N-Back Experiment

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ABSTRACT

This document is complementary to my master thesis "Person and Session Invariant Representation of EEG Signals via Deep Learning". It describes an experiment that I have conducted to gather EEG signals from participants while they play the N-Back game. The gathered dataset is located at the CSL cluster shared filesystem in the directory: $/share/temp/alturjmm/master\_thesis/nback\_experiment$.

Keywords: EEG-Dataset, N-Back Game

Introduction

The N-Back game is a widely used cognitive task and assessment tool in the field of psychology and neuroscience. It is designed to measure the working memory capacity and assess the ability to maintain and manipulate information in the short-term memory. The participants are presented with a sequence of rapidly flashing letters displayed at the center of the screen. The primary objective of this cognitive challenge is to discern whether the presently displayed letter *matches* the one presented at a specific distance of *n* steps back within the sequence. For instance, in the context of a 2-back game, participants are required to determine if the current letter matches the one that appeared two positions earlier in the sequence. The n-back game's level of difficulty can be modified by adjusting the value of *n*, with higher values posing progressively greater challenges for participants, thereby placing increased demands on their working memory capacity.

Setup

A participant is seated in front of a laptop wearing an EEG-Headset with eight dry electrodes. According to the 10-20 positioning standard, those electrodes are: Fz, C3, Cz, C4, Pz, PO7, Oz, PO8 as depicted in figure 1. The EEG data are recorded at 250 Hz sampling rate and the n-back game is developed as a WebApp. In order to automatically determine which part of the signals belongs to which task, timestamps are recorded and later used to slice the signal into segments with their respective labels. To indicate
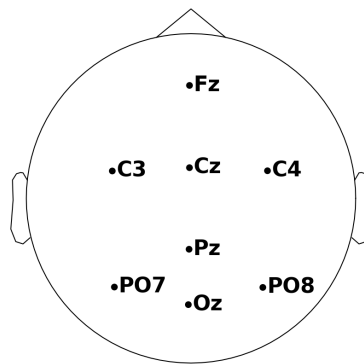

Figure 1. Sensors positions on the scalp

whether the current letter is a correct target, the keyboard of the laptop is used, where pressing the key *j* is an indication for true and *f* for false target respectively. As feedback, if the answer is correct, the screen is turned green on correct answers and red otherwise. The room in which the experiment took place was intentionally made quite to ensure there is no distractions, that might affect the quality of the recordings.

Workflow

The data were gathered for each participant individually with the following workflow: at the beginning of the experiment, a participant has to sit still in a relaxed state for one minute serving the purpose of a **baseline** level. Afterwards, a session of the n-back game is started. There are eight blocks with four levels of difficulty ranging from $n = 0$ to $n = 3$ for the whole session. During each block 30 letters are shown and only 10 of them indicate correct target answers. Each level is repeated twice in a 30 seconds block respectively. In the case of $n = 0$, the objective is solely to determine whether the current letter is x or not. After each block there is a 10 seconds pause followed by 5 seconds for showing instructions about the next block, giving the participant a chance to relax before the next block. In total, a complete session takes around 15 minutes.

Dataset

A total of 14 individuals took part in the experiment, comprising 10 males and 4 females, with an average age of 28 years old. Only one participant repeated the experiment 3 times (P01) for the purpose of evaluation across multiple sessions. Demographics data of each subject is presented in table 1. Some of

Subject	Age	Occupation	Gender	Highest Level of Education
P01	28	Student	M	Master of Science
P02	27	Student	M	Master of Science
P03	26	Student	M	Bachelor of Science
P04	29	Student	F	-
P05	30	Software Developer	M	Bachelor of Science
P06	38	Social worker	F	Media, Theater, pedagogy
P07	24	Student	M	Bachelor of Science
P08	30	Student	M	Bachelor of Science
P09	30	Student	M	Bachelor of Science
P10	28	Student	F	Bachelor of Arts
P11	30	Student	F	Bachelor of Science
P12	25	Student	M	Bachelor of Science
P13	25	Student	M	Bachelor of Science
P14	32	Student	M	Bachelor of Science

Table 1. Participants Demographics

the participants reported that, especially the third level was challenging, because their mind was telling them the current letter is correct but they could not act accordingly. However, for others it was not particularly difficult to solve any of the levels. Figure 2 shows the average answers of all participants over the different task difficulties.
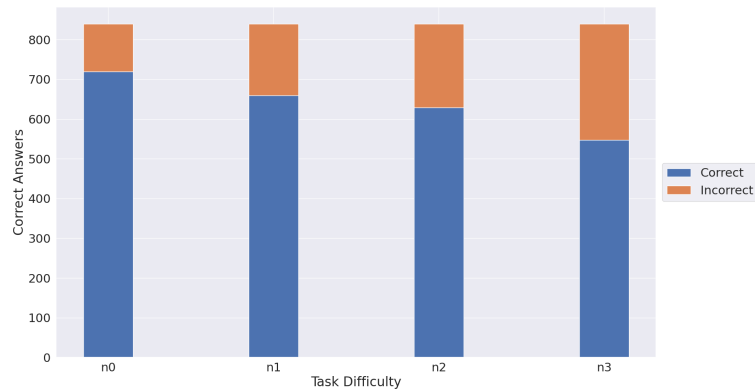

Figure 2. N-Back task difficulty

After inspecting the EEG data of each subject individually using PSD analysis, it has become evident

that not all of the recorded data are suitable for use. Specifically, subjects *P*04, *P*06 and *P*10 show abnormal distribution of frequencies across the whole session. Figure 3 illustrates the filtered frequencies within the range of [0.5, 30] Hz for the previously mentioned subjects in addition to subject *P*01, whose data demonstrate expected and normal frequency distribution. A more detailed inspection of the data of subject *P*04 reveals the presence of exceptionally rapid oscillations across all channels. Furthermore, subject *P*10 shows disturbance, shift in one channel and unexpected spikes. Similarly, subject *P*06 shows extreme shift in channel *Fz* and sudden spikes. On the other hand, subject *P*01 shows relaxed signals across all channels with no sudden spikes.
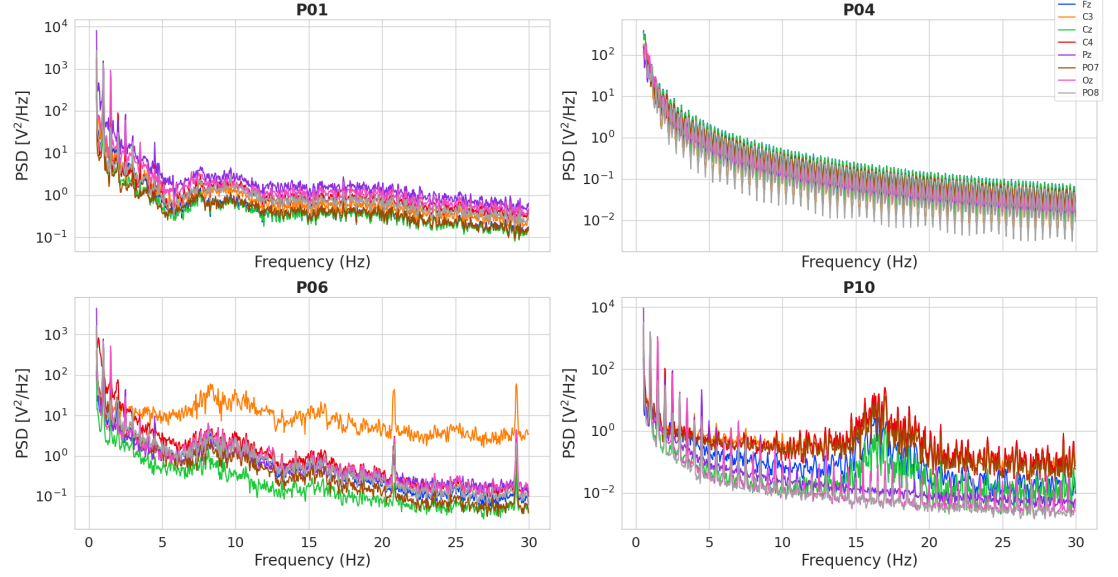

Figure 3. Recording Quality