
Physiological Self-Regulation of ACC Brain Activity using Biofeedback based on fMRI: Linguistic Tasks and Performance Evaluation

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◆ Outline:

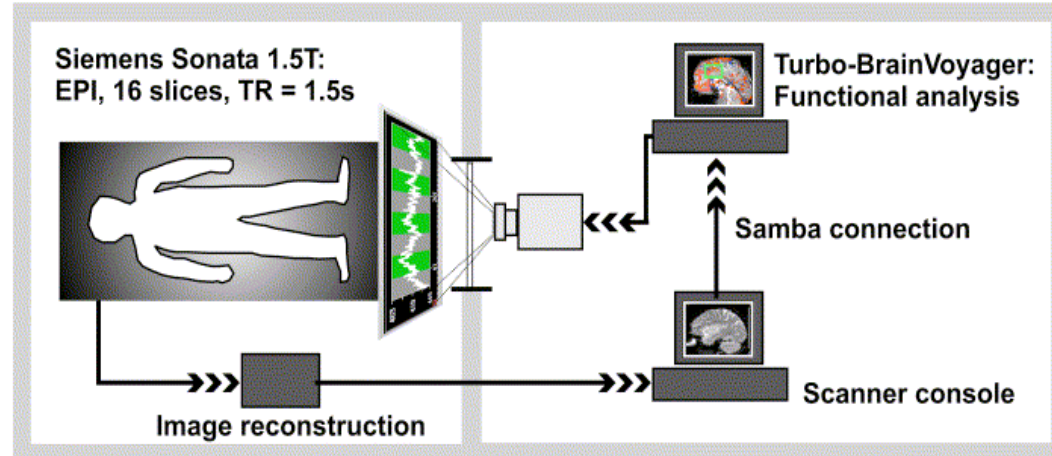
1. Introduction to the technique: biofeedback based on fMRI
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1. Introduction to the technique: biofeedback based on fMRI

The fMRI brain-computer interface is based on Turbo Brain Voyager (Goebel, 2001) and a 3T whole body scanner (Magnetom Trio, Siemens, Erlangen, Germany).

Experimental Setup and Data Flow



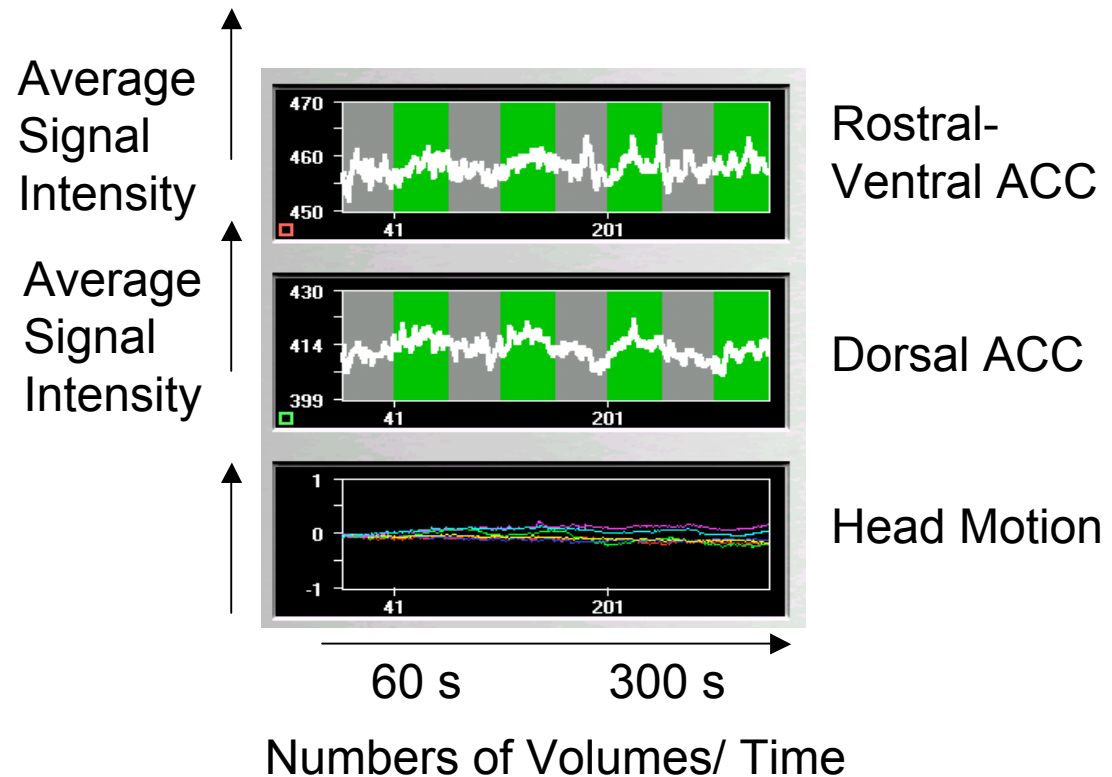
Processing time from acquisition to feedback < 2 s

(Weiskopf et al., 2003)



Turbo-Brain Voyager performs data pre-processing, statistical analysis and signal feedback in real-time (2 s). Pre-processing includes 3D motion correction. Head motion is displayed on-line to the subject.

Activation= Increase Signal
Baseline= Return to Baseline

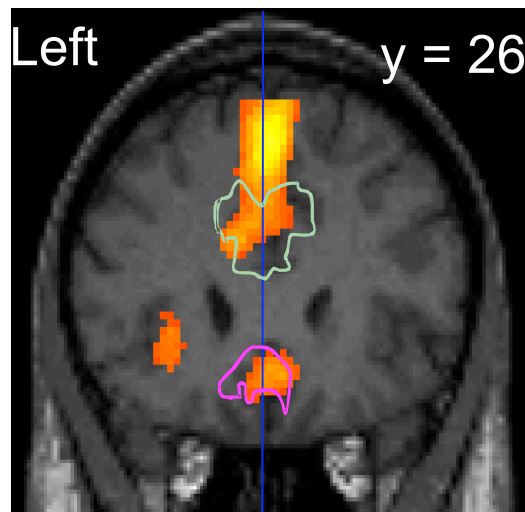


(Weiskopf et al., 2003)



2. The pilot study on ACC self-regulation

standard SPM99 and ROI analysis 24
covariates of head motion: 1st, 2nd order
+ spin history (Friston et al., MRM 1996)



(Weiskopf et al., 2003)

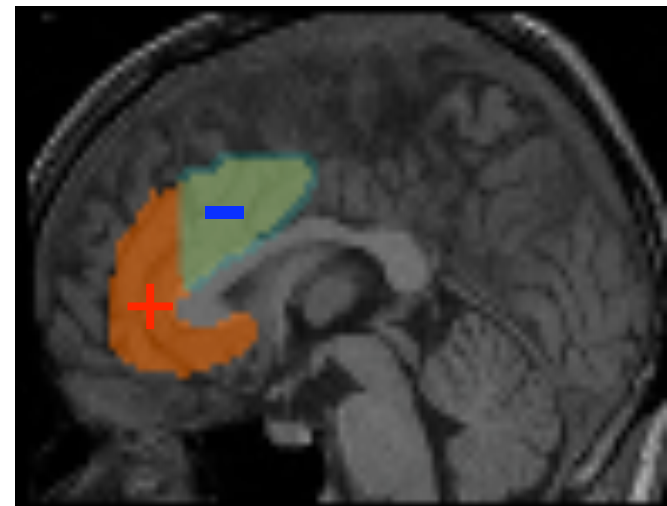
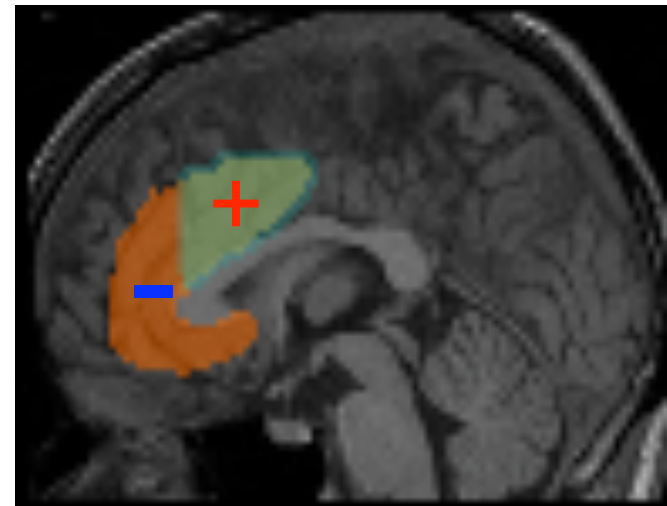
t-value



$P < 0,05$ (korr.)

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

Differential feedback design



3. The set-up of the experiment:

- ◆ self-regulation training (3 sessions): on-line updated feedback provides information on the differential activation level recorded between ACcd and ACad.
- ◆ “transfer” (2 sessions): the required self-regulation has to be performed. The subject is supposed to have learnt how to induce regional voluntary brain activity modulation. Feedback is not provided.
- ◆ linguistic tasks (2 sessions): the set-up of the “transfer” is maintained. Moreover two linguistic tasks are to be performed.



4. Assessments:

- ◆ D2-Test (Brickenkamp and Zillmer, 1998) to evaluate attention skills;
- ◆ Freiburger Persönlichkeitsinventar FPI-R (Ostendorf, 1997) to get information on personality traits;
- ◆ Raven Standard Progressive Matrices Test (Raven, 2000) to evaluate general intelligence and problem solving abilities;
- ◆ Self-Assessment Manikin (Bradley and Lang, 1994) to evaluate affective state (arousal and valence);
- ◆ Questions on strategies of regulation;
- ◆ Creative Imagination Scale (Wilson and Barber, 1978).



5. Hypothesis:

- ◆ It is assumed that up-regulation of ACcd improves the performance required by attention demanding tasks and error detection tasks in cases of semantic and syntactic violation.
- ◆ It is assumed that up-regulation of ACad improves the performance required by emotional information processing, specifically in detection of emotional intonation.



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- ◆ In order to test these hypothesis two linguistic tasks are used:

A “disambiguation task” is used to test improvement of linguistic performance, which is expected as a result of ACcd self induced up-regulation.

A “semantics/prosody conflict task” is used to assess improvement of linguistic performance expected as a result of ACad self-induced up-regulation.



6. The disambiguation Task:

A “grammaticality speeded judgement task” is used (Bader 2000). 70 declarative sentences are presented visually. Some of these sentences are ambiguous, some unambiguous and some grammatically incorrect.

◆ **Presentation times:**

224 ms/word plus 14 ms for very long words.

5 seconds for sentence presentation

2 seconds for sentence judgement

12 seconds as intertrial break

Total time for 70 sentences: 14 minutes



◆ **Task:**

As soon as the presentation of the last word is over the subject has to judge the correctness of the whole sentence pressing a button in the shortest time possible.

◆ **Measurements:**

reaction times

amount of errors

The disambiguation task: some examples

◆ **Ambiguous Sentences:**

subject/object „Johanna hat berichtet, dass sie einige der Besucher zu einem Ausflug überredet hat“

object/subject „Johanna hat berichtet, dass sie einige der Besucher zu einem Ausflug überredet haben“



◆ **Unambiguous Sentences:**

subject/object „Johann hat berichtet, dass er einige der Besucher zu einem Ausflug überredet hat“

object/subject „Johann hat berichtet, dass ihn einige der Besucher zu einem Ausflug überredet haben“

◆ **Ungrammatical Sentences:**

subject/object “Johann hat berichtet, dass er einige der Besucher zu einem Ausflug überredet haben“

object/subject „Johann hat berichtet, dass ihn einige der Besucher zu einem Ausflug überredet hat“



7. The semantics/ prosody conflict task:

◆ Material:

64 sentences selected from the Tübingen Affect Battery are presented acoustically (Breitenstein, 1996). The sentences are approximately the same length and were recorded by an experienced actress in three styles of emotional intonation: happy, sad, angry and neutral.

The material of the experiment comprises four sets of sentences which describe happy, sad, angry or neutral scenarios.

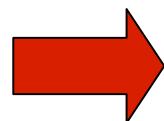
Some examples:



8. Which variables should be measured?

- ◆ error rate in prosody identification
- ◆ reaction times in prosody identification
- ◆ level of perceived difficulty in prosody identification
- ◆ level of perceived conflict between prosody and semantics
- ◆ identification of prosodic intonation

Should we recruit male or female subjects?



need of a pre-study



9. The pre-study:

20 subjects (10 males and 10 females)

64 sentences presented acoustically: four semantic categories (happy, sad, angry, neutral), and four prosodic categories (happy, sad, angry, neutral).

Presentation times: 2 seconds for sentence presentation
7 seconds for task performance
2 seconds as intertrial interval

Tasks:

- ◆ identification of prosodic intonation by means of emotional characterized images
- ◆ judgement on difficulty using a five point scale
- ◆ judgement on perceived conflict level between semantics and prosody by means of a five point scale



10. The semantics/ prosody conflict task: conflict judgement

Males

Females

Prosody

**S
E
M
A
N
T
I
C
S**

		Males				Females			
		Happy	Sad	Angry	Neutral	Happy	Sad	Angry	Neutral
SEMANTICS	Happy	0,9	3,3	2,3	1,6	0,9	2,4	2,5	1
	Sad	3,2	0,2	0,4	2,1	2,8	0,3	0,5	2,1
	Angry	2,7	2,5	0,3	2,5	2,7	2,4	0,2	2
	Neutral	1,7	1,5	1,4	1	1,4	1,2	1,4	0,4

mean = 1,7
SD = 0,9

mean = 1,51
SD = 0,6



11. The semantics/ prosody conflict task: level of difficulty judgement

Males

Females

Prosody

**S
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		Happy	Sad	Angry	Neutral	Happy	Sad	Angry	Neutral
Happy		1	0,9	1	1,2	0,5	0,6	1	0,5
Sad		0,6	0,4	0,5	1,1	0,4	0,1	0,3	0,4
Angry		0,8	0,8	0,5	0,7	0,6	0,7	0,1	0,5
Neutral		0,9	1,1	1,1	0,9	0,6	0,5	0,7	0,3

mean = 0,84
SD = 0,8

mean = 0,48
SD = 0,23



12. The semantics/ prosody conflict task: error rate

Males

Females

Prosody

**S
E
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	Happy	Sad	Angry	Neutral
Happy	1,5	0,5	3,7	2,5
Sad	1,2	1	0,7	1,2
Angry	1,7	0,5	1,7	1,5
Neutral	1,2	1,2	4	1,2

mean = 1,58
SD = 1,2

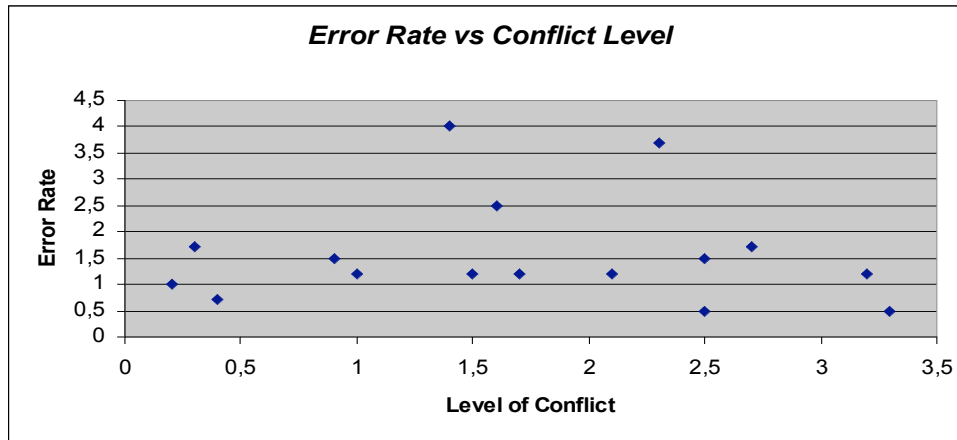
	Happy	Sad	Angry	Neutral
Happy	1	1,2	2,7	0,5
Sad	0,2	0	0,2	0,5
Angry	0,2	1	0,2	0,5
Neutral	0,2	0	2,7	0,5

mean = 0,7
SD = 0,4



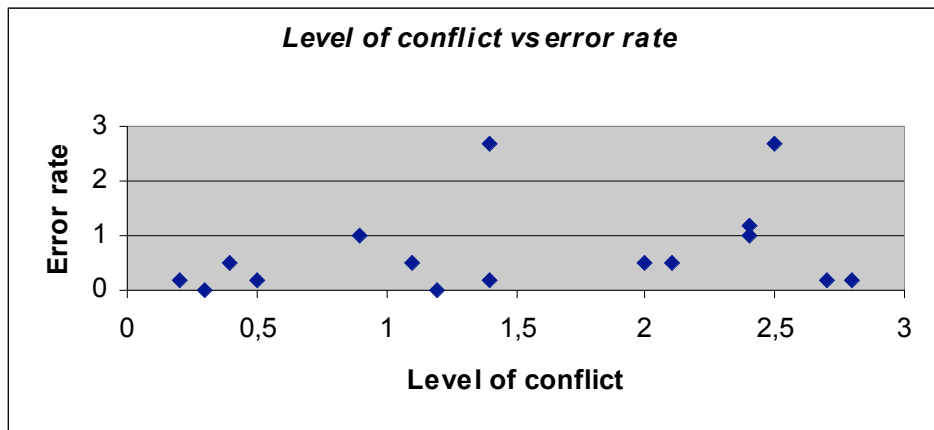
13. The results: a correlation analysis

Males



$$r = -0,036$$

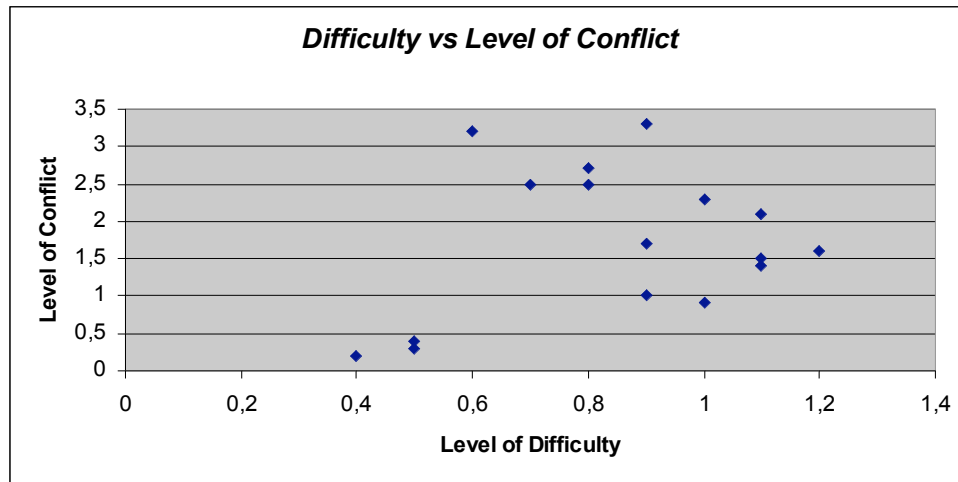
Females



$$r = 0,29$$

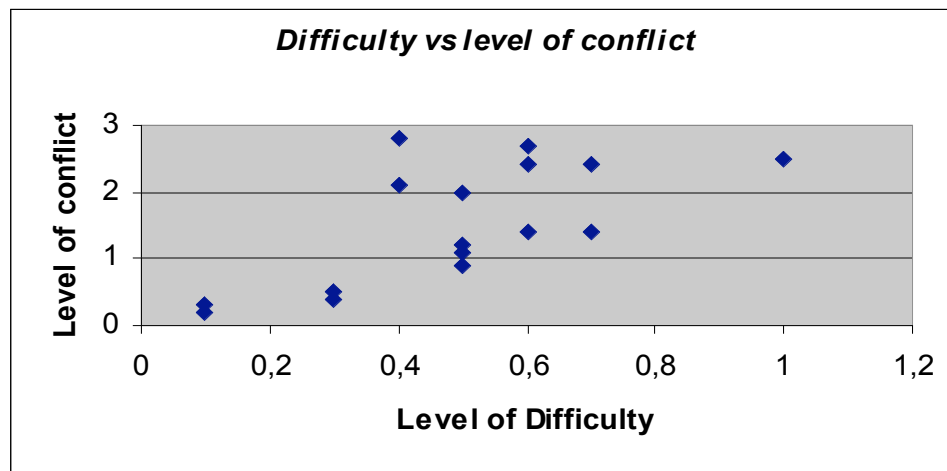


Males



$r = 0,27$

Females



$r = 0,067$

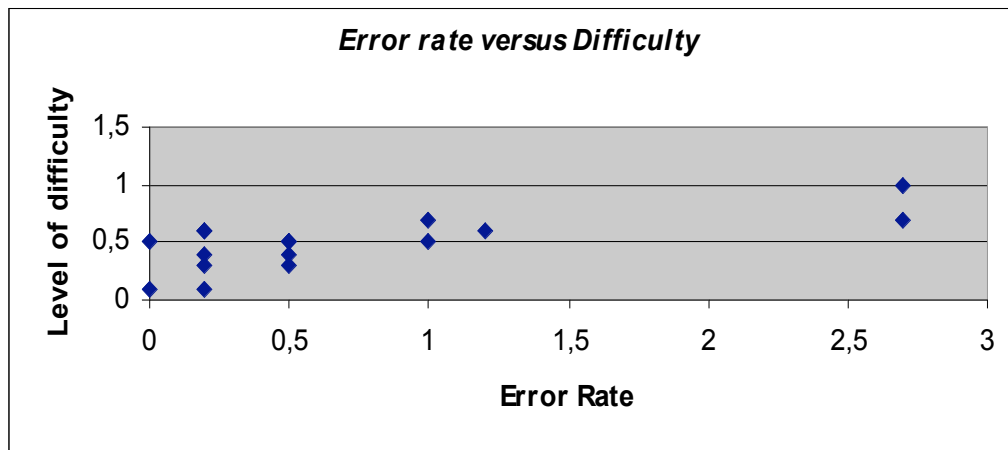


Males



$r = 0,438$
significant for $\alpha 0,05$
one-tailed test

Females



$r = 0,726$
significant for $\alpha 0,01$
two-tailed test



14. Summary of the results

- ◆ Male subjects exhibit a higher amount of errors in prosody detection and a more complex perception of conflict between prosody and semantics.
- ◆ Both groups exhibit correlation between error rate and level of perceived difficulty in prosody detection task.

15. Conclusions

- ◆ Recruitment of male subjects.
- ◆ Two fMRI studies are necessary in order to find out whether the linguistic tasks are suitable for ACcd and ACad.
- ◆ Analysis of brain activation induced by prosody detection and judgement of conflict is necessary in order to select a suitable task for training performance evaluation.



15. Outlook:

- ◆ Two fMRI experiments (two linguistic tasks, two variables, 20 subjects);
- ◆ BOLD feedback training experiment (10 subjects).



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Thank you!

