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Work Performance Measurement of Data Entry Employees in E-Commerce Industry Based on Mental Workload Value

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Abstract - This research aimed to measure the mental workload of data entry processing tasks in the e-commerce industry based on mental workload value. It was to determine the factors influencing mental workload mainly induced by the data entry process. The experiments without work instruction and with two types of work instruction were conducted to diagnose the mental workload. The measurement of the initial mental workload condition of data entry employees was conducted in the laboratory. Then, the Electroencephalogram (EEG) measurement using sensors from Emotiv was performed every 30 minutes, and the data of EEG measurements (focus, engagement, and stress) were collected using the laptop. Meanwhile, pulse measurement (heart rate) was measured before and after the work. Raw National Aeronautics and Space Administration Task Load Index (NASA-TLX) and reaction time measurement were conducted after the work. Through these experiments, the researchers identify that mental effort and fatigue are the significant determinants of mental workload value in the data entry process of the e-commerce industry. In respect of the results of work performance analysis, it is recommended that the placement of work instruction should be near the employee. Then, the task demand (minimum completion target) should be adjusted according to each employee's capacity.

Keywords: work performance, e-commerce, mental workload value

I. INTRODUCTION

In this vast development of the e-commerce industry by understanding the benefits and opportunities, companies, traders, and individuals are so eager to be involved in online trading since the Industry 4.0. Furthermore, e-commerce in Indonesia needs to establish a strategic action plan to take advantage of opportunities of demographic bonus, improve middle income, and broaden the scope of business (Aribawa, 2016). The Ministry of Industry of the Republic of Indonesia has developed infrastructures to support the economic activities in digital systems such as e-commerce business. It anticipates the needs and development of market trends. E-commerce for Small Medium Enterprise (SMEs) is also developed so that it will be applied in many sectors in Indonesia (Julisar & Miranda, 2013). Nevertheless, it is still important to improve the quality of the workforce as well. Thus, it can meet the technological advancement and achieve the efficient and effective mechanism of e-commerce business process.

Based on a recent study by Borghouts, Brumby, and Cox (2017), data entry is one of the main activities conducted by office workers on a daily basis, with the assumption of eight working hours a day. The data entry task is very important for several companies because it is a relatively straightforward task. The errors and the consequences can range from mildly annoying to very severe (Borghouts, Soboczenski, Cairns, & Brumby, 2015), by requiring additional information (Wiseman, Borghouts, Grgic, Brumby, & Cox, 2015) or using alternative input technology affecting the data entry processing (Oladimeji, Thimbleby, & Cox, 2011). The researchers confirm this by using several previous research statements that the data entry task is very suitable and chosen to develop in this study. Then, acknowledging this long working hour of data entry activity in an e-commerce company, the researcher recognizes the high risk of error during the process. The errors in data entry will affect the data quality with common errors such as cognitive-related mistakes (Barchard & Verenikina, 2013). Works involving computers affect the mental activity or health of the workers. It can result in the risk of mental fatigue in the workplace experienced by the workers (Cheng, Lee, Shu, & Hsu, 2007). Thus, it is assumed that there is a cognitive factor that may induce the (mental) stress in the workplace.

This research is based on the pre-interview results with four workers. They have many years of experience as an office worker in conducting data entry in an e-commerce company. With this interview results, the researcher obtains several factors inducing stress. Those are deadlines, the high amount of data, workplace noises, and verbal work instructions which are not allowed to be written down. Thus, stress due to work is a consequence of high work pressure that may impact workers physically (an increase of heart rate), psychically (frustration and anxiety), and behaviorally (errors in activity). These will negatively affect the work performance causing the gap between the realtime output of articles completed by the worker and the expected output. There are varieties of sources of labor stress. One is the individual's mental workload condition (Nachreiner, 1999).

The researchers also find several studies that prove there are correlations between workers' cognitive condition, their physical condition, and their performance (Mehta, 2016; Hollnagel, 1997). Thus, the measurement of mental workload is essential to measure the task demand of the workers in their activity and to predict the driving performance and the impact on the physical health of workers (Cain, 2007). However, the measurement of mental workload cannot be done directly (Matthews, Reinerman-Jones, Barber, & Abich, 2015).

The proper criterion to improve work performance is the mental effort of the employee during work. Some researchers state that the higher the employee's mental effort is, the more achievable the desired/expected work performance is (Brouwer, Hogervorst, Holewijn, & Van Erp, 2014). The high mental effort is associated with high mental workload (Hogervorst, Brouwer, & Van Erp, 2014). Thus, the work performance is closely related to mental workload.

Furthermore, for measuring mental workload, there are three important key categories. Those are subjective measurement, performance results, and psychophysiological measurements (Galy, Cariou, & Mélan, 2012). In this study, the researchers will accommodate all of the categories.

In this research, the researchers apply four methods to measure the mental workload, including Electroencephalogram (EEG), Heart Rate (HR), raw National Aeronautics and Space Administration Task Load Index (NASA-TLX), and reaction time. Moreover, there are two methods to measure the work performance, including error counts and completed articles after certain treatments are applied. Previous researchers have demonstrated that EEG signals are sensitive to cognitive (Knoll, Wang, Chen, Xu, Ruiz, Epps, & Zarjam, 2011). The load changes in various tasks in the EEG signal are confirmed to be related to mental workload measurement (Berka *et al*., 2007). The signal is well measured using affordable brain-sensing technology, Emotiv (Mcmahan, Parberry, & Parsons, 2015). The continuous (spontaneous) EEG signal is composed of oscillations in various frequencies. Those are assumed to reflect information representation and transfer within and across neuronal assemblies (Klimesch, Schack, & Sauseng, 2005).

The main aim of this research is to measure the mental workload of data entry processing tasks in the e-commerce industry based on mental workload value by testing several hyphoteses. There are mental fatigue on mental workload, mental effort on mental workload, mental workload on physical workload, mental workload on work performance, noise level on work performance, task demand on work performance, task difficulty on work performance, interaction of three factors on work performance, and work instruction on work performance. It is also to improve their performance by finding the factors affecting work performance.

II. METHODS

As a scientific justification for the participation selection, the researcher selects four undergraduate students to become the participants in this research. Their age is between 20-23 years. They must fulfill several criteria. They do not have any hearing and vision problems, and they have experience in working as a data entry employee in an e-commerce company for at least 1 to 2 years. For standard equipment to do the task, the researcher provides computers for all subjects. The computers' specification is a 17-inch LCD monitor, standard keyboard, a standard two-button mouse with a scroll button, CPU Intel Core i5 with 4 GB of RAM, and Windows 7 OS with Microsoft Office 2003 installed.

This research is conducted in Industrial Engineering Laboratory at Krida Wacana Christian University. The measurement of the initial mental workload condition of data entry employees is conducted in this laboratory. The environment and working conditions are set like the real working environment for doing the task. Furthermore, the simulation includes the various noise level produced by co-worker's chatter and similar articles (products or apparatus of industrial equipment). It is related to the real e-commerce industry to provide real difficulties as close as possible. All subjects are assigned to complete at least 30 articles (a term in the e-commerce industry; product data/specification) out of 50 sets in 2 hours. During two hours of working (experiments), the EEG measurement using sensors from Emotiv (Figure 1) is performed in every 30 minutes. The data of measurements (focus, engagement, and stress) are collected using a laptop with a Bluetooth connection. Meanwhile, the pulse measurement (heart rate) is measured before and after the work. Raw NASA-TLX measurement and reaction time measurement are conducted after the work because it relies on a multidimensional construct. It is to derive an overall workload score based on a weighted average of ratings on six subscales. Those are mental demand, physical demand, temporal demand, performance, effort, and frustration level. Particularly, the reaction time measurement is repeated 20 times. The results from these measurements are the initial value of work performance, mental workload, and the factors affecting mental workload value.

The experiment for system improvement is performed after obtaining the initial value of mental workload. Before the experiment is conducted, the subjects are required to meet the following prerequisites. The subjects are medically not having any vision or hearing impairment, and they are not taking any drugs/treatments in the last 24 hours (Mercado, Reinerman-Jones, Barber, & Leis, 2014). All these requirements are essential to prevent any intervention in neuron signal capture during psychophysiology measurements using the EEG device.

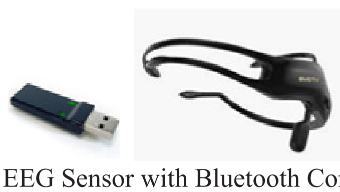

Figure 1 EEG Sensor with Bluetooth Connection

The subjects are assigned to input the articles into a Microsoft Excel file. It is designed similarly on how employees in the e-commerce company upload the data to the website. There are ten columns to be filled. Those are brand, name, short_desc, specification, netto_weight, dimension_length, dimension_width, dimension_height, dimension_unit, and volume_unit. The subjects are required to conduct this experiment for two hours with several treatment variables. First, the working environment with 82-87 dB represents a low level of noise, and 102-107 dB is a high level of noise. Second, the task is to complete at least 5 or 10 articles (as task demand). Third, task difficulty is represented by brochures with complete information (low difficulty) and incomplete information in which the subjects need to search the information using the Internet (high difficulty).

Each session is conducted for 15 minutes. It is with three times replication and two different types of work instructions. The temperature of the room is between 25-280C with adequate light provision. The examples of work instruction treatment of this experiment are shown in Figures 2 and 3 using the EEG measurement sensor.

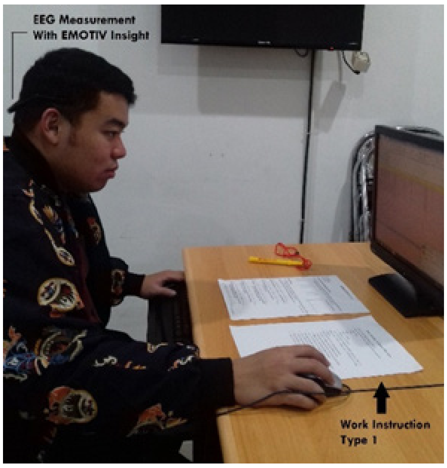

Figure 2 Experiment of Work Instruction Type 1

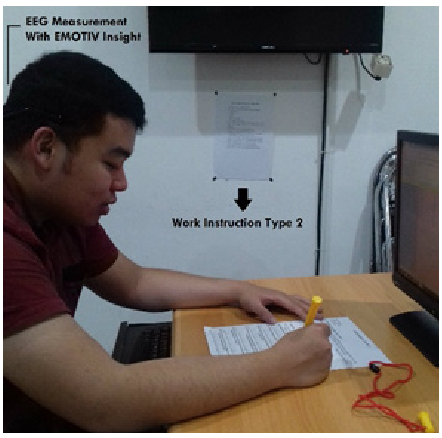

Figure 3 Experiment of Work Instruction Type 2

As seen in Figure 2, the work instruction is provided beside the subject's hand (on the table). Meanwhile, Figure 3 shows that the instruction is on the wall in the middle of the working room. Next, the dimension of the working table is 70 cm x 74 cm x 75 cm, while the working chair is 62 cm x 61 cm x 95 cm. After the experiment is performed, the researcher obtains the end value of work performance, mental workload measurement, and the factors affecting work performance. Thus, the research workflow diagram is presented in Figure 4.

III. RESULTS AND DISCUSSIONS

Based on the subjects' work performance in the initial condition, the researcher proposes that there is a significant interdependence between work performance and mental workload value. Free variables used are derived from the value of the effort (EF) dimension of the NASA-TLX questionnaire. It mentions that the cognitive variance affecting work performance is a mental effort (Mercado *et al.*, 2014). From the measurement, the results of raw NASA-TLX is between 68-74, Cardiovascular Load (CVL) is between 33-50%, and reaction time measurement is between 372-429. The researcher also measures EEG data. The average measurement data of focus is 46%, the engagement is 70%, and stress is 51%, as shown in Table 1. Based on this result, the subjects are ready to do the experiments.

Table 1 The Results of Mental Workload Value in Initial Condition

Measurement Method	**Results**
Raw NASA-TLX	68-74
CVL (%)	33-50%
Reaction Time	372-429 milisec
Average EEG Data	
Focus	46%
Engagement	70%
Stress	51%

In the initial condition of the data entry process, the researchers find a significant influence of physical workload on mental workload value. The results of pulse measurement using EEG reveal that mental fatigue and mental effort are significantly correlated to the heart rate. It represents mental workload ($F = 5{,}719, 7{,}037$; $p < 0{,}05$). This finding reinforces the results of subjective measurement conducted by the subjects. It finds that mental effort and mental fatigue significantly affect the mental workload.

Next, this research analyzes that task demand is the sole factor. It is significantly affecting the work performance as noise level (NL), task difficulty (TDif), task demand (TDem), and their correlations (see Table 2) in both different work instruction conditions. In this research, the researcher does not gather much evidence to prove the significance of noise level towards the data entry process. After doing the experiments, this study obtains that there is also no interaction between noise level, task demand, and task difficulty that affect work performance. It is due to the tendency of linear data patterns in the result. Thus, the significant factor affecting the data entry process can be explained by several statistical tests. The researcher conducts the paired t-test to identify the influence of different work instruction treatments on work performance. The researcher obtains the result, as shown in Table 3. The Mean is 1,177,

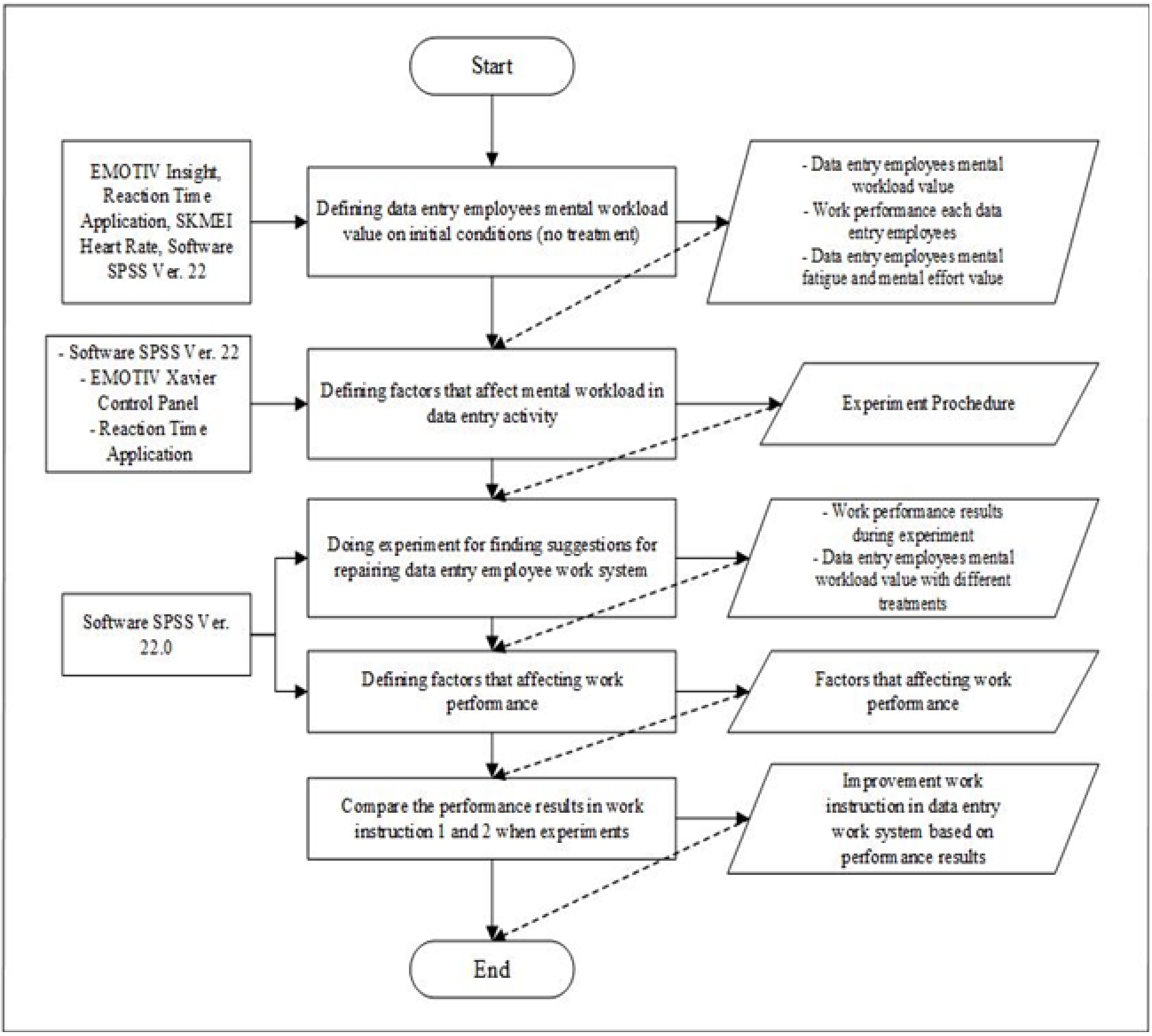

Figure 4 Flow Diagram of the Research

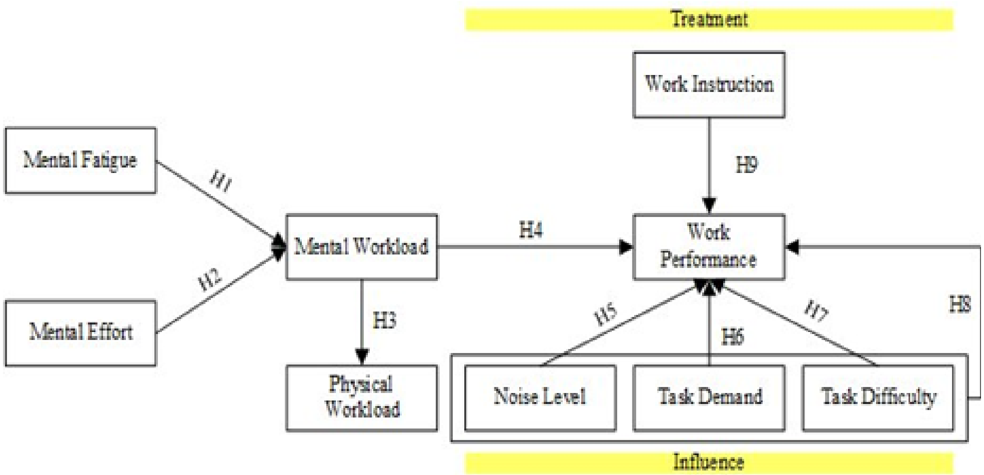

Figure 5 Theoretical Research Framework

S.Dev is 2,72, Standard Error Mean is 0,278, and the 95% confidence interval of the difference for lower and upper are 0,626 and 1,729 consecutively. The result of the paired test in Table 3 shows that the influence of different work instruction is affecting work performance.

The researcher conducts the discussion by analyzing the tests, experiments, and measurements. After doing all the steps, the researcher shows the initial condition of the mental workload of the data entry process. In this initial condition, the mental fatigue and mental effort notably determine the value of mental workload. This result is in accordance with the results of Käthner, Wriessnegger, Müller-Putz, Kübler, and Halder (2014).

Moreover, these results show that the mental workload experienced by the subjects also affects the physical workload as expressed in Mazloum, Kumashiro, Izumi, and Higuchi (2008). They agreed that mental workload was an influence on the individual's physic and psychophysiology. Ultimately, the mental workload experienced by the subject remarkably determines work performance. Therefore, the results also support the argument of Young, Brookhuis, Wickens, and Hancock (2015). The purpose of studying the mental workload of the employee is to understand its association with the employee's work performance. The treatment (work instruction) and the influence (noise level, task demand, and task difficulty) are shown in Figure 5.

Furthermore, the researcher obtains more hypotheses related to several work performance measurements, treatments, and their interactions. It is shown in Table 4. The hypotheses of H1, H2, H3, H4, H6, and H9 are rejected. Meanwhile, H5, H6, and H8 are accepted.

With several experiment conditions, the researcher concludes that only task demand significantly affects the work performance of the subjects. This result is similar to previous research that the task demand is a factor influencing work performance (Mazloum *et al*., 2008). On the other hand, task difficulty (Causse, Fabre, Giraudet, Gonzalez, & Peysakhovich, 2015) is not proven to affect work performance during the data entry process. This research has yet to succeed in revealing the correlation between task difficulty and work performance during the data entry process based on the hypothesis in Table 4. However, the researcher obtains other factors. This work is also unable to identify the correlation between noise level and work performance (Mallick, Badruddin, Haleem, Siddique, & Tandur, 2007). These three factors affecting work performance presumed to interact with each other in turn, are not establishing a significant interaction. So, this factor should be eliminated from factors affecting work performance, especially for data entry processing in e-commerce.

The choice of work instruction proposed as a system improvement is based on the evaluation of the subject's mental fatigue and mental effort during the experiment. Those two factors are determined to be the indicator of work performance improvement. The treatments proposed as system improvement measures are to place the work instruction near the employee (on the table) and to adjust the minimum target of article completion based on the manager's judgment/expectation towards certain employees. The results are contradicted with the statement that work instruction put on the wall in the middle of the room can reduce the employee's mental workload (Bosch, Könemann, De Cock, & Van Rhijn, 2017). For this condition, the researcher assumes that this distinct result is due to the difference in work instruction visualization. In this research, the subjects use a print-out document attached to the wall, whereas the other researchers utilize a projector to show the work instruction. Thus, as a result of the difficulty in viewing the work instruction with too small font and the necessity to move from a chair to see the work instruction, this condition will cause another stress factor to the employee. Furthermore, this condition is categorized as independent of the data entry activity.

Table 2 Results of Hypothesis Test

Variables	**Work Instruction 1**			**Work Instruction 2**		
	Sig	**α**	**Hyp.**	**Sig**	**α**	**Hyp.**
Noise Level	0,09	0,05	Accept	0,77	0,05	Accept
Task Difficulty	0,50	0,05	Accept	0,52	0,05	Accept
Task Demand	0,00	0,05	Accept	0,00	0,05	Reject
NL*TDif	0,60	0,05	Accept	0,12	0,05	Accept
NL*TDem	0,94	0,05	Accept	0,68	0,05	Accept
TDif*TDem	0,82	0,05	Accept	0,27	0,05	Accept
NL*TDif*TDem	0,60	0,05	Accept	0,15	0,05	Accept

Table 3 The Result of Paired T-Test from Experiment

	Paired Differences					t	df	Sig Q tailed
	Mean	S.Dev	Std. Error Mean	95% Confidence Interval of The Difference				
				Lower	Upper			
Perf.W1 –W2	1,177	2,72	0,278	0,626	1,729	4237	95	0,00

Table 4 Research Hypothesis Results

Hypothesis	sig	α	Results
H1: Mental Fatigue on Mental Workload	0,00	0,05	Reject
H2: Mental Effort on Mental Workload	0,03	0,05	Reject
H3: Mental Workload on Physical Workload	0,00	0,05	Reject
H4: Mental Workload on Work Performance	0,03	0,05	Reject
H5: Noise Level on Work Performance	>0,05	0,05	Accept
H6: Task Demand on Work Performance	<0,05	0,05	Reject
H7: Task Difficulty on Work Performance	>0,05	0,05	Accept
H8: Interaction of three factors on Work Performance	>0,05	0,05	Accept
H9: Work Instruction on Work Performance	0,00	0,05	Reject

IV. CONCLUSIONS

By using several types of measurement and various conditions in doing the data entry process, the researchers conclude that the employee's mental workload in the initial condition is high during the data entry process without treatment. This condition is based on the facts gathered by subjective measurement exhibiting a high mental workload value and reinforced by psychophysiological measurement. The measurement is stating that the data entry employee experiences mental fatigue when doing the task. The results of work performance analysis in initial condition (without treatment) show that undocumented work instruction can increase the risk of error during data entry.

Next, in this study, the researchers identify that mental effort and fatigue are the significant determinants of mental workload value in the data entry process of the e-commerce industry. Thus, the researchers recommend that the placement of work instruction should be near the employee. The task demand (minimum completion target) should be adjusted according to each employee's capacity. In the company, the researchers suggest this employee's capacity can be evaluated from the weekly performance data reports.

The experiment with a near-real job description approach has proven the relation between the mental workload values in this experiment to the mental workload values in the real data entry process. In addition, the noise level is found to be insignificant to work performance. The work instruction and task demand significantly influence work performance. The researchers' priority is to suggest a system improvement in the data entry process of the e-commerce industry in regards to the mental workload value of the employees.

Furthermore, there are some courses of action that can be considered for further research improvement. First, several ergonomic factors can be added as this research has disregarded it. The factors are ergonomics of keyboard and mouse, chair height, and physical features of employees. Thus, future researchers may consider the relationship between the ergonomics factor to the measurement of mental workload for a more accurate result. Second, this research is constrained by the working time of the subjects. The result may be affected by hurriedness, level of seriousness/concentration, and stamina (compared to the real employee in with real work demand) or other measurements of psychological factors (daily habits, working habits, or dietary habits). Third, the application of machine learning using fast computational algorithms such as clustering and classification can be a very interesting topic. In the future, this method will be applicable to predict the mental workload using real-time measurement sensors by comparing several ages of the employee during their work in a real condition (direct measurement).

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