 DOI: 10.3217/978-3-85125-467-9-226

Affective BCI for characterizing museum visitors response

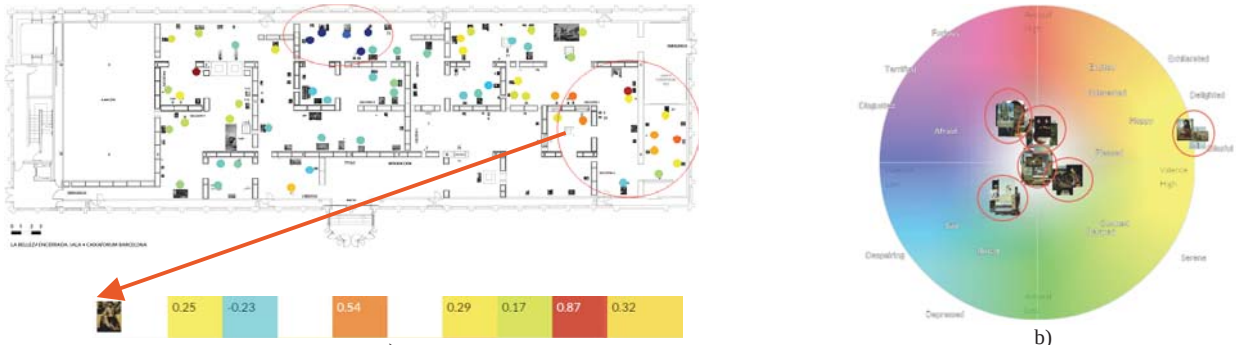
J. Acedo[1], A. Soria-Frisch[1*], D. Ibáñez[1], M. Castellano[1], S. Dunne[1]
[1]*Starlab Barcelona SLU, Neuroscience Business Unit*

*Av. Tibidabo 47b, 08035 Barcelona, Catalonia, Spain. E-mail: aureli.soria-frisch@starlab.es

Introduction: We present a novel methodology based on affective BCI (aBCI) for the analysis of subject emotional response during art exhibitions. The proposed methodology provides tools for better understanding visitors reaction to exhibition layout and art pieces. Starlab's ExperienceLab system was adapted to record electrophysiology signals during visitors' activity. We analyze 20 volunteers' data. The signals were mobile recorded while the volunteers visited the exhibitions on 14th-19th century paintings, and S. Salgado's photography at the museum CaixaForum. The emotional state is characterized following the circumplex model [1]. The used valence and arousal features are directly taken from current state of the art, whereas we propose novel fusion and clustering techniques for the final interpretation tools.

Material, and Methods: Three different electrophysiological signals were recorded for emotional characterization, namely Electroencephalogram (EEG), Electrocardiogram (ECG), and Galvanic Skin Response (GSR). Enobio was used for wireless recording EEG and ECG, whereas a Shimmer device recorded the GSR. The synchronization of all signals and positioning video was made using a tablet PC, which was carried by volunteers. The emotional subjective response is obtained through questionnaires, which were realized once the volunteer finished the visit. We select one clean signal interval pro art piece by visual inspecting the signals and associating it through the video sequence. Once done 4s epochs are cut and used for feature computation. We extract 2 valence features: EEG parieto-temporal gamma asymmetry [2], and frontal alpha asymmetry [3]. Eight arousal features are used: EEG frontal alpha-beta ratio [4], EEG parieto-occipital gamma power [5], heart rate and its variability, and GSR variance and number of events. The interested reader is referred to the original papers for further details on features. The U-test is then applied for evaluating the statistical significance of the features taking the questionnaire answers as ground truth. The obtained p-vales are first used to compute the weights within a weighted sum that fuses the 2 valence features into a unique final value. The 8 arousal features are fused analogously. Both fused values are lastly scaled into [-1,1] and used for the *exhibition highlight maps*. On the other hand a clustering analysis is used on the 10-dimensional feature set based on K-means (K=6). This allows establishing groups among art pieces in the circumplex space. The prototype of each cluster is transformed into coordinates of the final *circumplex representation* by independently fusing the valence and arousal components of the prototypes.

Results: The EEG gamma asymmetry ($p<0.01$) is the most significant valence feature. Significant arousal features are the EEG alpha-beta ratio ($p<0.01$) and the GSR variance ($p<0.001$). The fused valence and arousal are topographically registered with the exhibition map for associating individual subject and grand responses with exhibition layout in what we denote as *exhibition highlight maps* (see Fig. 1a). Lastly the *circumplex representation* is used for depicting art piece groups and its associated emotional complex response, e.g. blissful, serene, sad (see Fig. 1b).



a) b)

Figure 1. *Informative visualization system output. a) Highlight map and detail for 1 art piece (where color codes arousal/valence values). b) Art piece clustering (color codes areas in the circumplex).*

Discussion: The significance of GSR arousal confirms the existing literature. The significance of the arousal and valence EEG features proves its applicability. Obtaining unique arousal-valence values through data fusion constitutes a novel approach in aBCI, which increases the features significance level. Moreover novel methods for transforming aBCI results into information both on the highlights of the exhibition layout, and the value of the exhibited pieces from an emotional point of view are proposed and exploited for generating the final results.

Significance: A multimodal aBCI system including statistically significant EEG-based arousal and valence is successfully applied out-of-the-lab. Here the employed wireless EEG technology shows its potential. The proposed data fusion and clustering methods constitute a novelty, which empower the outcome visualization tools for museum aBCI applications.

Acknowledgements: La Caixa Foundation has funded the project works described herein in a private contract.

[1] Russell, J. A. (1980). A circumplex model of affect. Journal of personality and social psychology, 39(6), 1161.
[2] Li, M., & Lu, B. L. (2009). Emotion classification based on gamma-band EEG. In Proc. IEEE EMBC 2009 pp. 1223-1226.
[3] Coan, J. A., & Allen, J. J. (2004). Frontal EEG asymmetry as a moderator and mediator of emotion. Biological psychology, 67(1), 7-50.
[4] Bos, D. O. (2006). EEG-based emotion recognition. *The Influence of Visual and Auditory Stimuli*, 1-17.
[5] Aftanas, L. I. et al. (2004). Analysis of evoked EEG synchronization and desynchronization in conditions of emotional activation in humans: temporal and topographic characteristics. Neuroscience and behavioral physiology, 34(8), 859-867.