Development of an Unobtrusive Patch to Acquire EEG in the Home Setting for Studies of Alzheimer's Disease

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While poor sleep quality and napping are associated with Alzheimer's disease (AD), we currently lack data about the sleep-related effects of aging, demographic factors, and sleep disorders that are required to identify sleep biomarkers specific to AD. Electroencephalogram (EEG) directly reflects cortical neuronal activity thus it can be used to identify biomarkers that reflect neuronal dysfunction associated with AD. Despite the proliferation of "wearable technology" and sleep-focused smart-phone apps in the market, there is none that validates against polysomnography. Wearable devices marketed to the public have little inter-individual reliability for determining sleep when assessed against the gold standard, or have limited applicability in research due to inability to obtain raw data. Clinical-quality EEG recorders are expensive and bulky making them difficult for wide applications. New non-standard EEG systems designed for home uses are less costly; however raw data are difficult to obtain for precision analyses, and the devices are visually obtrusive (usually on the forehead) yet not comfortable for behavior studies. Furthermore, these devices rarely have occipital EEG data, which is required to distinguish quiet wake from light sleep. Therefore, there is a dire need for an inexpensive, non-cumbersome, simple, validated sleep-EEG data collection device to be used in the home setting.

In this context, we have developed an unobtrusive patch to be located in the mastoid-occipital area to collect EEG-sleep data in the home setting, supporting studies of AD. The patch uses Bluetooth Low Energy (BLE) to communicate with the user's personal smartphone thus EEG data can be remotely accessed and analyzed. The entire device is based on a flexible polymer membrane, to conformably attach to the non-planar anatomical surface behind the ear. Electrodes, the patch antenna operating at 2.4 GHz and circuit routings are made with gold thin films deposited by sputtering on flexible polymer substrates. The circuit is designed with surface-mount device (SMD) and low-power consumption components. The signals are amplified by an instrumentation amplifier (INA333, *Texas Instruments*) with an initial amplification gain of 5, followed by a filter stage (using OPA333, *Texas Instruments*) with a desired frequency range of 0.1 to 45 Hz. The chosen frequency band would help eliminate 60-Hz interference from electrical wiring in the environment. High-pass and low-pass Sallen-Key 2nd order filters are used with gains of 20 and 20, respectively. A rechargeable Li-polymer is utilized. With the use of all SMD components, our first prototype has a size of ~2×6 cm^2. **Figure 1** shows the conceptual design and a sample recording of an eyes closed-open EEG using our prototype, indicating the posterior dominant rhythm (PDR) during eyes-closed periods.

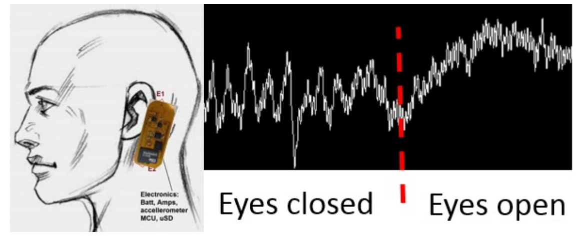

Figure 1. Conceptual design of the EEG patch and a regular eyes closed-open recording showing PDR.