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Mental Workload Assessment During Performance of Structured and Unstructured Action Sequences Under Different Motor Demands

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Mental workload (MWL) describes the degree of neural resource engagement used to address both high-level cognitive and low-level sensorimotor processing demands. 'Chunking' involves consolidation of a set of stored elements, such as actions, into fewer clusters (i.e., 'chunks') to reduce working memory recruitment. Despite work in cognitive and motor domains, chunking is not well understood in the context of cognitive-motor tasks requiring high- and low-level processing to execute action sequences (e.g., cooking, mounting/repairing devices). Further, how high- and low-level interactions affect MWL is unclear. **Purpose:** Examine how low- and high-level processing interactions influence performance, MWL and fatigue in an industrial context when imitating action sequences with different demands on both processing levels. **Methods:** Twenty participants watched an action sequence (the reference sequence) video showing how to maintain industrial equipment by removing an object from a PVC pipe with a tool without touching the pipe (i.e., without a touch error). Participants were divided into two groups who had to extract a small (low motor demand; LMD) or large (high motor demand; HMD) object from the pipe. Both groups completed two conditions: an action sequence with an obvious logical order meant to facilitate chunking (structured condition ST) and one with no pattern (unstructured, UN) meant to limit participants' ability to use chunking, thus increasing working memory engagement. Performance was assessed with sequence completion time (SCT), number of touch errors (TE) and Levenshtein distance (LD), the latter based on comparing the reference sequence to the executed sequences. Surveys were used to assess MWL and mental and physical fatigue (MF, PF). For statistical analyses, all data were log transformed to an approximately normal distribution and subjected to a 2 Group (LMD, HMD) x 2 Sequence (ST, UN) repeated measures ANOVA. **Results:** A main Sequence effect was identified such that SCT (ST = 21.27 ± 5.78, UN = 28.42 ± 9.48), LD (ST = 0.37 ± 0.66, UN = 2.17 ± 2.49), MWL (ST = 19.18 ± 18.58, UN = 45.36 ± 27.6) and MF (ST = 13.21 ± 17.56, UN = 20.32 ± 18.82) were all significantly lower ($p < 0.05$) for the ST relative to UN sequences. Additionally, a main Group effect was revealed showing higher TE for HMD (0.39 ± 0.44) compared to LMD (0.09 ± 0.15) participants ($p < 0.05$). **Conclusion:** Results suggest that during task execution, level of motor demand did not affect sequence completion, MWL or fatigue, only touch errors. This suggests that the cognitive resource allocation system is robust enough to handle sequences with different degrees of cognitive challenge irrespective of the level of motor demand. **Significance:** This work can inform training and rehabilitation strategies and has implications for system design and human-machine interactions.

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