EEG and cardiovascular correlates of working memory load and motivation

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Previous research has identified a number of EEG measures that are sensitive to computational effort in response to increased working memory load, e.g. frontal theta and suppression of alpha activity at parietal-occipital areas (Gevins et al, 1997). By contrast, very high levels of working memory load may cause computational effort to decline due to motivational factors, e.g. reduced likelihood of task success (Wright, 2008). Studies of motivational intensity have relied heavily on cardiovascular responses in order to index effort mobilisation, particularly systolic blood pressure. Frontal EEG asymmetry has been linked to motivational disposition towards approach and avoidance, but has not been investigated in connection with cognitive challenge or working memory load. The current paper is based on two studies that were conducted to investigate how both cognitive and motivational measures of psychophysiology responded to working memory load and the presence of financial reward. Participants in the first study (N = 20) were required to perform the n-back working memory task under three conditions: low load (1-back), high (3-back), and excessive (6-back). EEG, systolic blood pressure (SBP), and subjective self-report data were collected. The results revealed a linear increase of frontal theta activity in response to working memory load in combination with a decline of approach motivation as referenced by frontal EEG asymmetry (at fronto-central sites). The second study contained two independent variables: low/high/excessive working memory load (as in the previous study) in combination with a condition where financial reward was available that were contingent on performance. The goal of this study was to simultaneously manipulate cognitive demand and extrinsic motivation. Twenty participants took part in the study and the same dependent variables were measured. The results of the second study revealed a quadratic trend for frontal theta, i.e. theta increased from low to high load, but declined when load became excessive. This pattern of response was mirrored by changes in systolic blood pressure and upper- and lower-band of alpha activity, i.e. suppression of alpha reached a maximum level during high load. In addition, suppression of lower-alpha band was enhanced during the presence of financial reward, but only for low working memory load. The frontal asymmetry data indicated an increase of relative left activation (approach motivation) in response to financial reward, but only during high load condition. The implications of both studies for psychophysiological measurement of cognitive effort and motivation are discussed.

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