Chapter 6
A Review for Neuroimaging Techniques in Multimedia Learning:
An Experimental Framework

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ABSTRACT

The purpose of this study was to examine neuroimaging technologies for quantifying cognitive load in intelligent interactive multimedia systems for experimental applications by conducting a systematic review of all relevant papers published up to April 2020. The study's most striking finding is that electroencephalography, functional magnetic resonance imaging, functional near-infrared spectroscopy, and transcranial doppler ultrasonography are the most frequently used neuroimaging equipment in cognitive load research in multimedia learning. Forty papers were selected depending on the equipment that should be understood in the field of neuroimaging in examining cognitive load in multimedia learning, the benefits and drawbacks of neuroimaging devices, and the experimental protocol for cognitive load in multimedia research. The study's findings were analyzed, and numerous discrepancies in the research on cognitive load and multimedia learning were discovered.

DOI: 10.4018/978-1-6684-5619-4.ch006

INTRODUCTION

Cognitive Load (CL) Theory is a significant framework that gives instruction recommendations based on current knowledge about human cognition (Sweller, 2020). The theory intends to identify the ways information processing load inducted by learning tasks affects students' ability to process new information and construct it in long-term memory (Sweller, J., van Merriënboer, J. J. G., & Paas, F., 2019). According to the theory, any new information is primarily processed by working memory and stored in unlimited long-term memory (Anmarkrud, Ø., Andresen, A., & Bråten, I., 2019) (Sweller, J., van Merriënboer, J. J. G., & Paas, F., 2019). Working memory capacity is assumed to be limited (Baddeley A., 2012), and only limited items can be processed at a time (Cowan, N., 2001) (Miller, G. A., 1956). Cognitive overload occurs when the learner exceeds the working memory's capacity, restricted to processing the information. The CL theory thus aims to prevent this problem by efficiently designing the learning environment to optimize the limited working capacity and enhance the acquisition of knowledge (Sweller, J., van Merrienboer, J. J. G., & Paas, F., 1998).

CL Theory assumes three types of CL; extraneous CL, intrinsic CL, and germane CL (Paas, F., Renkl, A., & Sweller, J. C, 2003). The intrinsic CL increases with the large number of elements coming to the working memory for schema construction (element interactivity) to be processed simultaneously. The extraneous CL is explained with multimedia objects and design, and it results from inadequately designed learning materials. On the other hand, the degree of mental effort with schemas construction is related to germane load. And it is relevant to motivation and interest factors (Sweller, J., 2010) (Sweller, 2020). The intrinsic and extraneous CL reflect design factors, and those differ from the germane load, which would be explained in terms of subjective experiences. The revised CL theory model (Sweller, 2020) includes just two types: extraneous and intrinsic load. The deactivation of the germane load was because of the close interaction between the intrinsic and germane CLs, which resulted in the incapability to differentiate the distinctive impact of different factors on the overall CL. The germane CL is still known to be germane resources representing the amount of working memory capacity allocated to learning. Besides, CL triggered by the pertinent information processing and learning strategies is integrated into CL factor (Korbach, A., Brünken, R., & Park, B., 2017).

CL theory is primarily concerned with enhancing complex cognitive tasks by transforming current scientific knowledge to make the cognitive structures and process the guidelines for instructional design (Sweller, J., van Merriënboer, J. J. G., & Paas, F., 2019). Therefore, it has contributed to the field of multimedia learning as well. Multimedia learning happens when mental representations are constructed through pictures and words (Mayer, R., 2014b). While words could be in printed (e.g., on-screen text) or verbal (e.g., narration) forms, the pictures could be in static (graphs, illustrations, photos, charts, or maps) or dynamic (e.g., video, animation, or interactive illustrations) forms (Mayer, R. E., Moreno, R., 2003). The instructional design utilized in multimedia learning should be appropriate for the individual's cognitive processing, and it should avoid overloading memory during learning. The Cognitive Theory of Multimedia learning is built on CL theory and formed based on previous studies. The ways individuals process information and learn through multimedia approaches are addressed in theory (Mayer, R., 2014a) which includes three basic assumptions:

1) processing visual and audio information is performed through separate channels,
2) there is a limited amount of information per unit of time for each channel, and

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