Formulation of Mathematical Model to Determine The Risk of Computer Vision Syndrome (VCS) in The Use of An Ergonomic Drawing Tablet Application in Writing Modre Characters

I Wayan Santiyasa
Informatic Department of Udayana University, Bali, Indonesia
santiyasa@unud.ac.id

I Putu Gede Adiatmika and I Nyoman Adiputra
Medicine Faculty of Udayana University, Bali, Indonesia
ipgadiatmika@unud.ac.id, nadip2003@yahoo.com

Ida Bagus Alit Swamardika
Electrical Engineering of Udayana University, Bali, Indonesia
gusalit@unud.ac.id

Abstract
The use of computers in this present age is very widespread, as almost all human activities utilize computer technology to complete their tasks. With the aid of computers, completing tasks becomes more practical and efficient. However, prolonged and continuous computer use can lead to diseases including Occupational Health Hazard, which is commonly known as Computer Vision Syndrome (CVS). This syndrome is the number one occupational hazard in the 21st century. Common symptoms of CVS due to prolonged computer use are internal ocular symptoms (eye tension and pain), external ocular symptoms (dry eyes, irritation and pain), visual symptoms (blurred eyes, double vision). This study aims to evaluate the usability of the interface of the ergonomic drawing tablet application in the Balinese script writing system using a heuristic method. The heuristic method is based on the ten heuristic evaluation proposed by Molich and Nielsen. In that study, Molich and Nielsen evaluated the usability of an application which was used by workers to aid in completing their tasks. They applied mathematical modelling to determine the level of CVS experienced by the workers. In this study, the results showed that the level of CVS symptoms in the use of ergonomic drawing tablet applications in writing Balinese script based on the study of Molich and Nielsen are as follows. The percentage of workers who experienced CVS symptoms after using the ergonomic drawing tablets for 3-4 hours, 4-5 hours, and more than 5 hours is 29.46%, 34.26%, and 36.28% respectively. The odds-ratio (OR) of using ergonomic drawing tablets for 3-4 hours = 1.03, 4-5 hours = 1.17 and les than 5 hours = 1.23 with system usability level of 89.88%.

Keywords
Mathematical Modeling, Heuristic Interface Design, Computer Vision Syndrome, Usability.

1. Introduction
Computer Vision Syndrome (CVS) is a disease that includes Occupational Health Hazard due to prolonged computer use and is the number one occupational hazard in the 21st century (Beck 2010). People who work with computers more than 2-3 hours per day are at risk for CVS, especially on the use of desktop and laptop computers (Rathore 2017). Meanwhile, the use of tablet computers at work has a lower CVS risk than the use of desktop and laptop computers. Tablets have a touchscreen monitor facility, so the monitor on the tablet functions as input as well as output. With this touchscreen facility, it is also possible to input data in the form of scratches on the monitor for further processing. With this feature, it is then possible to put a signature on the document, or to make handwriting and drawing on the screen. These abilities have made tablet to be widely used in an interesting learning process. Such learning process includes how to write script which cannot be typed on the keyboard due to the unique characteristics possesed by the script. An example of the unique characteristic is the writing format is not entirely upright but must

be written at an angle, upside down and lying down (Suweta 2019). This unique form of writing makes it impossible to write the script with a keyboard thus must be written directly using handwriting. With these unique characteristics, a suitable computer technology-based tool is a computer tablet because it has a touchscreen display and drawing capabilities.

The main causal factors associated with CVS are environmental factors such as improper lighting, the position of the monitor, and the viewing distance. Other factors are the user's visual ability such as uncorrected refractive errors, oculomotor disorders, and eye abnormalities (Gowrinsankaran and Sheedy 2014). The CVS risk factors consist of physiological and environmental factors. The physiological factors include blinking frequency, age, gender, systemic disease, medication, use of contact lenses and cosmetics. The environmental factors include display display, length of exposure, lighting, contrast, and radiation that cause glare in the eyes in completing the given workload (Mowry and Ison 2015). The prevalence and complaints of CVS incidence when using tablets for too long are characterized by headaches followed by dry and sore eyes and pain around the eyes (Ranasinghe et al. 2016).

To reduce the risk of CVS in using tablets as a tool in writing modern characters, the application used is designed with an ergonomic interface to provide comfortable use of applications in writing modern characters. The interface design in this ergonomic drawing tablet application is designed with an ergonomic approach so that it is easy to use by the user and provides comfort when using it and is able to reduce the level of CVS risk. How to measure the comfort and risk of CVS in the use of an ergonomic drawing tablet application in writing *modre* characters is a research problem in this study. The usability test of the ergonomic drawing tablet application is carried out with the goals of finding out how easy the ergonomic drawing tablet application is, providing convenience to the user, and preventing the user from CVS risk. Meanwhile, to determine the level of CVS risk based on the causes and symptoms experienced by the user in using the application in writing *modre* characters, the interface of the application is evaluated heuristically by performing mathematical formulations.

1.1. Objectives

The objective of this study is to determine the risk of CVS in the use of an ergonomic drawing tablet application in writing *modre* characters. The classification of CVS symptoms is divided into three classes, namely internal ocular symptoms (eye tension and pain), external ocular symptoms (dry eyes, irritation, and burning), visual symptoms (blurred eyes, double vision). A mathematical formulation was carried out to determine the level of CVS risk in general in the use of ergonomic drawing tablet applications in writing modern characters. The purpose of this study is to analyze the effect of using ergonomic drawing tablets on CVS risk by conducting a heuristic evaluation of the interface of the application used. The evaluation is carried out based on the heuristic evaluation principles proposed by Nielsen (1990). Several aspects will be assessed in this study are the aesthetic and minimalist design as well as the flexibility and efficiency in the interface of the application used. An aesthetic and minimalist design mean that the interface should not contain irrelevant or rarely needed information. This will affect the focus of the user's vision thus it must be ensured that the visual design of the interface remains focused on important things that support the user's main goals. Flexibility and efficiency are also very important to consider so that the interface design is able to provide comfort to the user, speeds up work completion, and is able to reduce the duration of visual interaction with the tablet monitor.

2. Literature Review

The eye is a complex sensory organ that has an optical function to see (Tarwaka 2013). Optically, the eye has a lens system to help adjust the focus on the eye by changing the diaphragm, i.e. the pupil and retina, so that the view when looking at objects becomes clear. Sight is greatly influenced by the distance of view to the object when the eye receives light from the object as well as the ability of the eye lens to change shape to adjust to the sharpness of focus on the eye when viewing the object (Kuswana 2014). The eye can see objects clearly if the object is within sight, that is, between the point near the eye (punctum poximum) and the far point of the eye (punctum remotum). The punctum proximum is the closest point to the eye where if an object is placed, the eye is still able to produce a sharp image on the retina with the eye's maximum accommodation state. The distance between the eye points is affected by age. When you are an infant, the human eye has a point near the eye of about 10 cm, when the adult is 20 years the normal eye has a close point of about 25 cm, and at the age of 40 years the point near the eye becomes 50 cm. The point near the eye continues to increase with age as the eye loses its accommodating capacity. The punctum remotum is the farthest point the eye sees an object and is still able to focus the image falling right on the retina when the eye is not

accommodating. The normal eye is able to see objects that are very far away, thus the far point of the eye is infinite (Hall 2016).

Visual acuity is influenced by several factors, including: visual acuity, convergence, color discrimination, and dark adaptation (Tarwaka 2013). Visual acuity is the eye's ability to distinguish an object in detail, such as reading very small text in good contrast. Visual acuity is influenced by the condition of the object to be seen including the distance, the intensity of the light reflected by the object, and the speed of the object's motion. In addition, it is also influenced by eye characteristics and accommodation ability. Visual acuity will increase with level of light along with contrast level while it will decrease with age (Iridiastadi and Yassierli 2017). Convergence is the ability of both eyes to focus their eyes when looking at an object so that the object will still appear as one. In normal circumstances, the eye muscles will function automatically to focus the vision. However, some people cannot do it well, because the muscles around the eyeball experience stress and strain due to the imbalance in the function of these muscles. Color discrimination is the level of sensitivity of the retinal cones to wavelengths which is the basis of color discrimination. Color can be supported in good lighting conditions and the eye's ability to distinguish colors. (Tarwaka 2013; Iridiastadi and Yassierli 2017). Dark adaptation is the duration of the dark-light adaptation performed by the pupil of the eye. The adaptation of the eye from light to dark takes about 30 minutes, while for the other way around the time needed is around 1-2 minutes.

Forced visual acuity can cause permanent irritation and damage to the eyes and visual system. Visual disturbances are characterized by a number of ocular symptoms such as eye fatigue, dryness, redness, watery eyes, irritation, blurred vision, and muscle pain. These problems are collectively known as symptoms of Computer Vision Syndrome (Rathore 2017). CVS is a group of eye and vision health symptoms or problems which is caused by the eyes focusing too long while working on a computer or other digital device such as a tablet. In this study, CVS is grouped into three out of four categories proposed by Blehm, et.al in the research of Reddy et al. (2013), namely:
1. Asthenopic symptoms are eye strain, eye fatigue, and eye pain
2. Symptoms on the surface of the eye, namely irritation of the eyes, and dry eyes
3. Visual symptoms, namely blurred vision, slow focus on an object, double vision.

The CVS level is calculated by performing a mathematical formulation of all symptoms perceived by the user using the heuristic evaluation method by Nielsen and Molich (1990) as an approach to evaluating a human-machine system and its relation to usability.

In this study, an ergonomic drawing tablet application which is easy, comfortable and able to reduce cognitive load and eye fatigue, is developed by conducting studies through an ergonomic approach to make it easier to interact with the use of drawing tablets for users (Saifulloh and Noordin 2015). Application development is also aimed at being able to reduce cognitive load and eye fatigue by using a systemic, holistic, interdisciplinary, and participatory approach (SHIP Aproach) (Manuaba 2000), so that the basic principles of human-computer interaction (HCI) where applications are built can communicate easily with the user and as friendly as possible (Caesaron 2015) can be achieved.

3. Methods

This study focuses on evaluating the ease of use of ergonomic drawing tablets in writing *modre* characters and the risk of computer vision syndrome (CVS) that occurs by performing mathematical formulations of the observed symptoms. The methodology used is the heuristic evaluation version of Molich and Nielsen as an approach in evaluating a human-machine system in terms of usability. For this reason, this study is divided into two stages, namely data collection and the stage of mathematical formulation to determine the risk of CVS from the duration of using ergonomic drawing tablets and the level of usability of the application interface.

3.1. Data Retrieval

Before collecting the data, first, the research respondent group was determined based on the length of time using the ergonomic drawing tablet to complete the assignment. In this study, the respondent group was drawn from users who use ergonomic drawing tablets with a duration of 3-4 hours, 4-5 hours, and above 5 hours. While the number of respondents in this study was 50 users.

From the 50 users, subjective data were taken related to the usability of the ergonomic drawing tablet interface in writing *modre* characters by applying the heuristic evaluation method. In addition, CVS symptom data is also collected which is described by the user in using the ergonomic drawing tablet.

3.2. Mathematical Formulation

From a set of CVS symptoms that the users perceived when using ergonomic drawing tablets, namely internal ocular symptoms (eye tension and pain), external ocular symptoms (dry eyes, irritation, and pain), visual symptoms (blurred eyes, double vision) as determinants of CVS risk. Observing that every symptom is directly proportional to the risk, it means that in mathematics it can be interpreted that each symptom will equally contribute to the risk of CVS. We define X1, X2, X3 as the internal ocular symptom consisting of two sub-symptoms, the external ocular symptom consisting of three sub-symptoms, and the visual symptom consisting of two sub-symptoms respectively. From the research data, it is known that the mean contribution to CVS from internal ocular symptoms, external ocular symptoms, and visual symptoms are 28%, 41%, and 31%. By using the ten components of the heuristic evaluation, the following formulations can be formed mathematically as the following:

$$CVS = (0.28X1 + 0.41X2 + 0.31X3) / 10 \quad (1)$$

$$Usability = 90 - Avg\ (CVS) / 10 \quad (2)$$

4. Data Collection

There are two main dataset which are used in this study. The first dataset is the ergonomic drawing tablet user data which is grouped on gender and the use of glasses according to the duration of use. The second dataset is the the usage of ergonomic drawing tablets based on symptoms of computer vision syndrome (CVS) experienced by users according to the duration of time as shown in Table 1. and Table 2.

Table 1. Comparison of ergonomic drawing tablet user data based on gender and use of glasses

Demographic Characteristics	Duration of Tablet Use (Hours)		
	3-4	4-5	Les than 5
Gender, n (%)			
1. Female	10(20)	8(16)	2(4)
2. Male	15(30)	10(20)	5(10)
Using Glasses, n (%)			
1. Glasses	5(10)	4(8)	5(10)
2. No Glasses	20(40)	14(28)	2(4)

From table 1, it is known that 60% of the users of ergonomic drawing tablets are male and 40% of them are female. On the other hand, 28% of users of ergonomic drawing tablets wear glasses, while 72% do not wear glasses. While the data group based on the symptoms of computer vision syndrome perceived by the user while working using ergonomic drawing tablets is shown in Table 2.

Table 2. Frequency distribution of computer vision syndrome symptoms in ergonomic drawing tablet users

CVS symptoms (%)	Duration of Use Time (Hours)		
	3-4	4-5	Las than 5
Ocular Symptoms : **Internal Ocular Symptoms**			
1. Eyes feel tense	3(6.00)	3(6.00)	3(6.00)
2. Pain in the eyes and around the eyes	1(1.82)	2(4.22)	2(4.22)
External Ocular Symptoms			
1. Dry eyes	3(6.00)	3(6.00)	3(6.00)
2. Eyes feel irritated	3(6.00)	3(6.00)	3(6.00)
3. Burning sensation in the eyes	1(1.82)	1(1.82)	1(1.82)

Visual Symptoms			
1. Double vision	1(1.82)	2(4.22)	2(4.23)
2. Blurred vision	3(6.00)	3(6.00)	4(8.00)

5. Results and Discussion

5.1. Numerical Results

The number of samples in this study was 50 *modre* character writers who used the ergonomic drawing tablet application, consisting of 20 women and 30 men. Out of the 50 people, 14 of them wore glasses while 36 do not. To ensure that there is no significant difference between men and women, and wearing glasses or not, against the risk of computer vision syndrome (CVS) in the study sample, a difference test between groups is first carried out using the chi-square test at a significance level of $\alpha = 0.05$. as shown in Table 3.

Table 3. CVS risks of ergonomic drawing tablet user data based on gender and use of glasses

Demographic Characteristics	**Duration of Tablet Use (Hours)**			**p**
	3-4	4-5	Less than 5	
Gender, n (%)				
3. Female	10(20)	8(16)	2(4)	0.196
4. Male	15(30)	10(20)	5(10)	
Using Glasses, n (%)				
3. Glasses	5(10)	4(8)	5(10)	0.087
4. No Glasses	20(40)	14(28)	2(4)	

Table 3 shows that the ratio of ergonomic drawing tablet users in writing literary *modre* based on gender is 40% female, while male gender is 60%. The results of the *chi-square* test between the sexes of women and men obtained $\rho = 0.196$ ($\rho > 0.05$), which means that there is no significant difference in the CVS risk of using ergonomic drawing tablets in writing *modre* characters based on gender. Based on the use of glasses, it was found that 72% do not wear glasses while 28% do. The results of the *chi-square* test based on the use of glasses showed a value of $\rho = 0.087$ ($\rho > 0.05$), which means that there is no significant difference in the risk of CVS between using glasses and not using ergonomic drawing tablets to write *modre* characters.

Using the questionnaire responses related to CVS risk in using ergonomic drawing tablets in writing *modre* characters, statistical analysis was carried out to determine the level of CVS risk and its relationship with the usability interface of the ergonomic drawing tablet application in writing *modre* characters. In this study, usability was measured using the heuristic evaluation method version of Nielsen and Molich (1990) with ten approaches in evaluating a human-machine system in relation to usability. The questionnaire seeks to get a simple description of the relationship between tasks, namely writing *modre* characters and CVS symptoms so that it provides a comprehensive description of the possible CVS risk factors in using the ergonomic drawing tablet application as a tool in writing *modre* characters. The majority of CVS perceived as a whole was characterized by external ocular symptoms, namely 41.46%, while visual symptoms were 30.27%, and internal ocular symptoms were 28.26%. This shows that the symptoms of dry eyes, irritation to the eyes, and even sore eyes are sensitive CVS symptoms that can be experienced after using the ergonomic drawing tablet application for 3 hours or more. Meanwhile, visual symptoms such as blurred and double views are increasingly felt with the increasing duration of using the application in work as shown in Table 4.

Table 4. The results of the mann whitney test analysis on the CVS symptom score based on the duration of time using the ergonomic drawing tablet application

CVS symptoms (%)	Duration of Use Time (Hours)			p
	3-4	4-5	5<	
Internal Ocular Symptoms Eyes feel tense Pain in the eyes and around the eyes	7.82	10.22	10.22	0.047
External Ocular Symptoms Dry eyes Eyes feel irritated Burning sensation in the eyes	13.82	13.82	13.83	0.053
Visual Symptoms Double vision Blurred vision	7.82	10.22	12.23	0.002

The results of the Mann Whitney test showed that CVS symptoms due to visual symptoms were significantly different between the duration of using the ergonomic drawing tablet application with p = 0.002 (ρ <0.05), which means that the symptoms of blurred eyes and double vision will increase with the longer duration of application usage. Meanwhile, CVS symptoms caused by external ocular symptoms with a p-value greater than 0.005 were not significantly different between the duration of using the ergonomic drawing tablet application. This shows that the symptoms of CVS such as dry eyes, irritation of the eyes, and meta stinging are equally felt in the duration of using the application of 3 hours or more.
From the results of the bivariate analysis regarding the relationship between length of work using ergonomic drawing tablets and the incidence of CVS, the value of p = 0.028 is obtained with an odds ratio (OR) of 1.03 for 3-4 hours of work, 1.17 for 4-5 hours of work and 1.23 for length of work of more than 5 hours with 95% CI = 1.094-18.503 as shown in Table 5.

Tabel 5. The relationship between duration of time working at ergonimic drawing tablet and CVS incident

Duration of Using Ergonomic Drawing Tablet (hours)	CVS		OR	95% CI	p
	n	%			
3 - 4	15	30	1.03	1.094-18.503	0.028
4 - 5	17	34	1.17		
5 <	18	36	1.23		
Total	50	100			

Table 5 shows that the length of work using ergonomic drawing tablets is significantly related to the incidence of CVS. Furthermore, the risk of experiencing CVS after working for 3-4 hours, 4-5 hours, and more than 5 hours continuously 3%, 17%, and 23% respectively.

5.2. Graphical Results

With the formulation of a mathematical model with a heuristic evaluation approach in calculating the level of CVS, the use of the ergonomic drawing tablet application in writing modern characters, namely CVS = (0.28X1 + 0.41X2 + 0.31X3) / 10, from the CVS symptoms felt by the user, the CVS value for each working time duration is 29, 46% for a work duration of 3-4 hours, 34.26% for a work duration of 4-5 hours and 36.28% for a work duration of five or more hours as shown in Figure 1.

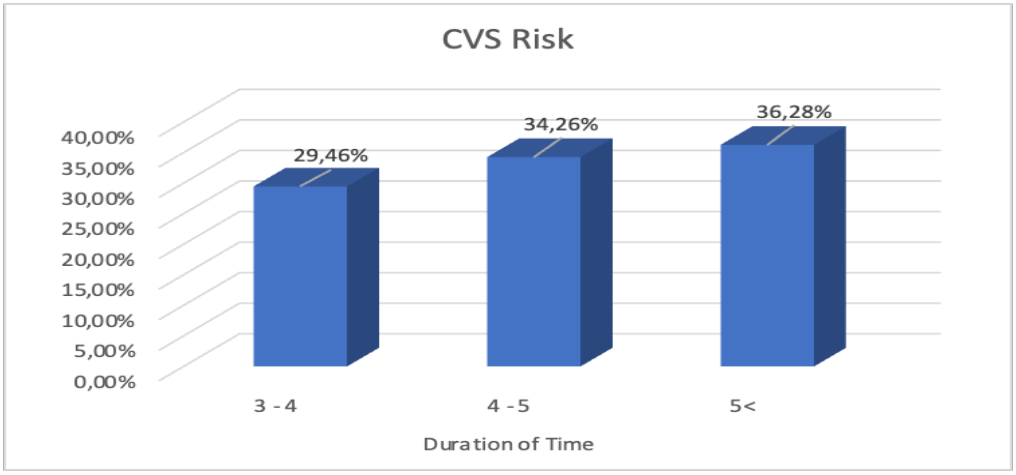

Figure 1. CVS risks using ergonomic drawing tablets

From the CVS risk value for each working time duration, we can calculate the usability level of the ergonomic drawing tablet application interface in providing convenience to the user in writing *modre* characters with the following formulation is 89.88%

A high level of usability means that the users have a high risk of CVS symptoms when working using the application for a long duration of more than two hours continuously.

The risk of CVS will increase in proportion to the duration of working time using the ergonomic drawing tablet continuously as shown in Figure 2. The duration of working time using ergonomic drawing tablets for more than 2 hours starts showing the risk of CVS even though it is still at a low stage, namely 3%. But if the user continues without taking a rest, the risk of CVS will increase rapidly to 17% or even 23%.

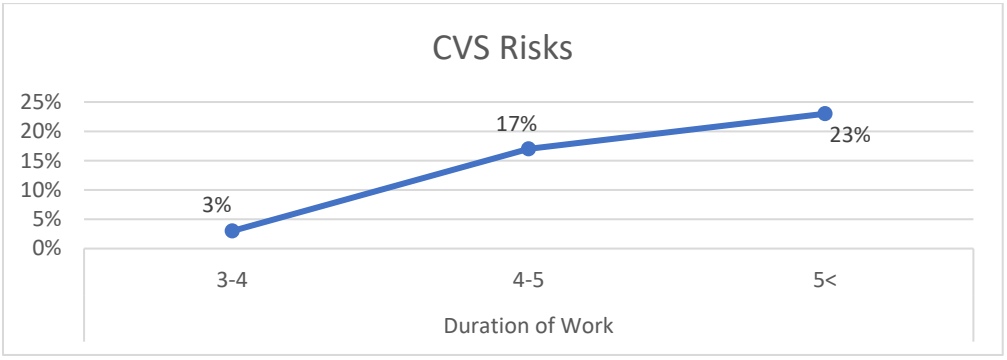

Figure 2. The relationship between increasing work duration and CVS risk

Each level of the CVS symptoms, namely internal ocular symptoms, external ocular symptoms, and visual symptoms, have different characteristics of the level of the symptoms. For external ocular symptoms, it tends to be high and stable, while for visual symptoms it tends to steadily increase with proportion to the increase in the duration of work time. While the internal ocular symptoms do not have a definite pattern, it may be difficult for the user to express these symptoms as shown in Figure 3.

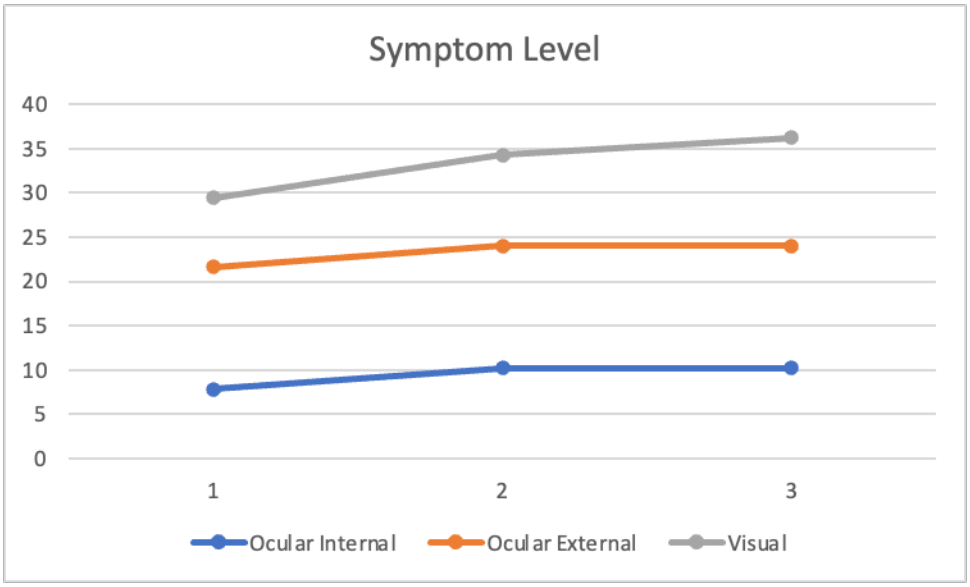

Figure 3. Comparison of Symptom Levels Using Ergonomic Drawing Tablets

5.3. Proposed Improvements

From the results of the study, both numerically and graphically in tracing CVS symptoms that users feel when using ergonomic drawing tablets as a tool in writing *modre* characters in this study using 3-4 hours, 4-5 hours and 5 hours more and using a sample size of 50. It is necessary to add the duration of work for the duration of less than 2 hours and 2-3 hours to get a more accurate tracking of CVS symptoms. Meanwhile, the amount of data may also need to be increased to two times so that the comparison of symptom levels between working time durations is more visible.

5.4 Validation

Table 6 below shows the validity and reliability test of CVS symptoms questionnaire.

Tabel 6. Validity and reliability test of CVS symptoms questionnaire

Correlations

		Y			Y
X1.1	Pearson Correlation	0,830*	X2.3	Pearson Correlation	0,770*
	Sig. (2-tailed)	0		Sig. (2-tailed)	0
	N	50		N	50
X1.2	Pearson Correlation	0,844*	X3.1	Pearson Correlation	0,770*
	Sig. (2-tailed)	0		Sig. (2-tailed)	0
	N	50		N	50
X2.1	Pearson Correlation	0,907**	X3.2	Pearson Correlation	0,907**
	Sig. (2-tailed)	0		Sig. (2-tailed)	0
	N	50		N	50
X2.2	Pearson Correlation	0,844*			
	Sig. (2-tailed)	0			
	N	50			

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
,976	7

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Case Processing Summary

		N	%
Cases	Valid	50	100,0
	Excluded[a]	0	,0
	Total	50	100,0

6. Conclusion

From the analysis and discussion of the results, the following conclusions can be drawn. (1) in general, the ergonomic drawing tablet interface design is good enough based on a heuristic evaluation with a usability of 89.88%. This means that the interface provides convenience for the users and comfortable to use. However, using the application for 3 hours or more continuously will give the user the risk of CVS with a sharp increase of 3% to 23%. (2) There is no significant relationship between user gender differences and the use of glasses in the use of ergonomic drawing tablets to the risk of CVS.

References

Beck, M., Becoming a Squinter Nation: Glasses Can Correct Near and Far, but What About Those Screens in Between?, Available: https://www.wsj.com/articles/SB10001424052748704868604575433361436276340, 2021.
Caesaron, D., Evaluasi heuristic desain antar muka (Interface) portal mahasiswa (Studi Kasus Portal Mahasiswa Universitas X). *Jurnal Metris*, vol. 16, no. 1, pp. 9 – 14, 2015.
Gowrisankaran S., and Sheedy, J, E., Computer vision syndrome: a review. *IOS Press Content Library,* 52(2), pp. 303-314, 2015.
Hall J. E., *Gyuton dan Hall Buku Ajar Fisiologi Kedokteran, Indonesian Edition*, Elsevier, 2016.
Iridiastadi, H., and Yassierli, *Ergonomi Suatu Pengantar, PT Remaja Rosdakarya*, Bandung, 2017.
Kuswana, W.S., *Ergonomi dan K3 Kesehatan Keselamat Kerja*, PT Remaja Rosdakarya, Bandung, 2014.
Manuaba A., Research and application of ergonomic in developing countries, with special reference to Indonesia, *Jurnal Ergonomi Indonesia,* vol. 1(1-6), pp. 24-30, 2000.
Mowry, C., and Ison, D. C., Assessing Computer Vision Syndrome Risk for Pilots. *Journal of Aviation/Aerospace Education dan Research*, vol. 24, no. 2, 79, 2015.
Nielsen, J., and Molich, R., Heuristic evaluation of user interfaces, *Proceedings of ACM CHI'90 Conference on Human Factors in Computing Systems*, pp. 25-62, 1990.
Ranasinghe, P., et al., Computer vision syndrome among komputer office workers in a developing country: an evaluation of prevalence and risk factors, *BMC Res Notes,* 9:150, 2016.
Rathore, I., Computer vision syndrome – an emerging occupational hazard. *Research Journal of Science and Technology,* vol. 9(02), 2017.
Reddy, S.C., Low, C.K., Lim, Y.P., Low, L.L., Mardina, F., and Nursaleha, M.P., Computer vision syndrome: a study of knowledge and practices in University Students. *Nepal J Ophthalmol,* 5(10), 161-168, 2013.

Saifulloh dan Noordin A., Evaluasi desain antarmuka dengan pendekatan kemudahan penggunaan (Studi Kasus Mobile App Sport Galaxy Center). *Jurnal Ilmiah DASI*, vol. 16, no. 4, pp. 55 – 58, 2015.
Suweta, I. M., Bahasa dan Kesusastraan Sebagai Bentuk Karakter, *Widyacarya*, vol. 3, no. 2, 2019.
Tarwaka, *Ergonomi Industri Dasar Dasar Pengetahuan Ergonomi dan Aplikasi di Tempat Kerja*, Harapan Press, Surakarta, 2013.

Biographies

I Wayan Santiyasa is a lecturer in informatics and a doctoral candidate in the field of ergonomics at Udayana University. Obtained bachelor and master degrees from Gadjah Mada University Yogyakarta. He focuses on exploring User Interface and User Experiences (UI / UX) with his research interests covering ergonomics, control systems, HCI and has published journals and conference papers both nationally and internationally.

I Putu Gede Adiatmika is a Professor of Ergonomics, and Director of the Udayana University Postgraduate Program. Obtained Bachelor of Medicine, Master of Health and Doctor of Ergonomics from Udayana University. He has published various journals and conference papers. Her research interests include ergonomics, physiology and occupational safety. He is on the Steering Committee of PEI.

I Noman Adiputra is a Professor of Ergonomics at Udayana University. He has published numerous national and international conference journals and papers. Her research interests include ergonomics and physiology. He is a member of the PEI.

Ida Bagus Alit Swamardika is an Associate Professor and Deputy Director for General Affairs, Finance and Cooperation at the Udayana University Postgraduate Program. Obtained a Bachelor's degree in Electrical Engineering from the Faculty of Engineering, Udayana University, Bali, a Masters and Doctorate in Ergonomics from Udayana University. He has published journal and conference papers. His research interests include ergonomics, control systems, HCI, Renewable Energy, electrical engineering. He is a member of PEI, IEA, IEEE, PII and IATKI