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Using Brainwave to Measure and Explore the Correlation between Attention and Cognitive Load

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Abstract: Currently, as the developments of the measuring techniques of non-invasive brain wave measurement instrument have become increasingly mature, it is widely applied for medical or educational researches. This study combined NueroSky and the cognitive load scale to discuss learning considerations and discover the learning pattern for each student. The experimental data found that most learners are more concentrated in the medium and low loads of learning-oriented tasks or non-learning-oriented tasks during their learning process, and the total task execution time or the attention duration of such kinds of tasks will last longer.

Keywords: Attention, Cognitive Load

1. Introduction

As science and technology become increasingly developed, learners can rely on the convenience brought by science and technology to learn new knowledge in an efficient manner. Based on the research of many scholars, this research understands the importance of attention, as attention is the beginning of all learning activities. When learners' attention is attracted, they will continue to concentrate on learning, and link such learning with their known knowledge. In this way, knowledge gradually becomes the long-term memories of learners, and is stored in the brain. Therefore, in order to discuss learners' learning environments at home, this research uses brain wave measurement instrument to record learners' attention during various activities, which is combined with the cognitive load scale to discuss learners' attention and cognitive load during various activities, and observe whether there exists significant relevance between attention and cognitive load.

2. Literature review

2.1. Brain wave

The potential signals of brain waves are very weak (about 5~100Hz) (Webster, 1998), thus, the detection and recording of EEG is quite difficult, as they are easily affected by external or other factors during the measurement process, meaning that brain wave data cannot be smoothly collected. As shown in Figure 1, according to the different frequencies, the EEG signal will divide brain waves into 5 main wave bands: α wave, β wave, γ wave, θ wave, and δ wave (Campisi, P., La Rocca, D., & Scarano, G.,2012; Sanei, & Chambers, 2007; Gregory, & Pettus, 2005). The β wave is also associated with attention and cognitive behavior.

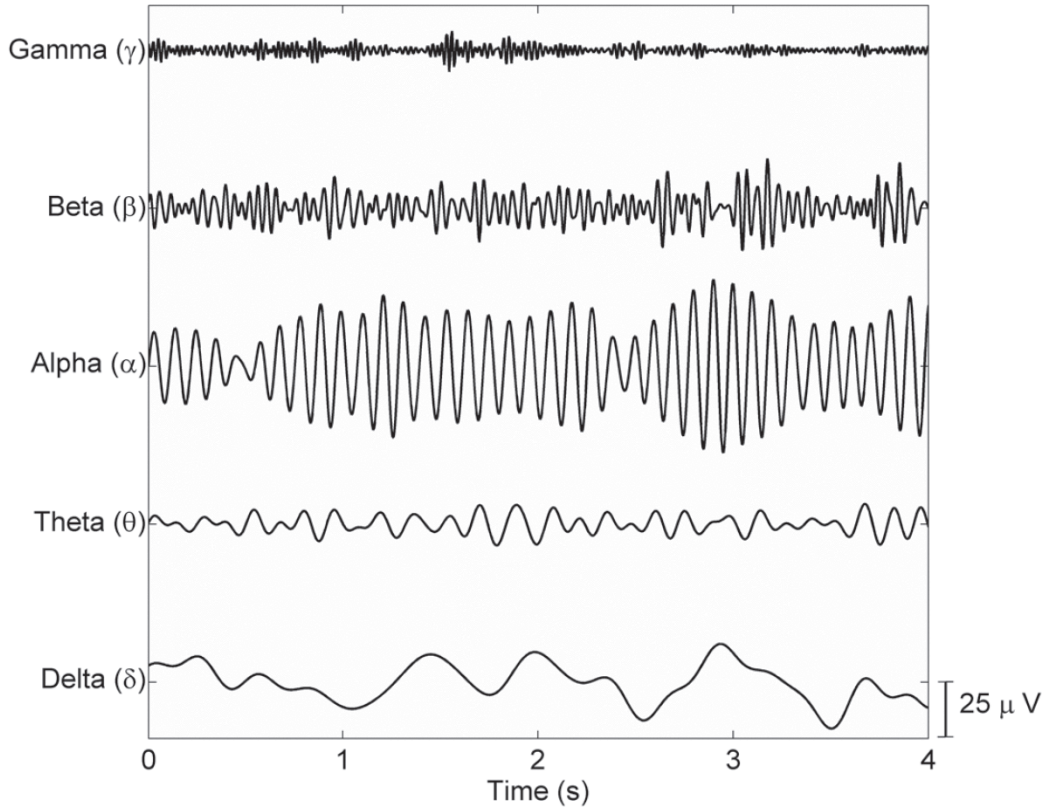

Figure 1. Kind of EEG (Campisi, P., La Rocca, D., & Scarano, G.,2012)

2.2. Learning attention

Attention plays a very important role in the learning process, as attention duration is closely related to brain activity, which directly affects learners learning effectiveness (Avery, M., 1994). The research and discussion of attention is very wide, and the explanation of attention vary according to different research fields. In the field of cognitive psychology, while it is believed that the capacity of the brain is not large, it can rapidly process received external messages, which is mainly because the brain has a mechanism for message filtering and attention, meaning the brain can effectively choose and process messages according to the external environment.

2.3. Cognitive load

Since the 1960s, research scholars in the field of cognitive psychology have put forward many different viewpoints and theories; however, the only conclusion commonly identified by scholars is that human cognitive resources are very limited during the process of message processing. According to one concept in psychology, cognitive load refers to the load generated in the human cognitive resource system when engaged in a specific job (Chandler et al., 1998 & Feinberg, S., & Murphy, M, 2000). The easier the work task, the less the individual cognitive load; the more the individual's professional knowledge, the less the relative cognitive load. Sweller et al. (1998) proposed that, in terms of "cognitive load", the traditional problem solving method emphasizes problem-solving skills during the process of cognitive load and problem solving, and learners must consume a great deal of cognitive resources to memorize them, thus, learners will have a smaller amount of cognitive resources to engage in learning and schema construction, which causes huge cognitive load. In addition, cognitive load is correlated to short-term memory capacity, meaning if individuals store a great number of messages in their short-term memory, it will cause "excessive" cognitive load.

3. Method

This research relies on MindWave Mobile, as provided by NeuroSky, to conduct the experiment, and complete a cognitive load scale after the experiment. MindWave Mobile is used to measure and collect learners' attention values when conducting various activities at home, and discusses whether there exists significant correlation between attention value and cognitive load.

3.1. Subjects

This research invites 10 students, including junior and senior university students and first-year and second-year graduates in the Department of Computer Science and Information Engineering, of a university in Taiwan as the experimental subjects.

3.2. Instrument

This research adopts NeuroSky's second-generation non-invasive brain wave measurement instrument (MindWave Mobile) as the tool to measure learners' attention values during their learning of various teaching materials. The brain wave retrieval technique of this EGG is used to collect the weak brain wave signals generated by learners, which are transmitted to the system via Bluetooth, and then, transferred as digital signals to be used as parameters. The device introduction is shown in Figure 2.

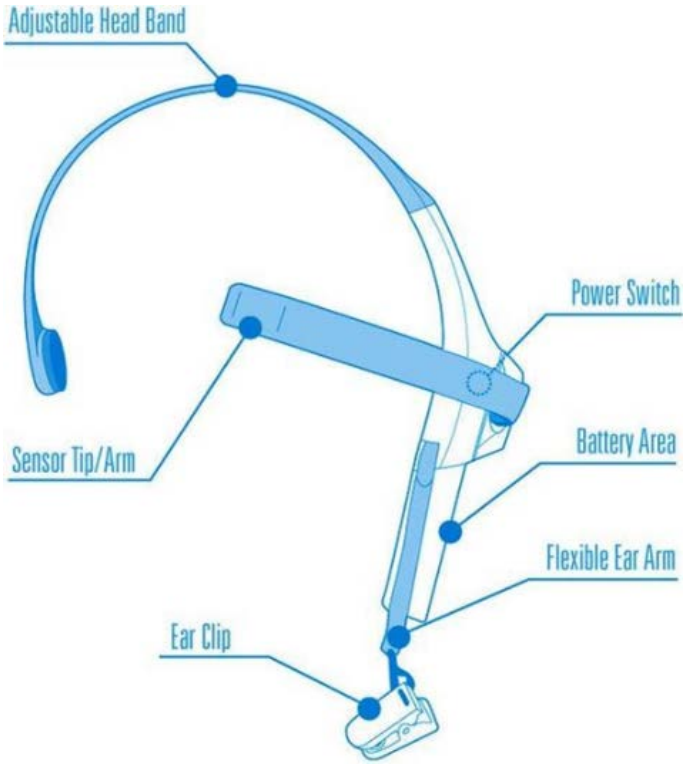

Figure 2. NeuroSky MindWave(Buduan, P. J. L., 2012)

3.3. Cognitive load questionnaire

In this research, learners are requested to fill in a cognitive load scale according to their current subjective judgment after learning the teaching materials. The cognitive load in this research is varied on the basis of the theory, as proposed by Sweller and Merrienboer in 1998, and by reference to the cognitive load scale, as proposed by Hwang and Chang in 2011. A five-point scale is used as the measurement standard for this research, which includes strongly agree, agree, common, disagree, and strongly disagree, in order to measure learners' cognitive load.

4. Results

4.1. Experimental Description

This research invites 10 students to measure the behavior events in their life, where each student learned or played video games, engaged in discussions in their own environment, and then, measured their attention values and filled in the difficulty level. SiTj is used to indicate the jth task of the ith student, and discuss the attention duration according to the following 3 different situations: different task duration, maximum duration of sustained attention, and “attention value is greater than average”.

4.2. Attention for Different Task Duration

As each learner’s task duration is different, this research sets 30min as the datum point to distinguish the data. It can be known from Table 1 that, if the task duration is greater than 30 minutes, the attention duration and maximum duration of sustained attention are better than the situation where it is less than 30 minutes. In Figure 3, blue color indicates sustained attention periods. It can be known from Figure 3 that, when learners do a task and their task duration is greater than 30 minutes, their attention is intermittent and cannot be maintained; if the task duration is less than 30 minutes, their attention can be better maintained. Therefore, this research finds that the attention durations for long and short tasks, as well as the maximum duration of sustained attention, are different.

Table 1: Mean and Standard Deviation of Attention for Different Task Durations

Group		Mean	S.D.
Task≥30 minutes	Task duration	41.06	13.45
	Total attention duration	20.00	7.60
	Duration of Sustained Attention	13.64	6.53
Task<30 minutes	Task duration	16.62	11.18
	Total attention duration	7.57	4.51
	Duration of Sustained Attention	6.89	3.97

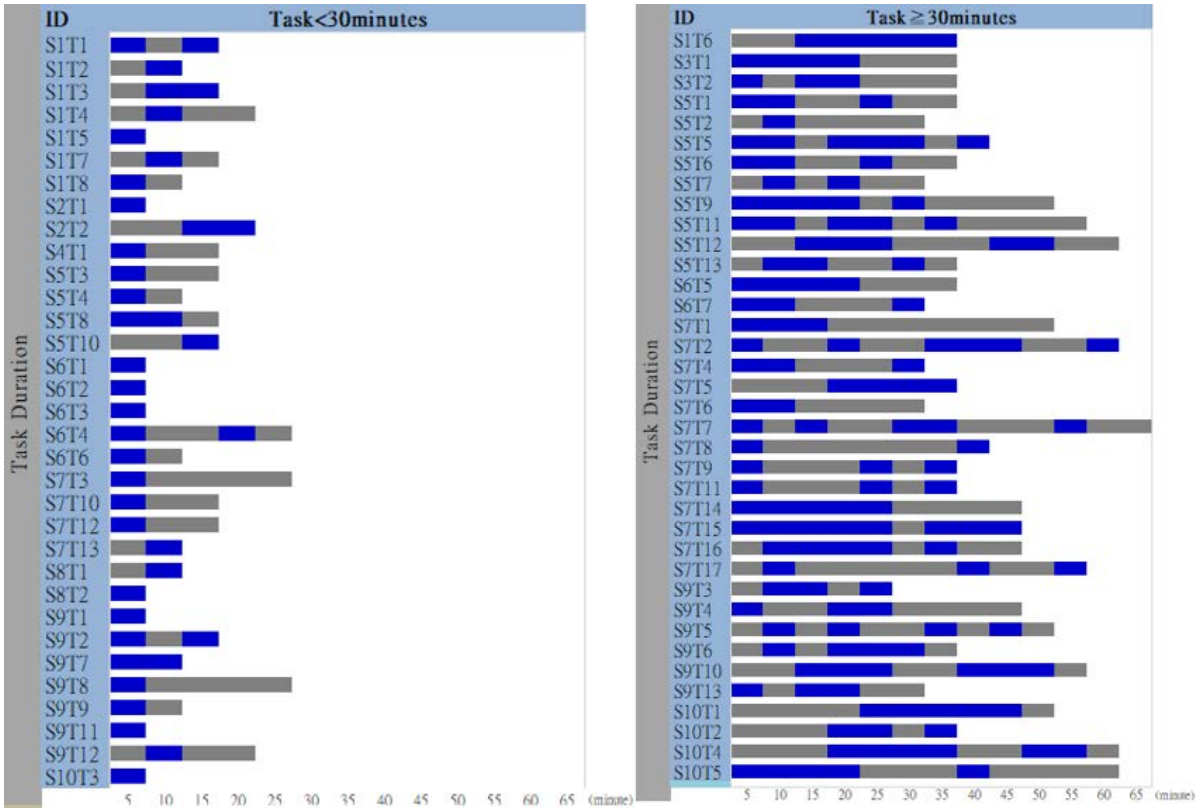

Figure 3. The Diagram of Sustained Attention of Different Task duration

4.3. Attention of above Average

In order to observe the tasks that make learners pay more attention, this research takes average attention duration as the datum point to distinguish the data. It can be known from Table 2 that, the learners whose attention value is greater than the average are better in task duration, attention duration, and maximum duration of sustained attention than those whose attention value is smaller than the average. In Figure 4, yellow color indicates attention periods. It can be known from Figure 4 that, the average attention duration and experimental duration of most learners whose attention value is greater than the average can last longer, and thus, belong to centralized attention; while the attention duration and experimental duration of most learners whose maximum duration of sustained attention is smaller than the average can last for a shorter time, and thus, belong to decentralized attention.

Table 2: Mean and Standard Deviation of Attention for above or below Average

Group		Mean	S.D.
Total attention>Mean	Task duration	43.03	11.18
	Total attention duration	21.21	6.38
	Duration of Sustained Attention	14.70	6.12
Total attention<Mean	Task duration	14.44	8.68
	Total attention duration	6.53	2.34

	Duration of Sustained Attention	5.69	1.75

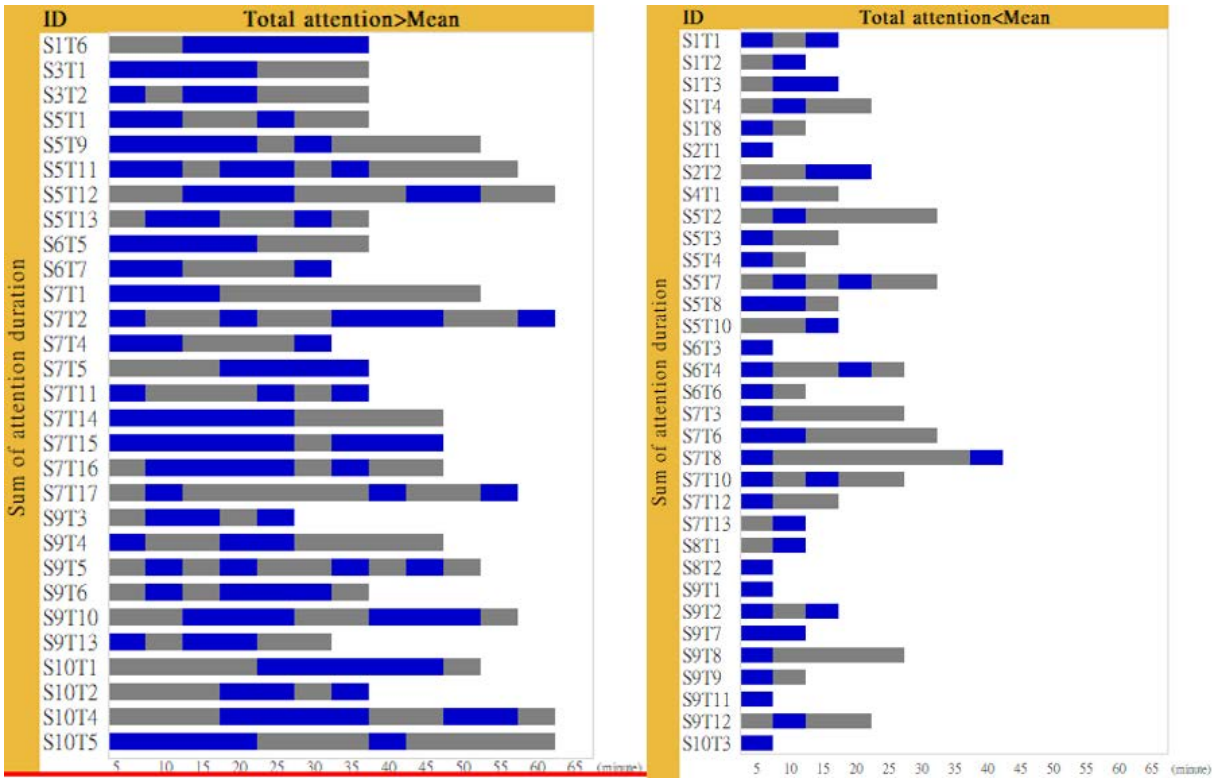

Figure 4. The Diagram of Attention Period for above or below Average

4.4. Attention for Different Duration of Sustained Attention

This section is aimed to understand learners' sustained attention, thus, this research takes the maximum duration of sustained attention as the datum point to distinguish the data. It can be known from Table 3 that, the learners whose maximum duration of sustained attention is greater than the average are better in task duration, attention duration, and maximum duration of sustained attention than those whose maximum duration of sustained attention is smaller than the average. In Figure 5, green color indicates attention periods. It can be known from Figure 5 that, the attention duration and experimental duration of most learners whose maximum duration of sustained attention is greater than the average can last longer, and thus, belong to centralized attention; while the attention duration and experimental duration of most learners whose maximum duration of sustained attention is smaller than the average can last for a shorter time, and thus, belong to decentralized attention.

Table 3: Mean and Standard Deviation of Attention for Different Duration of Sustained Attention

Group		Mean	S.D.
Sustained Attention>Mean	Task duration	39.14	13.91
	Total attention duration	20.00	7.28
	Duration of Sustained Attention	14.86	5.49
Sustained Attention<Mean	Task duration	17.14	12.91

Duration of Sustained Attention	6.86	3.66
Duration of Sustained Attention	5.00	0.00

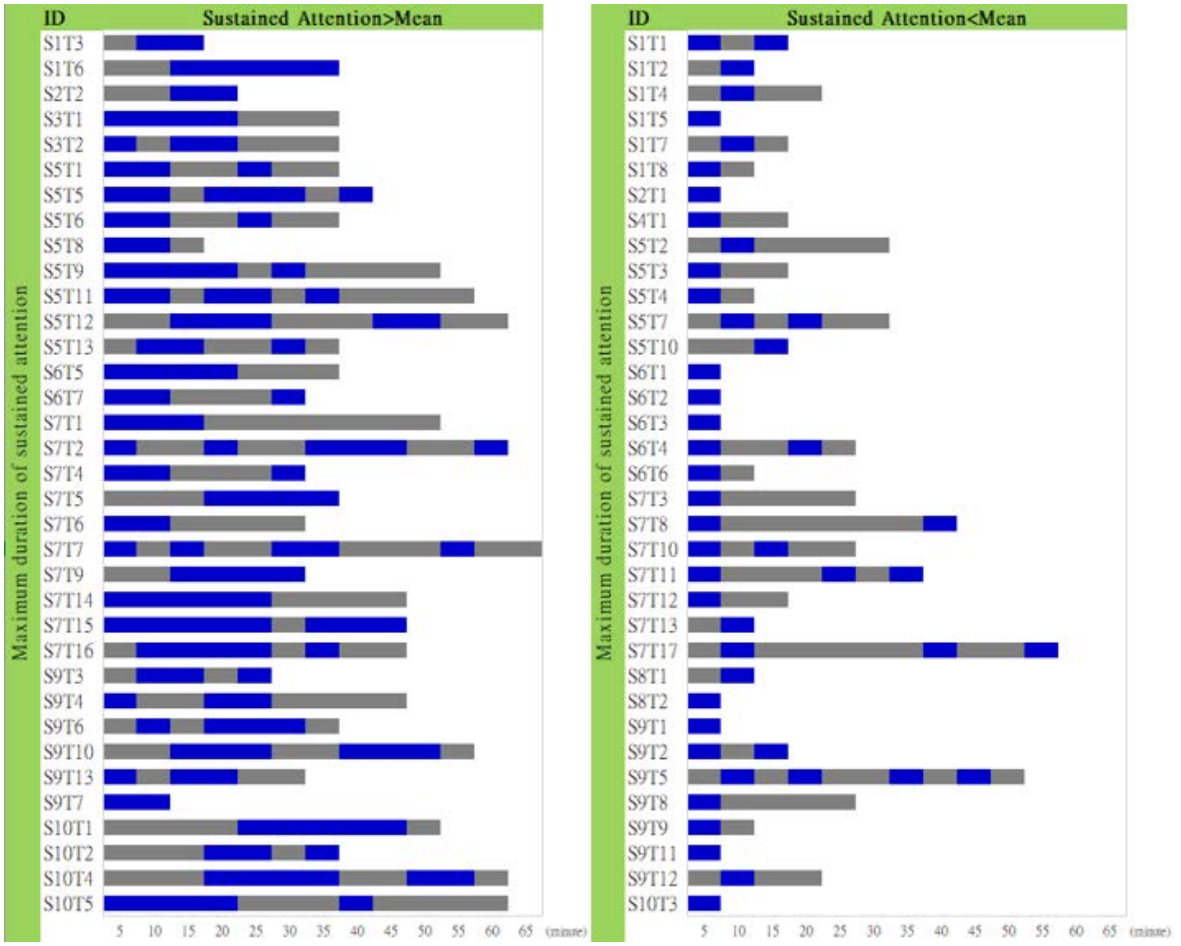

Figure 5. The Diagram of Attention Period for Different Duration of Sustained Attention

5. Conclusions

This study combined NueroSky and the cognitive load scale to discuss learning considerations and discover the learning pattern for each student. According to the experimental data, this research finds that most learners are more concentrated on the medium and low loads of learning-oriented tasks or non-learning-oriented tasks during their learning process, thus, their total task execution time and continuous attention duration will be longer; otherwise, in cases of more difficult tasks, attention cannot be maintained for longer operation times, and attention values are also relatively low during execution.

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