

An Exploratory Study of Learners' Brain States

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Abstract: In Intelligent Tutoring Systems, continuous analysis of learner's brain states is essential. Several studies have proposed different methods to evaluate learner's mental states in cognitive tasks. However, these studies do not take into account the nature of the cognitive task. In this paper, we have developed various categories of brain games in order to study the variation of some specific brain states (engagement, workload and distraction) depending on the type and difficulty of the game. The preliminary results showed a close relationship between the category of game, the workload mental state and learner's performance.

Keywords: Brain games, Engagement, Workload, Distraction, EEG

1 Introduction

In Intelligent Tutoring Systems (ITS) recognition of user brain states and cognitive status remains of great importance. To detect and assess users' alertness several studies have been undertaken in the field of artificial intelligence, human computer interaction, cognition and neuroscience [2, 3, 5]. The major part of these systems was based on two fundamental mental metrics, namely, mental workload and mental engagement. *Mental workload* can be seen as the mental effort and energy invested in terms of human information processing during a particular task. *Mental engagement* is related to the level of mental vigilance and alertness during the task. The loss or diminution of engagement is considered as a *distraction* [4].

In this paper we aim to study the behavior and the evolution of these brain states through their EEG signals [1] depending on the category and difficulty of task presented to the learner. Thus, we developed three categories of brain games (*memorization, concentration and reasoning*) and assessed their variation among learners.

2 Experiment and Results

In order to study the behavior of the brain in different cognitive games and track the impact of games' category on different player's brain states, we conducted an experiment with 20 participants (mean age=28, SD=4.67) from Montreal University. This study consists of 3 steps: (1) Initially, we installed the B-Alert X10 headset on the participant, (2) The participant is invited to do three tasks of baseline to establish a classification of brain state, and (3) finally, the participant is invited to play some brain games which are grouped into three main categories (*memorization, concentration and reasoning*). During all the experiment, EEG was recorded from 9 sensors integrated into a

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Wi-Fi cap, with a linked-mastoid reference. The sensors are placed according the 10-20 system. The EEG was sampled at a rate of 256 Hz, converted to PSD and processed by the B-Alert software. Thus, three brain states (Workload, Engagement and Distraction) were extracted and analyzed for this study.

An important result obtained from statistical analysis showed that workload and engagement states depend on the game category. This result is assumed after conducting three one way ANOVA tests (see table 1).

Table 1 Relationship between brain states and game category

Brain States	Results of ANOVA	
	F	p
Workload	3.32	0.04*
Engagement	18.33	0.000*
Distraction	0.56	0.57

This result is very consistent since learner's concentration and mental activity increase according to the nature of proposed task; more the nature or category of the task is interesting, more he is engaged on the task and he reasons.

Another result confirmed that the workload only depends on the game difficulty (One Way ANOVA: $F(2,224)=0.64$, $p=0.04^*$). However, no significant results were found for the engagement and distraction states.

3 Conclusion

In this paper, we have assessed the variation of three brain states (Engagement, Workload and distraction) obtained from EEG signal processing depending on the category and difficulty of game. We have successfully shown that Workload and Engagement states depend significantly on the category of game unlike distraction. Moreover, only the Workload state depends on the difficulty of game.

These results are important from an educative perspective because we should think more in terms of learner cerebral abilities according to the category of task in a game design. More precisely, we think to adapt the tutor's module, in intelligent tutoring systems, according to learner's cerebral states evolution and category of task presented to the learner.

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