

# A Quest for the Cortical Representation of Subjective Surprise With a Virtual Reality Neurofeedback Platform

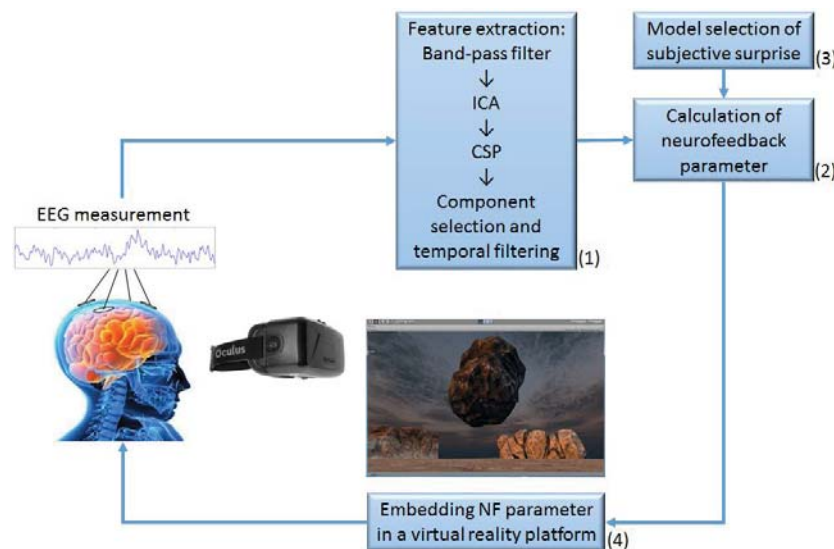
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**Introduction:** It is well known that responses to external stimuli are context dependent [e.g. 1,2]. Specifically, when a rare event occurs, it elicits the P300 event-related potential (ERP), while when a stimulus repeats itself responses are attenuated. Context dependency can be modelled by conditional probabilities of future events. Arguably, these are the measures that give rise to the experience of expectation and surprise. These expectations, or conditional probabilities, should depend on both the memory capacity of subjects and on their goals. Using the Information Bottleneck method developed by Tishby et al. [3], a trial-by-trial subjective surprise signal can be calculated, taking into account the subject's memory resources and goals. This calculated surprise signal can then be tested against physiological data.

**Methods and Results:** We examine the above hypotheses in the framework of an auditory oddball experiment. Our preliminary results indicate a correlation between the trial-by-trial measure of subjective surprise and an EEG metric based on the P300 component. Moreover, a platform we developed (see Fig. 1) containing a virtual reality game combined with EEG measurements, allows us to have an ERP-based neurofeedback (NF) in which the subject is getting feedback within the game on his current surprise-related EEG feature.



**Figure 1.** An ERP-based neurofeedback platform, composed of (1) a feature extraction step of spatial and temporal filtering, (2,3) calculating the NF parameter using the extracted feature and a pre-selected subjective surprise model parameters, and closing the NF loop with (4) a virtual-reality game, which the subject controls by manipulating the chosen EEG feature.

**Significance:** Our feature extraction method combined with our NF platform has several theoretical and practical advantages, compared to conventional procedures. This unique combination enables better assessment of the feature extraction process on one hand, and on the other hand it opens the path for better targeted and more engaging neurofeedback procedures.

## References:

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- [3] Tishby N, Pereira FC. The Information Bottleneck Method. In *Proceeding of the 37th Annual Allerton Conference on Communication, Control, and Computing*, 368–377, 1999.