Work Performance Improvement of Data Entry Employee In E-Commerce Industry Based On Mental Workload Value

Abstract *– Fourth Industrial Revolution creates boundless opportunities for businesses thus fostering the e-commerce industries. One key activity in e-commerce business process is data entry which converts data from hardcopy to softcopy. The high frequency of these data entry activities could increase the mental workload. This work aims to determine the factors influencing mental workload particularly induced by data entry process. To this end, experiments without work instruction and with 2 types of work instruction were conducted to diagnose the mental workload. The experiments employed questionnaire using Raw NASA-TLX, Electroencephalogram (EEG) measurement, Reaction Time measurement and Pulse measurement. By these experiments, we reveal that mental fatigue and mental effort factors significantly influenced the mental workload, and that it was necessary to provide work instruction near (on table) data entry employee.*

Keywords: Data Entry, Mental Workload, Raw NASA-TLX, Reaction Time, EEG, Pulse

I. INTRODUCTION

In this vast development of e-commerce industry and understanding the benefits and opportunities, companies, traders and individuals are so eager to be involved in online trading since the Industry 4.0. According to online article of our ministry (2017), The Indonesian Ministry of Industry has developed infrastructures to support the economic activities in digital system such as e-commerce business, anticipating to the needs and development of market trend. And from Julisar and Miranda (2013) they developed e-commerce for Small Medium Enterprise (SMEs) that will applied in many sector in Indonesia. Nevertheless, it is still important to improve the quality of workforce as well, to meet the technological advancement and achieve the efficient and effective mechanism of e-commerce business process.

Based on recent study from Borghouts and Cox (2017) mentioned that data entry is one of the main activity conducted by office workers in daily basis, with the assumption of 8 working hours a day. Acknowledging this long working hours of data entry activity in e-commerce company, we recognized the high risk of error during the process; whereas the errors in data entry would affect the data quality (Barchard and Verenikina, 2013), with common errors such as cognitive-related mistakes. Works involving computer/PC are some of those which affect the mental activity or health of the workers, resulting in the risk of mental fatigue in workplace experienced by the workers from research of Cheng et.al (2007). In other words, there is cognitive factor which may induce the (mental) stress in workplace.

Based on the pre-interview results to 4 workers with years of experience as office worker conducting data entry in an e-commerce company, factors that inducing stress 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 (increase of heart rate), psychically (frustration and anxiety) and behaviorally (errors in activity) (Dy, 1985). These would negatively affect the work performance, causing the gap between the real-time output of articles completed by the worker and the expected output. There are varieties of the sources of labor stress; one is individual's mental workload condition (Nachreiner, 1999). Several studies from Mehta (2016), Bommer and Fendley (2015), and Hollnagel (2015) proved that there are correlations between

Commented [S1]: Abstract is written in 150 – 250 words, yours is 128 words, please add more

Commented [S2]: Citations in the body of the article should correspond to those in the references (green shading)

workers' cognitive condition and their physical condition and their performance as well. 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 (Cain, 2007) and the impact to the physical health of workers. However, the measurement of mental workload cannot be done directly (Matthews et.al (2015). We get information from them and Galy et.al (2012) that for measuring mental workload, there are 3 key categories are necessary: Subjective Measurement, Performance Results, and Psychophysiological Measurement. In this research we applied 4 methods to measure the mental workload, including Electro-encephalogram (EEG) , Heart Rate (HR), Raw National Aeronautics and Space Administration Task Load Index (NASA-TLX) and Reaction Time; and 2 methods to measure the work performance including error counts and completed articles after certain treatments were applied.

The main objective of this research is to improve the system of data entry process in e-commerce industry based on mental workload value in order to improve data entry performance..

II. METHODS

A. Participants

Four undergraduate students who do not have any hearing and vision problem, had experience of working as a data entry employee in e-commerce company for at least 1 – 3 months, took part in the experiment. All subjects operated a computer with specification 17" LCD Monitor, Standard Keyboard, Standard 2 button Mouse with scroll button, CPU Intel Core i5 with 4 GB of RAM, Windows 7 OS, with Microsoft Office installed.

B. Experimental procedures

This study conducted the experiment in Industrial Engineering Laboratory in Krida Wacana Christian University. The measurement of initial mental workload condition of data entry employee was conducted in the laboratory. This condition was set similar to real working environment. The simulation set included noise level produced by co-worker's chatter and similar articles (products of industrial equipment) to real e-commerce industry in order to provide difficulties as close as possible. Subject was assigned to complete at least 30 articles (a term in e-commerce industry; product data/specification) out of 50 sets in 2 hours. During 2 hours of working (experiments), the EEG measurement was performed in every 30 minutes; pulse measurement (heart rate) was measured before and after the work; Raw NASA-TLX measurement and reaction time measurement were conducted after the work. Particularly, reaction time measurement was repeated in 20 times. The results from these measurements were the initial value of work performance, mental workload and the factors affecting mental workload value.

The experiment for system improvement was performed after we obtained the initial value of mental workload. Before the experiment was conducted, the subject was required to meet the following prerequisites: 1) Subject is medically proven not having any vision or hearing impairment and/or problem, and 2) Subject is not taking any drugs/treatments in the last 24 hours (Mercado, 2014). All these requirements are essential as to prevent any intervention in neuron signal capture during psycho-physiological measurement using EEG device.

The task which the subject was assigned to was to input the articles into a Microsoft Excel file, designed in certain way similar to the way e-commerce company's employee upload the data to website. There were 10 columns to be filled: Brand, name, short_desc, specification, netto_weight,dimension_length, dimension_ width, dimension_height, dimension_unit and volume_unit. Subject was required to conduct this experiment for 2 hours in the following variable treatments: 1) working environment with 82-87 dB which represents low level of noise and 102-107 dB which represents high level of noise; 2) a mission to complete at least 5 articles and 10 articles (as task demand); and 3) task difficulty, represented by brochures with complete information (low difficulty) and brochures with incomplete information in which the subject was required to gather it by browsing (high difficulty). Each session was conducted for 15 minutes with 3 times

replication and 2 different work instructions. The temperature of the room was 25-28^{0}C with adequate light provision. Figure 1 and 2 describe the examples of work instruction treatment of this experiment.

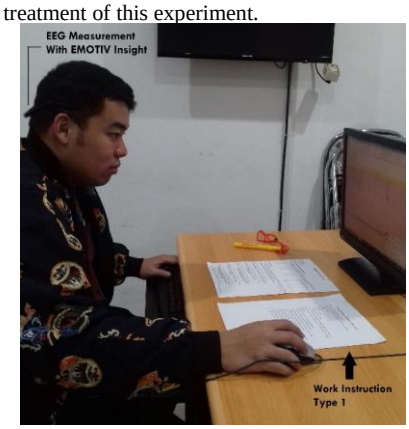

Figure 1. Work Instruction 1

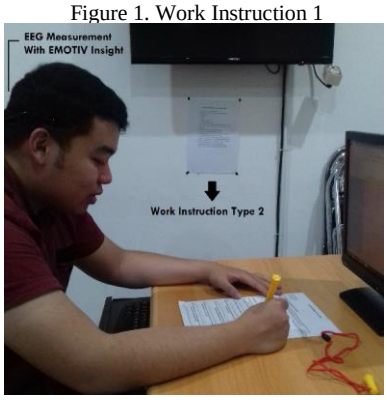

Figure 2. Work Instruction 2

As seen in Figure 1, the work instruction was provided just beside the subject's hand (on the table) whereas Figure 2 shows that the instruction was provided on the wall in the middle of the working room. The dimension of working table was 70 x 74 x 75 cm while the working chair had a dimension of 62 x 61 x 95 cm. After the experiment was performed, we obtained the end value of work performance, mental workload and the factors affecting work performance. Our research workflow diagram is presented in Figure 3.

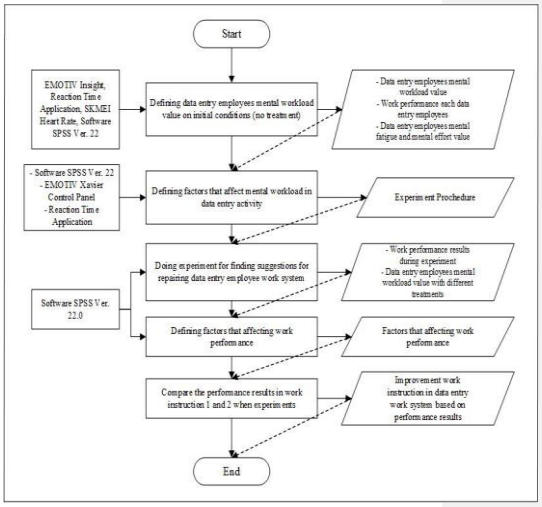

Figure 3. Flow diagram

III. RESULTS AND DISCUSSION

A. Initial Conditions

Based on subject's work performance in initial condition, it was certain that there was a significant interdependence between work performance and subject's mental workload value. Free variables used was derived from the value of EF dimension of R-TLX questionnaire; it was based on Mercado, Reinerman, Barber and Leis (2014) mentioned that the cognitive variance affecting work performance is mental effort. Therefore, the proper criterion to improve the work performance is the mental effort of the employee during work. According to Brouwer, Hogervorst, and Holewijn (2014) stated that the higher employee's mental effort, the more achievable the desired/expected work performance is. Also study from Hogervroust, Brouwer, and Van erp (2014) stated that nonetheless, high mental effort is, as well, associated to high mental workload. Thus, the work performance was closely related to mental workload.

Table 1 Results of Mental Workload Value in Initial Condition

Measurement Method	Results

Raw NASA-TLX	68-74
%CVL	33-50%
Reaction Time	372-429 milisec
EEG Data	
Focus	46%
Engagement	70%
Stress	51%

In the initial condition of data entry process, we found a significant influence of physical workload towards mental workload value. Our analysis of the results of pulse measurement using EEG revealed that mental fatigue and mental effort were significantly correlated to the heart rate which represents mental workload ($F = 5.719, 7.037$; $p < 0.05$). This finding reinforced our results of Subjective Measurement conducted by the subject, which it was found that mental effort and mental fatigue significantly affect the mental workload.

B. Experiment Results

Task demand was the sole factor significantly affecting the work performance as Noise Level (NL), Task Diffculty (TDif), Task Demand (TDem) and their correlations (see Table 2) in both different work instruction conditions. In this study, we could not gather much evidence to prove the significance of noise level towards data entry process. There was also no interaction between noise level, task demand and task difficulty that affected the work performance due to tendency of linear data pattern in our result; thus the significant factor affecting data entry process could be explained by several statistical test. We conduct paired T test to identify the influence of different work instruction treatment towards work performance; the result is as shown in Table 3.

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	Acce
Task Difficulty	0.50	0.05	Accept	0.52	0.05	Acce
Task Demand	0.00	0.05	Accept	0.00	0.05	Rejec
NL*TDif	0.60	0.05	Accept	0.12	0.05	Acce
NL*TDem	0.94	0.05	Accept	0.68	0.05	Acce
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 Result of Paired t test

	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	

Commented [S3]: Please arrange tables and figures neatly, you may arrange tables and figures on one column and article description on two columns

As shown in Table 3 the influence of different work instruction is affecting the performance of work

C. Discussion

In the initial condition of mental workload of data entry process, we revealed that mental fatigue and mental effort notably governed the value of mental workload; this result was in accordance to the results of Kathner, Wriessnegger, Muller and Halder (2014).

Moreover, the mental workload experienced by the subject also impacted the physical workload of the subject, as expressed in Mazloum, Kumashiro, Izumi and Higuchi (2008) that mental workload is an influence to the individual's physic and psycho-physiology. Ultimately, the mental workload experienced by the subject remarkably determined the work performance; therefore our conclusion also supported the argument of Young, Brookhuis, Wickens, and Hancock (2014) which is the purpose to study the mental workload of the employee is to understand its association to employee's work performance as shown in Figure 4. In this study we obtained more hypothesis that related to several work performance measurement, treatments and their interactions as shown in Table 4.

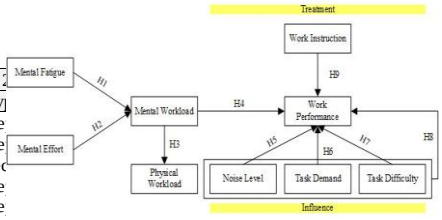

Figure 4. Theoretical Research Framework

Table 4 Research Hypothesis Results

Hypothesis	sig	α	Results
H1: Mental Fatigue against Mental Workload	0.00	0.05	Reject
H2: Mental Effort against Mental Workload	0.03	0.05	Reject
H3: Mental Workload against Physical Workload	0.00	0.05	Reject
H4: Mental Workload against Work Performance	0.03	0.05	Reject
H5:Noise Level against Work Performance	>0.05	0.05	Accept
H6: Task Demand against Work Performance	<0.05	0.05	Reject
H7: Task Difficulty against Work Performance	>0.05	0.05	Accept
H8: Interaction of 3 factors against Work Performance	>0.05	0.05	Accept
H9: Work Instruction against Work Performance	0.00	0.05	Reject

During experiment condition, only task demand was significantly affecting the work performance of the subject. This result is similar to Mazloum, Kumashiro, Izumi and Higuchi (2008) explaining that task demand is a factor influencing work performance. On the other hand, task difficulty which was often presumed to be affecting work performance from Causse, Fabre, Giraudet, Gonzales and Peysakhovich (2015) was proven not affecting work performance during data entry process; that being said, this research has yet to succeed in revealing the correlation between task difficulty and work performance during data entry process. This work was also unable to identify the correlation between noise level and work performance; thus our result is in contrast with the results from Mallick, Badruddin, Haleem, Siddique and Tandur (2007) . These three factors affecting work performance which were presumed to interacting each other in turn were not establishing a significant interaction.

The choice of work instruction that was proposed as a system improvement was based on the evaluation of the subject's mental fatigue and mental effort during the experiment, in which those two factors were determined to be the indicator of work performance improvement. The treatments we proposed as system improvement measures were to position the work instruction near the employee (on the table) and to adjust minimum target of article completion based on manager's judgment/expectation towards certain employee. This proposal contradicted the results from Bosch, Konemann and Van Rhijn (2017) which stated that work instruction placed on the wall in the middle of the room could reduce the employee's mental workload. Our distinct result might due to the difference in work instruction visualization. In our research, we used a print-out document attached on the wall whereas the other research utilized a projector to show the work instruction. As a result, the difficulty in viewing the work instruction with small font and the necessity to move from workspace just to see the work instruction might cause another stress factor to the employee; independent to the data entry activity.

Commented [S4]: Please arrange tables and figures neatly, you may arrange tables and figures on one column and article description on two columns

IV. CONCLUSION

Based on our results, we concluded that the employee's mental workload in initial condition was high during the data entry process without treatment based on the facts gathered by subjective measurement exhibiting a high mental workload value and reinforced by psycho-physiological measurement stating that the data entry employee experienced mental fatigue. The results of work performance analysis in initial condition (without treatment) showed that undocumented work instruction could increase the risk of error during data entry. Next, we identified that mental effort and mental fatigue were the significant determinants of mental workload value in data entry process of e-commerce industry. In respect of the results of work performance analysis, we recommended that the work instruction placement should be near the employee and task demand (minimum completion target) should be adjusted accordingly to each employee's capacity; while

personnel's capacity can be evaluated from weekly performance report.

Our research displays that experiment with a near-real job description approach could present mental workload values close to the mental workload values in real data entry process. In addition, noise level was found insignificant to the work performance whereas work instruction and task demand significantly influenced the work performance. Our priority is to provide a system improvement suggestion in data entry process of e-commerce industry in regards to mental workload value of the employees.

There are some courses of action that are considerable for further research improvement. First, ergonomic factors can be added up as our research had disregarded such factors as ergonomics of keyboard and mouse, chair height and physical features of employees. Thus, further research may consider ergonomics factor to the measurement of mental workload for more accurate result. Second, our research was constrained by the free time of the subjects so that the result might be affected by hurriedness, level of seriousness/concentration and stamina (compared to real employee in with real work demand) or other psychological factors. Further experiments can be designed for better accuracy by evaluating several ages of employee during their work in a real condition (direct measurement).

REFERENCES

Barchard, K. A and Verenikina, Y.(2013). Improving data accuracy: Selecting the best data checking technique. *Computers in Human Behavior*, vol. 29 no. 5, pp. 1917-1922.

Borghouts, J., Brumby, D. P., and Cox, A. L.(2017). Batching, Error Checking and Data Collecting: Understanding Data Entry in a Financial Office. *Proc. in 15th European Conference on Computer-Supported Cooperative Work - Exploratory Papers*.

Bommer, S. C. and Fendley, M. (2015). Reducing Mental Workload Resources in Human Systems Design for Manufacturing Operations. *Proc. Industrial and Systems Engineering Research Conference*.

Bosch, T., Könemann, R., de Cock, H., and van Rhijn, G.(2017). The effects of projected versus display instructions on productivity, quality and workload in a simulated assembly task. *Proc. 10th International Conference on Pervasive Technologies Related to Assistive Environments.*

Brouwer, A.M., Hogervorst, M.A., Holewijn, M., and van Erp, J. B. F.(2014). Evidence for effects of task difficulty but not learning on neurophysiological variables associated with effort. *International Journal of Psychophysiology*, vol. 93, pp. 242-252.

Cain, B. 2007. A Review of the Mental Workload Literature. [online]. [Downloaded from http://www.dtic.mil/cgibin/GetTRDoc?AD¼ADA474193 on 17 September 2017]

Causse, M., Fabre, E., Giraudet, L., Gonzalez ,M., and Peysakhovich, V.(2015). EEG/ERP as a measure of mental workload in a simple piloting task. *Proc. Manufacturing*, vol. 3, pp. 5230-5236.

Cheng, S.Y., Lee, H.Y., Shu, C.M., and Hsu, H.T.(2007). Electroencephalographic Study of Mental Fatigue in Visual Display Terminal Tasks. *Journal of Medical and Biological Engineering*, vol. 27 no. 3, pp. 124-131.

Dy, F. J. F.(1985). Visual display units: job contest and stress in office work. *International Labour Office Switzerland*.

Hogervorst, M. A., Brouwer, A.M., and van Erp, J. B. F.(2014). Combining and comparing EEG, peripheral physiology and eye-related measures for the assessment of mental workload. *Frontiers in Neuroscience*, vol. 8.

Hollnagel, E.(1997). Cognitive ergonomics: it's all in the mind. *Ergonomics*, vol. 40 no. 10, pp. 1170-1182.

Fallahi, M., Motamedzade, M, Heidarimoghadam, R., Soltanian, A. R., and Miyake,

Commented [S5]: References must consist of all sources cited in the article (yellow shading)

S.(2016). Effects of mental workload on physiological and subjective responses during traffic density monitoring: A field study. *Applied Ergonomics*, vol. 52, pp. 95-103.

Galy, E., Cariou, M., and Melan, C.(2012). What is the relationship between mental workload factors and cognitive load types. *International Journal of Psychophysiology*, vol. 83, pp. 269-275.

Julisar, Miranda,E. (2013). Pemakaian e-commerce untuk usaha kecil dan menengah guna meningkatkan daya saing. *Comtech* Vol 4 No 2, 638-645.

Käthner, I., Wriessnegger, S.C., Müller-Putz, G. R., Kübler, A., and Halder, S.(2014). Effects of mental workload and fatigue on the P300, alpha and theta band power during operation of an ERP (P300) brain-computer. *Biological Psychology*, vol. 102, pp. 118-129.

Mallick, Z., Badruddin,I. A., Haleem, A., Siddique, A. N., and Tandur, K. H. (2007). Ergonomic Evaluation of Data Entry Task Performance Under The Influence Of Noise And Task Structure- The Effect Of Gender. *International Journal on Mechanical and Materials Engineering*, vol. 2, no. 2, pp. 161-172.

Matthews,G., Reinerman-Jones, L. E., Barber, A. J., and Abich, J.(2015). The Psychometrics of Mental Workload: Multiple Measures Are Sensitive but Divergent. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, vol. 57, no. 1, pp. 125-143.

Mazloum, A., Kumashiro, M., Izumi, H., and Higuchi, Y.(2008). Quantitative Overload: a Source of Stress in Data-Entry VDT Work Induced by Time Pressure and Work Difficulty. *Industrial Health*, vol. 46, pp. 269-280.

Mehta, R. K. (2016). Integrating Physical and Cognitive Ergonomics. *IIE Transactions on Occupational Ergonomics and Human Factors*, vol. 4, pp. 83–87.

Mercado, J.E., Reinerman-Jones, L., Barber, A., and Leis, R.(2014). Investigating Workload Measures in the Nuclear Domain. *Proc. Human Factors and Ergonomics Society 58th Annual Meeting*.

Minister of Industry of Republic Indonesia. .(2017). Pemerintah Kembangkan Ekonomi Digital Berbasis Industri dan e-Commerce. [online] [Downloaded from http://www.kemenperin.go.id/artikel /18169/Pemerintah-Kembangkan-Ekonomi-Digital-Berbasis-Industri-and-e-Commerce on 04 November 2017]

Nachreiner, F. (1999). International standard on mental workload —The ISO 10075. *Industrial Health*, vol. 37, pp. 125–133.

Young, M. S., Brookhuis, K. A., Wickens, C. D., and Hancock, P. A.(2014). State of science: mental workload in ergonomics. *Ergonomics*.