Cognitive and neural mechanisms involved in performance monitoring during sustained attention: a comparison of errors made with and without awareness

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Introduction

The ability to maintain the focus of cognitive activity on a given stimulation source or task over extended periods of time, i.e. to **sustain attention** is a fundamental component of the cognitive capacities of human (Sarter et al, 2001).
Good sustained attention performance relies on the proper functioning of cognitive control mechanisms, including **error monitoring**.

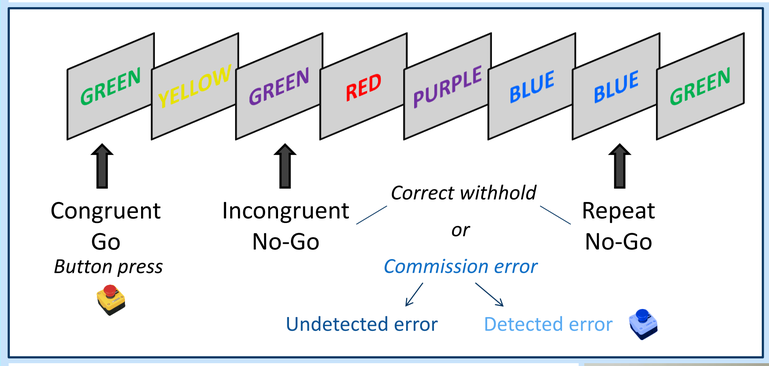
- Several ERPs and behavioral indices have been associated with error monitoring:
- Error-related negativity is assumed to reflect processes related to the early detection and evaluation of an error (**ERN**; Gehring et al, 1993).
- Error positivity is believed to index conscious aspects of error processing and may reflect the allocation of attention to an error (**Pe**; Ullsperger et al., 2010).
- Behavioral adjustments are typically observed in the form of slowing of response latencies for correct trials immediately following an error (post error slowing , **PES**; Rabbit, 1966).

→Although a few recent studies have observed decreases in ERN amplitude with time-on-task (Boksem et al; 2006; Kato et al, 2009), no study have examined the time-on-task effects on ERN and Pe by distinguishing errors made with and without awareness.

The aim of the present study is to assess **error monitoring** in healthy subjects by using a long-lasting error awareness task in order to distinguish errors made with and without **awareness**, in a **time-on-task perspective**.

Method

Subjects 8 healthy subjects at the moment (4 females and 4 males), aged 24.1 ± 3.4 years old and 14.9 ± 1.2 years of education.



Task

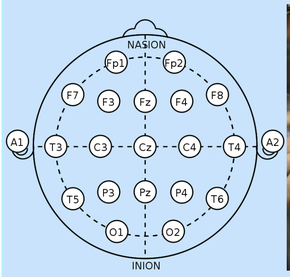
The EAT (Error Awareness Task; Hester et al., 2005) for 68 minutes.

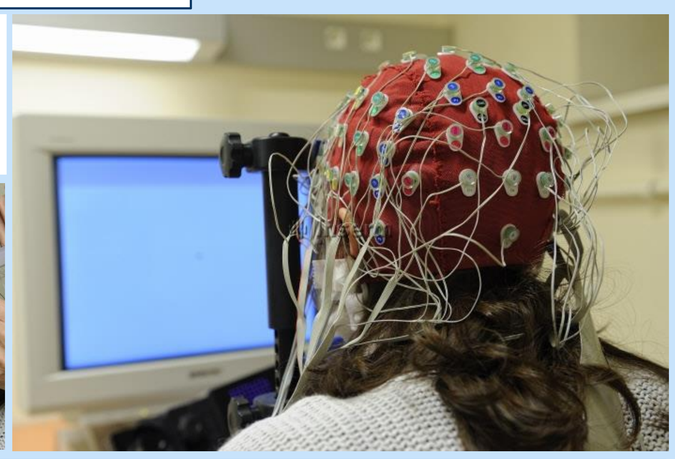
Participants were instructed to time their button presses to the offset of Go stimuli and to withhold this response for No-Go stimuli. They were trained to press a different button following any commission errors.

Measures : commission errors, reaction time (RT)

EEG recording : 64 electrodes

- Filters: - online : high pass : 0.01 Hz, low pass : 500 Hz
  - offline : low pass : 30 Hz
- ERN : negative peak between 0-100ms (Fz FCz Cz)
- Pe : mean amplitude 300-500 ms (Pz)

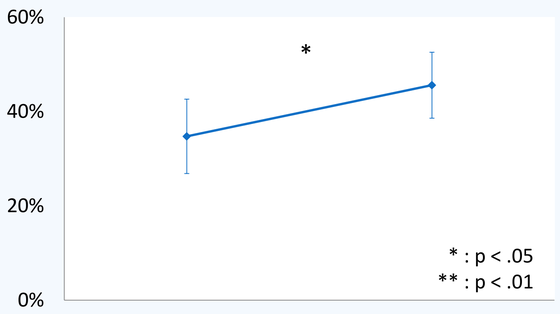




Performance and ERP data were submitted to analysis of variance (ANOVA) including the within-subject factors time-on-task (1st half/2nd half), type of response (correct withhold/undetected error/detected error or undetected error/detected error) and electrode (Fz/FCz/Cz).

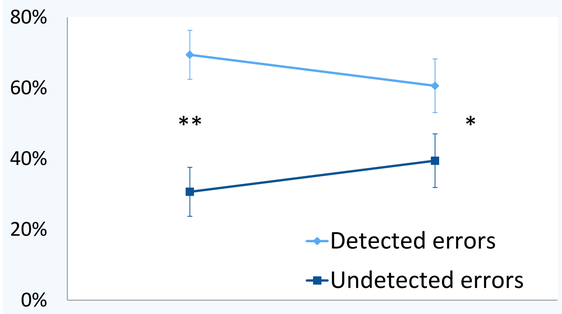
Results

Commission errors



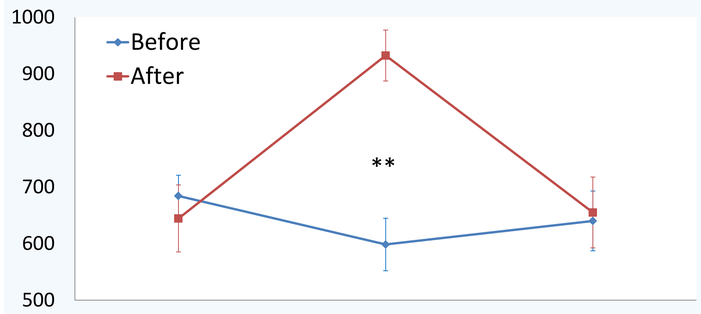
Time-on-task effect, F(1,7)=7.3,p<.05

Commission errors



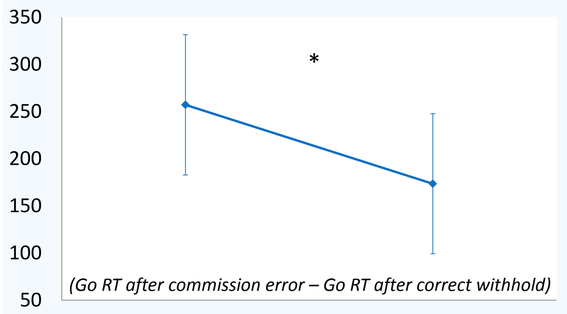
Interaction between type of response and time-on-task, F(1,7)=6.7,p<.05

Go RT before and after a No-Go trial (ms)

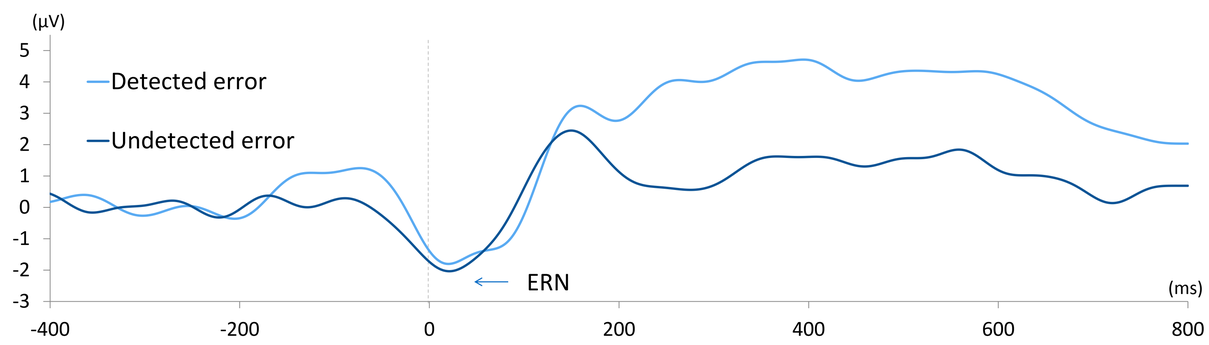


Effect of type of response on the PES, F(2,14)=13.9,p<.001

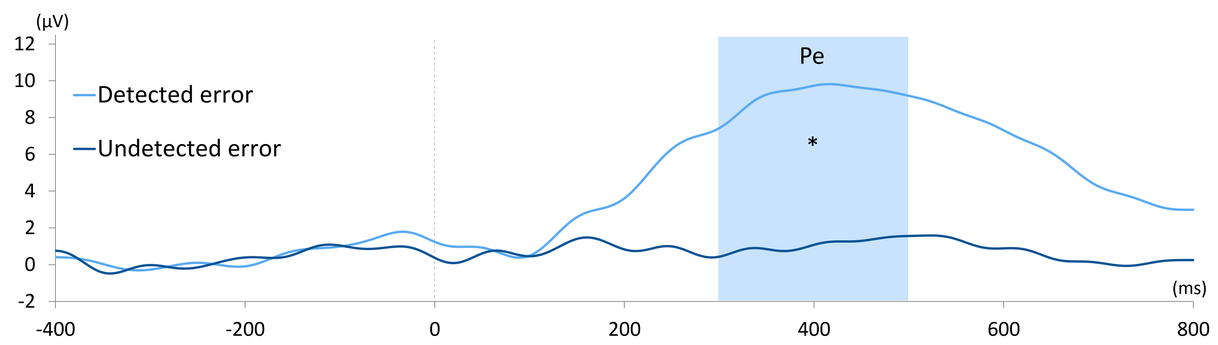
Post error slowing (ms)



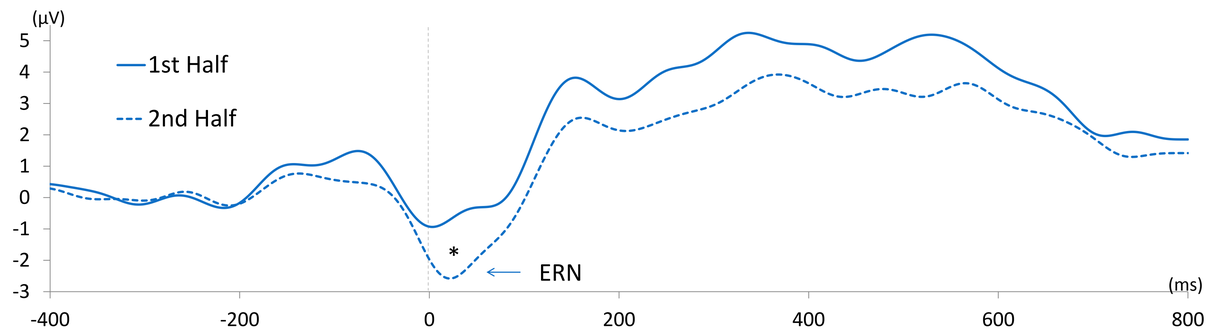
Time-on-task effect, F(1,7)=7.4, p<.05



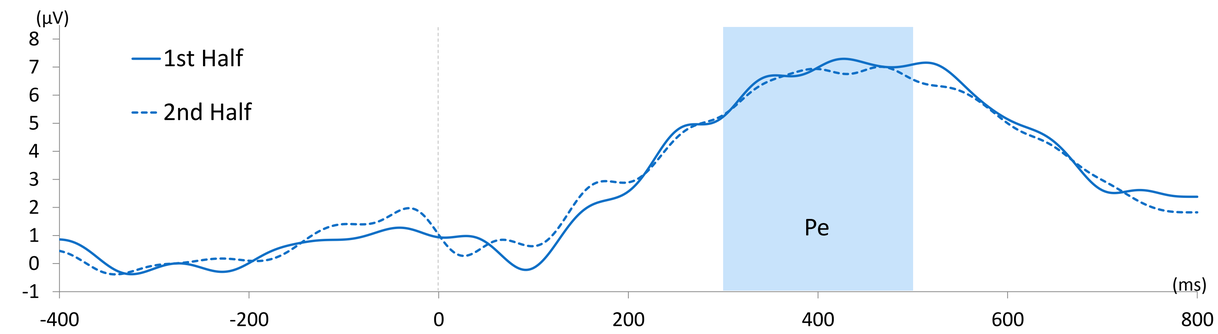
ERP waveform as a function of type of response in FCz.



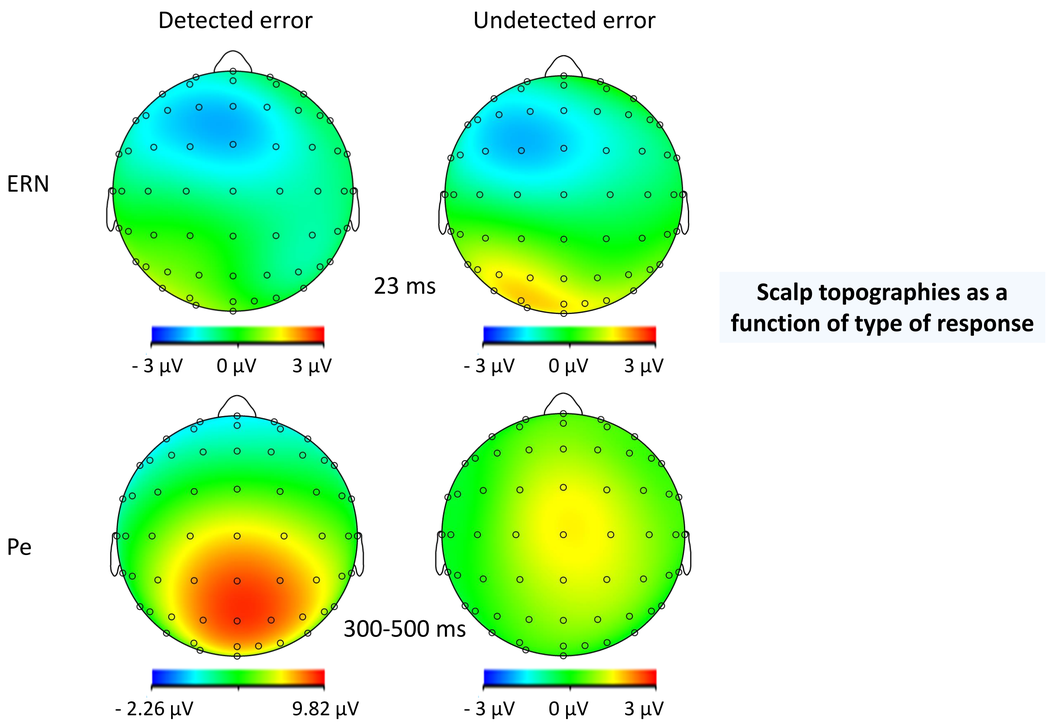
ERP waveform as a function of type of response in Pz.



ERP waveform as a function of time-on-task in FCz.



ERP waveform as a function of time-on-task in Pz.



Scalp topographies as a function of type of response

Conclusion on preliminary results

- **Sustained attention ability : vigilance decrement** in healthy subjects.
- **Neuronal cognitive control mechanisms:**
  - Early detection and evaluation of an error (**ERN**)
    - No differences in amplitude between detected and undetected errors.
    - Increase of amplitude between the 1st and 2nd halves of the task, which could be the result of an increase of errors' significance over time (larger amplitude is associated with increased salience of errors (Hajcak et al., 2005)).
  - Allocation of attention to an error, error awareness (**Pe**)
    - Component only observed after a detected error.
    - No change over time.
  - Behavioral adjustments (**PES**)
    - Only observed after a detected error.
    - Decrease over time, which may be linked to the vigilance decrement.

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