Development of a cyclic loading method for the study of patterns of breakdown in complex performance under high load

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Abstract

Prediction of operator breakdown in complex systems depends on detecting states of extreme strain resulting from sustained compensatory activity, associated with fatigue and loss of control. This research is aimed at identifying the underlying state(s) that correspond to this limit in terms of key psychophysiological markers. To address these issues the study used a new 'cyclic loading' method, based on strain testing methods in mechanical engineering. Manual control load on a process control task is increased until compensatory control limits are breached and primary performance begins to fail; then reduced until performance recovers to within normal limits. The cyclic loading method is shown to be a valuable tool for exploring the dynamics of operator/task interactions under high demand. Principal component analysis of correlations between hysteresis functions for relevant markers of strain (differences between loading and unloading response) showed evidence of two distinctive psychophysiological patterns, corresponding to fatigue/control and effort management processes. These findings suggest that prediction of operator risk will need to consider both early onset of fatigue effects, leading to loss of task control, and differences in effort management strategies employed by operators to maintain performance goals.

Introduction

Operator performance in complex, highly automated tasks typically appears to be reliable, despite the constant threat of disruption from demanding workload, environmental stressors and increasing fatigue (Hancock & Desmond, 2001; Hockey, 1997). Particularly in situations where the operator is highly motivated to avoid error (for example, safety critical systems), top-level task goals appear to be protected by an increase of effort. However, the use of such compensatory strategies also attracts costs or 'latent decrements': the adoption of less demanding (riskier) strategies, secondary task decrements, and increases in both subjective strain and physiological activation (Hockey, 1997).

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