Low Cognitive Load and Reduced Arousal Impede Practice Effects on Executive Functioning, Metacognitive Confidence and Decision Making

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Background

The ability to learn and maintain optimal cognitive and decision performance is often critical, but thought to be hampered by low levels of cognitive work load and environmental arousal (boredom and passive fatigue; Vogel-Walcutt, Fiorella, Carper & Schatz, 2012; Desmond & Hancock, 2001).

Practice Effects

The effects of low load and arousal on practice-related improvements have not been studied. Practice Effects (PEs) refer to improvement in performance associated with repeated administrations of the same or similar items, reflect declarative learning of repeated items and procedural learning of test relevant strategies. Recent evidence suggests that PEs are an indication of cognitive ability in their own right (e.g. Sychy, Kravil & Franchone, 2013). That is, cognitive decline can be inferred when typical PEs are not observed. Given this evidence, low load and low arousal may reduce PEs involved in competent decision making.

Decision Making

Decision making involves forming judgements about the world and making choices to achieve one’s goals. Judgements vary in their accuracy and can be generated via Type 1 and Type 2 processes. When judgements about the task at hand are accurate, the most competent thing to do is act confidently and decisively to achieve one’s goal. When accurate judgements about the problem cannot be formed, however, the most competent thing to do is address various ancillary goals, such as seeking more information.

The focus of the present experiment was to investigate how low levels of cognitive workload and arousal induced by external physical stimulation (a typical source of environmental arousal in operational contexts such as driving) may contribute to non-optimal levels of practice-related learning on cognitive and decision making tasks.

Aims and hypotheses

The primary aim of the study was to simultaneously assess changes in practice-related improvements, or lack of them, in inhibitory control, short term memory, metacognitive monitoring, and patterns of behavioural decision competence/ incompetence under conditions of low cognitive load and arousal.

H1. Practice effects (PE) will be positive. Participants will improve on all variables in a linear fashion with each additional test block.

H2. Low cognitive load and arousal will impede PE. The positive PEs described in H1 will be weaker under the low-load and no-motivation conditions.

H3. Low cognitive load will have a sustained effect such that the PEs described in H1 will be weaker overall for participants who start with the low-load drive (and do the moderate-load drive second) than participants who start with the moderate-load drive first (and have low-load second).

Method

Participants

A total of 70 participants (7 female, M_age=37.71 years, age range: 19-60 years), recruited via email invitations to the Defence Science and Technology Organisation (DSTO) personnel, volunteered to participate.

Measures

Control variables

1. Short Motion sickness questionnaire
2. Driving and Military Experience Questionnaire
3. Self-control Scale
4. Attention switching tasks

Repeated test battery

5. Medical Decision-Making Test (MDMT)
6. NASA-TLX
7. Stroop colour naming test

Secondary cognitive workload task

8. Letter swaps test

Procedure

All testing was done with groups of up to four participants per session and conducted in the LAMP Motion Platform (LAMP) simulation facility (see Figure 1) at DSTO. Each participant performed low and moderately engaging passenger tasks in two successive 20-minute simulated drives and repeated a battery of decision making and inhibitory control tests three times – before, between and after these drives. Pre to post changes in the variables of interest were tracked over the three testing blocks (providing practice) interspersed by the two simulated drives. One drive required sustained attention on the road only (low load), while the other required a cognitive task to be completed as well (moderate load) (see Figure 2). All participants experienced both drives, but the order in which they were experienced was manipulated. Participants were additionally allocated to experience both drives in a motion or no-motion condition.

Results

H1: Evidence of PEs

As hypothesised, participants’ performance significantly improved over the three test blocks, which were indicative of typical practice effects (Figure 3).

H2: Cognitive load and motion

The hypothesised negative effect of low cognitive load emerged in only half the variables and as significant for only judgement accuracy and optimality. Motion did not significantly alter any variable.

H3: Sustained effect of low cognitive load (order)

As hypothesised, the moderate-load-start group had greater overall practice related improvements in all but three variables than the low-load-start group, and five of these expected relationships were significant.

Conclusions

Overall, low cognitive load impeded PEs on most variables, and either low cognitive load or the absence of motion was sufficient to impede a subset, suggesting two distinct pathways that may cause a decline in cognitive performance.

Key implications of the present study for fatigue as a result of low load and arousal, practice effects and their interactions include:

• considering the detrimental effect of low cognitive load on operator performance
• designing operator strategies to mitigate suboptimal learning as a result of task disengagement
• the impact of practice not appearing to alter the successful detection of incorrect decisions – an important implication in high-risk contexts in which incorrect judgements are frequent


Funding: SAI, SK and EA were funded by the Defence Capability Development Group Project Land 121 Phase 4 (http://www.army.gov.au/OurFuture/Projects/Project/LAND-121) under the Research Agreement SS813. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Figure 1. The LAMP Motion Platform (LAMP) simulation facility.

Figure 2. Outline of experimental design for attentional load conditions.

Figure 3. Effect sizes, calculated as Cohen’s d, of the difference between pre to post moderate-load drive change and pre to post low-load drive change.

Figure 4. Means and 95% Confidence Intervals for MDMT diagnostic confidence, and MDMT decision competence, optimality and hesitance by the between subject conditions (low-load order and motion) across the three test blocks.