In-presence vs Remote teaching at driving schools: a neuroscientific study

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cieca

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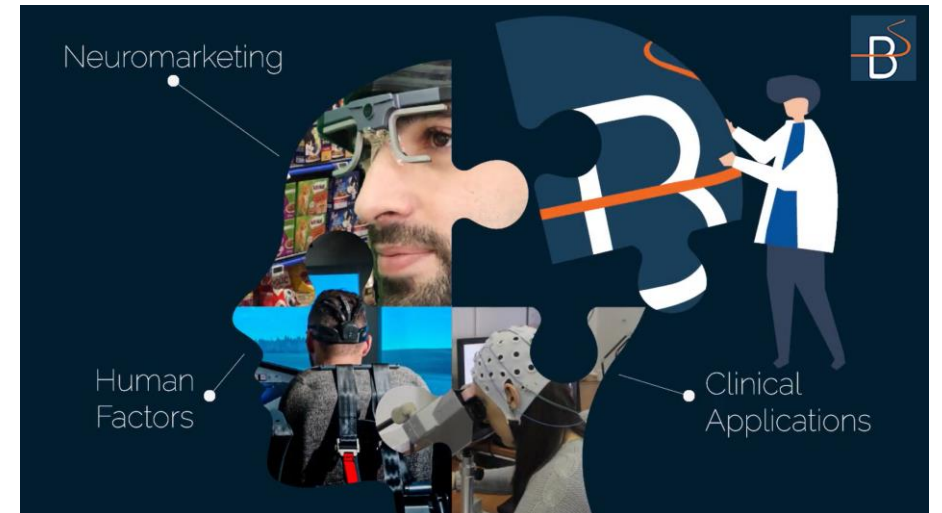
Who we are

Industrial Neuroscience Laboratories
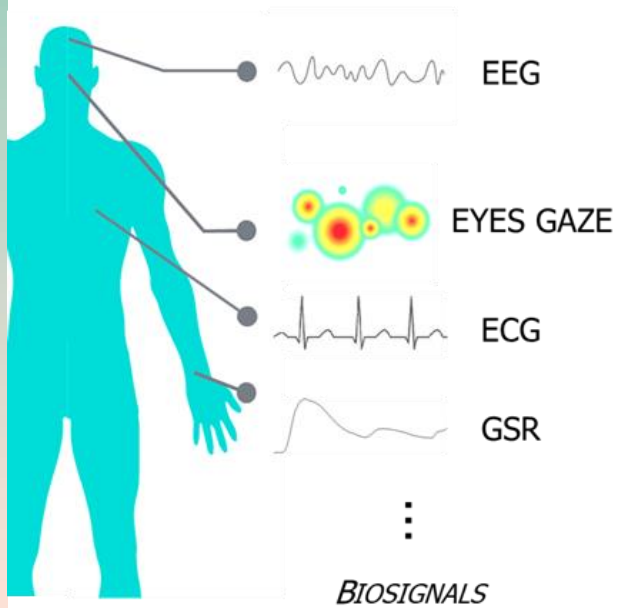Dept. Molecular Medicine
Sapienza University of Rome
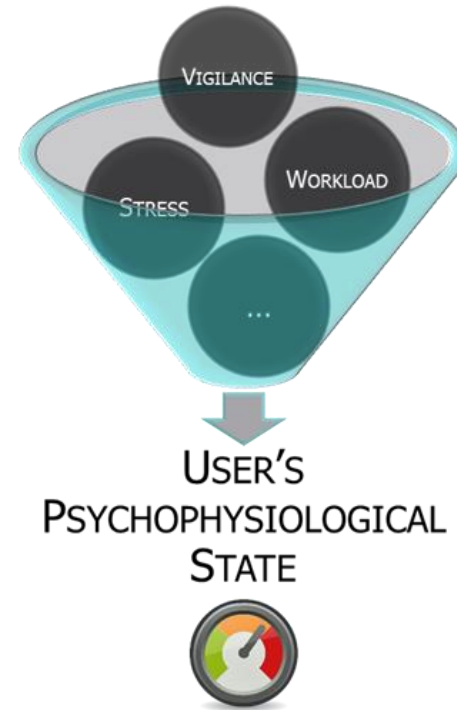
BrainSigns srl
Spin-off company of Ind. Neuro. Labs

The concept

NEUROMETRICS
OF SPECIFIC **MENTAL STATES**

VIGILANCE

WORKLOAD

STRESS

...

BIOSIGNAL
PROCESSING

USER'S
PSYCHOPHYSIOLOGICAL
STATE

EEG

EYES GAZE

ECG

GSR

BIOSIGNALS

CROSS - DOMAIN

**Cognitive Neuroscience
applied to operational environments**

The problem

Contextual circumstances, such as economic crisis and pandemic restrictions, are promoting *remote learning* in different domains.

Also driving education is living such a transformation: online courses are more and more offered for preparing theory exams.

Some topics, e.g. those ones related to road safety, are particularly relevant, therefore "remote" education is viewed with suspicion.

Objectives

Effectiveness of online education in a broader extent is largely debated. There are few, and even disagreeing results, about the comparison between "in-presence" and "remote" modalities.

➢ **To compare "in-presence" vs "remote" teaching in order to point out the difference of the former in terms of students' attention and engagement using cerebral and biometric indexes.**
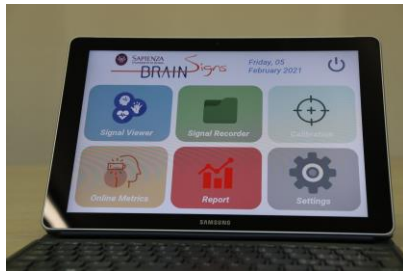
The study - Technology

MUSE-S

Headband for recording brain electrical activity (EEG).

Empatica E4

Wristband for recording heart activity (PPG) and skin sweating (EDA).

BrainSignsReader

System for synchronously recording biosignals from different devices.

The study - Methods

40 participants (students)

- All students for License B
- Age 25.9 ± 11.6 years old
- Gender balanced (17 males and 23 females)

Rome (Italy)

AUTOSCUOLE ROMA S.R.L.

5 experim. days
(06/07 - 27/09 – 28/09 – 11/10 – 12/10)

2 ROOMS

In-presence classroom

Remote classroom

NAPLES 2022
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The study - Methods

SAME TEACHER

SAME LESSON (**Topic:** *crossroads and related signage*)

The 40 participants have been divided into 5 sub-groups of 8 participants.

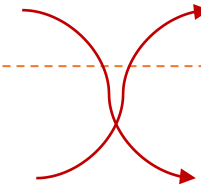|	FIRST HALF (30 min)	SECOND HALF (30 min)
In-presence classroom	Students 1-4	Students 5-8
Remote classroom	Students 5-8	Students 1-4

FINAL QUESTIONNAIRE (10 test questions, 5 for each lesson segment)

The study - Analysis

For each participant:

1. Brain and ocular activity

2. Skin sweating

3. Heart rate

Remote classroom

In-presence classroom

In both the conditions, an initial 1-minute-long baseline has been collected in order to get individual reference parameters.

Results related to 35 participants are presented in the followings (1 participant left the experiment; 4 participants had corrupted data).

Results

Results – Eye Blink Rate

The Eye Blink Rate has been demonstrated to be inversely correlated to attention and vigilance, i.e. increasing EBR is a biomarker of attention decreasing, loss of situation awareness and even drowsiness. Therefore, here below **the «inverse EBR» is showed as direct indicator of attention**.

McIntire, Lindsey K., et al. "Detection of vigilance performance using eye blinks." Applied ergonomics 45.2 (2014): 354-362..

Borghini, Gianluca, et al. "Measuring neurophysiological signals in aircraft pilots and car drivers for the assessment of mental workload, fatigue and drowsiness." Neuroscience & Biobehavioral Reviews 44 (2014): 58-75.
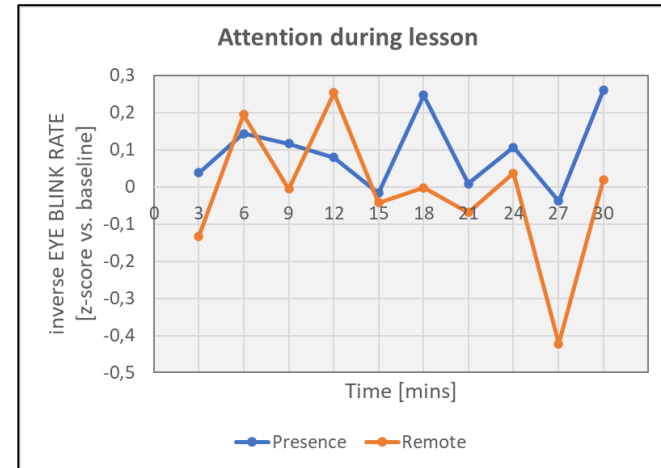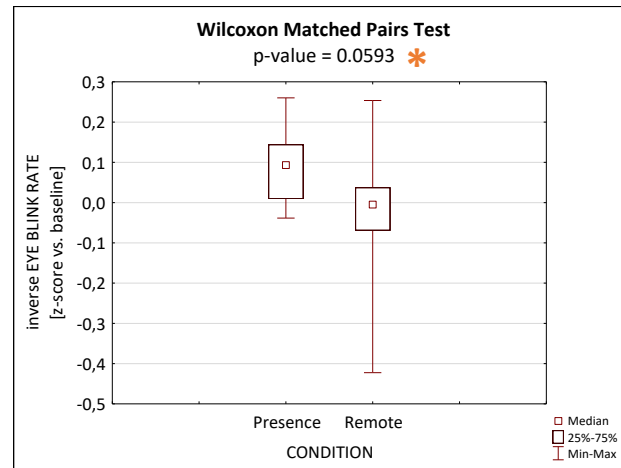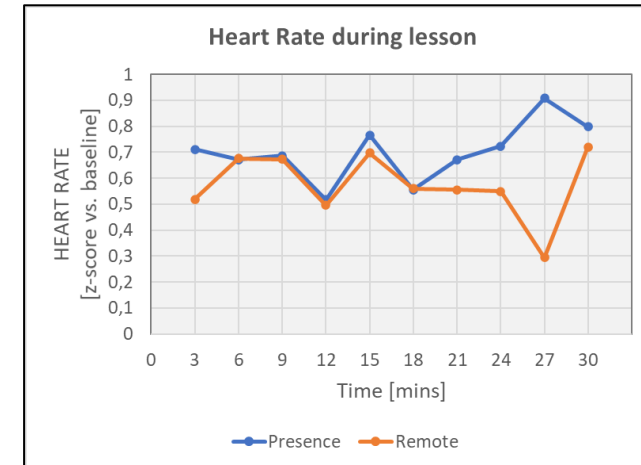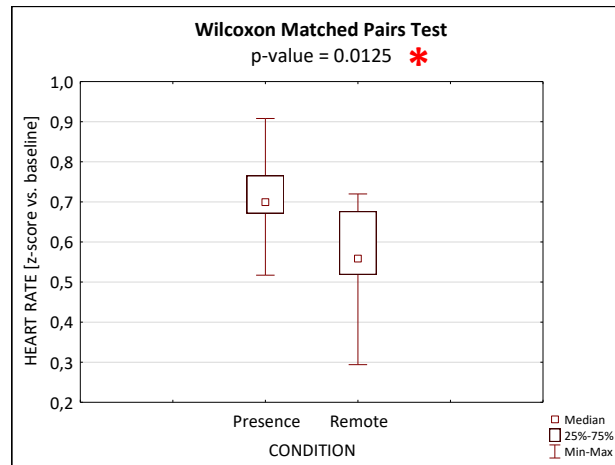

The statistical test on the left showed an almost statistically significant **higher attention during the "in-presence" lesson**. On the right, the dynamics over time showed how **this difference was emphasized during the second part of the lesson**, when students' attention by remote was even lower than baseline (*zero level*).

Results – Heart Rate

The Heart Rate has been demonstrated to be positively correlated to Mental Workload, i.e. **the increasing of this indicator should suggest a higher mental effort**.

Critchley, Hugo D., et al. "Cerebral correlates of autonomic cardiovascular arousal: a functional neuroimaging investigation in humans." The Journal of physiology 523.1 (2000): 259-270.

Hankins, Thomas C., and Glenn F. Wilson. "A comparison of heart rate, eye activity, EEG and subjective measures of pilot mental workload during flight." Aviation, space, and environmental medicine 69.4 (1998): 360-367.
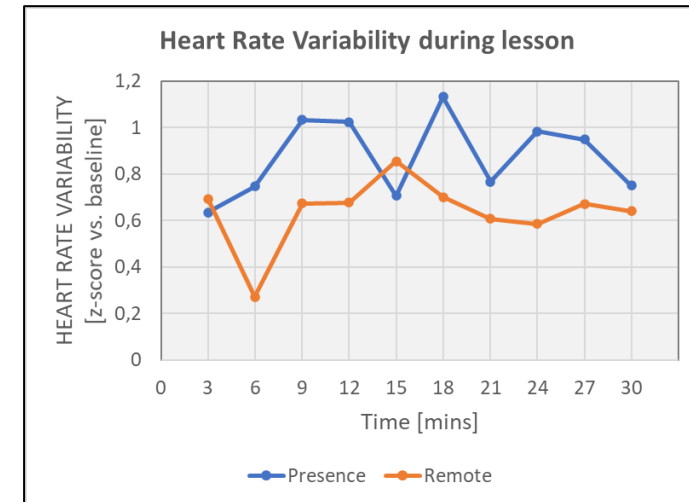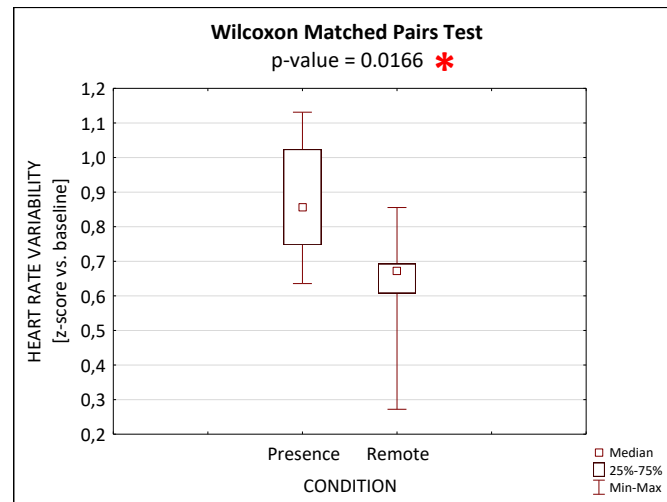

The statistical test on the left showed a statistically significant **faster heart rate during the "in-presence" lesson**. On the right, the dynamics over time showed that in both the cases the indicator was higher than baseline (so **the students were "mentally engaged"**), **but the indicator was always higher during "in-presence"** than "remote" condition, in particular in the second part of the lesson.

Results – Heart Rate Variability

The HRV indicator, computed as LowFrequencies/HighFrequencies, is considered a biomarker of Attention and Mental Effort. This indicator has been demonstrated **to increase when the user is cognitively involved in the task.**

Borghini, Gianluca, et al. "Measuring neurophysiological signals in aircraft pilots and car drivers for the assessment of mental workload, fatigue and drowsiness." Neuroscience & Biobehavioral Reviews 44 (2014): 58-75.
Mukherjee, Shalini, et al. "Sensitivity to mental effort and test–retest reliability of heart rate variability measures in healthy seniors." Clinical Neurophysiology 122.10 (2011): 2059-2066.
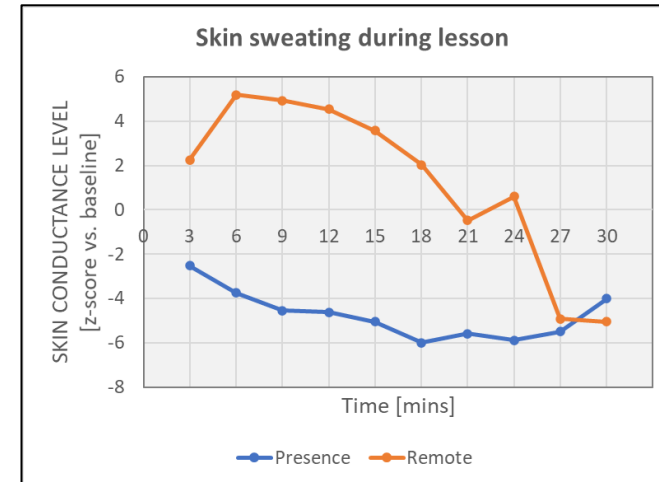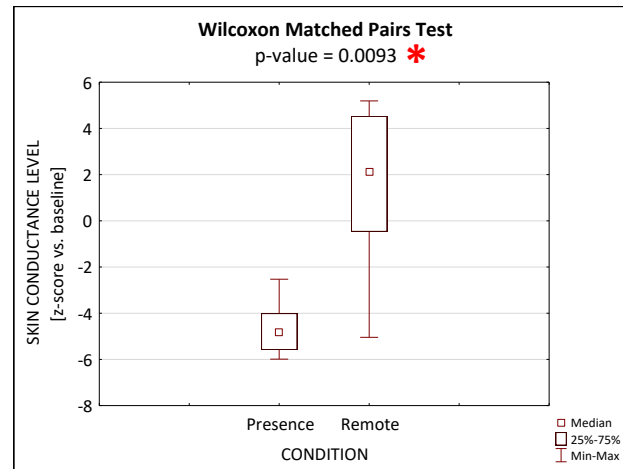

Both the statistical test on the left and the indicator trends over time on the right highlighted, **confirming previous evidences**, than **the students were more cognitively involved during the in-presence lesson**.

Results – Electrodermal activity

The Skin Conductance Level is considered a **biomarker of physiological arousal and even stress**.

Rosebrock, Laina E., et al. "Skin conductance and subjective arousal in anxiety, depression, and comorbidity." Journal of Psychophysiology (2016).

Borghini, Gianluca, et al. "Stress assessment by combining neurophysiological signals and radio communications of air traffic controllers." 2020 42nd IEEE EMBC. IEEE, 2020..


Both the statistical test on the left and the indicator trends over time on the right highlighted a significantly higher "activation" of the students during the remote lesson. This large difference, in particular at the beginning, could be linked to a **certain discomfort, and even stress, experienced because of the less immediate interaction with the teacher by remote**. Interestingly, this effect tend to disappear at the end, when the other indicators suggested a decreasing of attention.
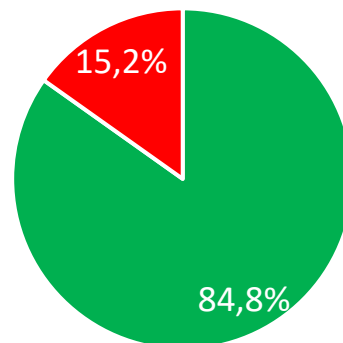
Results - Questionnaires

Each participant at the end had to fill a test of 10 questions, 5 on the first half and 5 on the second half of the lesson (thus balanced between "**presence**" and "**remote**" conditions).
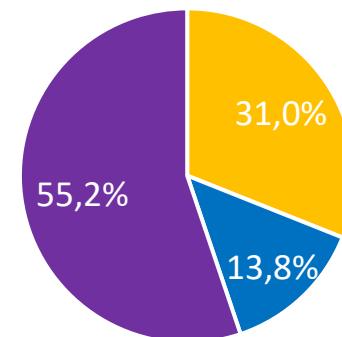
PRESENCE
(% of total answers)
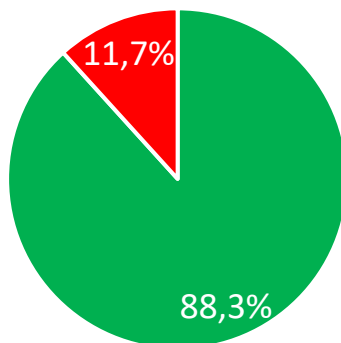
REMOTE
(% of total answers)

TEST PERFORMANCE
(% of students)

11,7%
88,3%

15,2%
84,8%

31,0%
55,2%
13,8%

■ RIGHT ■ WRONG   ■ RIGHT ■ WRONG   ■ Worst by REMOTE ■ Worst by PRESENCE ■ EQUAL

The students provided about **4 % more wrong answers when the questions were related to their remote lesson**. In addition (on the right), not few students but **almost one third of them (the 31 %) did more errors by remote**, i.e. the increased number of wrong answers on topics taught by remote was a frequent recurrence across students.

Discussions & Conclusions

Discussions

Analysis of neurophysiological indicators highlights **a higher «cognitive activity»**, in terms of attention and mental effort, **during the in-presence lesson**.

Analysis of skin sweating seems to suggest a **higher stress**, in particular during the first part of the lesson, **in students by remote**. This could be due to the less smoothness in interacting with the teacher. On the other hand**, "in-presence" lessons seemed to induce more calm among students**.

Analysis of questionnaires demonstrated **worst performance on the questions related to the matters taught by remote**.

Di Flumeri et al., 2022. "Neurophysiological evaluation of students' experience during remote and in-presence lessons. A case study at driving school". In press

Future applications

The use of physiological indicators help to obtain **insights about possible mental causes**, that are often **«blind» to an external supervisor**, such as attentional decreasing and stress increasing, as well as their dynamics **during the lesson itself**, as well as in **other applications such as practical driving lessons**.
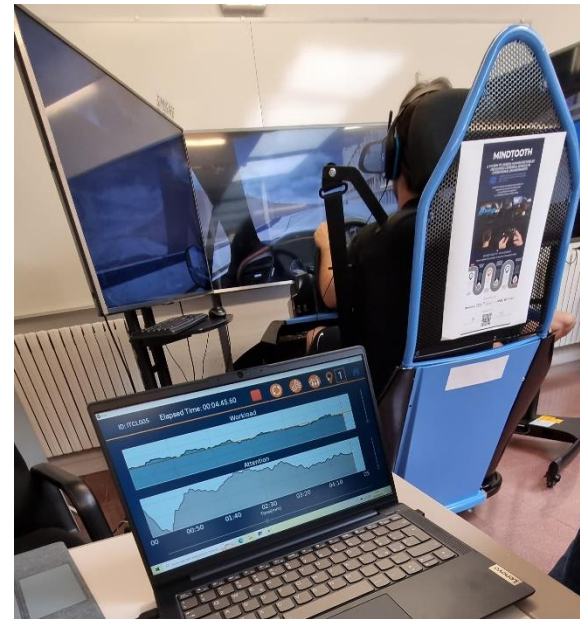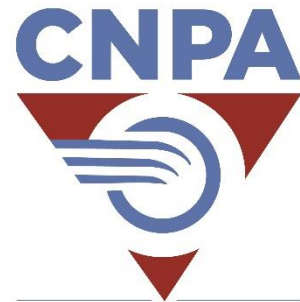
Future applications

Acknowledgments

Thank you for your attention!

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