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Supplementary material to

HUMAN-BASED DYNAMICS OF MENTAL WORKLOAD IN COMPLICATED SYSTEMS

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Supplementary Table 1: A sample table of characteristics of included studies

Reference	Reference type	Study design	Method of data collection	Instrument	Field	Setting	Analytical method	Variables and key results	Quality rating
Luque-Casado et al., 2016	Biological Psychology	Experiment: measure development	Twenty-four males undergraduate students	Heart rate variability (HRV) and NASA-TLX	Execution condition including the psychomotor vigilance task, a working memory task and a duration discrimination task	Computerized simulation	ANOVA and correlation	HRV varied as a function of task demands. A significant decrement in HRV as a function of time-on-task. The NASA-TLX varied as a function of cognitive workload.	**Good**
Fallahi et al., 2016	Applied Ergonomics	Experiment and a cross-sectional study: occupational health	Physiological signals (ECG, EMG) were recorded and the NASA-Task Load Index (TLX) was administered for 16 operators.	NASA-TLX, ECG and EMG	Traffic density monitoring	Real	ANOVA, Bonferroni multiple comparison, Greenhouse-Geisser correction	The findings indicated that increasing traffic congestion had a significant effect on HR, RMSSD, SDNN, LF/HF ratio, and EMG amplitude.	**Good**
Charbonnier et al., 2016	Expert Systems with Applications	Experiment: measure development	15 subjects performed a tedious but mentally demanding task on a computer during 90 min.	Karolinska Sleepiness Scale and EEG, EOG	Memory tasks	Computerized simulation	Signal analysis: time–frequency analysis	The index based on the alpha band is well correlated with an ocular index that measures external signs of mental fatigue over long periods of time.	**Good**

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Supplementary Table 2: The main and sub-factors (evidences) of mental workload, along with cited studies

Factor	Sub-factor (evidence)	Number of citations
Task demand and job characteristics	Task complexity	**15**
	Task difficulty	**9**
	Time constraint	**7**
	Speed	**2**
	Shift work	**2**
	Multitasking	**1**
	New technology	**1**
External and environmental stress	Heat stress	**6**
	Noise	**4**
	Air quality	**1**
	Lighting	**1**
	Hygienic conditions	**1**
Individual capabilities and characteristics	Mental and subjective capacity	**196**
	Autonomic sympathetic and parasympathetic response	**156**
	Cardiovascular capacity	**140**
	Mental response (brain activity)	**127**
	Cognitive ability and psychomotor performance	**66**
	Mental health, feeling and disorder	**27**
	Demographic characteristics	**6**

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Supplementary Table 3: Equation of some variables with inputs and initial value

Mental Workload (Level) = INTEG (Mental Workload Rate-Mental Workload Modification, 0)
Mental Fatigue (Level) = INTEG (Mental Workload-Mental Workload Modification, 0)
Resource Supply (Level) = INTEG (Resource Recovery Rate-Resource Consumption Rate, 100)
Psycho-physiological Response (Auxiliary) = WITH LOOKUP (Mental Workload*Individual Characteristics) ([(0,0)-(200,180)], (0,65), (27.5229, 93.1579), (110.092, 131.842), (195.719, 142.105), (199.388, 143.684))
Performance Pressure (Auxiliary) = ABS (100-Task Performance)
Task Performance (Auxiliary) = (Resource Supply*Productivity Ratio)
Mental Workload Rate (Auxiliary) = ABS (Task Demand*2*((External Stress + Performance Pressure + Time Constraint)/300))
Mental Workload Modification (Auxiliary) = (Mental Workload*Mental Workload Modification Index)
Individual Characteristics (Constant) = 1
Resource Recovery Rate (Auxiliary) = WITH LOOKUP (Psycho-physiological Response*Resource Recovery Index) ([(0,0)-(180,1)], (65,0), (93.0275, 0.109649), (103.486, 0.153509), (108.44, 0.179825), (113.945, 0.214912), (129.908, 0.337719), (153.578, 0.872807), (160.183, 0.929825), (172.844, 0.960526), (179.45, 0.960526))
Resource Consumption Rate (Auxiliary) = WITH LOOKUP (Psycho-physiological Response*Resource Consumption Index) ([(0,0)-(180,1)], (65,0), (75.9633, 0.254386), (89.1743, 0.508772), (112.844, 0.754386), (137.064, 0.903509), (162.385, 0.973684), (179.45, 0.986842))

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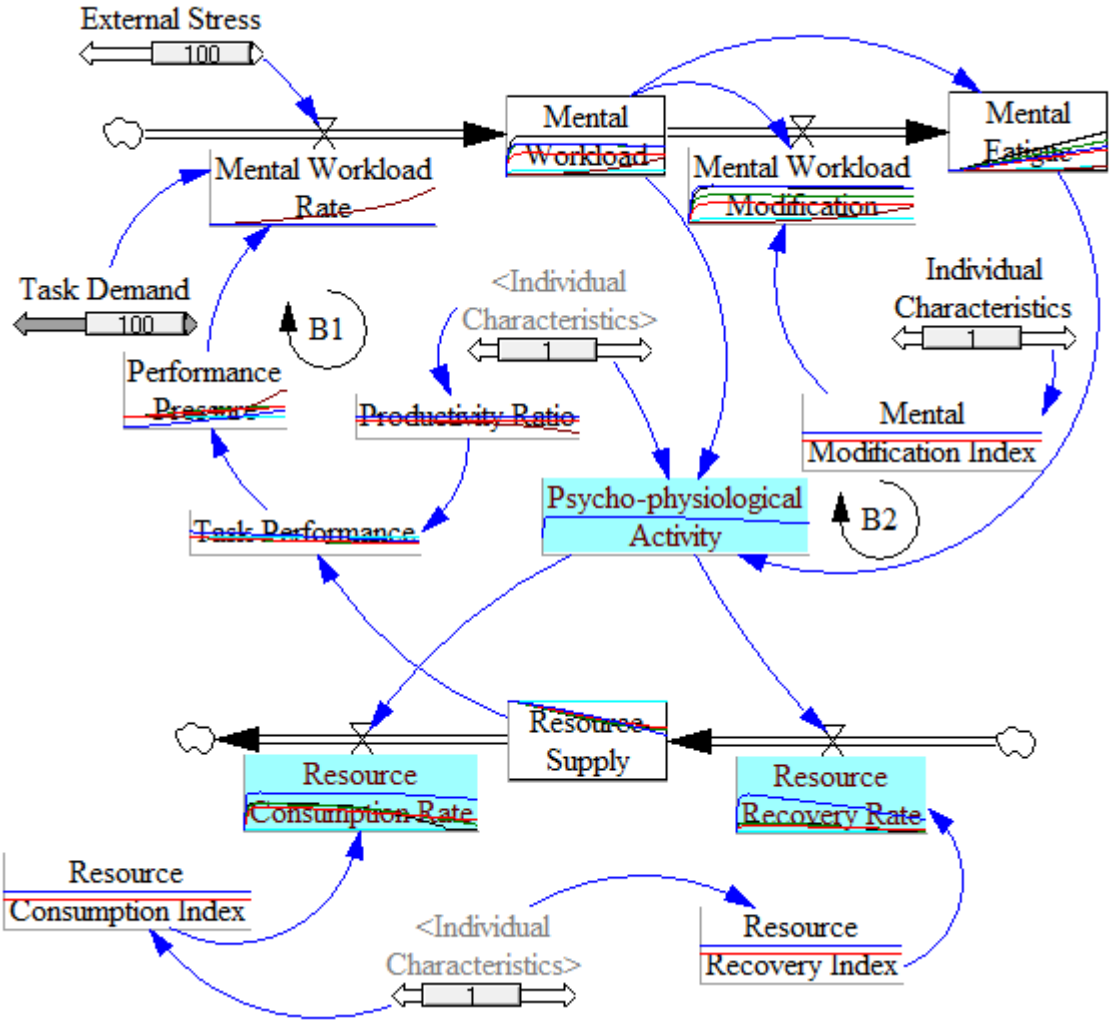

Supplementary Figure 1: Vensim software runs under different conditions on various variables in the human-based archetype of mental workload

REFERENCES

Charbonnier S, Roy RN, Bonnet S, Campagne A. EEG index for control operators' mental fatigue monitoring using interactions between brain regions. Exp Syst Applic. 2016;52:91-8.

Fallahi M, Motamedzade M, Heidarimoghadam R, Soltanian AR, Miyake S. Effects of mental workload on physiological and subjective responses during traffic density monitoring: A field study. Appl Ergon. 2016;52:95-103.

Luque-Casado A, Perales JC, Cárdenas D, Sanabria D. Heart rate variability and cognitive processing: The autonomic response to task demands. Biol Psychol. 2016; 113:83-90.