ABSTRACT

Cognitive measures are directed to assess the load of working memory while performing different tasks. Excessive load on working memory hinders learning or performance of individuals. Lexile measure is the current tool used in assessing the difficulty levels of text reading in English language. Studies on correlating the cognitive load with EEG for classifying tasks based on Lexile measures have been performed for native English speakers. In this work, an attempt has been made to analyze the scope of Lexile measure for assessing the cognitive load of normal subjects. The protocol included reading and recall of texts with different Lexile complexities followed by resting phases. For increasing Lexile level complexities, a considerable increase in cognitive processing was noticed during task phase. Further, an increase in beta power was noticed at the central region indicating active information processing and decision making. Relative theta power (Rθ=0.11) was significant (p=0.022) in low Lexile level material and gradually decreased as the difficulty level of the tasks increased. Relative theta power was found to be decreasing as the complexity level of the text material increased and was found to dominate in both mid frontal and mid parietal regions during the recall phase. During test phase an increase in alpha power was observed at parietal region reflecting active information processing. This was evident from the highly significant (p=0.022), relative alpha power (Rα =0.036) for recall of high complexity Lexile material compared to medium (Rα=0.005) and low (Rα=0.005) level materials. Thus, it is seen that this study could be more effective in analyzing the cognitive load of subjects with different working memory efficiency. Also, while performing analysis on instructional material design based on cognitive load of different subjects, such procedures seem to be more significant.

Keywords: Cognitive Load, EEG, Instructional Design, Lexile Measures, Power Spectrum, Recall

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1. INTRODUCTION

Cognitive Informatics (CI) studies the internal information processing mechanisms and natural intelligence of the brain such as, cognitive mechanism of the brain, cognitive processes of the mind, brain memory organization, knowledge representation, perception of external information, memory, learning, thinking, intelligence, autonomy, knowledge networking, and knowledge engineering (Wang & Wang, 2006). It attempts to solve problems in two connected areas in a bi-directional and multidisciplinary approach. In one direction, CI uses computing techniques to investigate cognitive science problems, such as memory, learning, and thinking. In the other direction, CI uses cognitive theories to investigate informatics, computing, and software engineering. CI focuses on the nature of information in the brain, such as information acquisition, memory, categorization, retrieve, generation, representation, and communication. With the support of modern information and neural science technologies, mechanisms of the brain and the mind will be systematically explored in CI (Wang et al., 2010, Wang et al., 2011).

Cognitive theory states that human memory comprises a very limited working memory and effectively an unlimited long-term memory. Organization of information processed plays an important role in learning and memory. Unorganized information needs high cognitive load while learning. Knowledge is perceived as schemas representing relationships among facts and concepts. The schemas define the load of the working memory since they allow many elements of knowledge to be treated as a single element in working memory compared to controlled, conscious processing that requires higher cognitive loads. For a learner to have a low cognitive load, the learning material must have been organized into structured schemas. If the elements that comprise the material are discrete, then the cognitive load will be high (Greitzer, 2002). Cognitive Informatics explains the importance of helping learners develop well connected knowledge structures. When the knowledge structure for a topic is large and well-connected, new information is more readily acquired and the richness of the connections facilitates information retrieval. Human brain organizes and categorizes new information in terms of what it already knows.

Cognitive load is the amount of load induced on the working memory by a cognitive process. A better understanding of the nature of human working memory helps in understanding the differences in cognitive abilities of individuals and their success rate in their efforts to accomplish their objectives. People vary widely in their working memory capacity and the amount of information that can be accessed. The same task can affect different users in different ways, and can induce levels of perceived cognitive load that vary from one user to another. This is due to a number of reasons - level of domain or interface expertise of the user, their age, mental or physical impediments being some of them. The cognitive load experienced by users in completing a task has a major impact on their ability to learn from the task, and can severely impact their performance, high load detracting them from learning. There has been increasing interest in maintaining an optimal level of cognitive load applied on the brain (Pass et al., 2003b).

Cognitive Load Theory (CLT) distinguishes between three types of cognitive load: intrinsic load, extraneous load, and germane load. CLT is concerned with the design of instructional methods that efficiently use people’s limited cognitive processing capacity to apply acquired knowledge and skills to new situations (i.e., transfer). The structures and functions of human cognitive architecture have been used to design a variety of novel and efficient instructional methods (Jeroen & John, 2005). The associated research has shown that measures of cognitive load can reveal important information for CLT that is not necessarily reflected by traditional performance-based measures (Pass et al., 2003b). Particularly, the combination of performance and cognitive load measures has been identified to constitute a reliable estimate of the mental efficiency of instructional methods.
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