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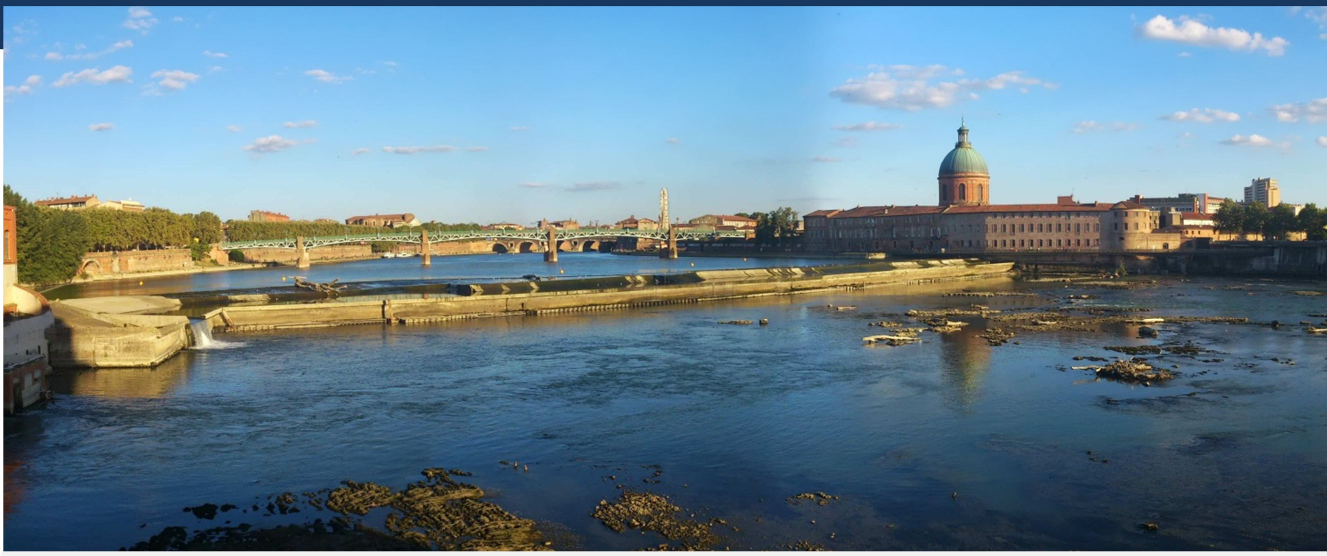

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Unobtrusive EEG measures of an oddball paradigm in flight simulator and real flight conditions: A case study.

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Content

Piloting aircraft is a demanding task in a dynamic, uncertain environment 1. Attention distribution is a key issue for piloting, relying on a tradeoff between focused and divided attention (i.e., avoiding distraction or detecting changes). Their homeostasis may be dismissed when demand exceeds mental capacity, canceling out the processing of incoming stimuli (e.g. auditory alarms). For instance, accidents analyses disclosed evidences of inattentional deafness in which pilots failed to respond to critical auditory warnings. Experiments in flight simulators [2] and real-flight conditions [3] demonstrated the possibility of implementing an electro-encephalography (EEG)-based brain-computer interface to detect and predict the likelihood of this phenomenon. Yet, these experiments used bulky systems uncomfortable to wear over long periods of time. New portable EEG systems offer a promising avenue for implementing neuroadaptive technologies in real world settings [3]. To benchmark these systems under ecological settings, we conducted a study in simulated and real flight conditions while recording the participant's brain activity with the cEEGrid system (TMSi, Oldenzaal, Netherlands [4]).

As this study is on-going we will present case study data from one participant (male, 45 y.o., 110 flight hours). The experiment was divided into two sessions: flight simulation – during which the participant had to perform approaches and landings on Toulouse Blagnac Airport – and real flight – during which the participant had to perform take-off, cruising and landing at Lasbordes airfield (Toulouse, France). For each task, two levels of workload were introduced: a low workload condition – i.e. normal flight conditions with good visibility in the flight simulator, and the role of pilot monitoring for the participant in real flight - and a high workload condition – i.e. flight with very degraded visibility in the flight simulator, and the role of pilot flying in-flight. During all flying situations, the participant was asked to perform an oddball task. For this, standard (388 in flight simulation and 364 in-flight) and target sounds (130 in flight simulation and 122 in-flight) were randomly sent to the participant (inter-stimulus interval of 2 to 4 seconds) who had to pull a trigger when hearing an odd/target sound.
Brain activity was recorded (500Hz) with non-invasive 10-channel cEEGrids (TMSi, Oldenzaal, Netherlands – see fig. 1b) positioned around both ears. Data (including sounds and responses) were streamed into LSL (LabStreaming Layer) to ensure synchronization. Continuous data were preprocessed (windowed-sync FIR>filter for line noise>Artifact Subspace Reconstruction>missing channels interpolation) and epoched time-locked to both sound displays Activities in the time and spectral were computed for the two mental load conditions, for each flying task.

Results show our ability to detect oddball Event-Related Potentials (ERPs - N100 delayed around 180ms and P300 [4,5]) and spectral activity in the flight simulator (fig. 1b) with only one participant. Despite encouraging results, we were unable to detect the same activities in real-flight conditions due to a very noisy environment. Nevertheless, an optimized adaptation of the preprocessing parameters may allow for a better extraction of the specific characteristics of the EEG activity related to oddball paradigms (N100 and P300 ERPs) and workload measures (observable in both the time and spectral domains).

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Figure 1. a) Disposition of one of the two 10-channel cEEGrid systems (left ear) and electrode names for that ear (localizations for the right ear are symmetrical with R1-R4 at the top and R5-R8 at the bottom). b) Mean ERPs (time-locked to the sound display – 0ms) and spectral activity at the L2 electrode across trials for one participant in the four conditions (High Workload –red– and Low Workload –blue– for hits –plain line– and standards –dashed line) in the flight simulator session. c) Mean ERPs

(time-locked to the sound display – 0ms) across trials for one participant in the four conditions (High Workload –red– and Low Workload –blue– for hits –plain line– and standards –dashed line) in real flight.

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