Psychophysiological Monitoring of Music Performance Anxiety and Cognitive Load through Thermography and Functional Near-Infrared Spectroscopy

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Background

- Music performance anxiety (MPA) is a significant challenge faced by musicians, impacting their overall performance quality and psychological well-being [1]
- MPA can compromise both musicians' technical skills during performances and emotional mental health, leading to a cycle of stress and underperformance.
- In this context, it could be beneficial to adopt non-invasive methods for monitoring the psychophysiological states of performers during live situations.



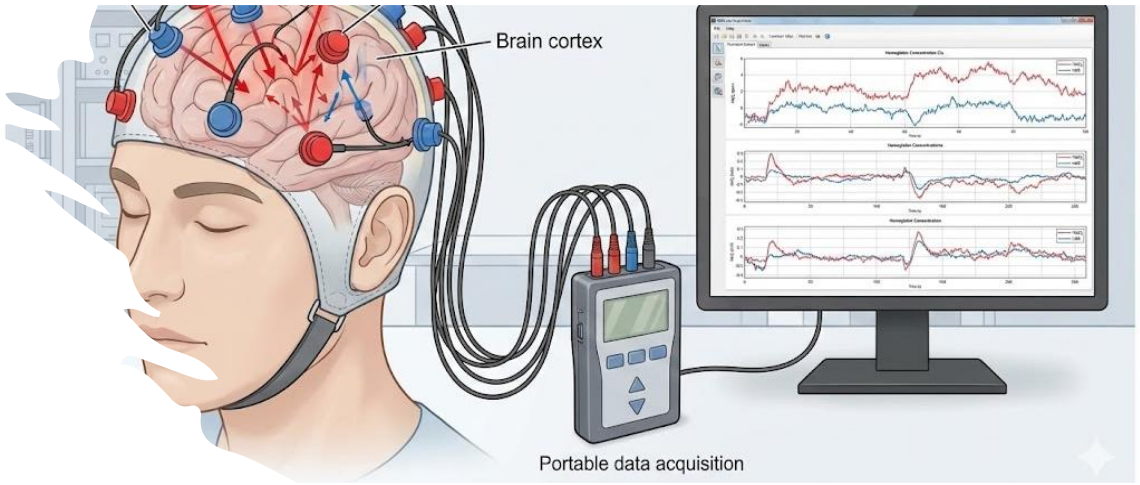
[1] *Taborsky, C. Musical Performance Anxiety: A Review of Literature. Update Appl. Res. Music Educ. 2007, 26, 15–25, 20 doi:10.1177/87551233070260010103*

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Aim of the study

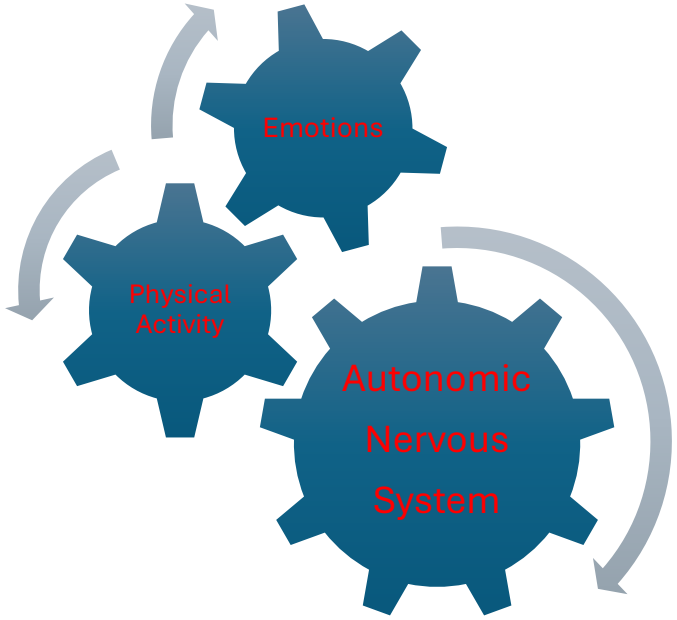
- This research aims to assess the psychophysiological state and cerebral activity of musicians during live performances.

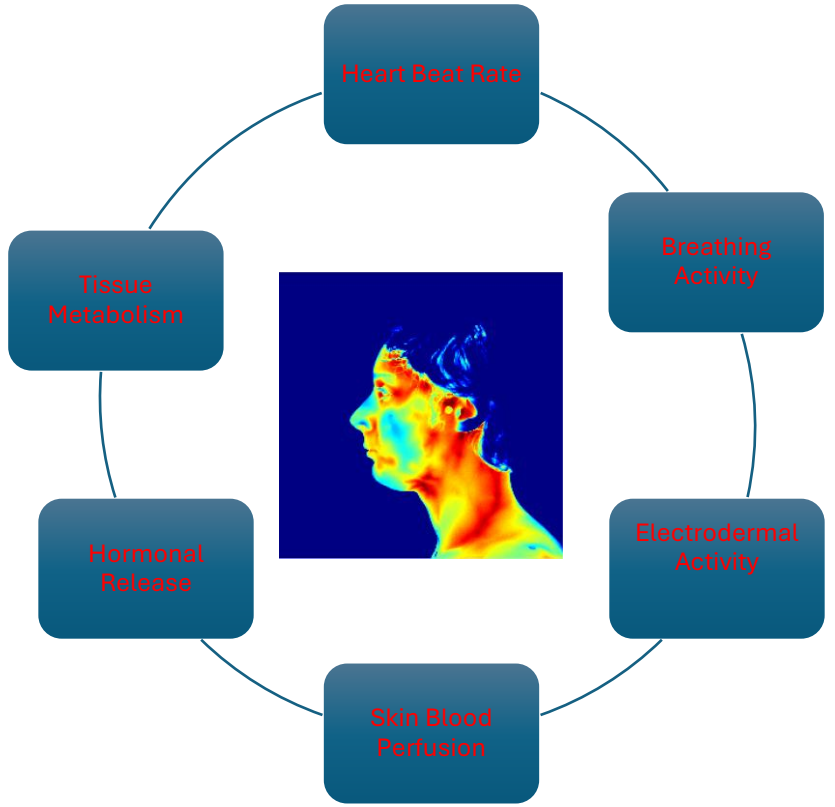




Infrared Thermography (IRT)

Infrared thermography (IRT) represents a promising tool for real-time monitoring of emotional condition[2]. IRT is a non-invasive, non-contact technique capable of assessing skin temperature, and it is already widely employed in both clinical and technological fields.





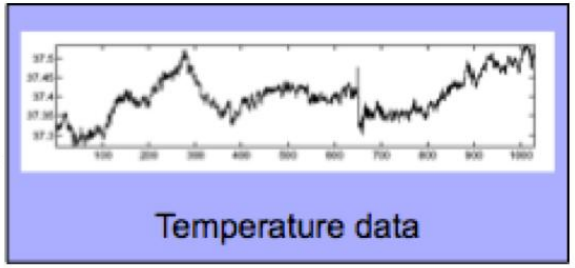
[2]*Clay-Warner, J.; Robinson, D.T. Infrared Thermography as a Measure of Emotion Response. Emot. Rev. 2015, 7, 157–162, doi:10.1177/1754073914554783.*

Infrared Thermography (IRT)

Thermal IR Video & Tracking of Rois



Temperature Data Processing



Modeling

States Classification

RAVE – Petitto et al, 2017

Merla, 2007, 2018
Perpetuini, 2018

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Materials And Methods

Facial temperature was recorded for four musicians (1 female; age: 28 ± 9 years) during both a rehearsal session and a live performance. Measurements were obtained using a physiological module named HIRA, developed by Next2u s.r.l. (www.next2u-solutions.com), which consists of co-registered RGB and infrared cameras.



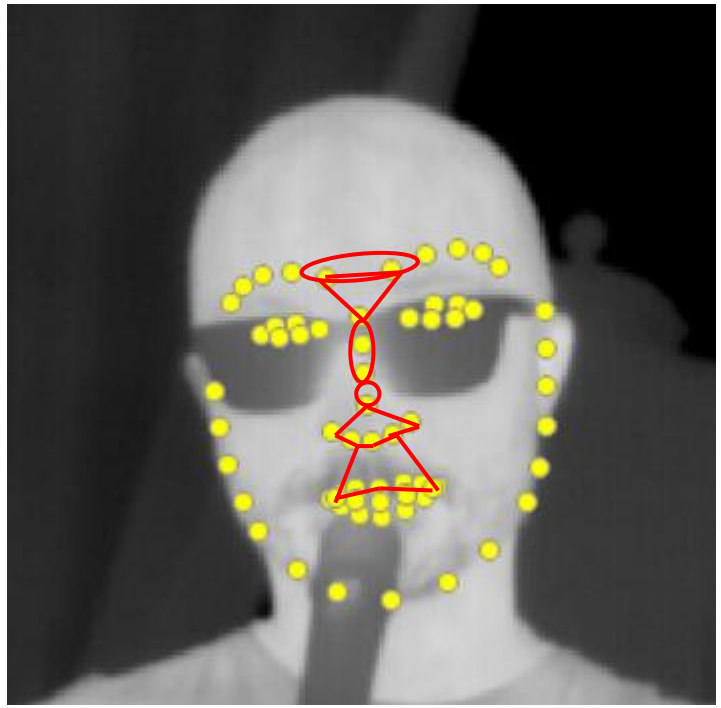


Materials And Methods

The temporal evolution of temperature was evaluated across six Regions of Interest (ROIs): the nasal tip, nostrils, nasal bridge, glabella, perioral area, and forehead, utilizing an integrated tracking algorithm. For each region, the following quantitative indicators were calculated:

- Skewness
- Kurtosis
- Sample Entropy

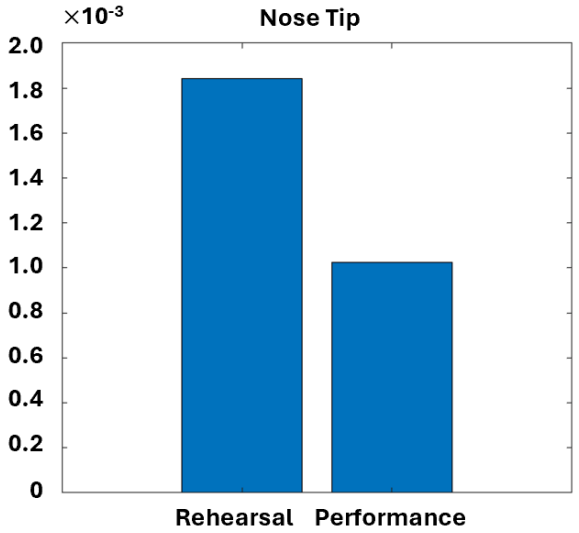
Furthermore, the HIRA module employs Machine Learning (ML) models applied to thermal features to assess stress levels and estimate the autonomic balance between the sympathetic and parasympathetic nervous systems.

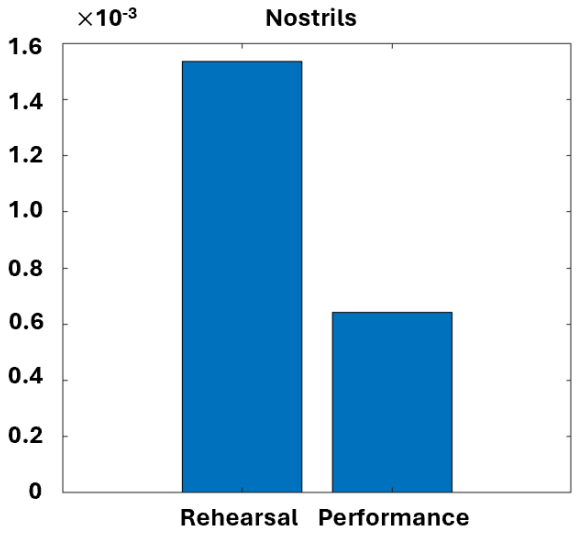


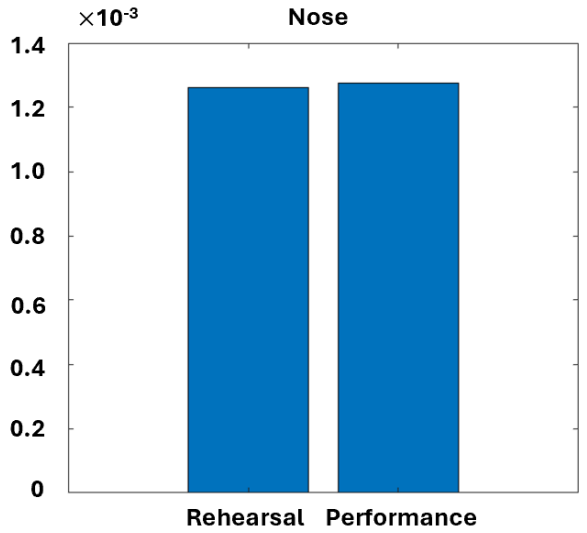
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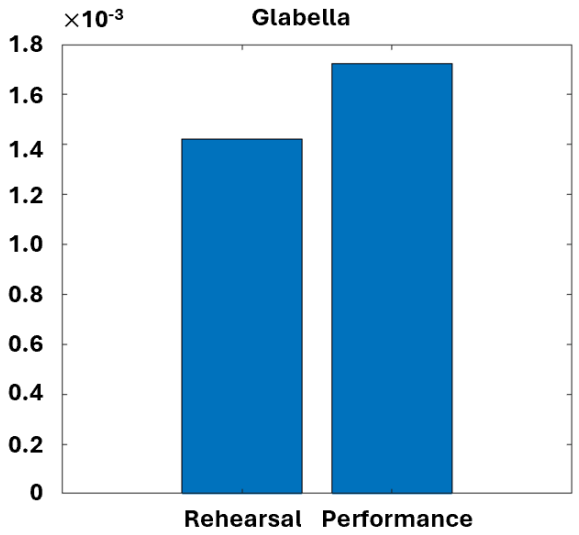
Results

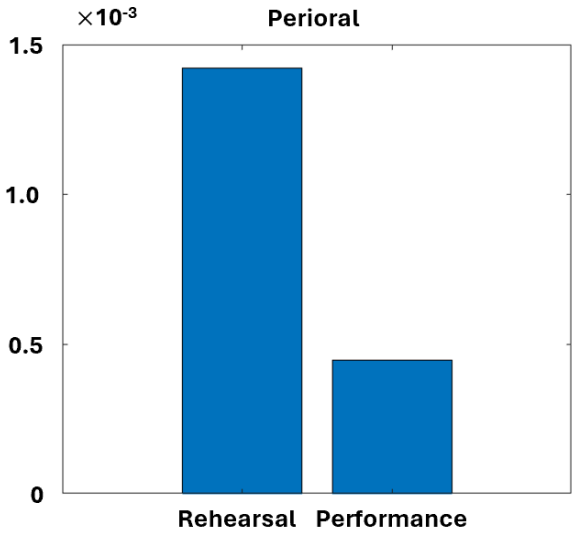
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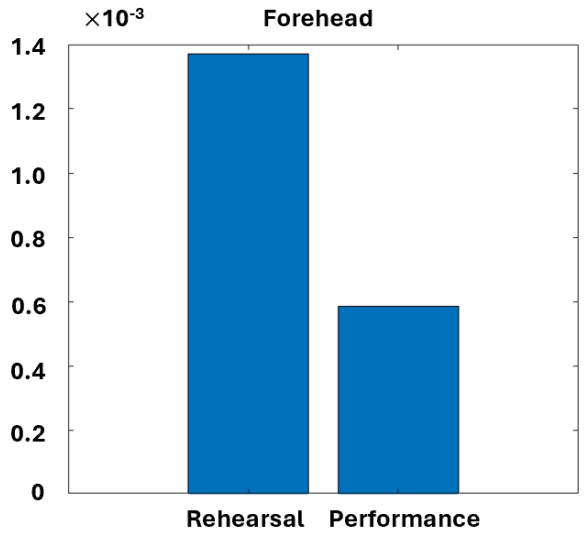








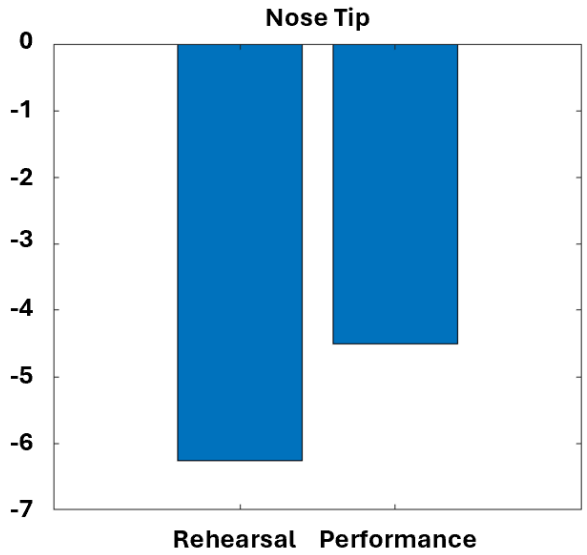


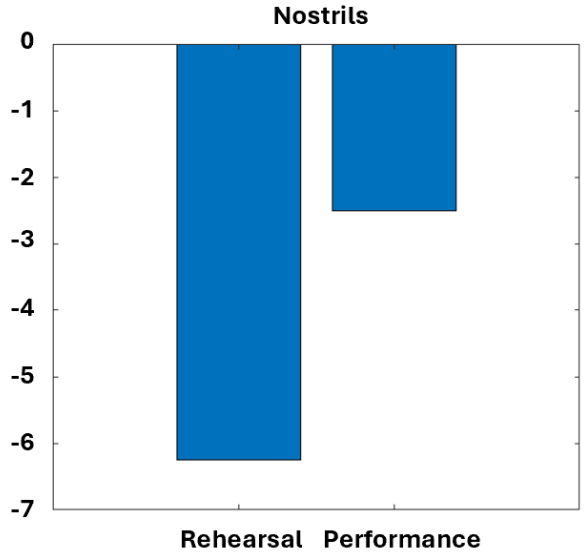


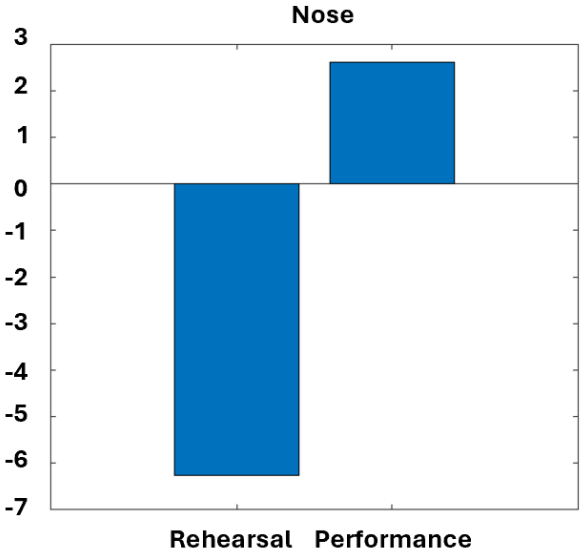
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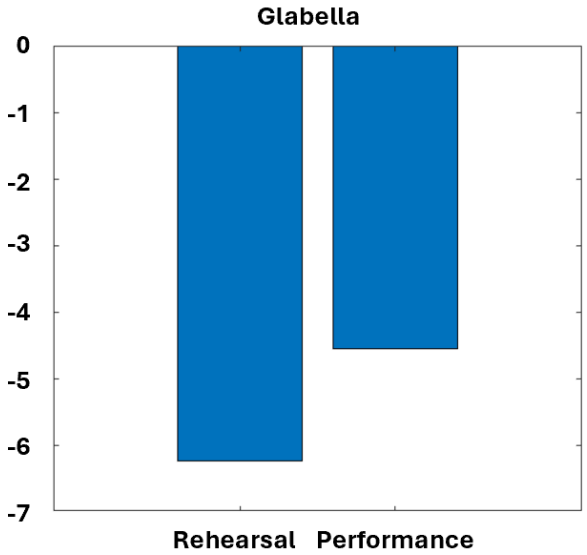
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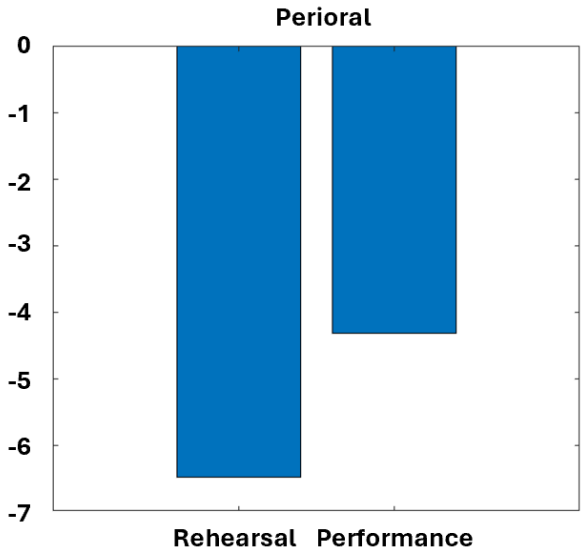
Skewness

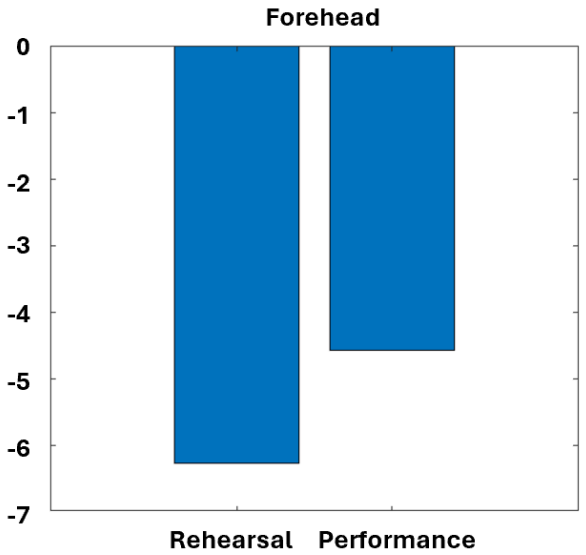






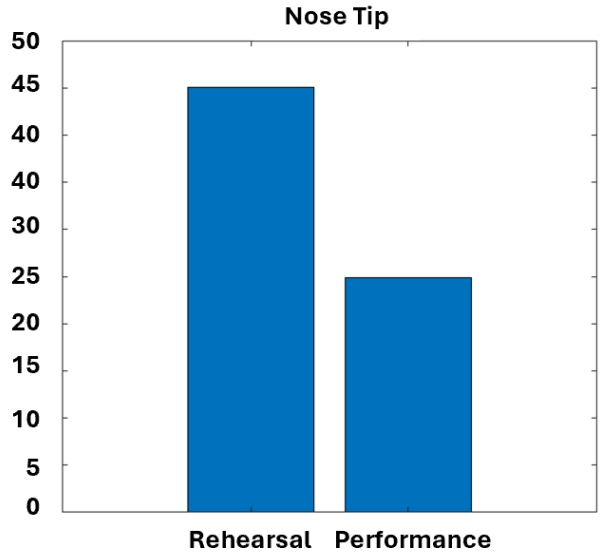


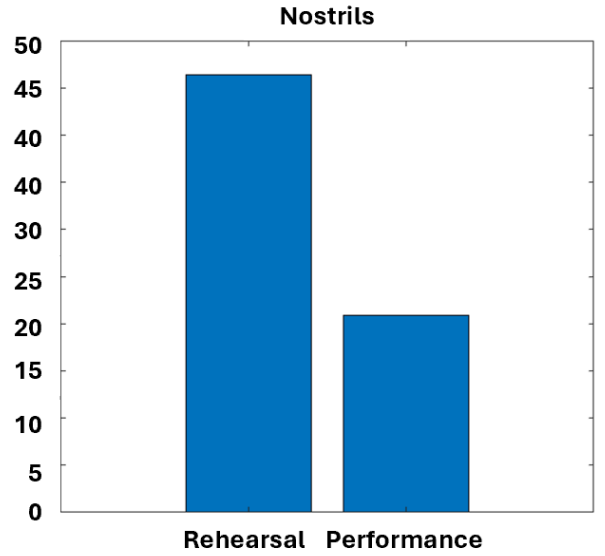


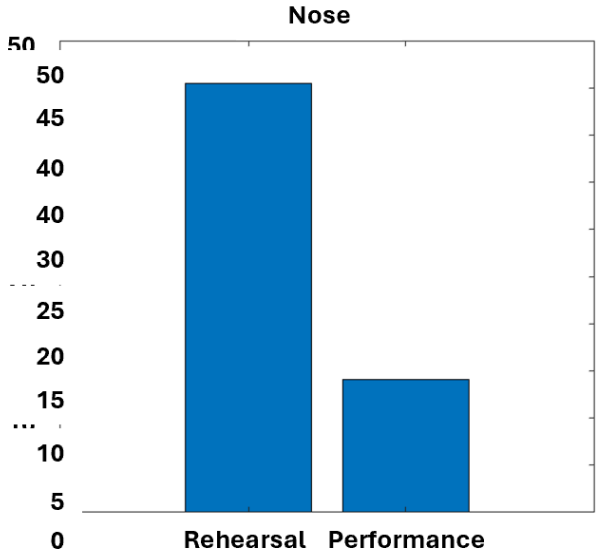


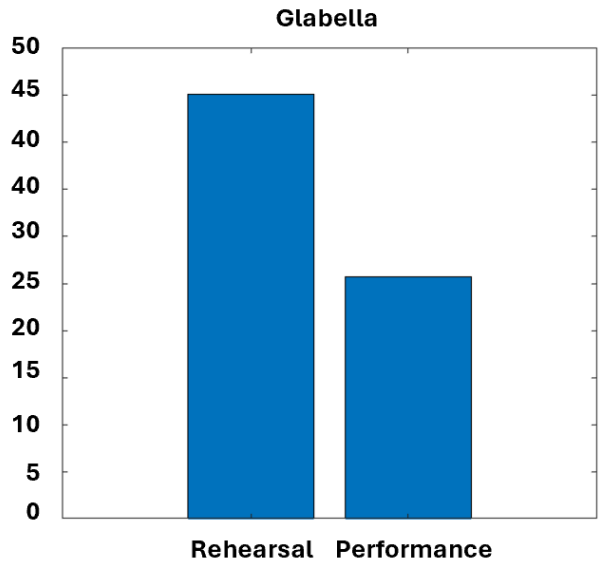
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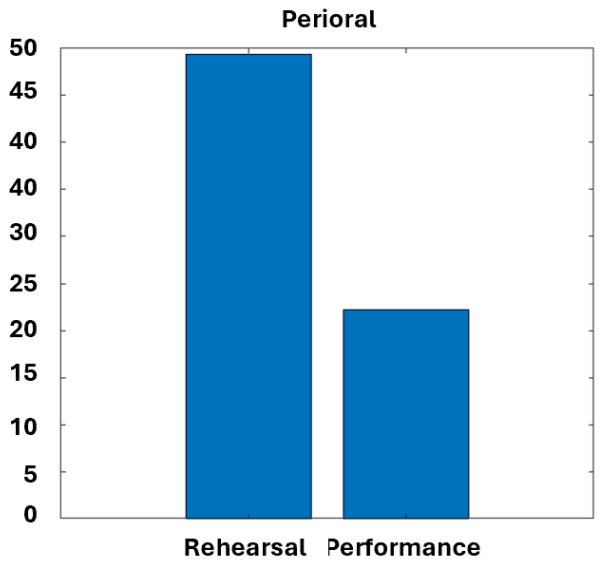
Kurtosis

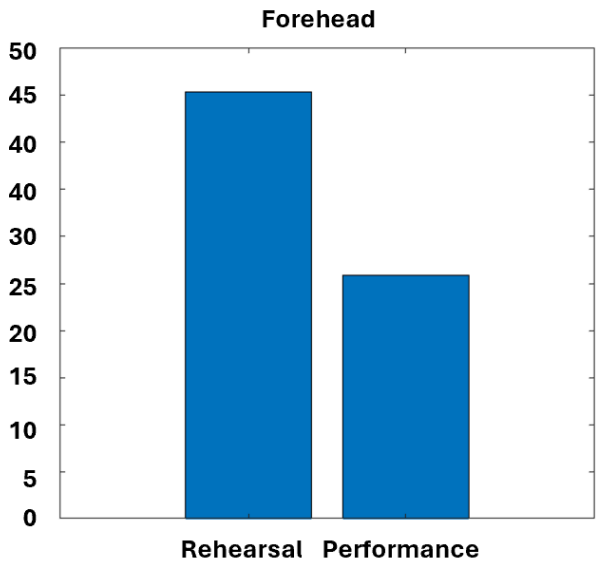




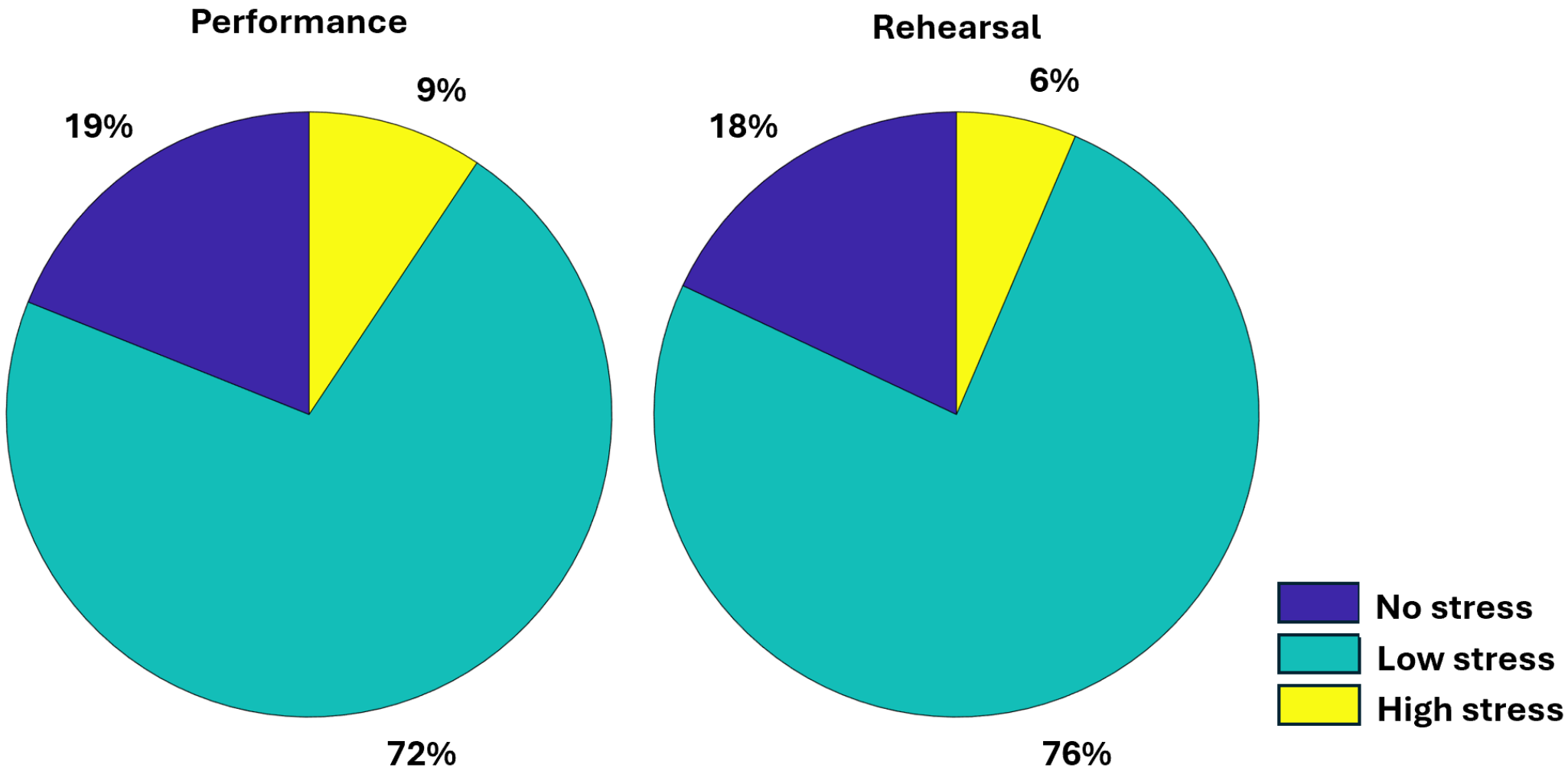






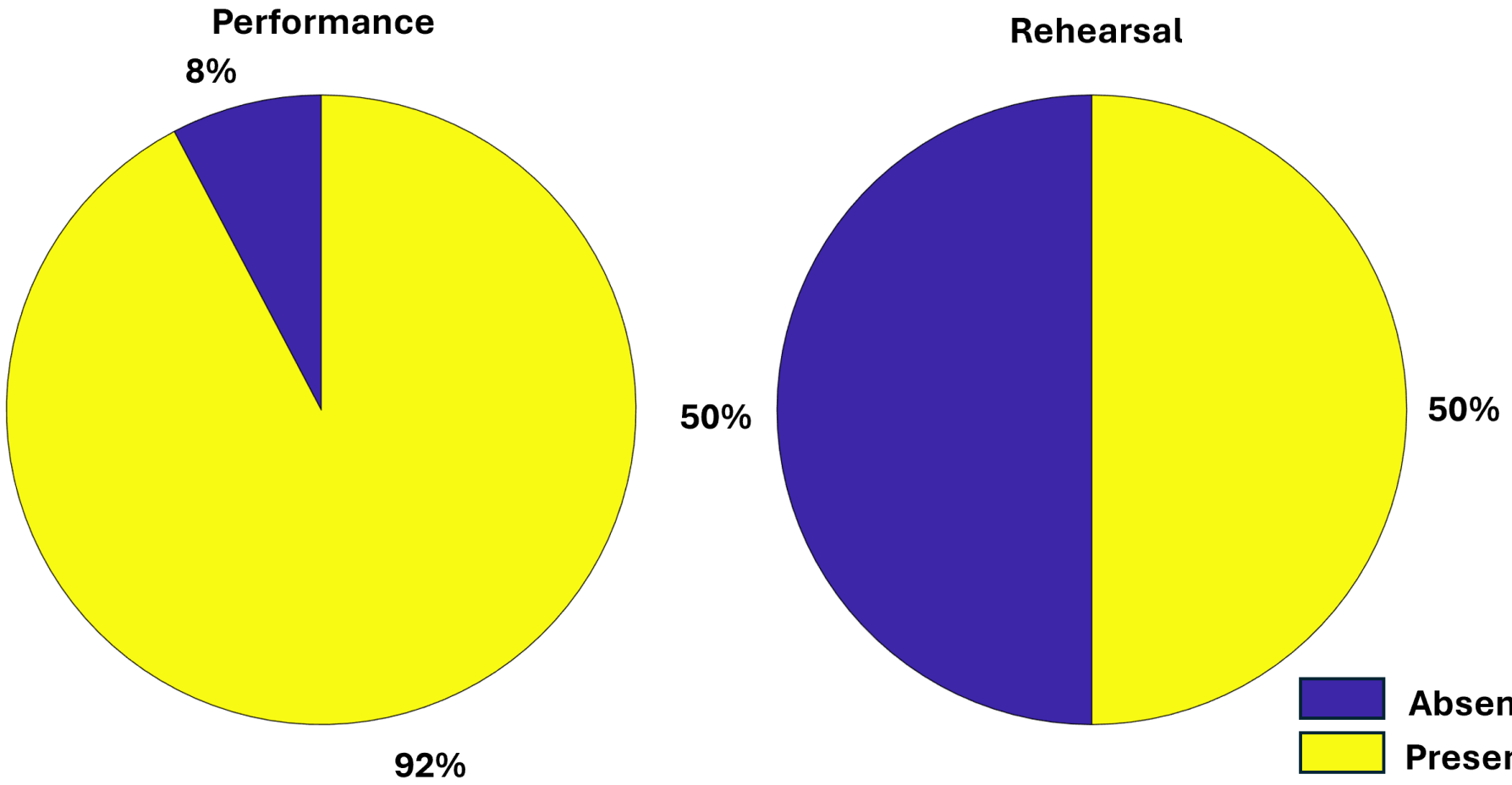


Results


Performance
9%
19%
72%
Rehearsal
6%
18%
76%
No stress
Low stress
High stress

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Results

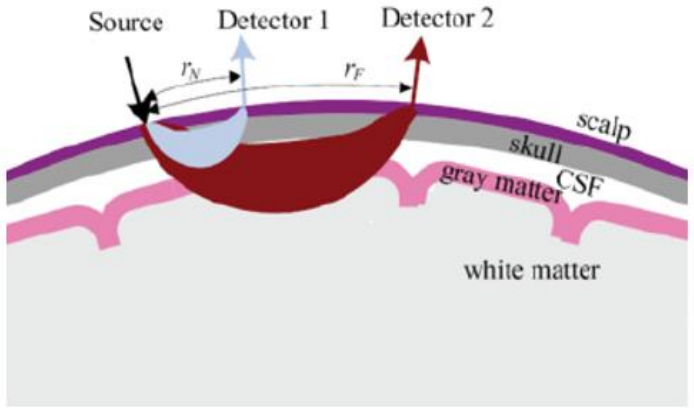


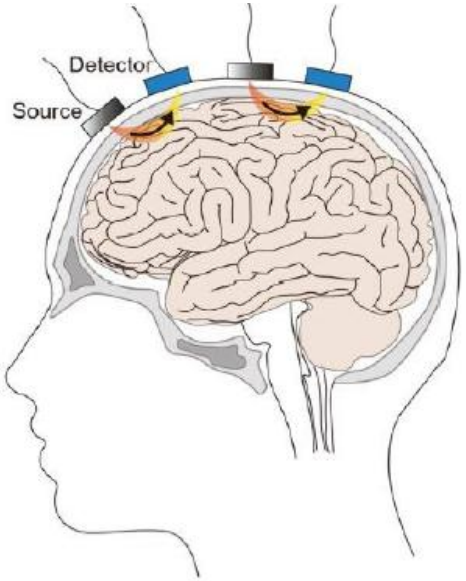
Discussions

- Infrared thermography was able to identify differences in autonomic nervous system activation between the two conditions.
- Artificial intelligence models consistently detected the presence of stress and autonomic nervous system activity in accordance with the initial hypotheses.
- Further data acquisition involving additional musicians is required, and the integration of cardiac activity measures should be implemented.



Functional Near Infrared Spectroscopy (fNIRS)







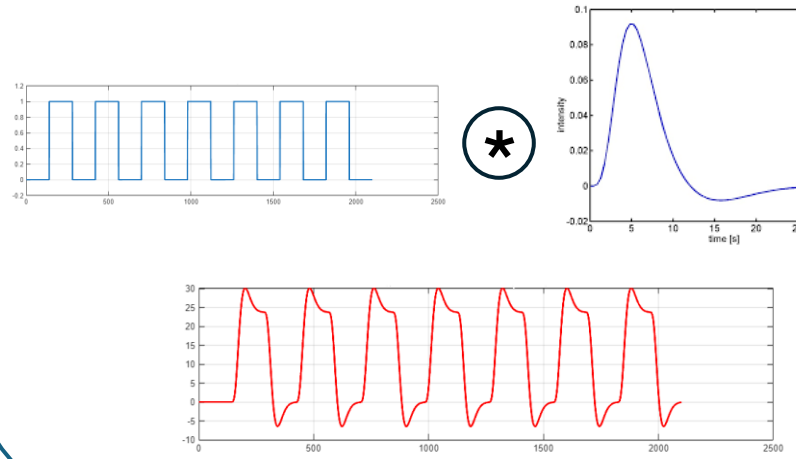
Scholkmann, Felix, et al. "A review on continuous wave functional near-infrared spectroscopy and imaging instrumentation and methodology." Neuroimage 85 (2014): 6-27.

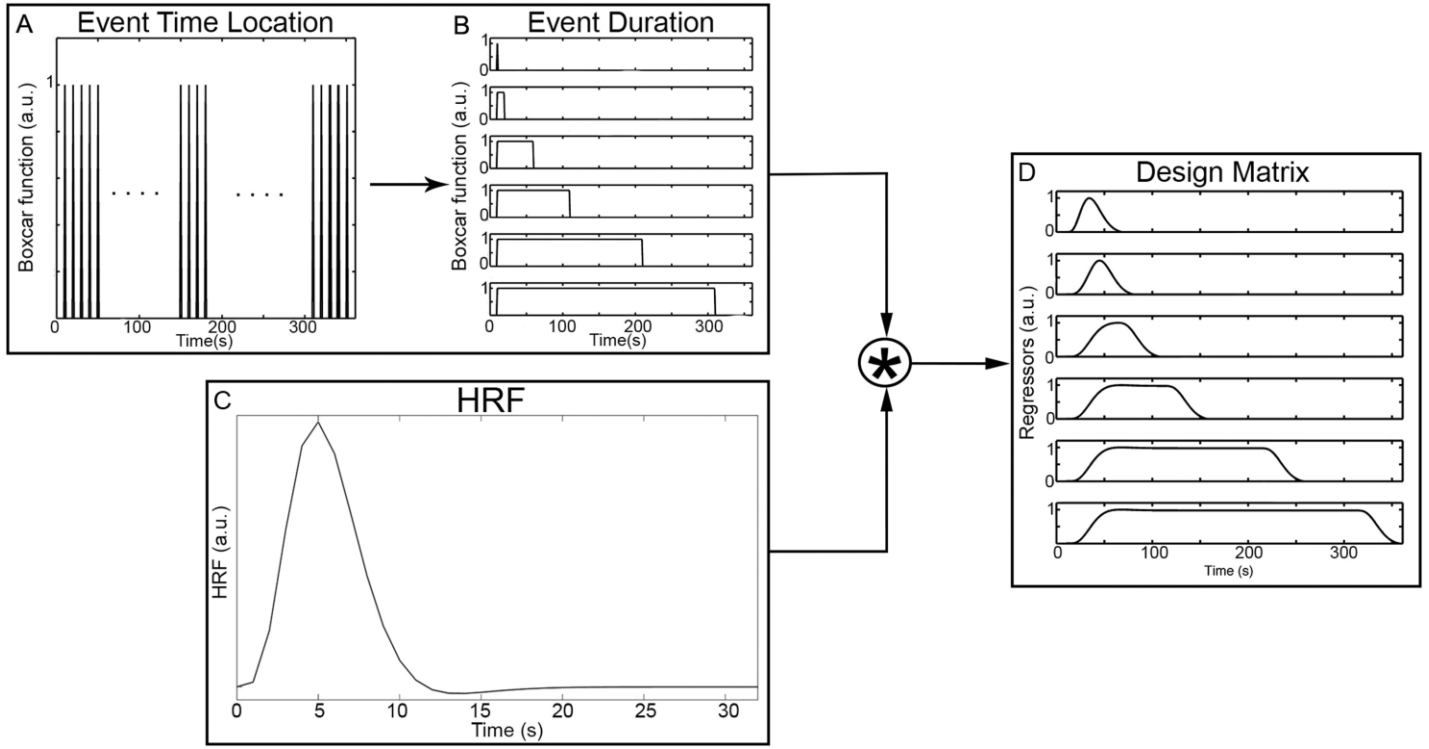
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General Linear Model (GLM) for brain activation detection

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} 1 & x_1 \\ 1 & x_2 \\ \vdots & \vdots \\ 1 & x_n \end{bmatrix} \begin{bmatrix} \beta_0 \\ \beta_1 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{bmatrix}$$

$$Y = X\beta + \varepsilon$$





Pinti, Paola, et al. "A novel GLM-based method for the Automatic IDentification of functional Events (AIDE) in fNIRS data recorded in naturalistic environments." Neuroimage 155 (2017): 291-304.

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Materials And Methods

Two musicians (2 males, aged 18 and 21 years; a saxophonist and a clarinetist, respectively) were enrolled in the study, and their brain activity was recorded during the live performance of a musical piece. Brain activity was measured using the Cortivision Photon Cap device, configured with a 38-channel montage targeting the prefrontal, frontal, and motor cortical areas, according to the international 10–20 system.







Figure 1. Participants of the study

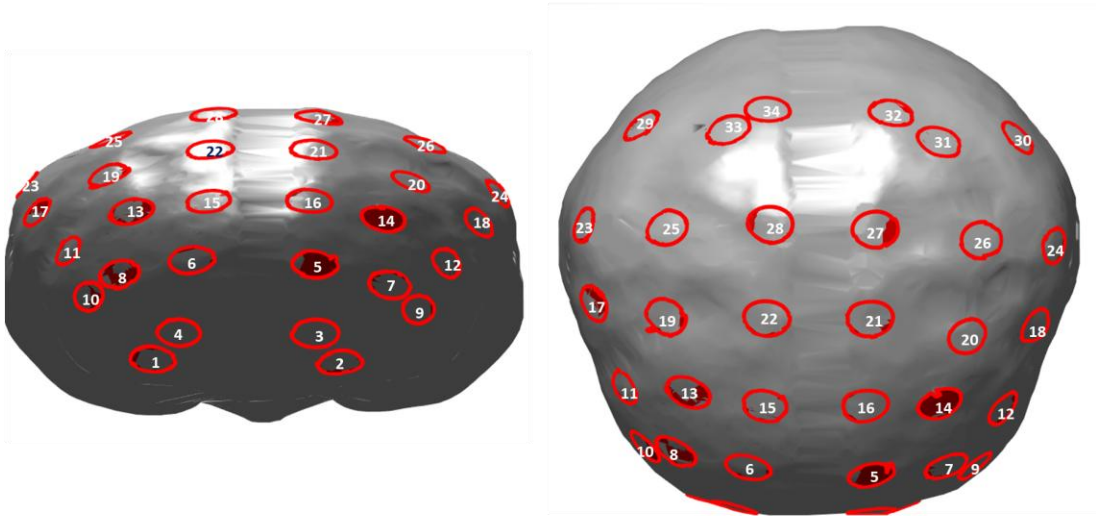
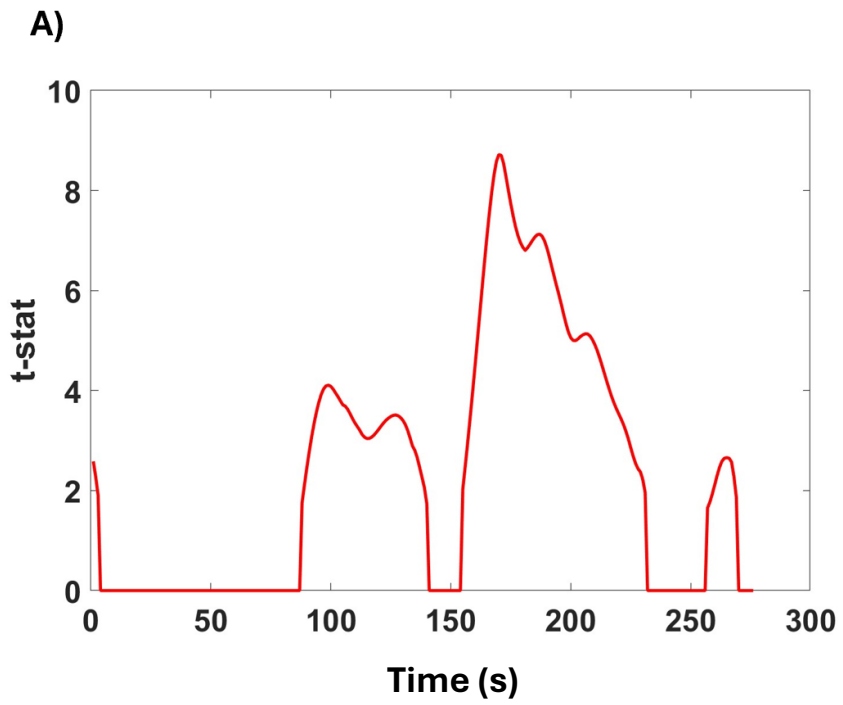


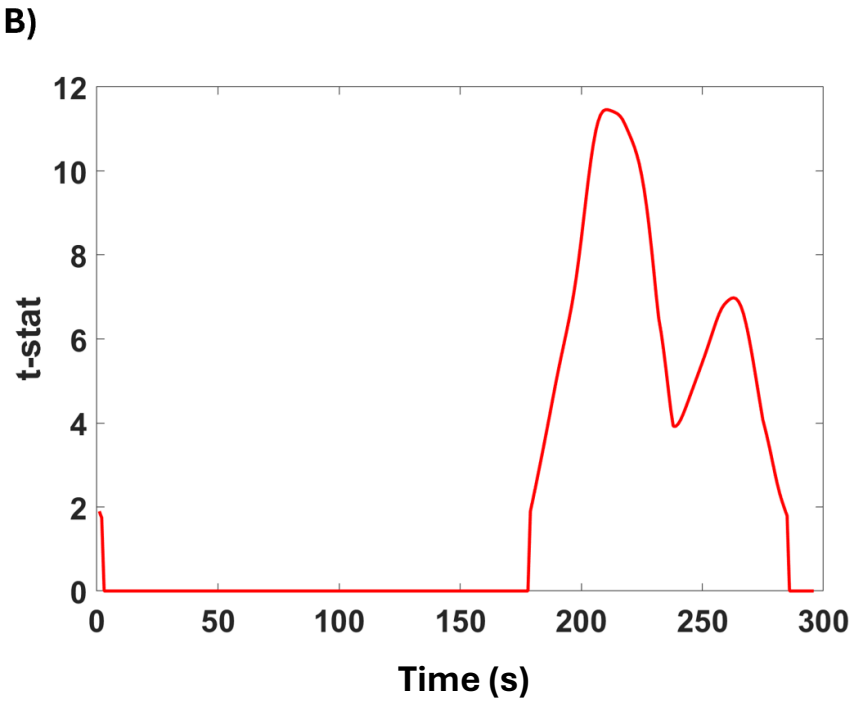
Figure 2. Channels' montage

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Results

For the saxophonist, an increase in activity was observed in the prefrontal region, with the mean t-statistic rising from 1.715 to 8.483 (Figure A). The clarinetist exhibited a comparable pattern in the prefrontal cortex, with the mean value increasing from 2.158 to 11.149 (Figure B).



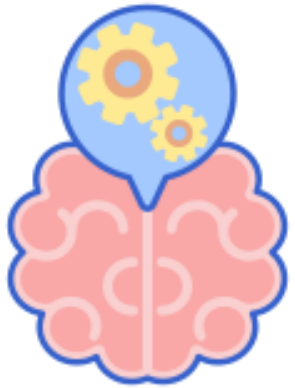


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Discussions and Conclusions

- This preliminary investigation contributes to the growing field of neuroimaging applied to musical performance, demonstrating the feasibility of using fNIRS to monitor musicians' cortical activity during live performances.

- From an applied perspective, the findings suggest that providing feedback on cortical activation could enable the development of targeted strategies for performance anxiety management and cognitive load optimization.





Thank you
for your attention



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