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Working memory resource depletion or motivational and attentional shift? A cardiovascular and behavioral study

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Keywords

Working memory, self-control, strength model, process model, compensatory effort, motivation

Context

Mental fatigue induced by prolonged self-regulation reduces performance during subsequent cognitive task. Various theoretical models attempt to explain these person's capacity reduction on a subsequent task. In order, to aid understanding we opted to select out the two main theoretical models. The Baumeister's strength model of self-control predicts that engaging in cognitive action consumes and depletes inner resources, leaving one in a state of "ego depletion" leading to failure on future tasks. On the other hand, the process model of Inzlicht et al. predicts that initial acts of control cause shifts in motivation and attention lead people to less engaged in further deliberative control.

Methodology

We induced mental fatigue using sequential task paradigm and evaluated working memory (WM) performance (i.e., success rate and d') and reaction time (RT) by asking participant to perform a WM task (2-back) before (i.e., pre) and after (i.e., post) a depleting (working memory updating task), control (watching neutral conferences) or continuous (2-back) task. To test whether behavior is more influenced by resource depletion or by a shift of motivation and attention, heart rate (HR), pre-ejection period (PEP) and heart rate variability (HRV) were used as indices of cardiovascular reactivity. The measure of physiological activity related to mental effort is necessary to interpret the decrease in performance on a subsequent task.

Forty-eight students from the University of Toulouse, France, were volunteered to participate. Participants were randomly assigned to one of the three conditions: Depleting (A), control (B) or continuous (C) condition.

Hypothesis

Considering the theoretical models described above and the methodology, the following hypotheses were made:

- **Hypothesis 1, Strength model:** Resources of participants should decrease in the depleting (A) and the continuous (C) conditions with more effort-related cardiovascular reactivity to slow-down the decrease of performance in the post 2-back condition. In the control condition (B), resources would be available and no behavioral and cardiovascular difference is expected.
- **Hypothesis 2, Process model:** We postulated that participants in depleting (A) and continuous condition (C) will have a decrease in performance with lower cardiovascular reactivity reflecting less mental effort investment in the post 2-back condition. Participants in control condition (B) with an attractive and low mental workload task (i.e.; viewing TED conferences) should be more motivated to invest effort on the subsequent task. Thus, we expected a stabilization or an increase in performance with higher cardiovascular reactivity.

Results

Note, that participants achieved a familiarization period (i.e.; 10 blocks of 30 trials) to limit future learning in the 2-back task. We observed a stabilization of the reaction time and success rate from block 8 and 3 respectively.

Regarding our results between pre and post 2-back task, performance resulted from a greater success rate and d' in control condition, worse success rate and d' in continuous condition, and no significant difference in depleting condition.

In addition, there were significant cardiovascular reactivity differences between pre and post 2-back task. Compared to the continuous condition which had lower cardiovascular reactivity related to mental effort on the subsequent 2-back task, depleting and control condition showed a greater cardiovascular reactivity. No other significant effect emerged.

Discussion, Conclusion

First, participants in depleting condition (A) showed a compensatory effort mobilization which explain by a greater mental effort investment (i.e., greater cardiovascular reactivity) on the subsequent 2-back task to stabilize performance. One possible interpretation is that participants in depleting condition (A) consume resources on the effortful central task which are subsequently unavailable (**hypothesis 1, strength model**).

Secondly, participants in continuous (C) condition had a similar performance-related decrease mental effort investment (i.e., lower cardiovascular reactivity) which suggest a motivational or attentional disengagement rather than resources consumption (**hypothesis 2, process model**).

Finally, participants in control condition (B) outperformed with a greater effort mobilization on the second 2-back task. One possible interpretation is that fifty minutes of attractive TEDs conferences videos allowed these participants to fully invest themselves in the subsequent 2-back task (**hypothesis 2, process model**).

Be that as it may, cardiovascular measures provided new information to explain decreases in subsequent task performance. Indeed, quantify resources mobilization through physiological measures highlighted what performance alone cannot. Note, that the sequential task paradigm generates motivational and attentional shifts who could explain the difficulty of replicating ego depletion effect. Futures research is needed to expand the understanding of the underlying physiological mechanisms during sequential task paradigm.