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

Perrine Rose Rose Seguin, Emmanuel Maby, Anatole Otman, Mélodie Fouillen, Dominique Morlet, Jacques Luauté, Pascal Giroux, Jérémie Mattout

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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)

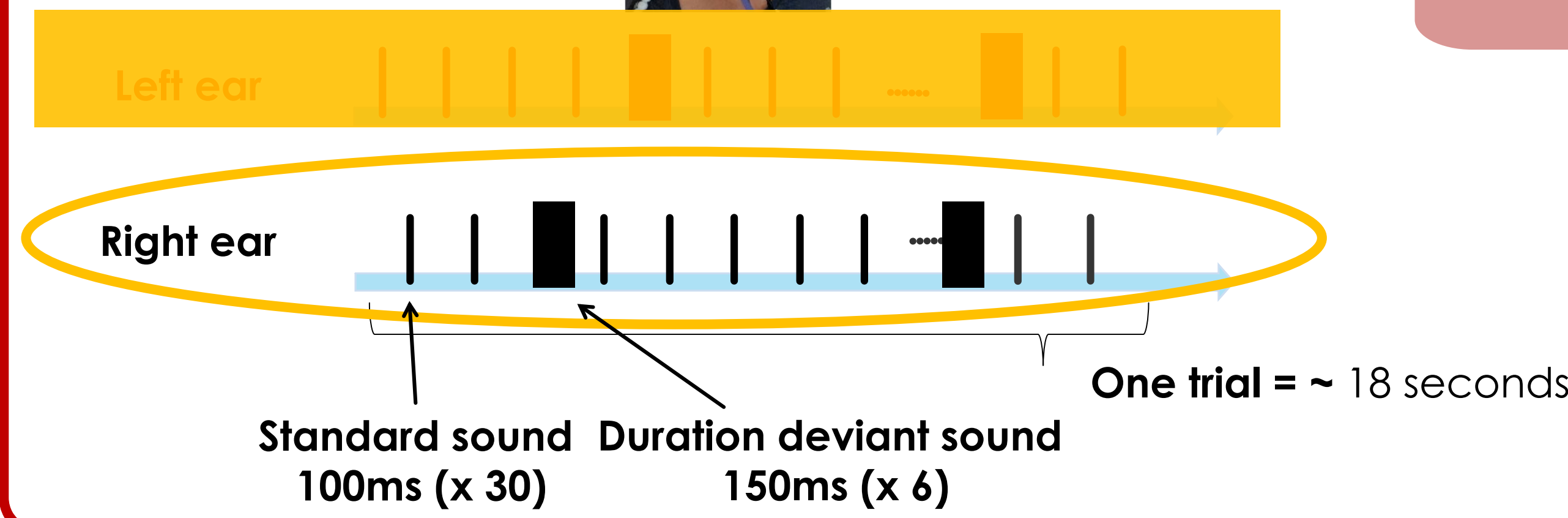
Protocol

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.

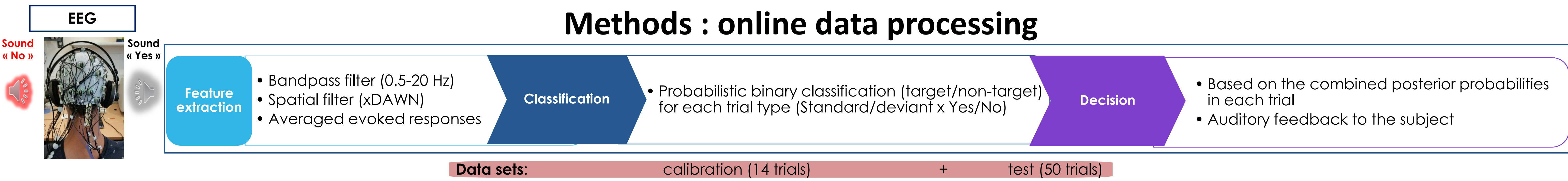


Analysis:
-Online (real-time) : BCI accuracy**
-Offline (a posteriori) :
▪ evoked responses,
▪ design optimization

Datasets:
- 18 healthy subjects
- 7 patients



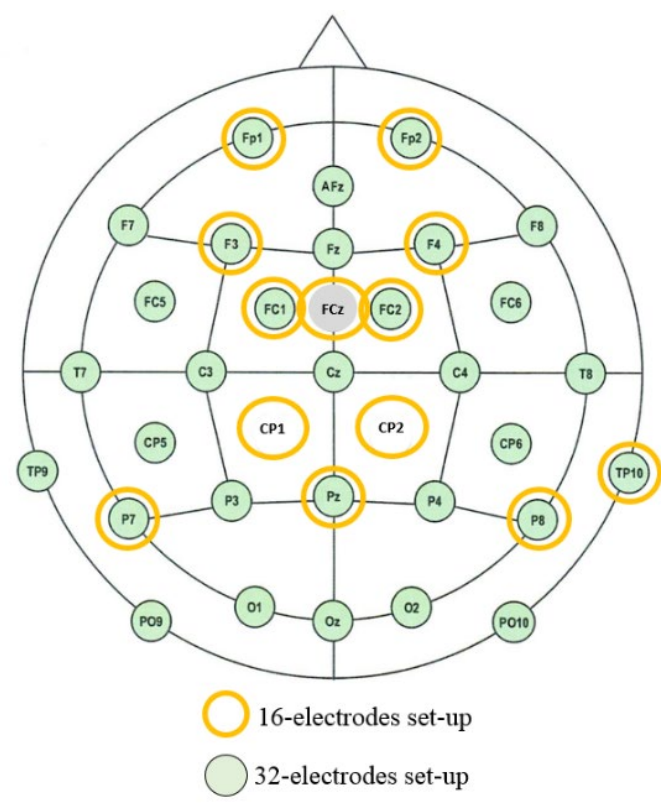
Methods : online data processing



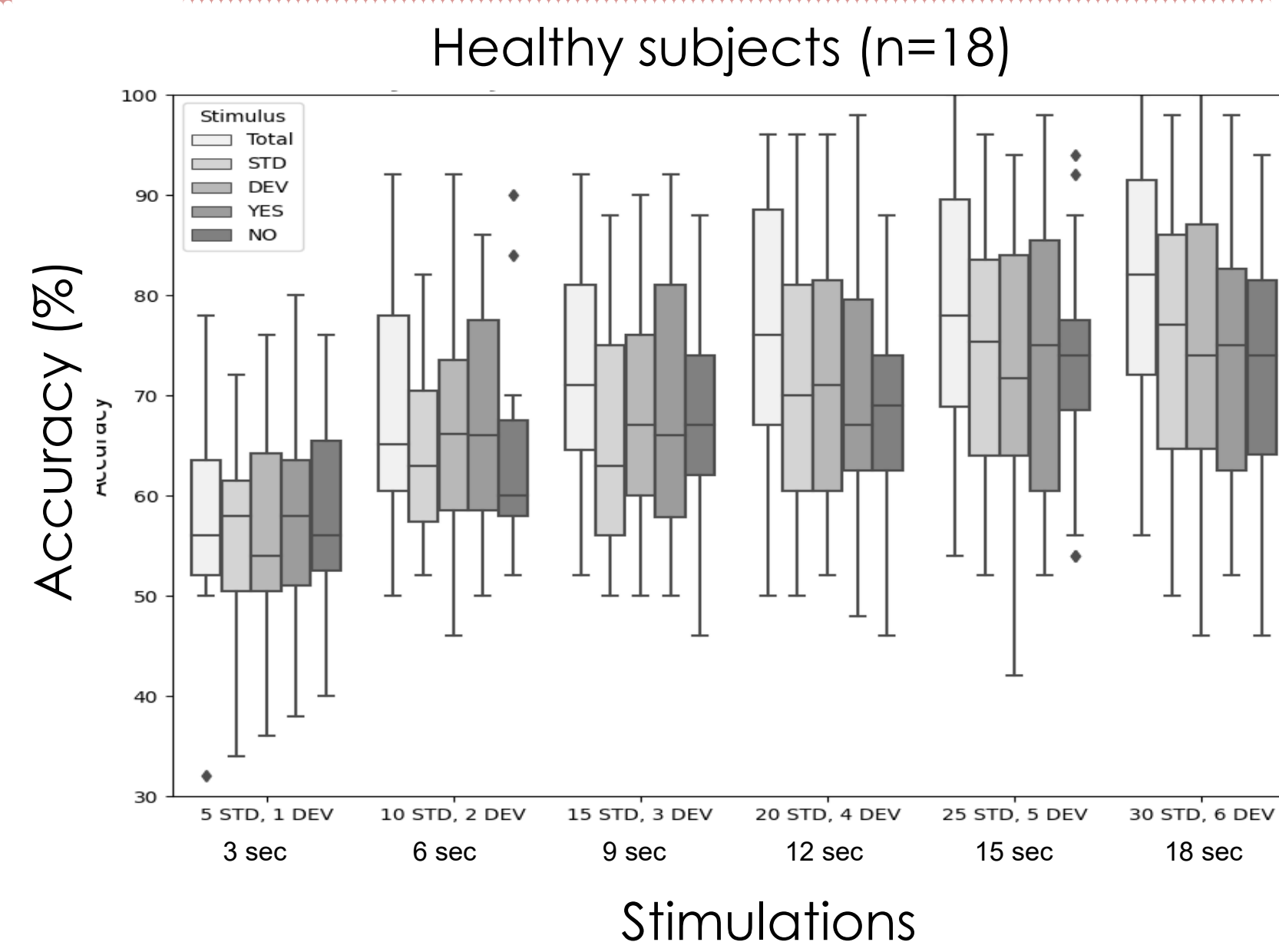
Offline results

Offline reduction of the number of electrodes

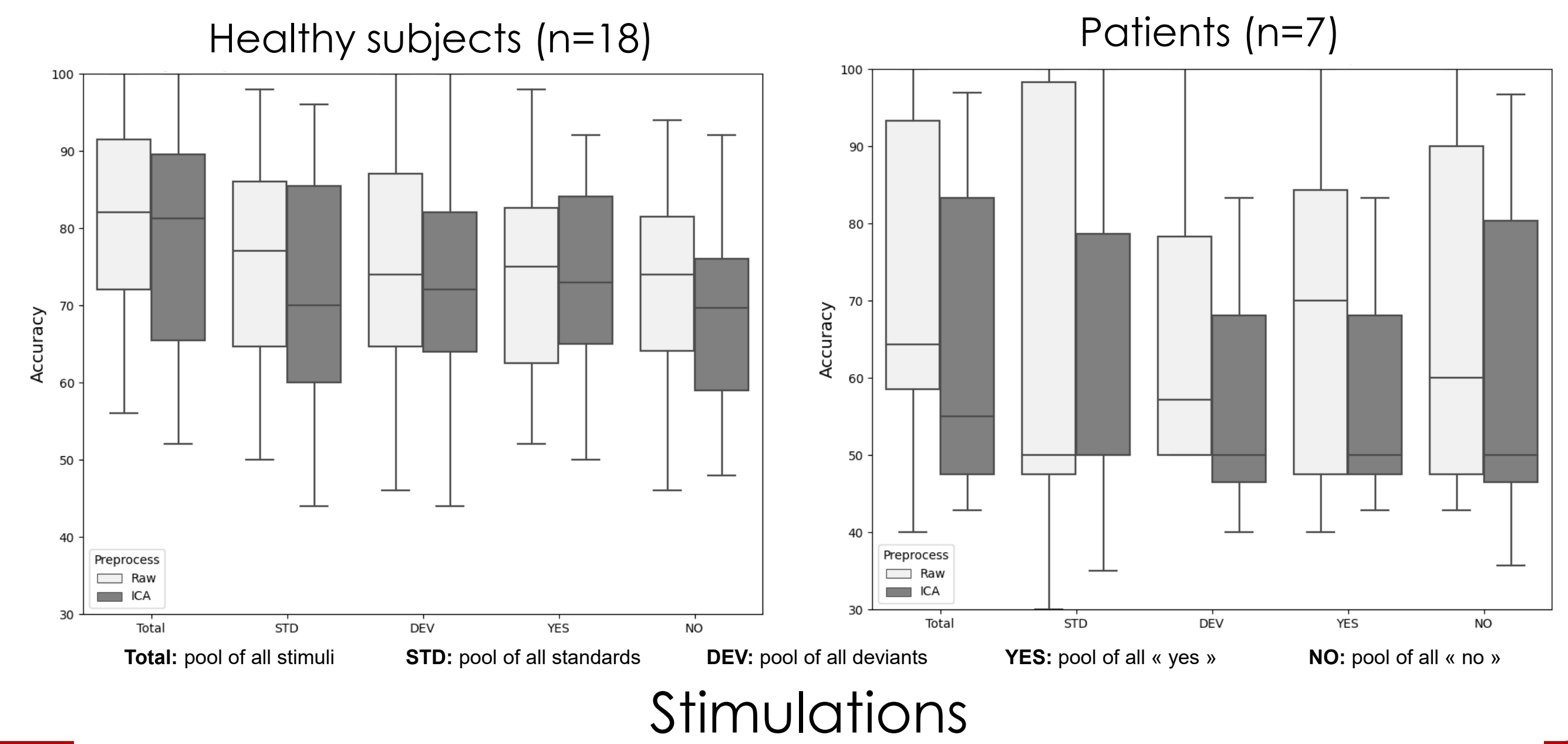
	32 electrodes	15 electrodes
Accuracy	~ 86%	~81%



Offline reduction of trial duration



Effect of ICA pre-processing

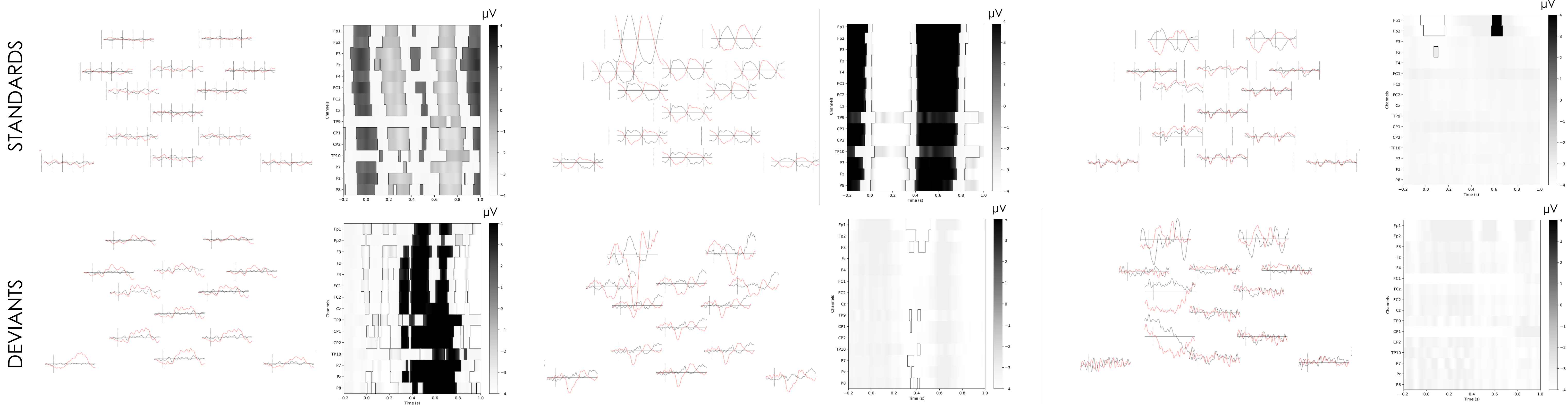


Individual evoked potentials

Healthy subject
Accuracy: 100%

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

Patient without BCI control
Brainstem injury



— 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