A Multivariate Correlation Assessment of Chess Proficiency Using Brain Signals

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***Resumo*—Chess game has attracted the interest of many academic works with several experiments carried out to address the differences in brain activation on proficients and non-proficients chess players. However, none of these works takes into account explicitly the cognitive patterns of the chess players to rank and classify them. In our work, we aim to present a cognitive model, using EEG and multivariate statistical methods, to assess chess volunteers and compare their performance to the traditional metric based on accuracy and response time. In total, 32 volunteers have participated in this study based on visual stimuli computationally generated. Our main results show that it is important not only to top rank the volunteers with high accuracy and low response time, but also understand how the main brain processes occur to a chess expert to achieve such top performance.**

***Index Terms*—Chess, Electroencephalography, Pattern Recognition**

I. Introduction

Chess game has attracted the interest of many academic works in distinct areas of the scientific knowledge, due to its compact and controlled environment for fundamental questioning about human reasoning. Such areas include neuroscience, cognition, perceptual psychology, signal processing and computational vision [1]–[3].

In neuroscience and cognition areas, several experiments have been carried out in the last decade regarding to differences in brain activation on proficients and non-proficients chess players. Some studies have used positron emission tomography [4], single photon emission computerized tomography [5], magnetoencephalography [6], [7], magnectic ressonance imaging [8]–[16], and electroencephalography EEG [17]–[19], among others. However, the classification between proficients and non-proficients in those articles is essentially related to ELO rating (professional ranking system used in chess tournaments created by Arpad ELO) [20], to the amount of time dedicated to chess or a test based on accuracy and response time. None of these metrics takes into account explicitly the brain activation to rank and classify chess players.

This paper aims to present a brain signal processing technique, using EEG and multivariate statistical methods, that classifies chess players into proficient or non-proficient cognitively. To validate the results of this implicit neural measure we compare it to the standard proficiency metric based on accuracy and response time.

In the next section, we present the materials used in this experiment. In section III, we present the methods, including the data sample, the protocol and the technique to process the EEG signals. Section IV shows the results of the brain signal processing and the proficiency metric. Section V presents the discussion of such results and, finally, in section VI we make conclusions from the present work.

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II. Materials

Brain electrical signals were obtained through an EEG device, OpenBCI. This is an open-source equipment, it has sampling frequency of 125Hz and resolution of 32 bits per channel. In this experiment, we have used an EEG headcap to acquire 16 channels according to the 10-20 conventional system, which was used as reference for the positioning of the electrodes [21], [22]. Figure 1 shows the 10-20 system on the left side and the chosen 16 electrodes in orange and two potential references in blue on the right side.

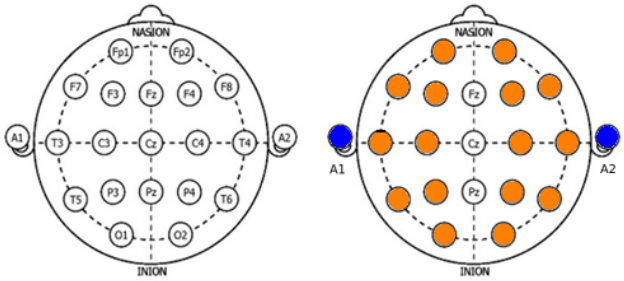

Figura 1. Electrodes' positioning.

A. Tasks and Stimuli

To create the test, attention was given to the level of difficulty of the questions, number of questions elaborated for each category, number of affirmative and negative responses and intelligibility of the proposed questions. Fifty-one questions were presented and separated in five categories: C1 is Object