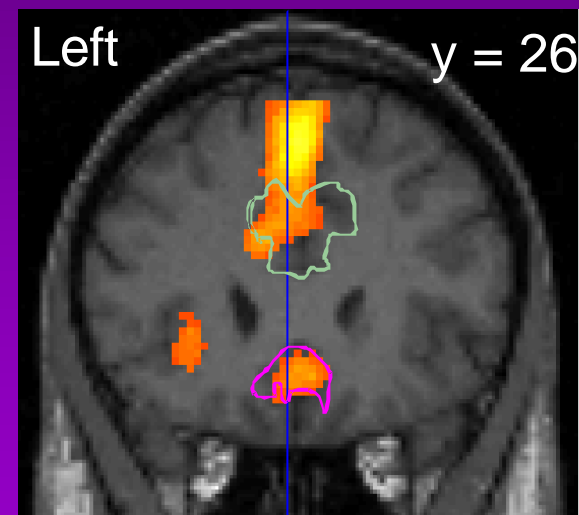
6. A previous study on physiological self-regulation of ACC activity suggests that humans can achieve the control of the activation in this area of the brain, (Weiskopf & Veit, 2003).

- ◆ Standard SPM99 and ROI analysis

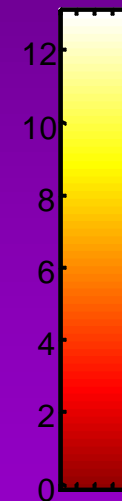
- ◆ 24 covariates of head motion: 1st, 2nd order + spin history (Friston et al., MRM 1996)



P < 0,05 (korr.)



t-value



P < 0,05 (korr.)

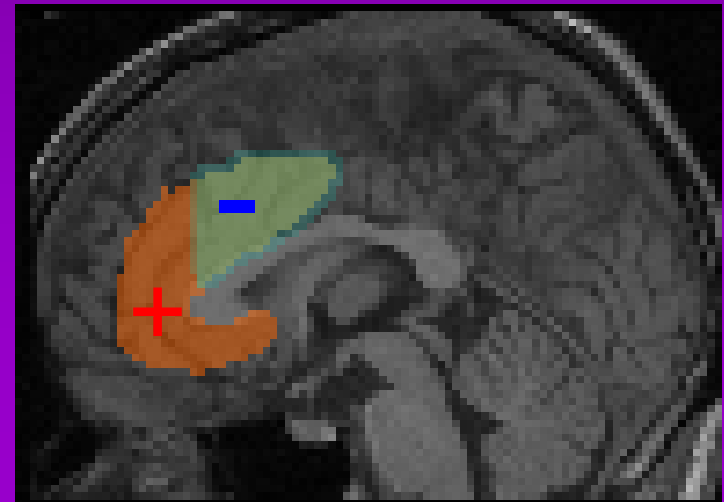
Signal increase during activation block, p < 0.05 (corrected), extent > 10 voxels

7. Method and Materials:

The visual feedback consists of the differential BOLD signal recorded from the rostral-ventral (ACcd) and the dorsal (ACad) parts of ACC.

The task:

- ◆ Increase of ACcd activity with simultaneous decrease of ACad activity
- ◆ Increase of ACad activity with the simultaneous decrease of ACcd activity



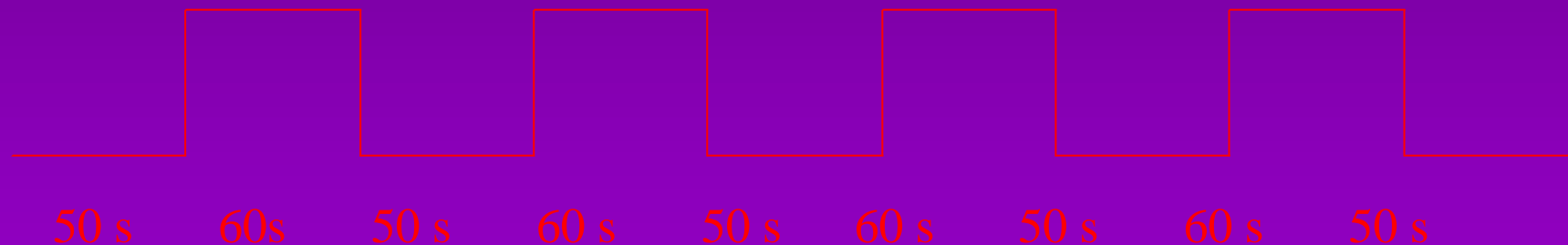
8. Hypothesis:

It is assumed that successful differential self-regulation of ACC activity induces:

- a) Faster disambiguation and understanding of “garden path sentences”.
- b) Improvement of disambiguation performance for auditory presentation (see below).

9a. Training Experimental Design:

Every fMRI training session is composed by four activation blocks and four baseline blocks. During the activation blocks the subject's task consists of increasing the required activity of ACC. During the baseline blocks no performance is required.



 Activation Blocks

9b. Experimental Design:

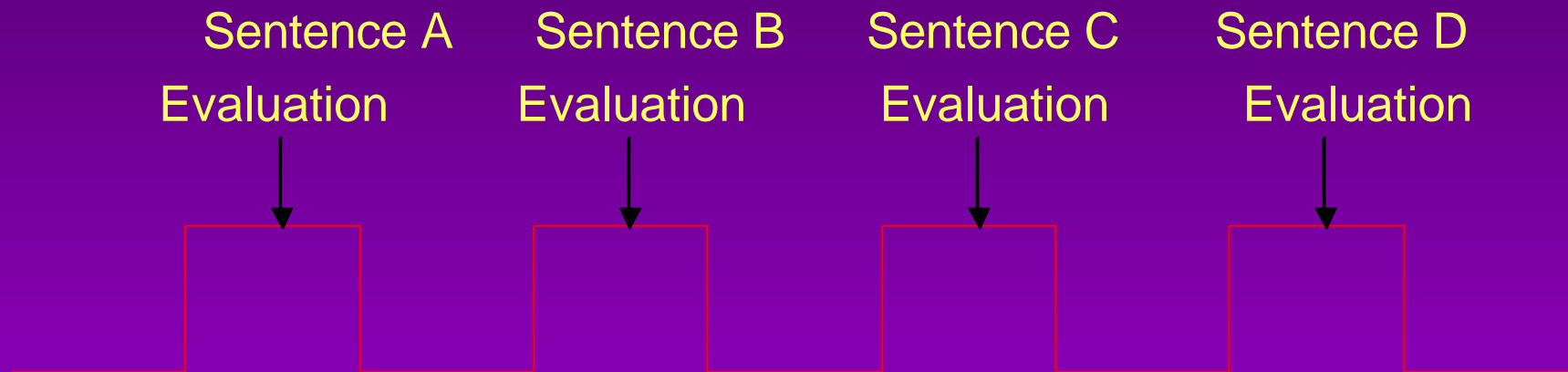
During the first and the last training sessions a semantic disambiguation task takes place.

During every activation block a “garden path sentence” is presented. The subject’s task consists of understanding the meaning of the sentence as fast as possible and to press a button when the disambiguation is made.

An example of “garden path sentence” (Self Paced Reading Experiment, Pafel, 2003):

“Einen dieser Romane hat jede Schülerin gelesen,
die diesen für die Abiturprüfung vorbereiten musste”

Half of the sentences are presented in a visual form and the other ones in an auditory form.



10. Assessments:

- After every session:

“Self Assessment Manikin” (Bradley and Lang, 1994) to self-evaluate the affective state (valence and arousal);

- Before the beginning and after the end of the training:

“Deux Barrage”, (Porcu, 1998) to evaluate attention skills;

“Verbaler Lern und Merkfähigkeitstest” (VLMT: Query, 1983) to evaluate learning abilities.

“Cognitive and Emotional Counting Stroop Tasks (Bush and al., 2000)“

Befindlichkeits-Skala” (D. v. Zerssen und D.M. Koeller, 1976) for the assessment of momentary feeling.

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