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Effects of an integrated physiological signal-based attention-promoting and English listening system on students' learning performance and behavioral patterns

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ABSTRACT

Abundant research has shown that the status of students' sustained attention affects their learning performance, especially in those learning environments which allow students to control their learning progress. The purpose of this study was to investigate the effects of a brainwave signal-based attention-promoting mechanism on university students' learning achievements and learning attitudes in an English listening course. A quasi-experimental design was conducted to collect the learners' attention levels, learning achievement, learning attitudes, and perceived usefulness. The students' learning attention states were monitored via an EEG sensor, and learning assistance was given when their attention levels waned. A total of 40 students in an English course at a university in Taiwan participated in the study. The experimental results showed that the proposed approach significantly improved the students' English listening achievement compared with those who learnt with the conventional English online learning approach owing to successfully maintaining the students' attention level during the learning process. Moreover, sequential analysis was conducted to analyze the sustained attention levels of students with sequential/global learning styles. It was found that the attention-promoting mechanism benefited the global-style students more than the sequential-style learners.

1. Introduction

Sustained attention during learning process has been recognized as an important factor of effective learning (e.g., Hidi, 1995; Reynolds, 1992; Risko, Buchanan, Medimorec, & Kingstone, 2013; Wilson & Korn, 2007). Researchers have indicated that students' learning outcomes rely heavily on their sustained attention and continued focus on learning objectives (Chen & Huang, 2014; Lyon & Krasnegor, 1996). Students might fail to receive crucial information if they do not pay full attention to in-class or online lectures, since attention plays a critical role in the cognitive learning process and has a great influence on learning outcomes (Chen & Wu, 2015). Nowadays, it has become an important issue to assist students continuously sustain attention in autonomous learning and web-based lectures. For example, Rush et al. (2010) attempted to develop an Audience Response System (ARS) to maintain students' attention in a professional educational setting, and found that it could enhance their attention and interest.

English is the most popular and important foreign language in many non-English-speaking countries (Nunan, 2003). However, learning a foreign language is challenging for most students since continuous and effective practice is required (Schmidt, 2012), and attention is considered to be one of the key factors affecting students' learning performance (Sethuraman & Smith, 2013). Therefore, scholars have emphasized the importance of providing learning supports to help students continuously pay attention to English learning activities (Mitchell, Myles, & Marsden, 2013), in particular, in online learning environments where learners can make personal learning progress (Hsia, Huang, & Hwang, 2016; Yang, Chuang, Li, & Tseng, 2013).

Researchers have also indicated the potential of using sensing technologies to keep students in the attentive state during the learning process by detecting their learning status and providing instant feedback or quiz accordingly (Chu, Hwang, & Tsai, 2010; Hwang, 2014). Two kinds of attention measures are commonly

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used to measure students' degree of attention. The first one is an attention scale and answered by students (Das, 1986); the second one uses a physiological signal devise to measure the attention signal (Chen & Huang, 2014; Chen & Wu, 2015; Ilgaz, Altun, & Aşkar, 2014; Rebolledo-Mendez et al., 2009).

In recent years, the advancement of human physiological signal detecting and processing technologies has further provided opportunities to achieve this aim (Rebolledo-Mendez et al., 2009). Brainwave sensors are one such human physiological signal detecting technology that provides a Brain-Computer Interface (BCI) (Chen & Huang, 2014). In the past, brainwave sensors required a great deal of preparatory work, and the electrode needed to be fixed on the experimenter's head with gel. It was therefore difficult to apply brainwave sensor devices in the classroom. Nowadays, it is possible to collect accurate brainwave data with a brainwave detecting headset with only simple preparation. The MindSet earphone developed by NeuroSky (San Jose, CA, USA) (http://www.neurosky.com/) is such a brainwave sensor which can detect human electroencephalogram (EEG) signals. It looks and is used just like a normal headset, and hence the users need no additional training; in addition, its reliability has been indicated by several previous studies (Chen & Huang, 2014; Rebolledo-Mendez et al., 2009).

The aim of this study was to propose a physiological signal-based attention-promoted system for improving students' English learning performance and attitudes. To evaluate the effectiveness of the proposed approach, an experiment was conducted to examine the students' performance in an English listening course. Moreover, to further investigate the factors affecting the students' performance, the students' learning behaviors and their personal characteristics (i.e., learning styles) were also considered. We examined the impact of the approach on the global and sequential styles since global-style students prefer to receive non-linear messages, while the sequential-style students prefer to learn by following a well-designed sequence. The intervention of attention-promotion mechanism could cause quite different impacts on those two styles of students, and hence it is worth studying this issue. Accordingly, the following research questions are investigated:

(1) Do the students who learn with the brainwave signal-based attention-promoted approach show better learning achievement than those who learn with the conventional English online learning approach?
(2) Do the students who learn with the brainwave signal-based attention-promoted approach show higher learning attitude than those who learn with the conventional English online learning approach?
(3) Did the students find the brainwave signal-based attention-promoted approach based on physiological signals useful?
(4) Are there differences between the effects of the brainwave signal-based attention-promoted approach on the attention degrees of the students with different learning styles?

2. Related work

2.1. Computer-assisted language learning

English is the most widely spoken language in the world, and in most countries it is the most important foreign language to learn. Therefore, in order to improve students' English learning effects and motivation, developing an effective approach to lead students to learn in a real context has become an important issue. Furthermore, combining various learning strategies and activities can also be beneficial in the field of computer-assisted language learning (CALL). Besides, Chen, Zhang, and Liu (2014) found that second and foreign language (L2) learners' listening strategies would directly influence their learning in a Web-based CALL system.

CALL is a way to help students learn in a computer-assisted environment. It consists of multimedia technology with text, audio, and video in computer-assisted environments, which can help teachers present more elements of the course content, arouse students' interest, and improve their learning performance.

Many studies have pointed out that CALL is effective. Liao (2010) carried out experiments on the effect of CALL software on English perceptual training, and the results showed that learners' English language learning experience should be taken into consideration. The tutorial design of the CALL system is another issue to be discussed. Liou (2012) conducted an experiment to infuse Second Life (SL) into a CALL course, and the 25 participating college students confirmed the effectiveness of using SL for English learning as it provides an easy way to build an environment for the students to interact and immerse themselves in the learning experience.

From this, it is clear that CALL applied to learning English can effectively help students learn. Therefore, in this study, a CALL learning system was designed and integrated with English listening learning in order to enhance learning performance.

2.2. Sustained attention awareness and its applications for education

The sustained attention mentioned in this study is the value measured by the MindSet headset. From the eSenses of attention, the meter value is reported on a relative eSense scale of 1–100. The value consists of the magnitude of eight types of EEG. It contains a series of 3-byte unsigned integers in the following order: delta (0.5–2.75 Hz), theta (3.5–6.75 Hz), low-alpha (7.5–9.25 Hz), high-alpha (10–11.75 Hz), low-beta (13–16.75 Hz), high-beta (18–29.75 Hz), low-gamma (31–39.75 Hz), and mid-gamma (41–49.75 Hz), as indicated in the MindSet handbook. This value refers to the level of concentrating and focusing on specific matters when doing something or thinking so as to effectively deal with that matter, i.e. the level of concentration (James, 1890).

Research on the correlation between sustained attention and learning has presented that a student's class behaviors would affect his/her learning and academic performance, where attention deficits are a key indicator (Hidi, 1995; Reynolds, 1992; Risko et al., 2013; Wilson & Korn, 2007). Corno (1993) indicated that attention could indeed improve students' learning performance as long as the students have a certain degree of learning motivation or have a competitive intention. Sarter, Givens, and Bruno (2001) defined sustained attention as the foundation of attention; therefore, how to keep students continuously paying attention is an important consideration for scholars.

To enhance students' attention and to further promote their learning performance, Ilgaz et al. (2014) used contextual cues presented to users in e-learning environments, and guided students' attention to help them learn. Börner, Kalz, and Specht (2014) investigated if an attention-aware display design could capture the students' attention, and its influence on their knowledge gain. The results showed that the attention of 52 participants from a university was attracted and retained by the display design through the facilitation of the acquisition of knowledge (i.e., the comprehension of the presented information). Apparently, attention and the learning process are closely connected, and attention is a key factor in learning.

Consequently, a brainwave signal-based attention-promoted English learning system based on BCI-MindSet equipment is proposed. The system aims to enhance students' sustained attention in an English listening course so as to have them thoroughly invest in