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# Introduction

## Materials and Methods

The diagram illustrates the EEG + fNIRS recording setup. It shows the following components and connections:

- PsychoPy**: A laptop used for stimulus presentation, connected to the **STIMULI PRESENTATION** box.
- STIMULI PRESENTATION**: A box that receives input from PsychoPy and sends signals to the **bluebox** and the **Græel EEG v2** module.
- bluebox**: A central processing unit that receives signals from the **Trigger isolator** and the **Græel v2 trigger module**, and sends signals to the **c-pod** and the **Curry (EEG) Aurora (fNIRS)** laptop.
- Trigger isolator**: A device that receives signals from the **On battery** unit and sends them to the **bluebox**.
- On battery**: A power source for the **Trigger isolator**.
- c-pod**: A device that receives signals from the **bluebox** and sends them to the **Curry (EEG) Aurora (fNIRS)** laptop.
- Curry (EEG) Aurora (fNIRS)**: A laptop used for NIRS recording, connected to the **bluebox** and the **Græel EEG v2** module.
- Græel EEG v2**: A module that receives signals from the **bluebox** and the **Curry (EEG) Aurora (fNIRS)** laptop, and sends them to the **Græel v2 trigger module**.
- Græel v2 trigger module**: A module that receives signals from the **Græel EEG v2** module and sends them to the **bluebox**.
- Ethernet**: A network connection between the **Curry (EEG) Aurora (fNIRS)** laptop and the **Græel EEG v2** module.

The protocol consisted of alternating neutral/negative blocks (figure 2), each including 10 standardized images presented for 2s with short randomized inter-stimulus intervals. Images were selected from affective databases (IAPS, GAPED, EmoPics, EmoMadrid, COMPASS, OASIS, SMID, BAPS; negative: valence  $\approx -1.9$  to  $-1.1$ , arousal  $\approx 0.6$  to  $1.6$ ; neutral: valence  $\approx -0.1$  to  $0.6$ , arousal  $\approx -0.9$  to  $-0.3$ ). After each block, participants rated their emotional experience using visual

analogue scales assessing valence, from very negative to very positive, and arousal, from not intense at all to very intense. Session 1 included rest followed by 12 reactivity blocks (6 neutral, 6 negative) used to estimate an individual reactivity index. Subjects were asked to react naturally to the images. Session 2 included 2 reactivity blocks (1 neutral, 1 negative) to verify index stability after rest, followed by 4 regulation blocks (2 neutral, 2 negative). Participants were asked to down-regulate their response to negative stimuli using one of the proposed strategies explained orally before session 2: distancing, cognitive reappraisal, or mindfulness<sup>4</sup>.

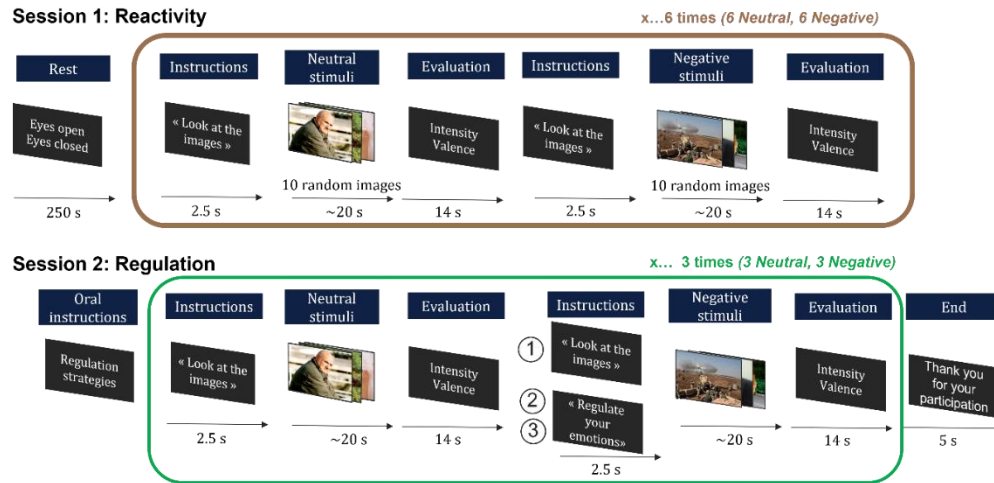


Figure 2. Emotional reactivity/regulation protocol.

#### Data acquisition and analysis.

To validate the protocol, behavioral analyses compared valence and arousal ratings of each block and subject between neutral and negative blocks. In parallel, an ongoing preliminary biomarker analysis was performed using the developed bimodal experimental bench to estimate an individual emotional reactivity index through a subject-specific, real-time-compatible sliding-window pipeline. EEG, fNIRS, and coupling features were extracted, and relevant features were selected, fused, and fed into a sequential model to track emotional reactivity and regulation.

## Results and Conclusions

Behavioral analysis supported an emotional contrast between neutral and negative blocks for most participants. Our results are consistent with previous encouraging fMRI findings implicating prefrontal-limbic mechanisms in emotional reactivity and regulation. In post-processing analyses, the bimodal EEG-fNIRS pipeline showed preliminary individual signatures able to distinguish emotional states. Moreover, first analyses using the subject-specific, real-time-compatible pipeline suggest the presence of frontal bimodal signatures that may help monitor reactivity and regulation. No significant correlation was observed between the estimated physiological regulation index and participants' self-perceived regulation success. Given that self-ratings were collected informally may reflect explicit appraisal of regulation rather than the full physiological regulation process, this suggests that EEG-fNIRS monitoring could provide complementary information to subjective reports. Although preliminary and based on a small sample of 10 healthy volunteers, this pilot study validates the bimodal EEG-fNIRS setup and protocol as a methodological basis for future studies in BD patients and neurofeedback applications aligned with current guidelines<sup>5</sup>.

## References

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