

# NAFAS Unobtrusive Mobile EEG Electrodes: First Results

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## Abstract

We show that known event-related brain responses can be recovered from a low number of novel, comfortable, flex-printed EEG electrodes placed on hairless areas of the skin.

## Introduction

Project NAFAS [1] aims to apply passive brain-computer interface (BCI) technology to, in one track, improve neuroadaptive human-computer interaction, and, in another track, develop neuroadaptive artificial intelligence. To that end, NAFAS includes research and development into both hard- and software obstacles that have thus far prevented major commercial deployment of neurotechnology. One of the focus points is an easy-to-use, comfortable, unobtrusive, mobile EEG suite, enabling the long-term acquisition of EEG data in real-world, everyday contexts [2].

## Materials And Methods

We compared our prototype electrodes to state-of-the-art electrodes, based on data from a total of 39 participants. 20 participants wore 96 equidistant passive electrodes, plus two EOG channels, recorded using a BrainAmp DC at 1 kHz with a reference at the tip of the nose (high-density recordings). 19 different participants wore our novel electrodes, which consisted of bilateral electrode patches applied to the left and right side of the face (“patch recordings”). The electrode patches are a novel design based on [3]: printed Ag/AgCl electrodes on a carrier of thermoplastic polyurethane, using electrolyte gel as the contact material between electrode and skin. Each patch contained 4 EEG sensors around the ear, 1 under the eye, and 5 on the forehead. On the right patch, the electrode at the preauricular point serves as the ground electrode; for the present study, the patches were recorded reference-free using a Brain Products actiCHamp amplifier at 500 Hz.

The electrode comparison was based on the seven distinct event-related potentials (ERPs) elicited by all tasks included in the ERP CORE [4]. Our main goal was to recover the same or similar neural signatures using the patch recordings that we could also identify from the high-density recordings.

To this end, both recordings were processed using a parallel pipeline. For ICA decomposition: filtering between 1-100 Hz, downsampling to 250 Hz, channel rejection via a collection of automated methods, common average reference (CAR), and independent component analysis (ICA). For plotting ERPs: filtering between 0.1-20 Hz, channel rejection corresponding to the previous ICA pipeline, CAR, rejection of automatically identified artifactual components from the ICA pipeline, and channel interpolation. Note that for the patch recordings, the identification of artifactual ICA components happened manually, and bad channels were rejected without interpolation, as no measured sensor locations were available at the time. We then extracted ERPs following the ERP CORE guidelines with regards to epoch timings, baseline correction, channel selection, and region of interest. For the patch

recordings, we compared the task-wise ERPs with the high-density recording by (1) selecting a channel whose morphology looked closest, and (2) projecting the channel-time data for each participant and task onto a virtual channel using the first principal component analysis (PCA) component, which was calculated based on the grand average ERP difference wave for each task.

We also evaluated the usability and wearability of the novel electrodes using informal interviews with the participants wearing them.

## Results And Conclusion

Fig. 1 (top) shows the results of four task-wise grand-average ERP comparisons for the high-density recordings (HD, left), patch single-channel averages (middle), and patch virtual channel averages (right). This shows that the first prototype of the novel electrodes developed for the NAFAS project allows known ERPs to be recovered using a small number of electrodes placed on hairless areas of the forehead and around the ear. Furthermore, participants found the novel patch electrodes comfortable, in fact reporting being largely unaware of them. Future work will focus on further improvements regarding materials, self-applicability, as well as coverage.

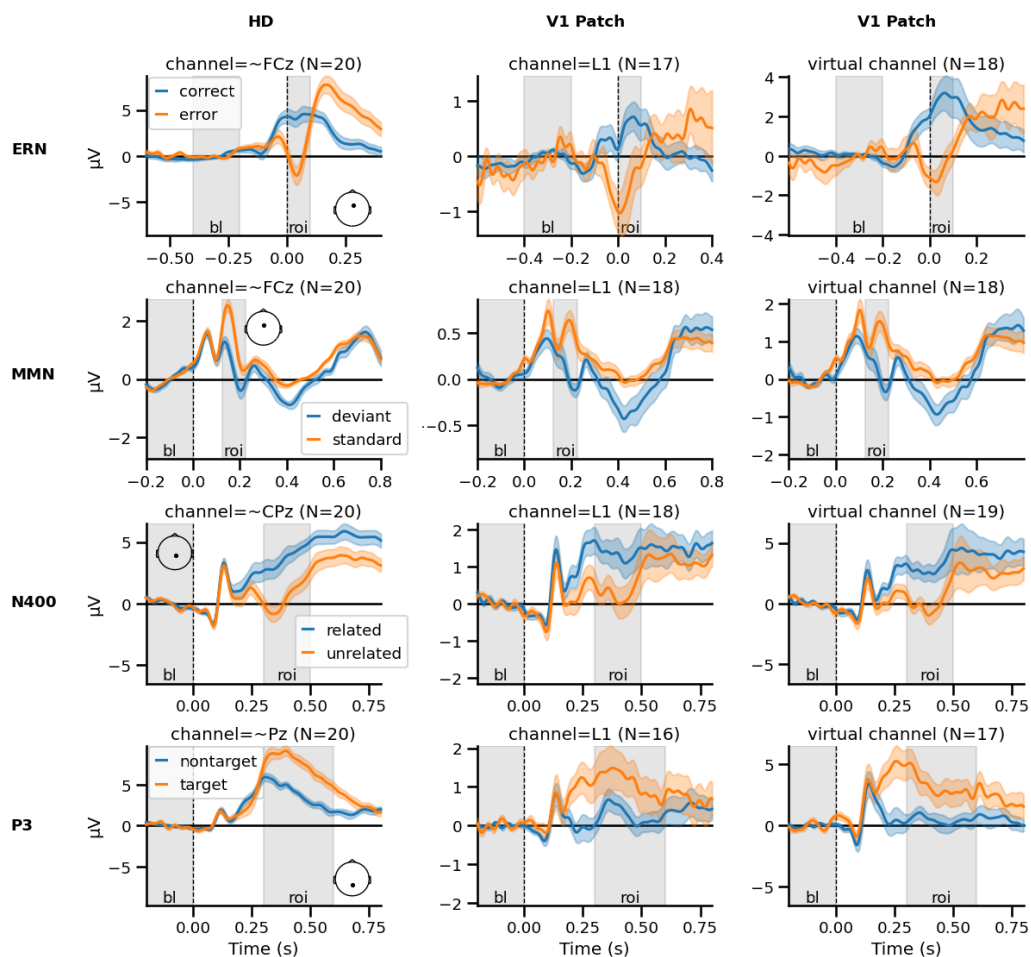


Figure 1, top: Comparison of grand-average ERPs. Left column: Taken from high-density recordings, looking at sites suggested by the ERP CORE. Middle column: Taken from single patch electrodes, consistent across participants. Right column: Linear combination taken from all available patch electrodes.

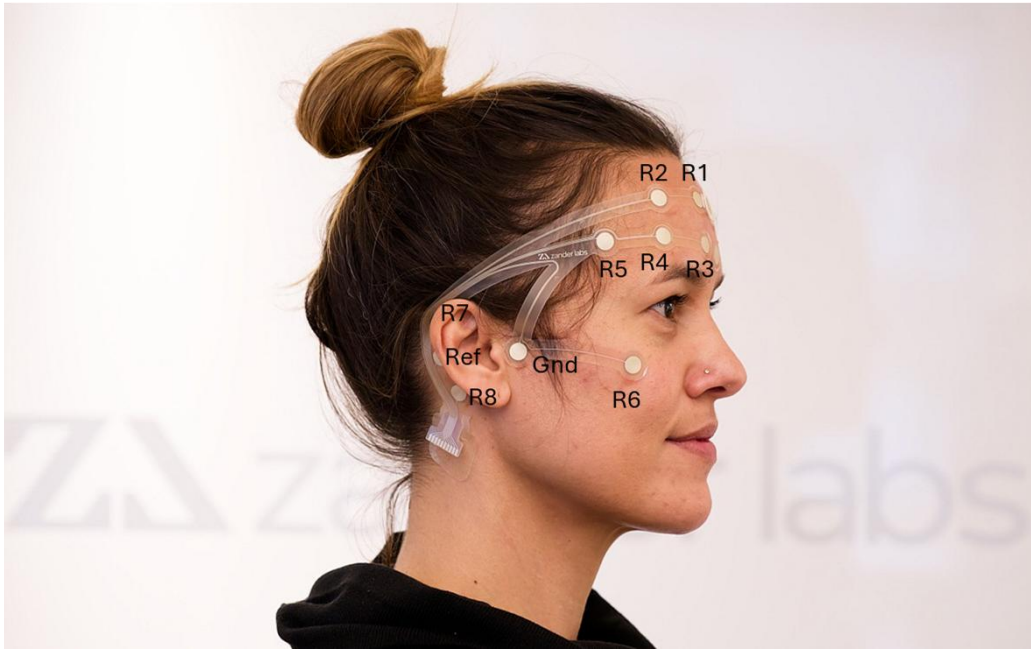


Figure 1, bottom: Photo with channel names indicated.

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