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## **Attentional markers during auditory BCI: healthy subjects and patients with locked-in syndrome**

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### ► To cite this version:

Perrine Rose Rose Seguin, Emmanuel Maby, Anatole Otman, Mélodie Fouillen, Dominique Morlet, et al.. Attentional markers during auditory BCI: healthy subjects and patients with locked-in syndrome. Cortico days 2022, Mar 2022, Autrans, France. . hal-04095581

**HAL Id: hal-04095581**

**<https://hal.science/hal-04095581>**

Submitted on 11 May 2023

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### Introduction

Syndrome (Complete) Locked-in Syndrome

Pathologies Brainstem lesion Severe cerebriolesion Amyotrophic Lateral Sclerosis

Impairments Motor +/- Sensory +/- Cognitive

Activity limitations Communication

**Aims :** Detect consciousness and restore communication  
**How ?** With an auditory Brain-Computer Interface (BCI)

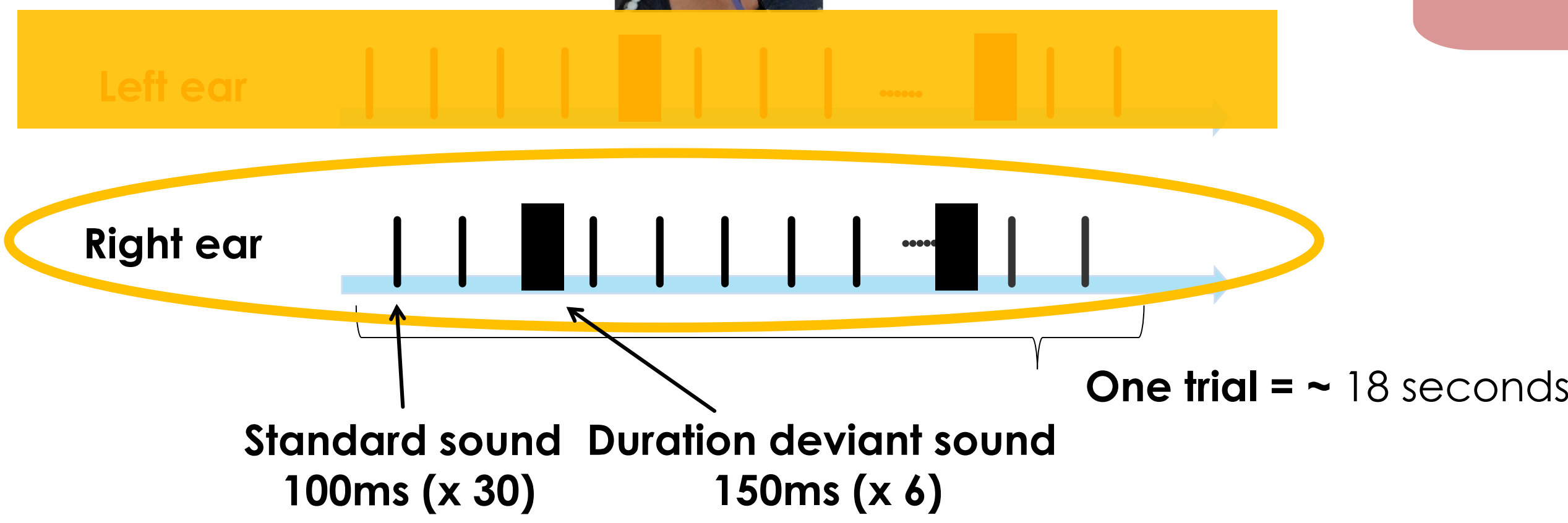
### Protocol

**Instructions:** To answer « Yes » : Please, pay attention to the right audio stream and try to count the deviant sound « Yes », without paying attention to the left.

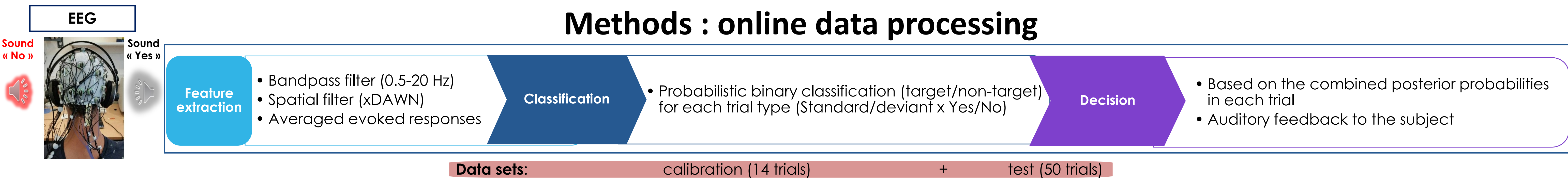


**Analysis:**  
-Online (real-time) : BCI accuracy\*\*  
-Offline (a posteriori) :  
▪ evoked responses,  
▪ design optimization

**Datasets:**  
- 18 healthy subjects  
- 7 patients



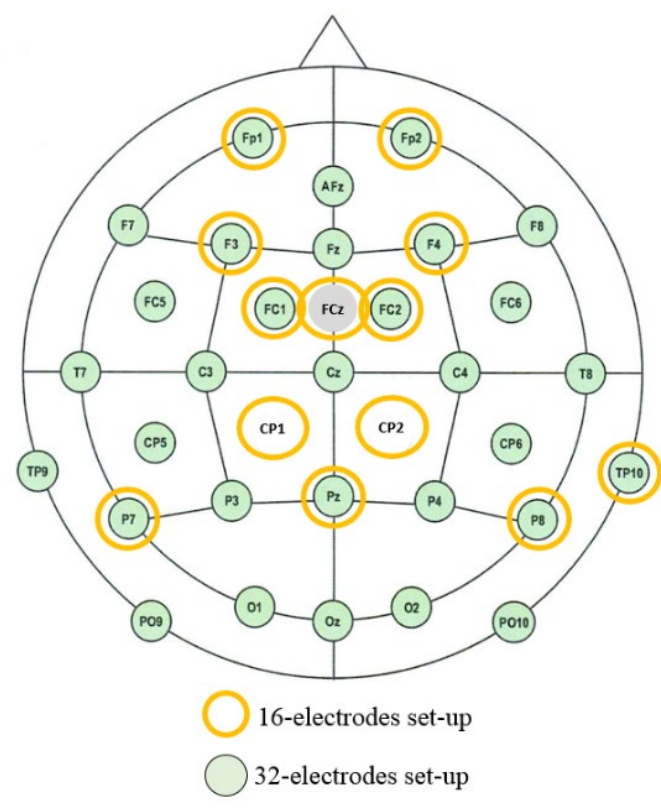
### Methods : online data processing



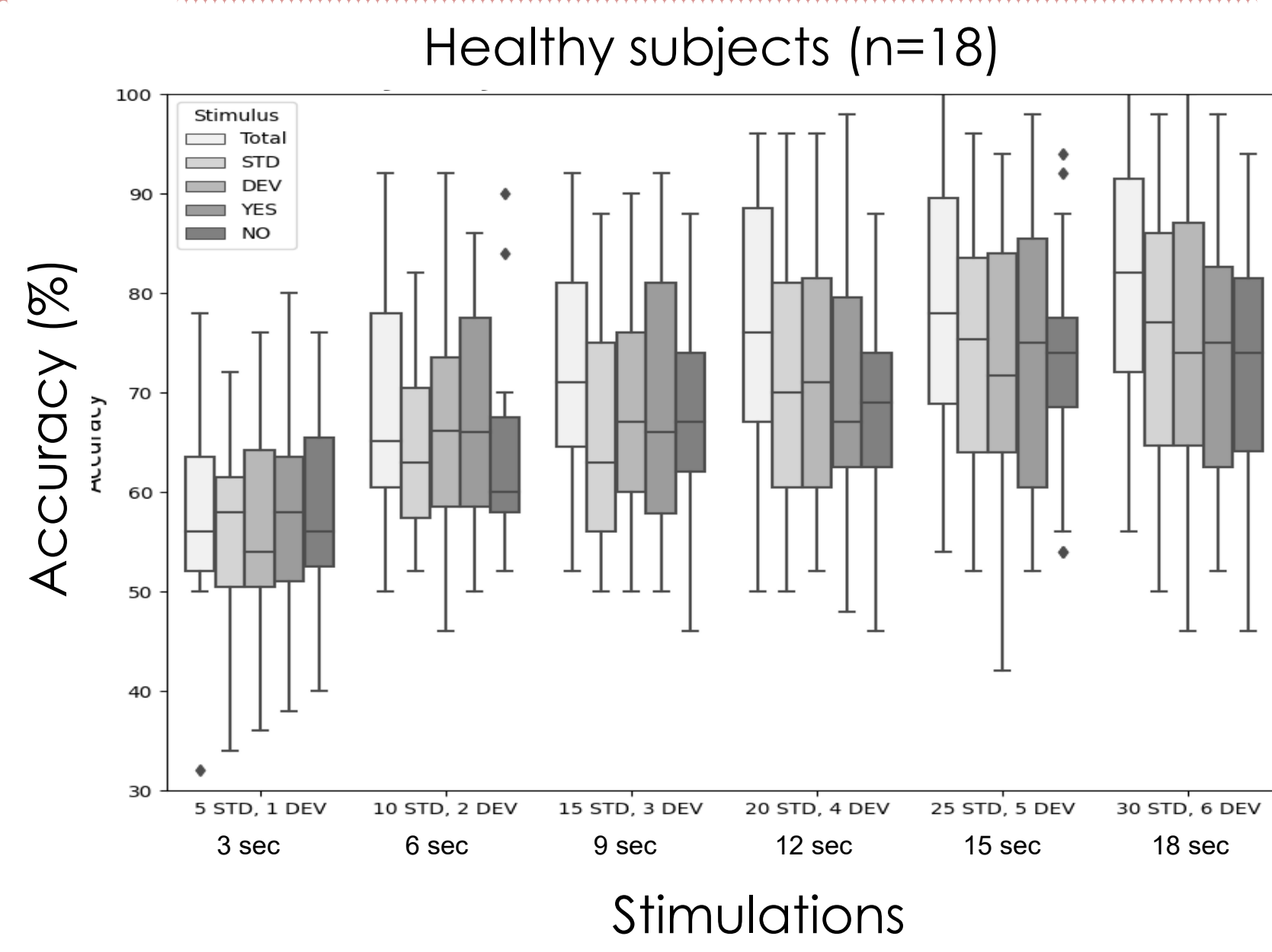
### Offline results

Offline reduction of the number of electrodes

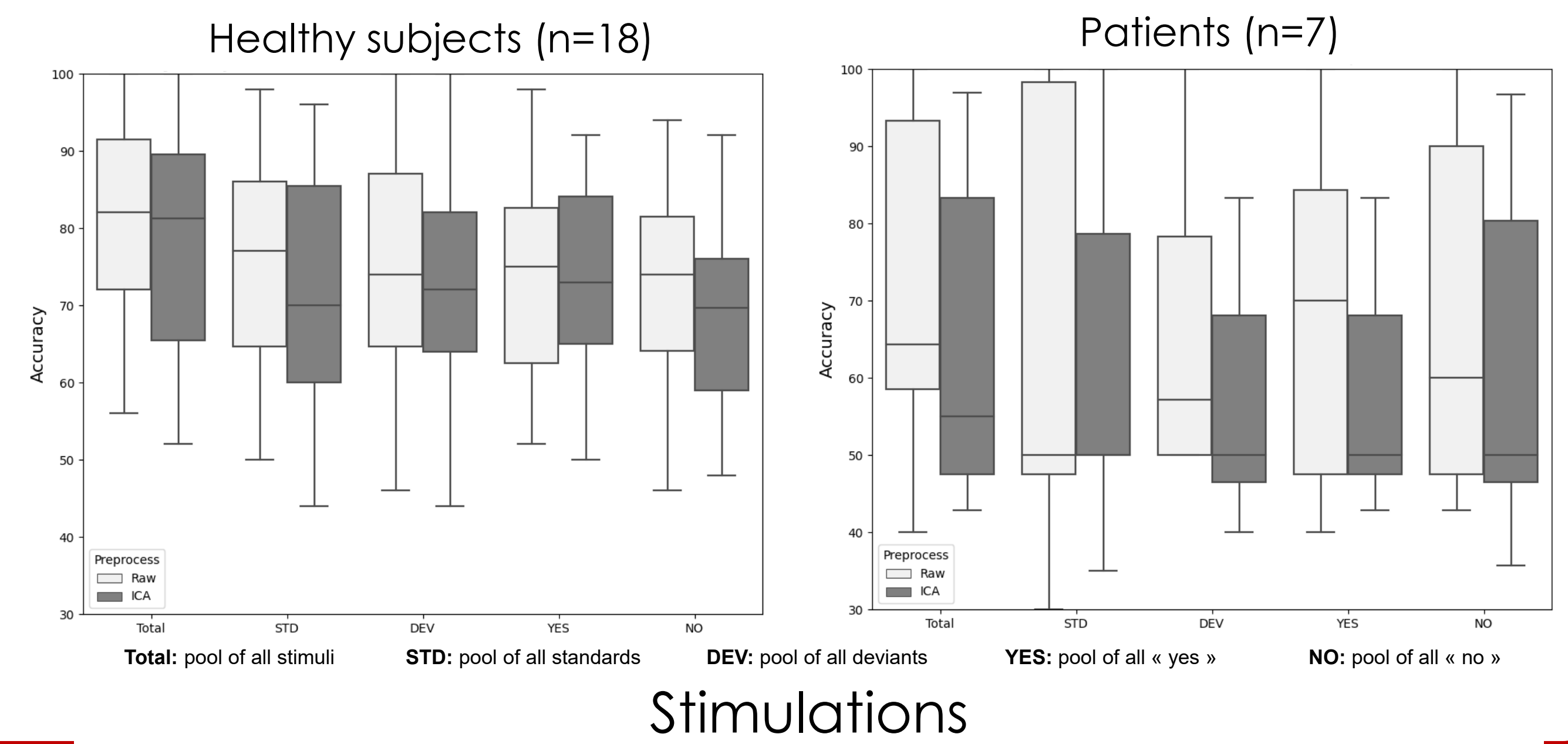
	32 electrodes	15 electrodes
Accuracy	~ 86%	~81%



Offline reduction of trial duration



Effect of ICA pre-processing

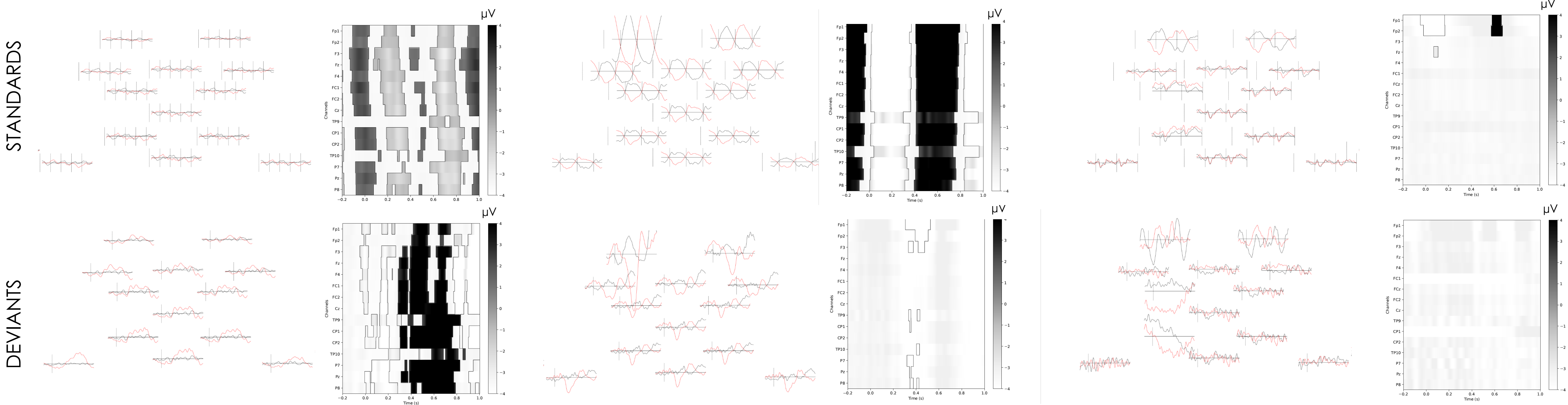


### Individual evoked potentials

Healthy subject  
Accuracy: 100%

Patient with online BCI control  
Accuracy: 100%  
Amyotrophic lateral sclerosis

Patient without BCI control  
Brainstem injury



Significant attentional modulation for each electrode  
Method: Threshold-free cluster enhancement (Smith and Nichols, 2009)

— Attended | 1sec, [ 5 μV  
— Ignored | Stimuli onset

	Healthy subjects	Patients
Response to deviance	94 % (17/18)	29 % (2/7)
Attentional modulation on STD	83 % (15/18)	29 % (2/7)
Attentional modulation on DEV	72 % (13/18)	42 % (3/7)

### Discussion

#### Attentional markers

- **Standards:** a steady-state potential arises at the frequency of the attended stimulus, its shape varies across subjects
- **Deviants:** they elicit a P3b component

#### Clinical results

- Even when they control the BCI, patients show abnormal attentional modulation patterns
- The impact of oculomotor impairment onto covert attention has to be further explored

### Conclusion

#### Auditory BCI

- Show a drop of performance in conscious but severely paralyzed patients
- Patients tend to show a very frontal activity that has to be explored
- Attention abilities may be affected in case of severe (oculo-)motor impairment