The Autonomic Craving Signature: physiological signals as a daily-life biomarker of craving

E. Baillet[1,2,3]; F. Serre[1,2,3]; H. Si-Mohammed[4]; C. Romao[1,2,3]; A. Bruneau[1,2,3] ; C. Vacher[1,2,3]; T. Monseigne[1,2,3]; C. Jeunet-Kelway[5]; M. Auriacombe[1,2,3]

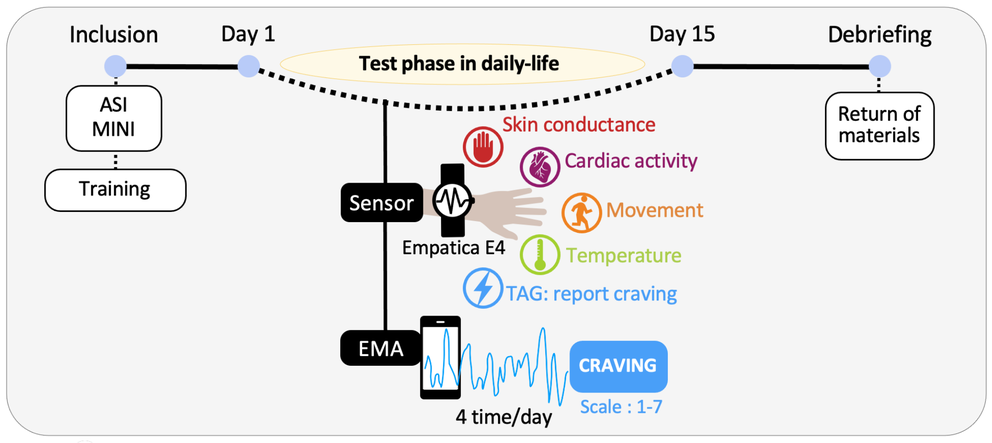
[1]University of Bordeaux, F-33076 Bordeaux, France
[2]CNRS, SANPSY, UMR 6033, F-33076 Bordeaux, France
[3]Pôle Interétablissement d'Addictologie, CH Ch. Perrens and CHU de Bordeaux, F-33076 Bordeaux, France
[4]Univ. Lille, CNRS, Centrale Lille, UMR 9189 CRIStAL, F-59000 Lille
[5]Univ. Bordeaux, CNRS, EPHE, INCIA, UMR 5287, F-33000 Bordeaux

INTRODUCTION

Addiction is characterized by a loss of control over use of reinforcers such as substances (alcohol, tobacco, cannabis...). **Craving** is a clinical phenomenon defined as a strong urge to use (Auriacombe et al., 2018) and plays a central role in addiction (Gauld, Baillet et al., 2023). Craving is a dynamic phenomenon that fluctuates in intensity and frequency and the daily variations of which are prospectively associated with use by Ecological Momentary Assessment (EMA) method (Cleveland et al., 2021; Serre et al., 2015). In a meta-analysis pooling 51, 788 substance-suing participants from 237 studies, **craving was reported to prospectively predict substance use and relapse**, suggesting it could play a causative role (Vafaie & Kober, 2022). Yet, identifying/reporting craving episodes can be difficult for some patients (Raftery et al., 2020). The identification of biomarkers of craving could compensate for this. Craving is associated with **changes in autonomic nervous system (ANS)** and **unique neurobiological changes** (Sinha et al., 2009), that would be identified in daily-life (Carreiro et al., 2020, 2021).

The main objective was to identify a transdiagnostic and reliable pattern of physiological signals of ANS (heart rate, electrodermal activity, skin temperature and accelerometry) associated with craving captured in daily-life using a multimodal metho(EMA and wearable sensor).

METHODS

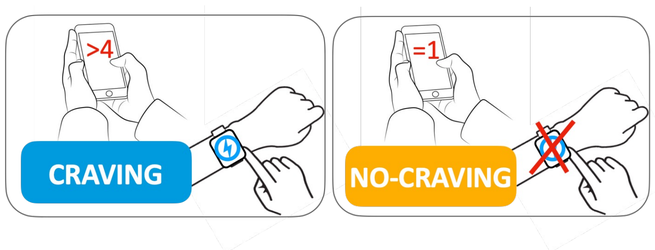


Feature extraction

Based on the literature (Lutin et al., 2021), several feature were extracted for each signal recorded to reflect their real values.

Feature selection

Epochs of **10' before and after** the craving event or randomly in the no-craving period.



Feature filtering

Features were rejected in case of low variance (Min-Max normalization) (≤0.00025) and high correlation (≥0.98)

Dimension Reduction

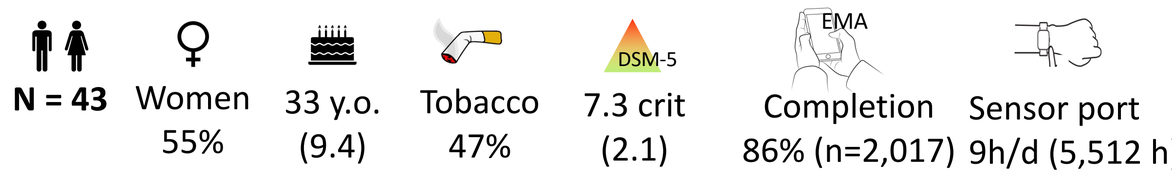
Principal component analysis produces a **linear combination of features** (called principal components (PCs)) ordered according to their ability to explain the total variance of all features, regardless of class.

Machine Learning

Binary classification

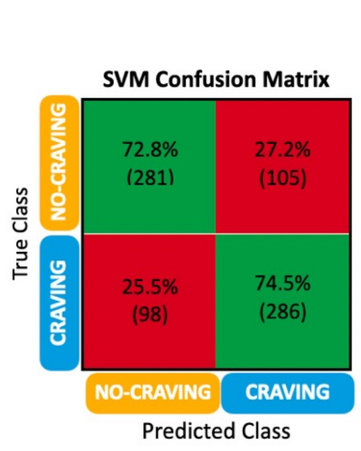
Linear Discriminant Analysis (LDA), Support vector machine (SVM). Then, evaluation of classification algorithm with standard metrics: **sensitivity, specificity, accuracy and area under the curve (AUC) of the receiver operating characteristic (ROC) Curve.**

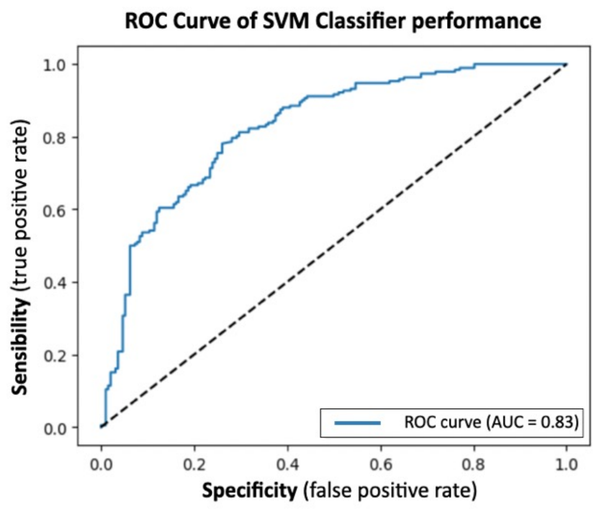
RESULTS

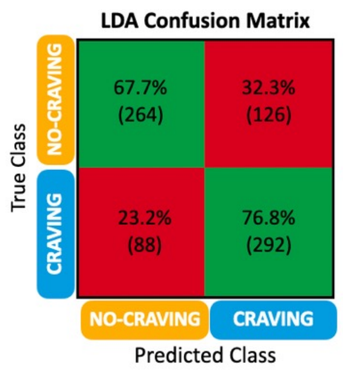


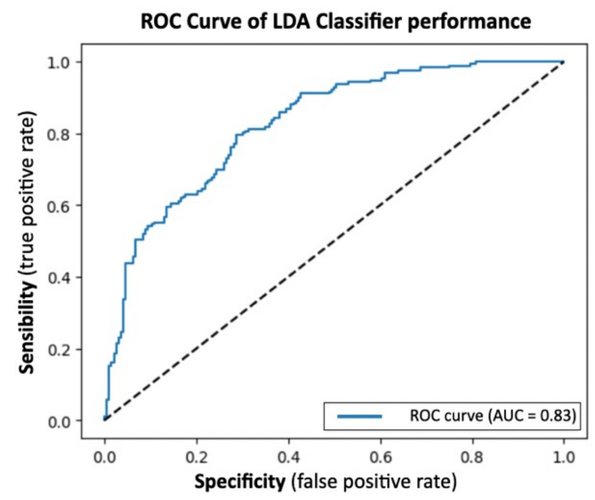
N = 43	Women 55%	33 y.o. (9.4)	Tobacco 47%	7.3 crit (2.1)	Completion 86% (n=2,017)	Sensor port 9h/d (5,512 h)

- **92 physiological features** have been extracted and normalized;
- Principal Analysis Component (PCA) has been performed on 5 participants who have at least 20 samples/class
- PCA showed that **31 principal components (PC)** (linear combination of original features) are sufficient to explain 99% of the data variance
- The first PC explains **74% of the total variance** and made up of **skin conductance features** and the second PC, who explains **8% of the total variance**, is made up of **heart rate variability features**









DISCUSSION

Using SVM and LDA classifiers, physiological signals allowed us to discriminate episodes of craving vs. no-craving with a high cross-validation accuracy (73.6% and 72.2% respectively). This result provides both information on the general state of arousal and on a specific response to craving.
Limitations: much data had to be discarded and the ACS was identified from 5 participants out of 43 and requires to be replicated. The next step would be to test the generalization of this model on a new dataset.

CONCLUSION

The identification of craving from physiological data could be an important step in the development of prognostic biomarkers of relapse in SUD. The ACS paves the way to the development, in daily-life, of protocols of craving regulation that could build a sustainable warning system that would be activated when this pattern is present to allow a just-in-time intervention or a relay towards care if needed.

Contacts: emmanuelle.baillet.1@u-bordeaux.fr ; marc.auriacombe@u-bordeaux.fr

PARTNERS

Financial support: PhD doctoral grant to E. Baillet by French Cancer and Public Health institutes
Conflict of interest: None.