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How Does Mental Workload Influence the Adoption of Clinical Information Systems: An Exploratory Study

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Abstract. Mental workload and technology acceptance are relevant factors that relate to use behavior and performance. Studies show a potential moderating effect of mental workload on predictors of technology acceptance. Aim of this study was the investigation of predictors of technology acceptance (UTAUT) related to clinical information systems and their relation to mental workload. This quasi-experimental study with 48 participants used the following measures: NASA TLX and UTAUT questionnaire. Participants had to perform three tasks on a clinical information system as well as four task-levels of the n-back task with increasing difficulty. Analyses show a high level of technology acceptance (M=3.82, SD=.76) and confirm performance expectancy as the most relevant predictor of behavioral intention (β=.48, p<.001). A linear regression showed that a high level of mental workload has an influence on performance expectancy (F1,46=8.438, p<.05). The study shows an influence of mental workload on acceptance, the strength and role of which (e.g. moderation) needs to be further investigated, especially in the context of other determinants.

Keywords. Mental Workload, UTAUT, Technology Acceptance, Clinical Information Systems

1. Introduction

1.1. Background

In recent years, the mental workload (MWL) of employees in the healthcare sector has increased significantly [1]. MWL is a multimodal, multidimensional, and complex concept that describes the relationship between a person's available and therefore limited resources and the demands of a task [2]. One method to measure MWL reliably and validly is the NASA TLX [3]. The level of MWL has an influence on different areas of professional life and is a key factor when it comes to adoption of Clinical Information Systems. MWL affects general performance parameters such as decision-making behavior [4], performance [5], occupational parameters such as job stress or job satisfaction, or even mental health (increase in depression, burnout, etc.) [7]. MWL also

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affects people who interact with technology in their daily work, which places high cognitive demands on users. The negative correlation between MWL and performance is one example of such an effect.

Beside high workloads that influence the use of and satisfaction with digital health technologies i.e. clinical information systems, the adoption of health information technology plays an important role in the efficient use of these systems [8].

One approach to investigate the adoption of healthcare technologies is the unified theory of acceptance and use of technology (UTAUT) [9]. The predictors of behavioral intention to use a technology (BI), used as a measure of acceptance, are performance expectancy (PE), effort expectancy (EE), social influence (SI) and facilitating conditions (FC) [9]. Brown identified different antecedents of EE and PE that relate to tasks and personal factors [10]. Identified antecedents include technostress as well as MWL [11,12]. Dang assumes that: an increased workload leads to a low perceived level of task performance and therefore to a low level of PE and EE when using social media search systems [12].

1.2. Aim/ Hypotheses

The aim of this explorative study was to investigate the relationship of MWL and predictors of technology acceptance/BI in context of clinical information systems
Hypotheses:

- PE, EE, FC, SI predict BI in context of using clinical information systems
- The level of MWL influences the PE/EE/BI

2. Methods

2.1. Participants

All participants were recruited from Social Media (LinkedIn) primarily at the Faculty of Health Care of the Niederrhein University of Applied Sciences. Inclusion criteria were: Aged between 18-70 years, experience in a healthcare profession or studying a healthcare related subject (e. g. nursing). The study was performed in accordance with the ethical standards laid down in the Declaration of Helsinki and approved by the ethics committee of the RWTH Aachen University (Vote-No: EK 138/21, chairman: Prof. Dr. Schmalzing). Prior to the start of the study, informed consent was obtained from each participant.

2.2. Material

A diagnostic screen, mouse and keyboard were placed on a table. The experiment consisted of two different task paradigms and three different questionnaires. The entire experimental procedure was controlled with a self-developed program in a lab [13].

The n-back-task: During the n-back task [14] the participants are shown letters on a screen and then have to decide according to a given rule whether the letter is a target or a distractor. Relating to the level of the n-back task, participants have to decide if the stimulus (letter) matches a stimulus (letter) n-trials before [15]. For the n-back task of level 1 (n=1-back task), for example, the target would be the identical letter to the previously displayed letter. The participants should respond to these targets as quickly

as possible by pressing j (for target) or k (for distractor) on the keyboard. The rule (f. ex. n=1 back) is kept constant during one segment of the experiment. By increasing n in the n-back task, we increased the difficulty of the task in subsequent segments.

Tasks performed on the PACS: The participants had to perform three tasks with increasing difficulty on a picture archiving and communication system (PACS) (©Visus) [16]. The difficulty levels were validated by three external experts (physicians, medical informatics specialists).

- Level 1: Accessing patient data (date of birth, study date) and making entries
- Level 2: Determining preliminary findings and interpreting results
- Level 3: Screening these findings and measuring an abnormality

Questionnaires: Participants were asked to answer the Raw NASA TLX [17], an adapted UTAUT questionnaire [18], and demographic questions referring to their age, qualification and job as well as their previous experience in clinical information systems/JiveX. The raw NASA TLX provides a valid measurement of the overall workload of a task and more efficient version as the original NASA TLX [19] and consists of six predefined dimensions [20,21]. Three of them measure demands (mental, physical, temporal demands), the other three measure the way a participant deals with a task (self-rated performance, effort, frustration level). Since our task did not involve physical demands, we excluded this dimension. We further used a modified version of the UTAUT questionnaire to assess overall acceptance [18] that includes PE, EE, SI and FC as predictors of BI. The questionnaire consists of 18 items rated on a 5-point Likert scale from “do not agree at all” to “fully agree”.

2.3. Experimental Design and Procedure

The experimental design and procedure are displayed in figure 1.

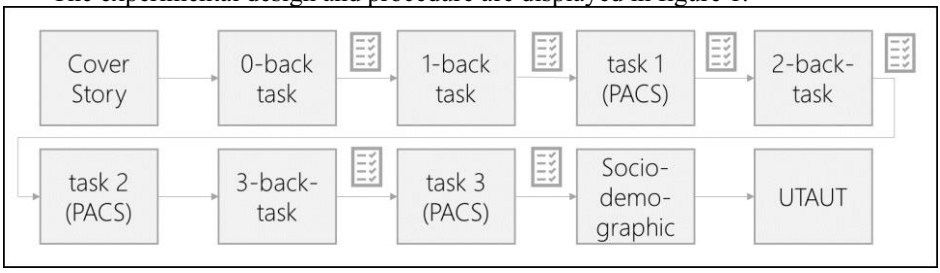

Figure 1. The experimental design should lead to an increasing workload level of the participants variated by different factors (n-back task and tasks performed on the system alternated). Each task was followed by the NASA-TLX ( ). Acceptance and sociodemographics were surveyed at the end of the implementation.

2.4. Data Analytics/Statistical Analyses

The data analysis was completed using SPSS version 27 (IBM Analytics). We processed a stepwise hierarchical regression analysis to assess the predictors of acceptance and linear regressions to assess the relationship of MWL and predictors of acceptance.

3. Results

3.1. Sample

A total of 48 subjects (66.6% female) with a mean age of 31.13 (SD 11.7) participated in the study. 11 had completed training in a health-related profession, 13 in a related field and 20 were students in health-related studies.

3.2. Reliability Analyses and Technology Acceptance of the PACS and relationship between MWL and UTAUT

The internal consistency of the subscales is listed in the following: PE (.901), EE (.791), FC (.652), SI (.921), BI (.802), NASATLX (.774 -.864). Therefore, internal consistency is acceptable to satisfying for all subscales except for the subscale of SI.

Acceptance of using clinical information systems was high (M=3.82, SD=.76, range 1-5 4, 1-5) [22]. Preliminary correlational analysis showed the highest correlations with acceptance for PE (r=.427, p<.001), SI (r=.410, p<.001), FC (r=. 411, p<.001). A significant hierarchical stepwise regression model included only 1 of 3 eligible variables ($F_{1,46}$=15.929, p<.001). There was no sign of severe multicollinearity. Only PE remained significant (β=.48, p<.001) as a predictor of BI. The explained variance was 24.1%.

For the analyses of the relationship and predictors of MWL, we proceeded with preliminary correlational analyses. There was a significant negative correlation between EE (r=-.307, p<.001), PE (r=-.319, p<.001) and high scores of the NASA TLX from tasks performed at the clinical information system.

There was a significant correlation between PE (r=.394, p<.001), SI (r=.353, p<.05) and high scores of the NASA TLX of the n-back task. A linear regression showed that a high level of MWL has an influence on PE ($F_{1,46}$=8.438, p<.05).

4. Discussion

Our study identified PE as the most relevant predictor of BI, which is in line with other findings [18]. We also identified preliminary evidence for the role of mental workload in the relationship of predictors and acceptance itself.

The individual calculations show that the studied factors have a relevant influence. Unfortunately, the sample is too small to investigate the influence of the various determinants in a multidimensional regression model.

5. Conclusions

The study shows an influence of mental workload on acceptance, the strength and role of which (e.g. moderation) needs to be further investigated, especially in the context of other determinants.

References

1. Körber M, Schmid K, Drexler H, Kiesel J. Subjective Workload, Job Satisfaction, and Work-Life-Balance of Physicians and Nurses in a Municipal Hospital in a Rural Area Compared to an Urban University Hospital. [Subjective Workload, Job Satisfaction, and Work-Life-Balance of Physicians and Nurses in a Municipal Hospital in a Rural Area Compared to an Urban University Hospital]. Gesundheitswesen 2018;80(5):444-452. PMID:28201830
2. Wickens CD. Multiple resources and mental workload. Hum Factors 2008;50(3):449-455. PMID:18689052
3. Le Hart SG S. Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. Advances in psychology 1988(52):139-183.
4. Soria-Oliver M, López JS, Torrano F. Relations between mental workload and decision-making in an organizational setting. Psicol Reflex Crit 2017;30(1):7. PMID:32026983
5. Hancock PA, Matthews G. Workload and Performance: Associations, Insensitivities, and Dissociations. Hum Factors 2019;61(3):374-392. PMID:30521400
6. Pourteimour S, Yaghmaei S, Babamohamadi H. The relationship between mental workload and job performance among Iranian nurses providing care to COVID-19 patients: A cross-sectional study. J Nurs Manag 2021;29(6):1723-1732. PMID:33690932
7. Akca M, Küçükoğlu MT. Relationships Between Mental Workload, Burnout, and Job Performance. In: Chandan H, Realyvásquez-Vargas A, Arredondo-Soto KC, Hernández-Escobedo G, González-Reséndiz J, editors. Evaluating Mental Workload for Improved Workplace Performance: IGI Global; 2020. ISBN:9781799810520. p. 49–68.
8. Momani AM, Jamous MM, Hilles SMS. Technology Acceptance Theories. International Journal of Cyber Behavior, Psychology and Learning 2017;7(2):1-14. doi:10.4018/IJCBPL.2017040101
9. Venkatesh, Morris, Davis. User Acceptance of Information Technology: Toward a Unified View. MIS Quarterly 2003;27(3):425. doi:10.2307/30036540
10. Brown SA, Dennis AR, Venkatesh V. Predicting Collaboration Technology Use: Integrating Technology Adoption and Collaboration Research. Journal of Management Information Systems 2010;27(2):9-54. doi:10.2753/MIS0742-1222270201
11. Abd Aziz NN, Aziz MA, Abd Rahman NAS. The mediating effects of student satisfaction on technostress–performance expectancy relationship in university students. JARHE 2022. doi:10.1108/JARHE-03-2021-0117
12. Dang Y, Zhang Y, Brown SA, Chen H. Examining the impacts of mental workload and task-technology fit on user acceptance of the social media search system. Inf Syst Front 2020;22(3):697-718. doi:10.1007/s10796-018-9879-y
13. lab.js: A free, open, online experiment builder: Zenodo; 2021.
14. Kirchner WK. Age differences in short-term retention of rapidly changing informaion. Journal of Experimental Psychology 1958(55).
15. Herff C, Heger D, Fortmann O, Hennrich J, Putze F, Schultz T. Mental workload during n-back task-quantified in the prefrontal cortex using fNIRS. Front Hum Neurosci 2013;7:935. PMID:24474913
16. Visus (2017). JiveX.
17. Said S, Gozdzik M, Roche TR, Braun J, Rössler J, Kaserer A, Spahn DR, Nöthiger CB, Tscholl DW. Validation of the Raw National Aeronautics and Space Administration Task Load Index (NASA-TLX) Questionnaire to Assess Perceived Workload in Patient Monitoring Tasks: Pooled Analysis Study Using Mixed Models. J Med Internet Res 2020;22(9):e19472. PMID:32780712
18. Breil B, Salewski C, Apolinário-Hagen J. Comparing the Acceptance of Mobile Hypertension Apps for Disease Management Among Patients Versus Clinical Use Among Physicians: Cross-sectional Survey. JMIR Cardio 2022;6(1):e31617. PMID:34989683
19. Hendy KC, Hamilton KM, Landry LN. Measuring Subjective Workload: When is one scale better than many? Human Factors: The Journal of the Human Factors and Ergenomics Society 1993;35(4):579-601.
20. Hart SG. Nasa-Task Load Index (NASA-TLX); 20 Years Later. Proceedings of the Human Factors and Ergonomics Society Annual Meeting 2006;50(9):904-908. doi:10.1177/154193120605000909
21. Grier RA. How High is High? A Meta-Analysis of NASA-TLX Global Workload Scores. Proceedings of the Human Factors and Ergonomics Society Annual Meeting 2015;59(1):1727-1731. doi:10.1177/1541931215591373
22. Hennemann S, Beutel ME, Zwerenz R. Drivers and Barriers to Acceptance of Web-Based Aftercare of Patients in Inpatient Routine Care: A Cross-Sectional Survey. J Med Internet Res 2016;18(12):e337. PMID:28011445