Assessment of Mental Workload by Subjective Analysis Technique and Electroencephalography in the Sample Program Testing

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***Abstract* —The purpose of this research was to study the assessment of mental workload by subjective analysis technique and electroencephalography in the sample program testing. The different types of the workload were assessment as follow: Evaluation of Posture Operation by RULA, Windows and Android operating systems and Manual.**

A performance of the research was divided on these three parts. First, studied and reviewed of the evaluation. Second, applied the evaluation form, NASA TASK LOAD INDEX (NASA-TLX) and compared with the brainwave of electroencephalography (EEG). Third, estimated and compared the performance of workload.

A result of the assessment of mental workload by subjective analysis technique and electroencephalography. It can be concluded that. Evaluation of Posture Operation by RULA method. The heaviest workload is evaluated work postures using manual calculations. The minimum workload is RulaSU Android operating system.

***Index Terms*—Ergonomics, Cognitive, Mental Workload, Electroencephalography (EEG), RULA.**

I. Introduction

Working with certain tools affects both the body, thinking and mind, such as manual handling, machine control, and inspection. The mental workloads are including heavy duty vehicle inspections, large truck drivers, large-scale surveillance and control systems in the control room. An also, including product design, computer program design applications. The result is not only a physical burden, but It also affects the thinking and mind. This could reduce the quality, performance decrease and misused or work more. And also, it can lead to many accidents and losses.

The assessment of workload to suit the capabilities of the workers to the operations were essential. The workload that is appropriate for the worker will affect the efficiency of the work system in terms of productivity. On the other hand, if the workload is excessive, it can cause fatigue. As a result, overall job performance decreases. [1]-[2]

This research focuses on assessment of mental workload using the Satisfaction Survey form the NASA TASK LOAD INDEX (NASA-TLX) and compared with the brainwave of electroencephalography (EEG). The different types of the mental workload for assessment as follow: Evaluation of Posture Operation by RULA, Windows and Android operating systems and Manual. The RULA (Rapid Upper Limb Assessment) is the method of posture analysis that the software was developed for convenience applying in the field evaluation. Then the data was analyzed statistically. It promotes the application that useful for assessing the environment and work habits, leading to improvements in the work environment. [3]-[6]

II. Objective

1) Apply the mental workload using the evaluation form and the brainwave measuring instrument in the sample program test.

2) Study the relationship between psychological and brainwaves.

3) Set the experiment of mental workloads task that affect brainwaves.

III. Methods

Based on the comparison of mental workload from brainwave measurement for an ergonomic workload assessment, there are a number of steps to take. Therefore, the procedure of studying the comparison of mental workload from the measurement of brain waves according to the principles of ergonomics. It consists of steps to work. [7]-[9]

1) Review of the principles and theories related to the assessment of workload Ergonomics.

2) Study the use of the satisfaction survey form, TASK LOAD INDEX (NASA-TLX) and EEG

3) Review related research

4) Choose a sample work.

5) Two task load design

6) Work process tests

7) Evaluation of workload obtained from analysis of work process test and statistical analyses.

8) Performance summary

Flow Chart Steps to Study

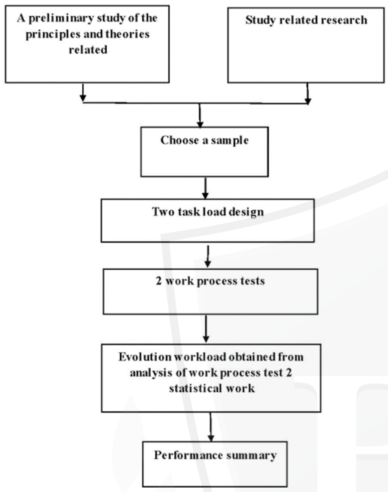

Fig. 1. shows the research process.

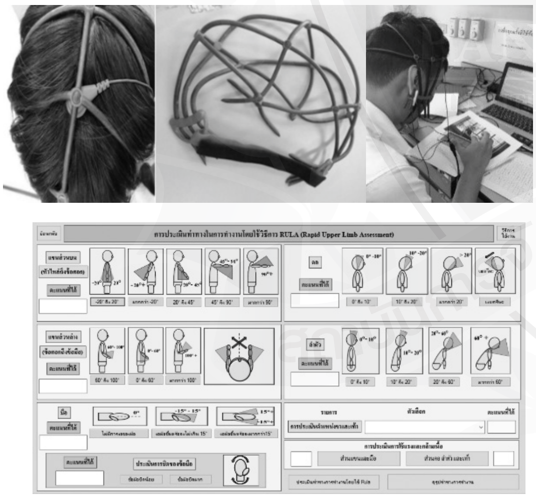

Fig. 2. Equipment Setting and The Menu of RULA Software Screen in Windows.

The Appling the NASA TASK LOAD INDEX (NASA-TLX) form and the brainwave (EEG)

3.1 The using of NASA-TLX form are divided into 6 dimensions as follows.

1. Mental Demand.
2. Physical Demand
3. Temporal Demand
4. Performance
5. Effort
6. Frustration

Procedure to use evaluation form NASA-TLX form

1. Set the weighted points in all 6 dimensions by setting the weighted values respectively. Feeling in different dimensions from 0-5, the sum of the weighted values must be equal to 15.
2. Make a grade based on the subjective level in each 6-dimensional assessment, from 0-20 points.
3. Get the points in each dimension, multiplying the weighted values of each dimension.
4. Bring the multiplication result together.
5. Take net sums divided by the weighted values net weight gain is already achieved.

3.2 Using a brainwave equipment (EEG)

1. Install the device with the tester.
2. Turn on the brainwave (EEG)
3. Open the program that will be used in conjunction with the EEG and set in computer input programs.
4. Test workload, then measured through a brainwave (EEG)
5. Analyze the results from graphs in the frequency range of interest.

IV. Tools

4.1 The different types of the mental workload for assessment as follow: Evaluation of Posture Operation by RULA, Windows and Android operating systems and Manual.

4.2 Satisfaction evaluation form, NASA TASK LOAD INDEX (NASA-TLX)

4.3 NeXus-10 Neuropsychological for EEG measurement

4.4 Camera and camcorder

4.5 Computer for statistical analysis

V. Results

5.1 Results of performance and quality assessment

5.1.1 Evaluating program performance in term of times

Table I shows the results of data collection and comparison between manual calculation compare with program in Windows and Android operating systems.

Activity	Manual	Windows	Android
Operation ○	12	10	10
Transport ⇨	0	0	0
Delay ▽	0	0	0
Inspection □	4	1	1
Storage D	0	0	0
Time (sec)	**203.89**	**71.48**	**64.41**

Data collection to compare data between manual calculation and using Rula SU program in Windows, Android operating systems. The RULA method was used to calculate score of posture analysis. From the manual calculation method, the average time spent evaluating the task was 203.89 seconds. The RulaSU in Windows operating systems average user experience is 71.48 seconds. RulaSU uses an average of 64.41 seconds for the Android operating system.

5.2 Evaluation of Statistical Time Data

When the time value is tested statistically. It was found that the distribution is normal and different.

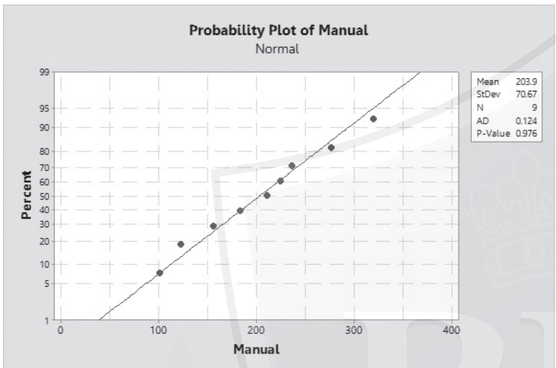

Fig. 3. Graph of time distribution of manual.

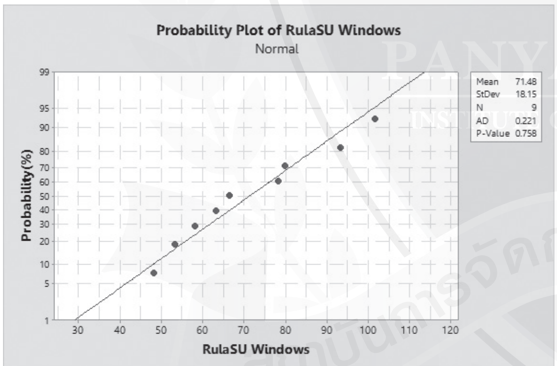

Fig. 4. Graph of time distribution of Windows operating systems.

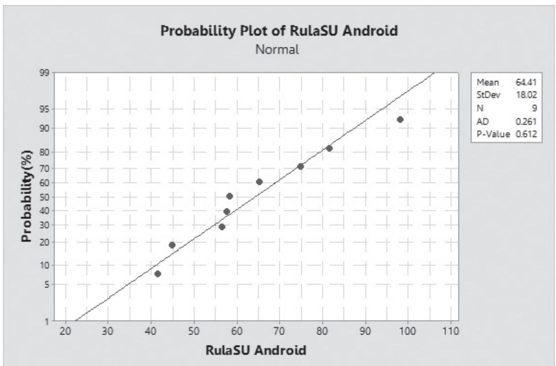

Fig. 5. Graph of time distribution of Android operating systems.

From the 3 graphs, it can be seen that the intersection is linear. The clustering characteristics are not clustered. And the distance between each point is almost the same. Three vehicles can be classified as Normal Distribution.

5.2.1. Test the hypothesis using the T-Test statistic.

-time correlation coefficient between manual and Windows operating system

Two-Sample T-Test and CI: Manual, RulaSU Windows

```
Two-sample T for Manual vs RulaSU Windows

                N   Mean  StDev  SE Mean
Manual          9  203.9   70.7       24
RulaSU Windows  9   71.5   18.2      6.1

Difference = μ (Manual) - μ (RulaSU Windows)
Estimate for difference:  132.4
95% CI for difference:  (80.9, 184.0)
T-Test of difference = 0 (vs ≠): T-Value = 5.44  P-Value = 0.000  DF = 16
```

Fig. 6. T-Test Analysis.

P-Value = 0.000, which is less than 0.05, rejecting the main assumption. It was concluded that the correlation coefficient of time data between manual and the Windows operating system to evaluate gestures using the RULA method was significantly different at the 95% confidence level.

Time correlation coefficient between manual and Android operating system

Two-Sample T-Test and CI: Manual, RulaSU Android

```
Two-sample T for Manual vs RulaSU Android

                N   Mean  StDev  SE Mean
Manual          9  203.9   70.7       24
RulaSU Android  9   64.4   18.0      6.0

Difference = μ (Manual) - μ (RulaSU Android)
Estimate for difference:  139.5
95% CI for difference:  (87.9, 191.0)
T-Test of difference = 0 (vs ≠): T-Value = 5.74  P-Value = 0.000  DF = 16
```

Fig. 7. T-Test Analysis.

P-Value = 0.000 which is less than 0.05, reject the main assumption. It was concluded that the correlation coefficient of time data between manual and Android operating system to evaluate gestures using the RULA method are significantly different at a 95% confidence level.

- time interval relationship value Windows operating system and Android operating system.

Two-Sample T-Test and CI: RulaSU Windows, RulaSU Android

```
Two-sample T for RulaSU Windows vs RulaSU Android

                N  Mean  StDev  SE Mean
RulaSU Windows  9  71.5   18.2      6.1
RulaSU Android  9  64.4   18.0      6.0

Difference = μ (RulaSU Windows) - μ (RulaSU Android)
Estimate for difference:  7.07
95% CI for difference:  (-11.10, 25.25)
T-Test of difference = 0 (vs ≠): T-Value = 0.83  P-Value = 0.420  DF = 15
```

Fig. 8. T-Test Analysis.

P-Value = 0.420, which is greater than 0.05, accept the main assumption. Thus, it was concluded that the temporal relationship between RulaSU and Windows operating system and the RulaSU implementation of Android operating system to evaluate gestures using RULA method were not significantly different. At a 95% confidence level

5.2.2. Assay Assumptions Using ANOVA One-Way Statistical Analysis

One-way ANOVA: Manual, RulaSU Windows, RulaSU Android

```
Method
Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor  Levels  Values
Factor       3  Manual, RulaSU Windows, RulaSU Android

Analysis of Variance

Source  DF  Adj SS  Adj MS  F-Value  P-Value
Factor   2  111111   55555    29.51    0.000
Error   24   45184    1883
Total   26  156294

Model Summary

      S    R-sq  R-sq(adj)  R-sq(pred)
43.3896  71.09%     68.68%      63.41%

Means
Factor          N   Mean  StDev       95% CI
Manual          9  203.9   70.7  (174.0,  233.7)
RulaSU Windows  9  71.48  18.15  (41.63, 101.33)
RulaSU Android  9  64.41  18.02  (34.56,  94.26)
Pooled StDev = 43.3896
```

Fig. 9. One-Way ANOVA.

P-Value = 0.000 which is less than 0.05, reject the main assumption. Therefore, the correlation coefficients of the three data types were significantly different at the 95% confidence level.

5.3 Results of psychological workload study using NASA TASK LOAD INDEX

1. Mental Demand
2. Physical Demand
3. Temporal Demand
4. Performance
5. Effort
6. Frustration

TABLE II
NASA-TLX SCORE OF MANUAL

Windows			
Topics	Average weight	Average raw score	Net score
Mental Demand	4.78	14.44	69.01
Physical Demand	0.56	7.11	3.95
Temporal Demand	1.78	9.33	16.59
Performance	3.78	13.78	52.05
Effort	1.44	9.33	13.48
Frustration	2.67	10.78	28.74
		Net score =	183.83
		Net weighted average score =	12.26

TABLE III
NASA-TLX SCORE OF ANDROID

Android			
Topics	Average weight	Average raw score	Net score
Mental Demand	4.33	13.33	57.78
Physical Demand	0.00	4.67	0.00
Temporal Demand	1.67	7.22	12.04
Performance	4.44	14.89	66.17
Effort	2.33	8.33	19.44
Frustration	2.22	8.89	19.75
		Net score =	175.19
		Net weighted average score =	11.68

TABLE IV
NASA-TLX SCORE OF ANDROID

Manual			
Topics	Average weight	Average raw score	Net score
Mental Demand	4.78	17.22	82.28
Physical Demand	1.00	9.44	9.44
Temporal Demand	2.22	12.00	26.67
Performance	0.44	9.00	4.00
Effort	3.33	14.89	49.63
Frustration	3.22	14.11	45.47
		Net score =	217.49
		Net weighted average score =	14.50

The results of mental workload evaluation are divided into the following methods.

- Evaluation of work postures using the RULA

TABLE V
AVERAGE NET SCORE OF WEIGHT AGIN OF ALL 3 METHODS OF 9 SUBJECTS

Method / Value	Manual	Windows	Android
Net weighted average score	14.50	1226	11.68

From the NASA-TLX, the weighted average net score. During the experiment, the 3 methods are mean as follows:

1. Manual method = 14.50
2. Windows operating system = 12.26
3. Android operating system = 11.68

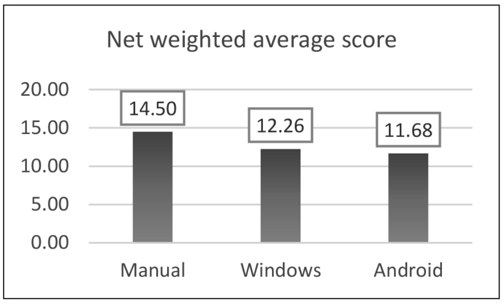

Fig. 10. the average of the net weighted scores for each of the 9 participants.

Based on the results of the 9 experiments, it was concluded that the method with the heaviest workload was Evaluate work postures using manual calculations. And the method with the minimum workload is How to use Android RulaSU program.

5.4 Results of the EEG Analysis Program (EEG)

TABLE VI
Average Gamma Wave Under Normal Conditions And While Experimenting Through All 3 Methods

Method / person	baseline	Manual	Windows	Android
1	3.67	6.58	5.64	6.01
2	4.47	5.46	6.72	4.83
3	6.01	9.38	7.50	6.82
4	3.23	4.64	3.87	4.26
5	6.93	9.97	7.78	7.04
6	6.23	8.02	7.04	8.01
7	4.82	7.34	5.62	5.95
8	4.44	5.42	5.97	6.84
9	6.11	10.03	6.35	6.25
Mean	5.10	7.43	6.28	6.22

From the table, the results of the 9 brainstorming experiments show that Gamma

Amp. At normal and 4 experimental conditions have mean (Gamma Amp) 35-45 Hz as follows:

1. Baseline Normal Conditions = 5.10 μV
2. Manual calculation method = 7.43 μV
3. Windows operating system = 6.28 μV
4. Android operating system = 6.22 μV

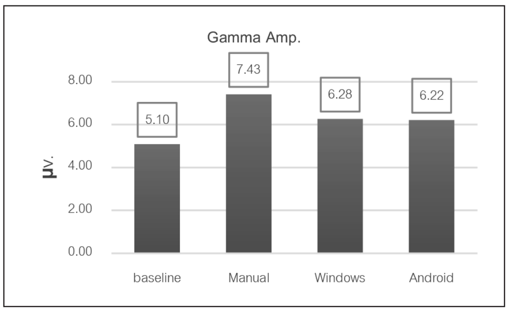

Fig. 11. the average Gamma Amp. of 9 people.

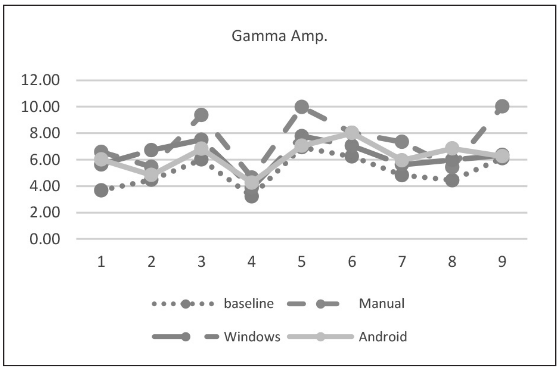

Fig. 12. Graph Average Gamma wave trend.

Based on the results of the 9 experiments, it was concluded that the method with the heaviest workload was evaluate work postures using manual calculations. and the method with the minimum workload is Android RulaSU program.

VI. Conclusion

6.1 Performance and Quality Assessment

- Evaluating program performance.

By comparing data between manual calculation methods with RulaSU applications, Windows operating systems, Android operating systems, it was found that using RulaSU, Windows and Android operating systems. There are fewer work procedures than the manual calculation method. Step 5 Time spent evaluating Windows workload is less than word methods. Manual 132.41 seconds and Android operating system time estimate are less than the 139.48 second manual calculation method. The result of the RulaSU program is a data acquisition window and summary that allows users to understand the results. Easier assessment So there are steps to get the data more convenient and take less time than manual calculating.

6.2 Statistical Time Evaluation

From the hypothesis test, One-Way ANOVA statistics were used to compare time correlation coefficients of application programs for estimating workload, various methods. In different ways of working, it found that time correlation coefficients between manual computation methods, RulaSU applications, Windows and Android operating is significantly different at 95% confidence level.

6.3 Workload Evaluation with NASA TASK LOAD INDEX (NASA-TLX) form

The experiment compares the work load of both people and by giving each job the same thing.

The method with the heaviest workload is Evaluate work postures using manual calculations. And the method with the minimum workload is Android RulaSU program.

6.4 Results of the analysis by the brainwave (EEG)

Based on the comparison of the work load, the work amplitude evaluation using the RULA method. The method with the heaviest workload is Evaluate work postures using manual calculations. and the method with the minimum workload is Android RulaSU program

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