Real-time neurophysiological measure of individual and team operators' cognitive performance for defence applications

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What are the human factors (HF) ?

Why it is so important to measure HF

- Over **1.2 million people die each year on the world's roads**, with millions more sustaining serious injuries and living with long-term adverse health consequences. **Human error is the main cause** of the 57 % of road accidents and a contributing factor in over 90 % of them.

- More than **70% of aviation accidents are due to human errors**, most of them caused by pilots' overload or mental status impairment.

- **Medical errors cause high people mortality**, about 100.000 people per year. Furthermore, about the 10 % oh hospitalized patients experienced complications on their treatments due to medical mistakes.

The Human Factor is
the most important but the less controllable factor
in operational environments.

(Boeing Report, 2011)
(Feyer and Williamson, 2011)
(WHO Report, 2015)

Teamwork assessemnt: state-of-the-art

Conventional methods to gather information about individual's psychophysical and operational status, and evaluate teamwork are typically based on **expert supervision** (e.g. briefing and de-briefing), **self-reports**, or **performance statistics**.

These measurements are highly **operator-dependen**t (who may be prone to personal experience, cognitive, and emotional biases), require to **interrupt the execution of tasks** (i.e. invasiveness and low temporal resolution), and **do not include information** related to team members' cognitive demand and emotional profile (i.e. paucity of user's insights).

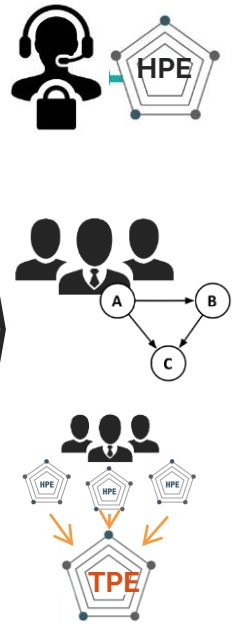
It is therefore clear how these measurements alone cannot be used to accurately and properly assess the members of a team and consequently their teamwork.

The idea

✗ **LACK OF OBJECTIVES TOOLS FOR ASSESSING OPERATORS' PERFORMANCE**, BOTH AT INDIVIDUAL AND TEAM LEVEL.

✗ **DIFFERENT NEUROPHYSIOLOGICAL MEASURES OF SINGLE HUMAN FACTORS**, WITHOUT PROVIDING A SYNTHETIC MEASURE OF PERFORMANCE.

✗ **LACK OF FUNDAMENTAL RESEARCH** ON MENTAL STATES IN OPERATIONAL ENVIRONMENTS, **ONLY FEW SINGLE BIOSIGNALS CONSIDERED**.

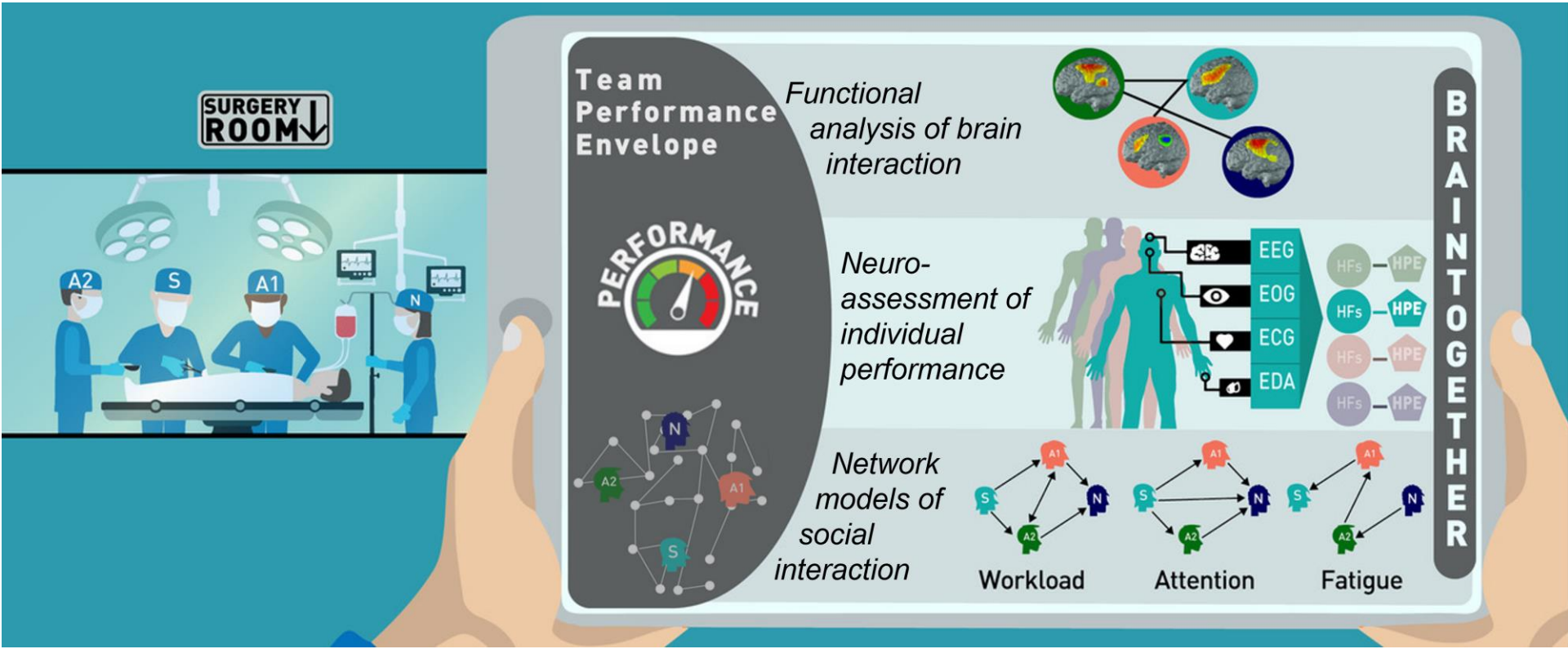


✓ **MULTIMODAL NEUROPHYSIOLOGICAL CHARACTERIZATION** OF RELEVANT HUMAN FACTORS (WORKLOAD, STRESS, ATTENTION, SITUATION AWARENESS, FATIGUE) FOR OBJECTIVE AND COMPREHENSIVE EVALUATION OF **HPE**.

✓ MODELLING THE TEAMS THROUGH **GRAPH THEORY**, BY TAKING INTO CONSIDERATION **SOCIAL INTERACTION VARIABLES** (HIERARCHY, HOMOGENEITY, TYPE OF COLLABORATION, ETC).

✓ **HYPERSCANNING OVER HF NEUROMETRICS** OF ALL THE TEAM MEMBERS TO OBTAIN A SYNTHETIC AND OBJECTIVE ASSESSMENT OF **TEAMWORK**

The measuring of team cooperation



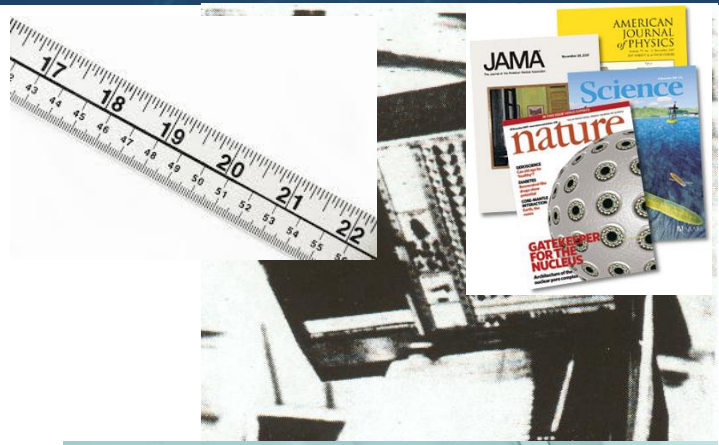
The Rationale

SCIENTIFIC RESEARCH

NEUROMETRICS

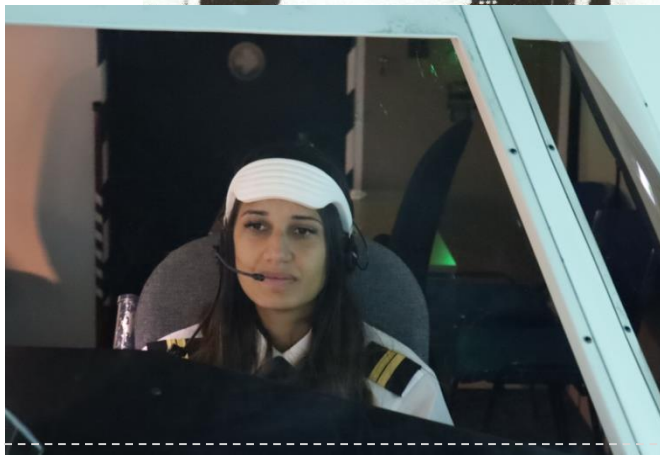
Indexes based on neurophysiological signals

How to do that in real environments:



1) To realize portable and easy-to-use cerebral measurements devices to be used during training without interfere with normal practices

2) To measure efficiently and in a scientific way the main neuro-metrics associated with relevant mental states (e.g. stress, mental workload, etc).



Science and technologies have been developed with different aeronautic partners along a decade

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Experimental Protocol description

Operational Scenarios

In a B-737NG Simulator the EXP and the UNEXP pilots have carried out three operational scenarios, each designed to induce respectively:

Workload | **Cooperation** | **Stress**

6 Unexperienced crews [UNEXP]:

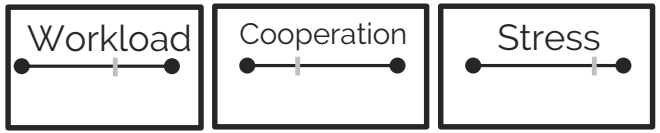
Integrated ATPL with Multi Crew Cooperation course

5 Experienced crews [EXP]:

IntegratCaptains and First Officers with extensive airline experience. Type rated on B737 (same as the simulator)

1) Subjective VAS (by Pilots/ Trainer)

POST scenario



DURING each scenario (for workload and cooperation)

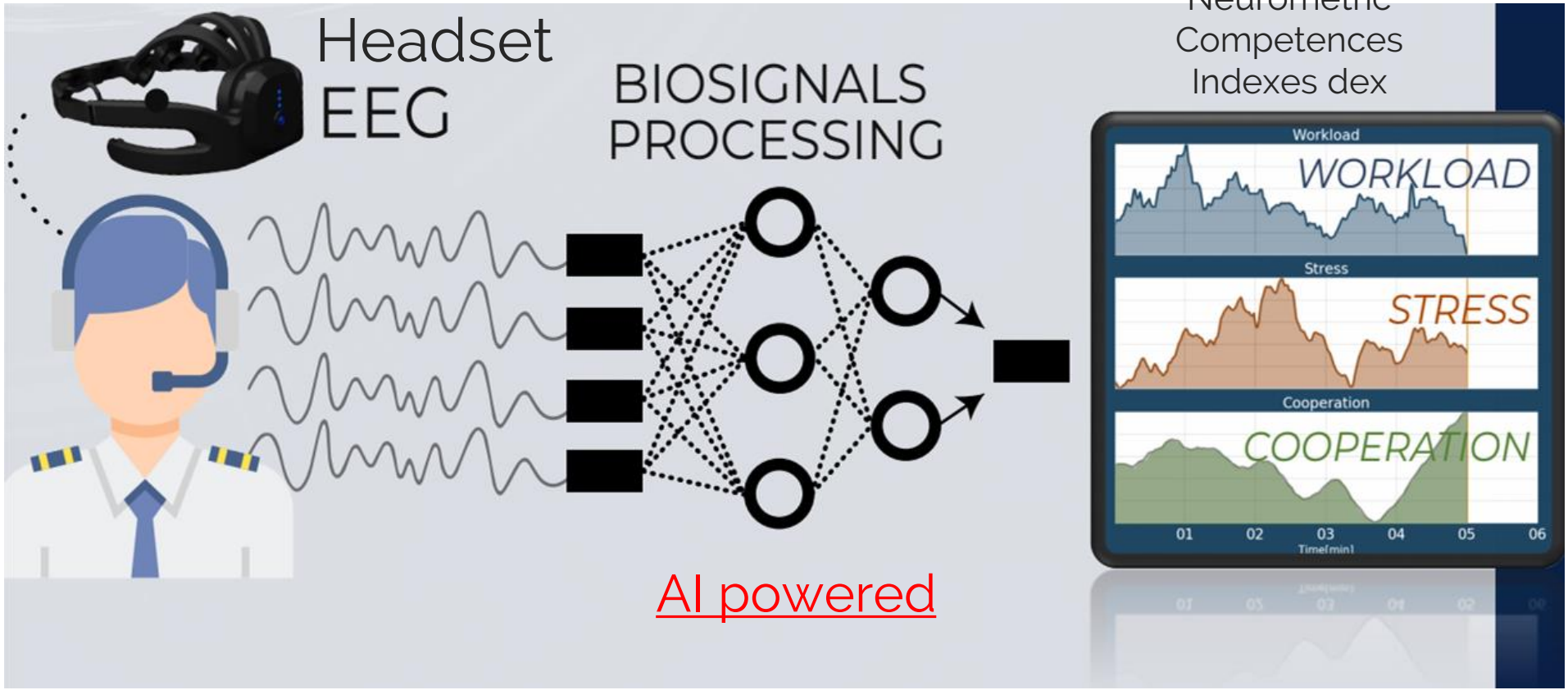
2) Behavioural (assessed by Trainer)

DURING each scenario

3) Pilots' Mindtooth Neurometrics

CONFIDENTIAL

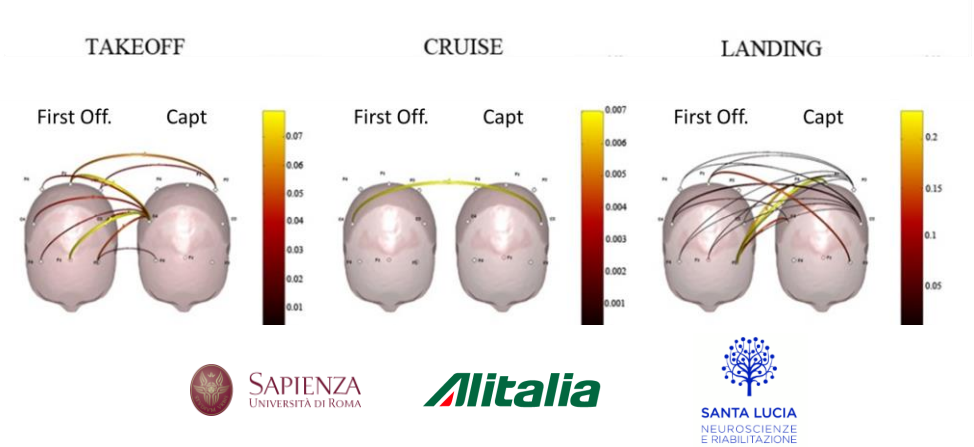
Setup



Pilots' CRM estimation

STRESS
Human Performance neurometrics toolbox for highly automated systems design

Crew Resources Management Assessment

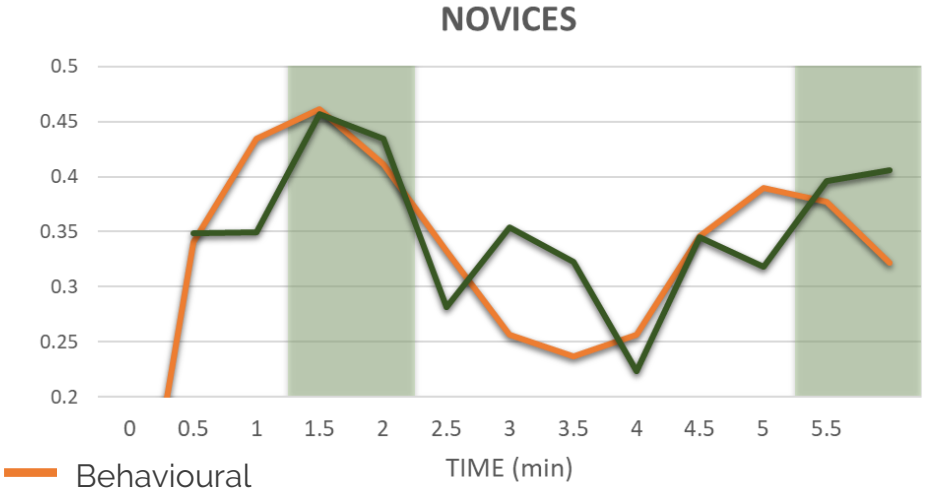


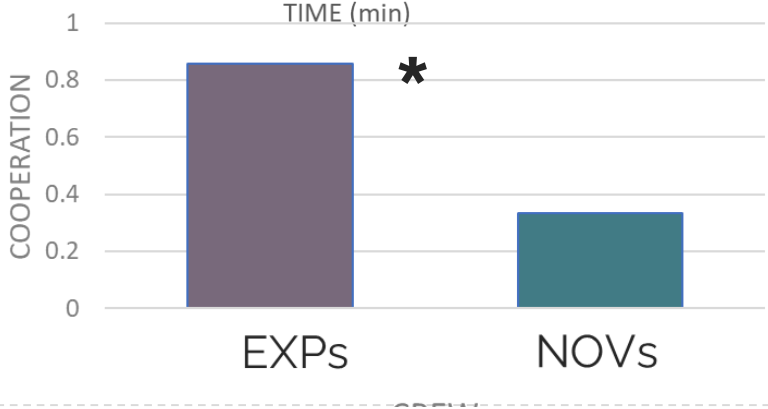
For the purpose of optimizing the Crew Resource Management (CRM), the interaction has been investigated by simultaneous recordings of brain signals during flight simulations and real jumps.

(Toppi, Borghini et al, 2016 – PlosONE)

Real –time pilots cooperation assessment

Cooperation index estimated during pilot's training

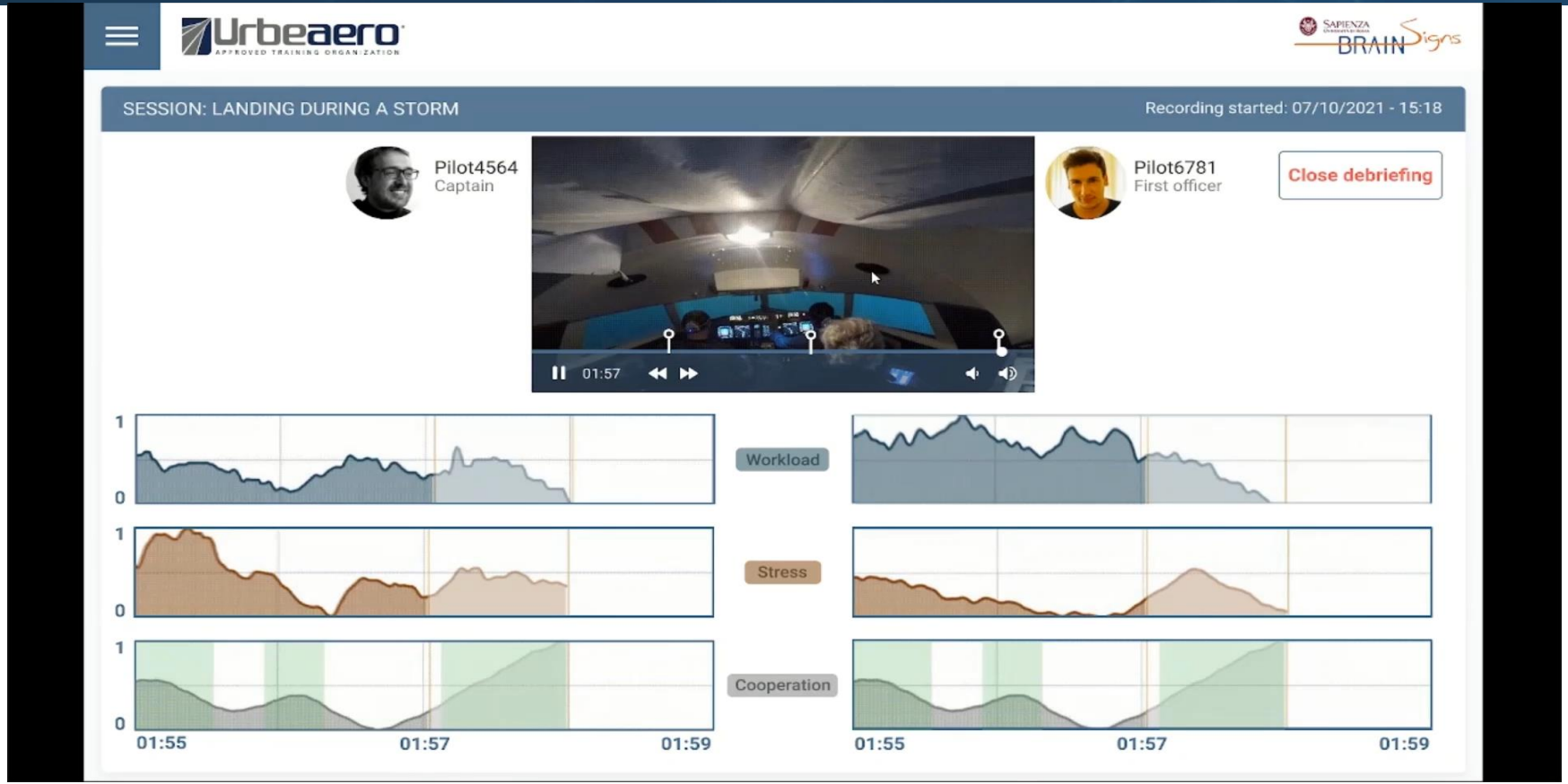




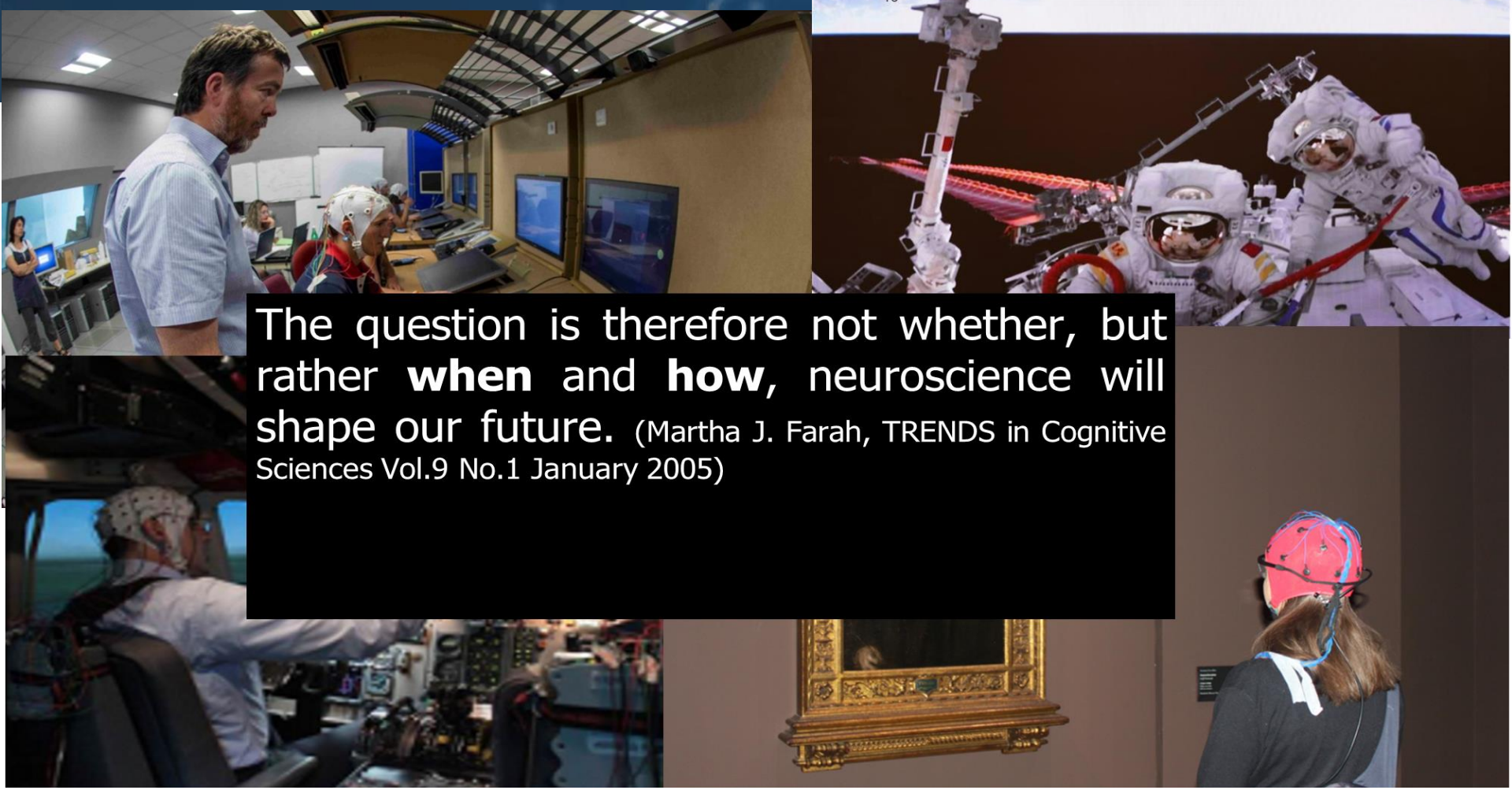
Behavioural
Neurometric
Neurometric class

- ✓ The Cooperation index is correlated with the behavioural score assessed by the trainers (Average among pilots).
- ✓ Moreover The cooperation of Expert Pilots was higher than that one of Novices.

Cooperation estimation during a simulated emergency



Ongoing activity: teamwork on 4 members



The question is therefore not whether, but rather **when** and **how**, neuroscience will shape our future. (Martha J. Farah, TRENDS in Cognitive Sciences Vol.9 No.1 January 2005)

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