Blood glucose as an index of mental effort

Stephen H. Fairclough and Kim Houston
School of Psychology
Liverpool John Moores University, UK

Abstract

Mental effort is defined as energy mobilisation in the service of cognitive goals. The aim of this study was to operationalise mental effort in terms of blood glucose levels, and to compare the sensitivity of this metabolic variable to cardiovascular indices of effort. Twenty-nine participants performed a Stroop task for forty-five minutes under three conditions of cognitive demand: (a) Congruent stimuli, (b) 50% Incongruent stimuli, and (c) Incongruent stimuli. The results indicated that blood glucose was sensitive to both cognitive demand and time-on-task whereas the 0.1 Hz variable was only sensitive to a time-on-task effect. The implications of these findings for further research are discussed.

Introduction

Mental effort investment has been described as energy mobilisation in the service of cognitive goals (Gaillard, 1993; Gaillard, 2001). The mobilisation of mental effort represents a compensatory strategy to protect performance in presence of increased task demands and the presence of psychological stressors (Hockey, 1993, 1997).

A number of studies have measured cardiovascular activity to index mental effort, specifically the mid-frequency component of heart rate variability (0.07-0.13 Hz), also known as the 0.1 Hz component of sinus arrhythmia (Mulder, 1979, 1985, 1986). The 0.1 Hz component is influenced by short-term changes in blood pressure that represent the resonance of the vasomotor system (van Roon, 1998). Earlier research demonstrated the sensitivity of the 0.1 Hz component to various sources of task effort, e.g. increased memory set size and time-sharing in working memory (Aasman, Mulder, & Mulder, 1987; Mulder & Mulder, 1981). It has also been argued that the sensitivity of this measure is suspect and the index tends only to distinguish gross changes in task demands (Jorna, 1992; Wilson, 1992).

An alternative strategy to mental effort measurement is to use metabolic correlates of cognitive activity that represent the process of energy mobilisation at a physiological level. It is common knowledge that hypoglycaemic levels of blood glucose (< 2.2 mmol/L) cause a range of physiological and psychological disturbances, e.g. trembling, confusion (Benton, Parker, & Donohue, 1997). However, recent studies support the hypothesis that fluctuations of blood glucose within a normative range may exert significant influence on cognitive performance. These studies employed a

In D. de Waard, K.A. Brookhuis, S.M. Sommer, and W.B. Verwey (2003), *Human Factors in the Age of Virtual Reality* (pp. 225 - 232). Maastricht, the Netherlands: Shaker Publishing.