HoliDes

HOLISTIC HUMAN FACTORS AND SYSTEM DESIGN OF ADAPTIVE COOPERATIVE HUMAN-MACHINE SYSTEMS

Empirical analysis of cognitive workload effects

ARTEMIS

Introduction

Empirical analysis of cognitive and communication processes is a procedure aimed at answering particular research questions. It is based on a rigorous methodology going from hypothesis to observations or data, passing through different steps.

1. The first step is the definition of the topic of interest and the main research question. The research hypothesis needs to be declined into variables, events or dimensions of a particular behavior that will be matter of observation or measurement.
2. Given a research hypothesis, the next fundamental step is the selection of the paradigm, a task specifically defined to induce a certain human behavior that will be observed or measured. Tasks need to be controlled in term of conditions (for example the introduction of different levels of complexity of the same task), order and time of presentation to prevent fatigue effects in participants.
3. Another critical aspect concerns the choice of the sample of participants that has to be fully representative of the population it is extracted from. In addition, the dimension of the sample has to be adequate respect to the aim of the research: for example in case of statistical inferences on data the number of participants have to be higher than 20 in order to obtain statistically significant information.

Empirical analysis in HoliDes has been leveraged in different studies. We herein document the study about the workload effects aimed to support the research about **cognitive workload assessment in the aeronautic domain** [1].

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References

[1] Lopez Lobo, J., Del Ser, J., De Simone, F., Presta, R., Collina, S., Moravek, Z. (2016). Cognitive Workload Classification using Eye-tracking and EEG Data. HCI-Aero '16, September 14-16, 2016, Paris, France © 2016 ACM. ISBN 978-1-4503-4406-7/16/09…$15.00DOI: http://dx.doi.org/10.1145/2950112.2964585

Empirical Study

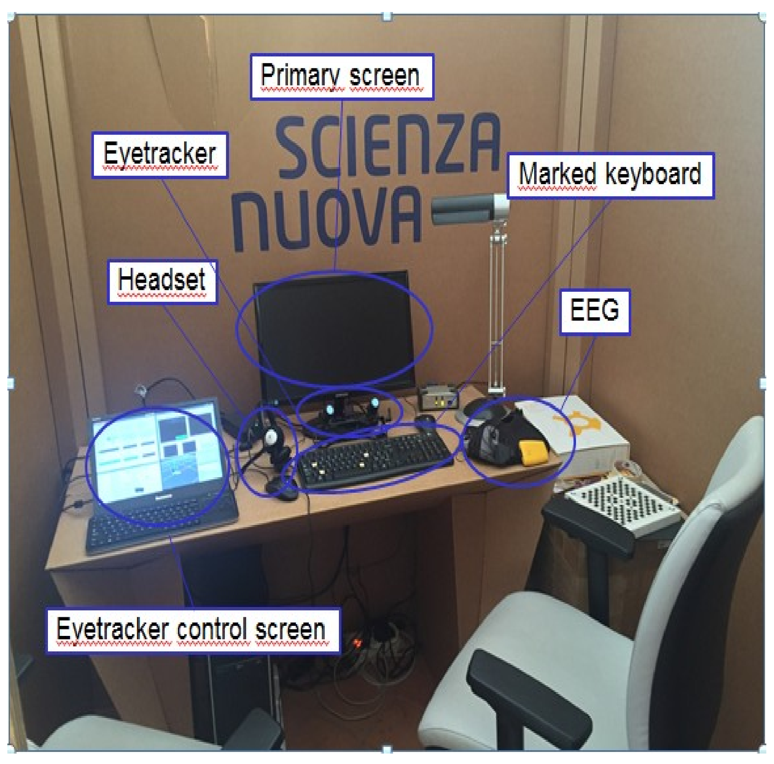
1 - **Objectives**: in the aeronautic context the main aim of the experiment was to answer the question "how does the human behavior change under workload effects?". To answer this question it was fundamental to collect and compare data about the human behavior in a workload condition and in a control condition.

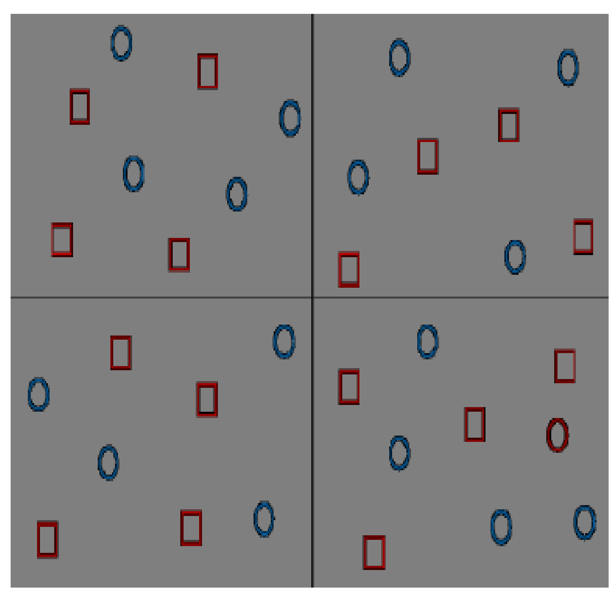
2 – **Paradigm**: The cognitive workload can be defined as a mental condition that can be revealed by the worsening of performance measures in a primary task due to a secondary interfering task. Typically, it has been studied experimentally in Cognitive Psychology by means of the dual task paradigm, where the performances are measured in terms of response times in the execution of both the primary and the secondary task. According to that, we have designed a dual-task paradigm experiment conceived to show the workload effects on directed attention processes, such those that are involved when controlling a cockpit. The primary task was a visual search task while the secondary task was a syntactic transformation. We were interested in observing the workload effects associated with the transformation of different types of sentences. Indeed, we had different classes of transformation:

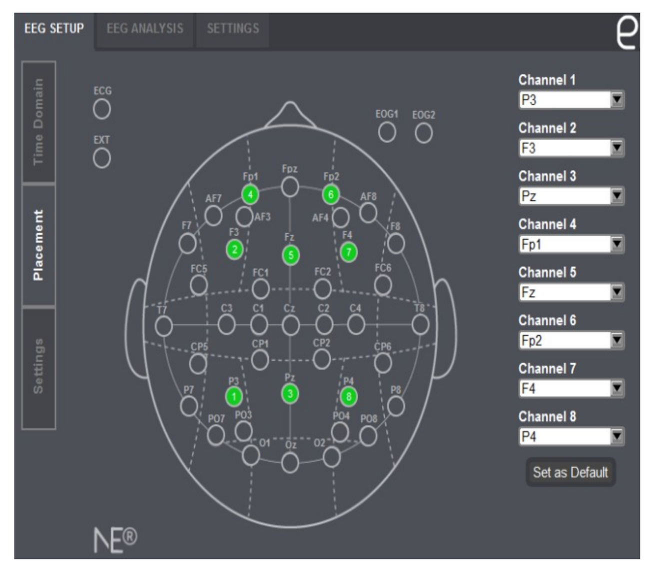
- transformation from passive to active (a)
- transformation from active to passive (b)
- transformation of ambiguous phrases, i.e., phrases that are designed to intentionally raise doubtfulness or uncertainty as regards the syntactic transformation to be performed (c)
- no transformation (i.e., phrases that cannot be transformed, named 'control phrases')

3 – **Equipment**: We have performed this experiment twice: the first time without recording EEG and eye-tracking data and the second time recording them in a synchronized way thanks to the **RTMaps** tool. This methodology is due to the fact that we want first to prove that we are able to induce different workload effects by controlling the conditions of the experiments. Only then, we have replicated the experiment by adding the EEG and eye-tracking recordings and we exploited the findings of the previous analysis to label the collected data.

4 – **Procedure**: The stimuli were presented on a computer screen. The display were divided into four parts. Participants were asked simply to touch the keyboard button corresponding to the portion of the screen where the target appeared: Q to indicate top left, P for top right, Z for bottom left and M for bottom right. The time between the onset of the stimulus and the touch of the button were collected. Participants have also been asked to transform phrases from active to passive and vice versa. Phrases were presented in a headset and participants had to speak aloud in a microphone. This equipment resembled that used by a pilot to talk with the control tower.







Conclusion. We identified significantly different effects in the different conditions: (a) <-> low workload, (b) <-> medium workload, (c) <-> high workload. We replicated the experiment with psycho-physiological data to prepare a labeled dataset exploitable for the benchmarking of supervised workload classification approaches.

FEATURE	DESCRIPTION
alpha_1, …, alpha_8	Alpha power (micro volts squared) from channel 1 to channel 8 of the EEG device
theta_1, …, theta_8	Theta power (micro volts squared) from channel 1 to channel 8 of the EEG device
r_eye_clos	Right eye closure (percentage)
l_eye_clos	Left eye closure (percentage)
r_pup_dmt	Right pupil diameter (millimeters)
l_pup_dmt	Left pupil diameter (millimeters)
corr	Correctness (boolean value equal to 1 when both primary and secondary tasks are performed correctly)

Consortium

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