The impact of working memory load on psychophysiological measures of mental effort and motivational disposition

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Abstract

Mental effort may be conceived in terms of computation (energy mobilization for cognitive tasks) or motivation disposition (decision to invest or withdraw task effort). The current study measured cardiovascular, electroencephalographic (EEG) and pupillometric data in order to capture computational and motivational aspects of mental effort. Working memory load was manipulated using a verbal version of the N-back task using 6 different load levels, ranging from 1-back (easy) to 6-back (extremely hard). 18 participants completed the task after pre-trial training. Performance and psychophysiological activity was measured during task completion along with subjective reports of motivation and workload. Results showed omnibus effects for load on performance and subjective effort, systolic blood pressure and pupil dilation. Load effects were also present on EEG anterior and parietal alpha suppression, and on theta power at anterior frontal scalp sites. Frontal EEG asymmetry, which indexes motivation, showed greater relative left activation for low and high loads compared to baseline, hypothesized to reflect expectancy at low loads and approach motivation at high loads. No effect was found for the highest load compared to baseline, thought to indicate reduced approach motivation due to overload. Results are discussed in relation to developing computer systems to detect high mental workloads using psychophysiology.

Introduction

Physiological computing describes systems that capture psychophysiological changes in the user in order to inform real-time software adaptation (Allanson & Fairclough, 2004; Fairclough, 2009). PC systems rely on psychophysiology to create a representation of the psychological state of the user in real-time, e.g. changes in cognitive activity, positive and negative emotions, high vs. low task motivation. The PC paradigm encompasses several existing strands of research/applications, from the control of adaptive automation (Wilson & Russell, 2003) to the use of psychophysiology to represent user emotion (Picard et al., 2001). The cycle of data collection and system response wherein psychophysiological change is transformed into adaptive control may be described as a biocybernetic loop (Pope et al., 1995).

In D. de Waard, A. Axelsson, M. Berglund, B. Peters, and C. Weikert (Eds.) (2010). *Human Factors: A system view of human, technology and organisation* (pp. 423 - 433). Maastricht, the Netherlands: Shaker Publishing.