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Abstract

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Assessing focus through ear-EEG: a comparative study between conventional cap EEG and mobile in- and around-the-ear EEG systems

Gabrielle Cretot-Richert
gabrielle.cretot-richert@etsmtl.ca,
Corresponding author

Maarten De Vos
Maarten.DeVos@esat.kuleuven.be

Stefan Debener
stefan.debener@uni-oldenburg.de

Martin Georg Bleichner
martin.georg.bleichner@uni-oldenburg.de

Jérémie Voix
jeremie.voix@etsmtl.ca

While our attention is becoming a commodity that an ever-increasing number of applications are competing for, it might be worthwhile to invest in modern day tools and devices that aim at detecting our mental states to improve our focus and protect it from outside interruptions. Electroencephalography (EEG) may reflect concentration levels and thus, could allow monitoring of these mental states. If EEG equipment became wearable and inconspicuous, innovative brain-computer-interface (BCI) technology could measure mental load in daily life situations and offer helpful feedback. The purpose of this study is to investigate the potential of ear-EEG to determine focus levels using spectral features extracted from EEG signals recorded inside and around the human ear. Mobile ear-EEG data were collected concurrently with a conventional EEG (cap) system. Two tasks were used to elicit different cognitive processes: first, a mental arithmetic task measured cognitive workload for ten participants. Second, an N-back task assessed working memory for fourteen participants. The goal was to differentiate between low and high cognitive demand. Power spectral density (PSD) of the EEG signals were analyzed to find differences across

recording systems. The spatial distribution between levels were compared using the cap EEG data. Classification models with different feature sets were compared and suggest that better results can be achieved with better frequency resolution and a broader EEG range. Recording conditions, cap and ear-EEG were compared for a twelve and for a two-channel model. The two-channel ear-EEG model represented in-ear data specifically. For the arithmetic task, single-trial classification results show that we could differentiate between low and high cognitive workload above chance-level for all participants (10 out of 10), over both recording equipment and for all channel models. The mean accuracy for the twelve-channel models were 96 % (cap-EEG) and 95 % (ear-EEG). For the two-channel models, mean accuracies were 75 % (cap-EEG) and 74 % (in-ear-EEG). For the N-back task, single-trial classification also revealed above chance-level accuracies for all participants (14 out of 14) with mean accuracies for the twelve-channel models of 94 % (cap-EEG) and 92 % (ear-EEG), and 75 % (cap-EEG) and 73 % (in-ear-EEG) for the 2-channel models. These results suggest that ear-EEG can be used to reliably differentiate between levels of cognitive workload and working memory, in particular when multi-channel recordings are available, and could in the near future be integrated into wearable devices.