

DLR Workload Assessment Tool (DLR-WAT) – Official English Version

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Abstract

This article presents an official English translation of the "DLR - Workload Assessment Tool" (DLR-WAT), an originally German language questionnaire for subjective self-assessment of workload originally published in 2018. The DLR-WAT assesses deviations from a subjective optimum of workload more explicitly than existing measurement tools such as the NASA-TLX. The rationale behind the development of this tool is found in the increasing coexistence of humans and automation technology in sociotechnical systems across application domains such as transportation. Automation technology assists and takes over tasks formerly executed by humans as actors, resulting in changing human roles ranging for example from more passive monitoring tasks to short term interventions in cases of malfunction. In general, automation can relieve humans and increase their comfort. Yet, the issue of unbalanced workload and especially more prevalent underload needs to be targeted given the changing task environments faced by staff in the transportation domain. However, instruments for the subjective assessment of workload have so far lacked clear differentiation between underload and overload anchored in relation to a subjectively optimal level of workload. The DLR-WAT was developed to fill that gap, while greatly relying on the general format of the widely established NASA-TLX. The tool comprises a total of eight subscales. On six of the eight subscales (information acquisition, knowledge retrieval, decision-making, motor and physical demand, temporal demand, effort), the respondent can indicate his or her state of workload in relation to the personal optimum, which is located in the middle of each subscale. The two other subscales of the DLR-WAT (frustration, performance) are designed one-dimensionally, since an optimal level of frustration is characterised by the absence of frustration and the highest possible performance equals the theoretical optimum. The consideration of the personal optimum of workload in the first six subscales is thought to enable more detailed workload analyses distinctively imaging underload and overload in the areas represented by the subscales. In designing future transportation systems, this tool enables identification of the targeted balance between overload and underload across subscales and allows informed subsequent allocation of tasks between humans and automation accordingly.

Keywords

workload, cognitive ergonomics, workload assessment

Rationale, Administration and Scoring

The DLR-WAT (Grippenkoven, Rodd & Brandenburger, 2018) has been designed as an instrument to subjectively assess human workload, especially in human-machine systems with varying degrees of automation, both in the area of underload and overload on eight subscales. Through the introduction of a subjective optimum as a reference in the centre of each subscale it is thought to enable comparisons of different task configurations to identify optimal task characteristics corresponding to an optimal level of subjective workload. A multidimensional workload metric frequently administered in research

is the NASA Task Load (Staveland & Hart, 1988). Staveland & Hart (1988) assume that workload is influenced by effort, individual characteristics, abilities and skills that these factors affect several workload dimensions. In the German version of the NASA-TLX, workload is accordingly assessed on six independent scales: Mental demand, physical demand, temporal demand, effort, task accomplishment and frustration. The scales of the NASA-TLX are designed as a continuum from very low to very high demand, without specifically considering the possibility of an optimal level of demand or workload. This deficiency is addressed with the DLR-WAT as a further developed alternative to the NASA-TLX. The total of eight subscales used in the DLR-WAT are broadly correspond to the scales of the widely accepted NASA-TLX. Since the relevance of mental workload in relation to physical workload is increasing in modern digital work contexts, the first item of the NASA-TLX, mental demand, is split in the DLRWAT, based on the steps of human information processing (cf. Wickens & Hollands, 1999). Thus, the first item of the NASA-TLX, mental demand, is split into the three items information acquisition, knowledge retrieval and decision making. This allows for a more differentiated consideration of the components contributing to overall mental workload and a sequential differentiation of different steps of human information processing. It is assumed that the average of these three subscales can be used as the total value of mental workload, equalling the first scale of the NASA-TLX. In addition to the three items on mental workload, the DLR-WAT includes five further items: motor demand, temporal demand, effort, frustration and performance. The metric on which the DLR-WAT subscales are based ranges from 0 to 200, with a value of 100 indicating the centred subjective optimum of workload on the first six subscales. The value 0 stands for the greatest possible underload and the value 200 at the other end of the scale for the greatest possible overload. Thus, the deviation from the subjective optimum in the DLR-WAT is defined as a deviation from the value 100 in a range of values from 0 to 200. Participants can indicate their workload at any point of the continuous scale, analogous to the NASA-TLX. For the subscales Frustration and performance, no two-sided scaling was chosen for reasons of plausibility, since an optimal level of frustration is characterised by the absence of frustration and the highest possible performance equals the theoretical optimum. The range of values on the subscale frustration consists of values between 100 and 200, as the absence of frustration can be regarded as the optimum and is therefore assigned a value of 100 to ensure congruence in the meaning of the values across all eight subscales. For the same reason, the range of the last subscale, performance, contains values only from 0 to 100, since maximum performance is regarded as the optimal state and thus had to be operationalised by the value of 100. It can therefore be stated that across all subscales, the value 100 operationalises the optimal and deviations represent under- or overload. All subscales can either be added up to a total workload score or individually weighted and then summed to account for individual research foci.

References

- Gripenkoven, J., Rodd, J., & Brandenburger, N. (2018). DLR-WAT: Ein Instrument zur Untersuchung des optimalen Beanspruchungsniveaus in hochautomatisierten Mensch-Maschine-Systemen. In *AAET- Automatisiertes & vernetztes Fahren*. ITS Automotive Nord.
- Staveland, L., & Hart, S. (1988). Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. *Advances in Psychology*, 52, 139-183.
- Wickens, C. D., & Hollands, J. G. (1999). *Engineering Psychology and Human Performance* (Third Edition). Upper Saddle River, New Jersey: Prentice Hall.

DLR-WAT Instrument

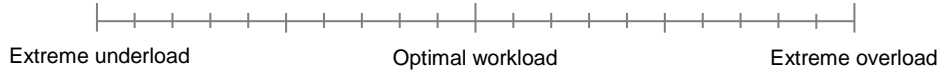
Participant: _____

Workload Assessment Technique (DLR-WAT)

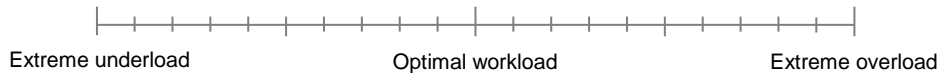
Date: _____

Please assess your workload due to the current task regarding the following criteria. The center of each scale represents your personal workload optimum. You can place your mark anywhere on the horizontal line of the scale, using the existing tick marks as an orientation.

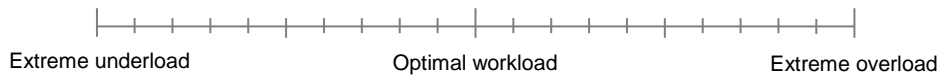
Information acquisition: How much workload did you experience due to the search for and perception of external information during the task? (Was your workload regarding information sampling in the range of underload, in an optimal range or in the range of overload?)



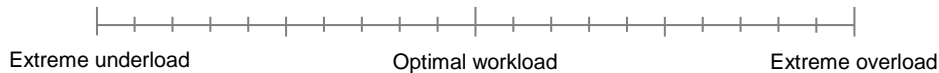
Knowledge retrieval: How much workload did you experience due to the retrieval of relevant knowledge from memory during the task? (Was your workload regarding knowledge retrieval in the range of underload, in an optimal range or in the range of overload?)



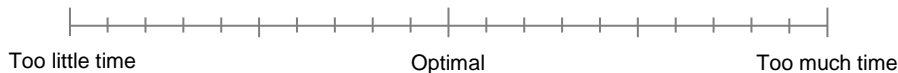
Decision making: How much workload did you experience due to decision making and response selection during the task? (Was your workload regarding decision making in the range of underload, in an optimal range or in the range of overload?)



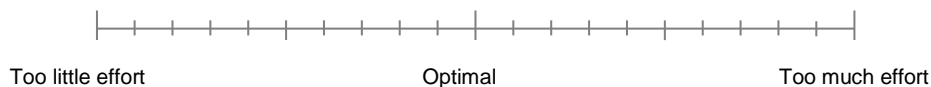
Motor and physical demand: How much workload did you experience due to necessary motor skills and physical strain during the task? (Was your motor and physical workload in the range of underload, in an optimal range or in the range of overload?)



Temporal demand: How much workload did you experience due to the temporal demand during the task? (Was your temporal demand in the range of too little time, optimal range or in the range of too much time?)



Effort: How much effort did you have to invest (mentally and physically) to perform in the overall task? (Did you feel the effort you had to put in was too little, optimal, or too much?)



Next, please rate your frustration and performance during the task.
Please note: A deviation of your personal optimum is only possible in one direction for the following scales.

Frustration: How frustrated did you feel while working on the task? (Please indicate the level of your frustration on the scale from "not frustrated (optimal)" to "extremely frustrated".)



Performance: How would you rate your performance in the overall task? (Please indicate your performance on the scale from "very poor" to "very good (optimal)".)

