Effect of Head-Mounted Display Virtual Reality with Visual Intervention on Motion Sickness Symptoms

Efekt ekrana virtualne stvarnosti nataknutoga na glavu (koji ima vizualnu intervenciju) na simptome morske bolesti

K. K. Wardani
Institut Teknologi Sepuluh Nopember
Visual Communication Design
Surabaya, Indonesia
E-mail: kartikawardani@its.ac.id

K. B. Artana
Institut Teknologi Sepuluh Nopember
Marine Engineering Department
Reliability, Availability, Maintainability and Safety Laboratory
Indonesia
E-mail: ketutbuda@its.ac.id

E. Zulaikha
Institut Teknologi Sepuluh Nopember
Human Centered Design Laboratory
Industrial Design Department
Indonesia
E-mail: e_zulaikha@prodes.its.ac.id

F. I. Prastyasari*
Institut Teknologi Sepuluh Nopember
Marine Engineering Department
Indonesia
E-mail: fadilla@its.ac.id

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Abstract

Motion sickness (MS) is often experienced by individuals on moving vessels which the symptoms include fatigue, anxiety, dizziness, as well as vomiting. These conditions arise when the brain receives conflicting signal from eyes, vestibular receptors, and non-vestibular receptors. While medication is often used to treat MS, non-drug alternatives can also be considered for this purpose. Therefore, this research aimed to address this problem by producing non-drug therapy tool, namely Virtual Reality (VR). Specifically, head-mounted display (HMD) VR The display was used to present visual of sea horizon with islands. To evaluate the impact on reducing MS symptoms, the research compared clear visibility with reduced visibility as form of visual intervention. Approximately two types of videos were prepared using different color tones, namely cold and warm. The research also considered passengers' position as a variable that correlated with MS. To assess the relationship between visual intervention and MS reduction, various parametric statistical tests were used, including Multiple Linear Regression and Paired t-test. In cases where the data did not meet the assumptions of parametric testing, nonparametric Wilcoxon test was applied. The result showed that the use of warm tone videos led to a significant reduction in MS symptoms, as evidenced by the outcome of t-test. Similarly, passengers' position significantly affected MS, but visual intervention did not affect the condition.

KEY WORDS
head-mounted display
multiple linear regression
motion sickness
virtual reality

Sažetak

Od bolesti kretanja često pate osobe na brodovima u plovidbi, a simptomi uključuju: zamor, tjeskobu, pospanost, kao i povraćanje. Ta stanja pojavljuju se kada mozak prima konfliktni signal iz očiju putem vestibularnih i nevestibularnih receptora. Iako se često koriste lijekovi da bi se liječila bolest, alternative lijekovima također se mogu uzeti u obzir za ovu svrhu. Stoga je cilj ovog istraživanja riješiti problem nekemijskim alatima, tj. virtualnom stvarnošću VR (virtual reality). Naime, ekran virtualne stvarnosti nataknut na glavu upotrijebljen je da bi prikazao vizualni obzor mora s otocima. Da bi se procijenio odnos smanjenja simptoma bolesti kretanja, istraživanje je usporedilo čistu vidljivost i smanjenu vidljivost kao oblik vizualne intervencije. Pripremljena su približno dva tipa videa s različitim tonovima boja, hladnima i toplima. Istraživanje je također uzelo u obzir smještaj putnika kao varijablu koja je korelirala s morskom bolešću. Da bi se procijenio odnos između virtualne stvarnosti i smanjenja morske bolesti, upotrijebljeni su različiti testovi statističkih parametara, uključujući višestruku linearnu regresiju i upareni t-test. U slučajevima kada podaci ne zadovoljavaju pretpostavke parametarskoga testiranja, primijenjen je neparametarski Wilcoxon test. Rezultat je pokazao da je uporaba toplih tonova dovela do značajnoga smanjenja simptoma morske bolesti, kao što je evidentirano t-testom. Slično tome, smještaj putnika značajno je utjecao na one pogođene bolešću, ali vizualna intervencija nije utjecala na uvjete.

KLJUČNE RIJEČI
ekran nataknut na glavu
višestruka linearna regresija
morska bolest
virtualna stvarnost

* Corresponding author

1. INTRODUCTION / *Uvod*

The Industrial Revolution 4.0 is bringing rapid technological advancements across multiple sectors. An example of the most significant innovations arising from this period is Virtual Reality (VR), which has been applied in various fields such as education [1], healthcare [2], entertainment [3], etc. Typically, the technology allows users to interact in a simulated environment generated by a computer. Through VR, a real-world environment is recreated to form new fictitious background that only exists in visual world. This technology is very helpful in simulating scenarios that are challenging to replicate directly in the physical world [4].

VR is typically experienced through a head-mounted display (HMD) combined with motion detection devices designed to stimulate all the senses of users. Additionally, this tool can be applied as a non-pharmacological therapeutic tool to alleviate visual blur associated with motion sickness (MS) in ship passengers, which is the focus of the research presented here.

The use of VR for MS has also been assessed for aerospace applications, where training in virtual environment has effectively reduced nausea and improved task performance in disorientating surroundings. Results show that trained subjects with VR are 40% less susceptible to MS compared to untrained individuals [5]. Moreover, VR has been explored as a tool to reduce anxiety, nausea, and vomiting which are common side effect experienced by pediatric patients receiving chemotherapy. Following this discussion, Immersive virtual reality (IVR) was found to reduce anxiety and distress symptoms including nausea and vomiting among the patients [6].

MS has become a subject of research since the condition was first discussed by [7]. This condition occurs when brain receives conflicting signal from eyes, vestibular receptors, and non-vestibular receptors [8]. Despite the type of vehicle, MS symptoms are triggered by linear acceleration and repeated angular changes of the head. The primary cause of MS is body movements induced by waves which act as critical stimuli on the body [9]. Additionally, symptoms can be avoided by taking a short walk to the main deck and observing the ship and ocean. Prevention of MS without medication includes avoiding strong odors and spicy or oily foods, excessive alcohol, and smoking as well as refraining from traveling on a full stomach [10].

The typical response of body to MS is nausea, which can significantly affect general comfort. Several research prove that this response also includes psychological factors. For example, color psychology examines how different colors can influence emotional and mental responses. Cold colors (cold tone) and warm colors (warm tone) as examples color psychology have different psychological effect on the body both mentally and emotionally [11] [12].

The research presents the experimental investigation and statistical analysis on the use of HMD VR with visual intervention to alleviate MS symptoms in ship passengers. The process aim to reduce the need for therapeutic drugs to treat MS. This research focuses on establishing a relationship between visual intervention and MS symptoms. Three dependent variables are applied to the sample, namely age, blood pressure, and medication factor. In addition, image quality, color type, and passengers' position are selected as independent variables to examine the potential impact on MS symptoms.

2. RELATED WORKS / *Slični članci*

2.1. Head-mounted Display Virtual Reality (HMD VR) / *Ekran virtualne stvarnosti nataknut na glavu*

VR is a technology based on computer graphics, which allows the creation of virtual scenes and objects to be manipulated by users through input devices. This simulation can be experienced scenarios through output devices that engage senses such as sound, touch, and smell while users feel high reality during interaction. VR combines three main aspects namely immersion, interaction, and imagination as shown in Figure 1. Moreover, creating a sense of presence is a major motivation for using VR in education and other domains. This research examines several factors influencing users interaction and the result shows that deficiencies in visual presentation, such as poor graphics, reduce the sense of reality experienced in VR [13].

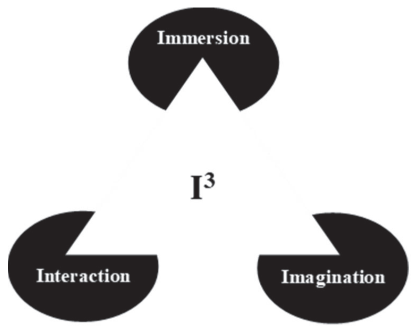

Figure 1 Dimensions of VR
Slika 1. Dimenzije virtualne stvarnosti

Previous research has shown that people using HMD VR with darker visual are more prone to experience *MS* than those with brighter graphics. Other influential factors includes the quality of graphics shown in *VR* as lower-quality or rough graphics tend to increase the probability of *MS* compared to smoother, higher-quality graphics [14].

2.2. Motion Sickness (MS) / *Morska bolest*

MS occurs when sensory information from the inner ear fails to synchronize correctly between different sensors. Symptoms often mistaken for fatigue or boredom are triggered by motion exposure. Importantly, without the presence of nausea and vomiting, a decrease in performance may go unrecognized as a sign of MS [15]. Experimental results have shown that nearly all people with normal vestibular function experience some level of MS when exposed to provocative physical body movements, vestibular-ocular reflex disorders, or optokinetic stimulation [16].

2.3. The Influence of Color on Human Psychology / *Utjecaj boja na ljudsku psihu*

Color psychology is based on mental and emotional effect that colors have on humans in various aspects of life. In color therapy, colors are often connected to emotion which can affect mental or physical state of a person [17]. The influences of colors are generally observed across two main categories, namely warm and cold tones. Warm tones are colors with red end of the spectrum are categorized as warm colors, including red, yellow, and orange. These colors can cause a wide range of emotional reactions from comfort, and warmth to anger as well as violence. On the other hand, cold tones are are considered more calming compared to warm color category. The colors in the cold tone category include green, blue, and purple. In addition, the influence of color on human psychology often causes feelings of calm as well as sadness.

3. RESEARCH MODEL AND EXPERIMENT MODEL / *istraživanja i eksperiment*

3.1. Sailing Route and Duration / *Plovidbena ruta i trajanje*

Passenger ships are designed to transport people from one location to another. During the design of a ship, stability would be crucial for safety, as it ensured balanced between gravitational force and buoyancy. Moreover, the movement of the ship could lead to MS among passengers. In this research, test was conducted on ship for passengers sailing from Tanjung Perak Port Surabaya, Indonesia to Gili Mas Port Lombok, Indonesia) with a total duration of 20 hours. Sea conditions on this route were relatively calm with an average wave height ranging from minor (0-0.1 m) to medium (1.25-2.5 m). The VR experience for passengers boarding on this route was designed to last for 14 minutes. This duration was selected based on research by Santoso [18], stating that 10% of passengers showed the first MS symptoms after 30 minutes, 10% after 2 hours, and 10% after 8 hours, respectively. Therefore, the duration of sailing effectively covered all these time frames. The overall route of the ship at the time of the experiment was shown in Figure 2.

3.2. Experiment Variables / *Varijable eksperimenta*

This research cumulatively showed the process and results conducted in different stages. In stage 1, HMD VR was used with a causative approach to evaluate the effect of blurriness on the severity of MS. Following that, a symptomatic method was used in the second stage of this research to examine MS in passenger ships with visual aspect of blurriness. This research marked as the third stage, added the color tone and passengers' position as independent variables.

3.2.1. Free variables / *Slobodne varijable*

MS was closely related to the physical movements experienced by human body. While passengers were onboard of a sailing vessel, an individual body moved in response to the movement of ship which was influenced by sea current, wave, or wind. During the voyage, the ship shows six degrees of freedom (DOF) including heave, sway, surge, roll, pitch, and yaw. Wertheim et al. [19] explored the effect of combinations of heaving, pitching, and rolling motion on individuals. The research aimed to test the traditional assumption that MS on a vessel was primarily triggered by the heave motion, while the pitch and roll motions were considered ineffective. However, this research did not consider motion of ship in the water as the experiment was performed in real environment rather than a simulator. Consequently, motion of ship during the investigation was considered as free variable.

3.2.2. Dependent variables / *Ovisne varijable*

Table 1 showed the review of all sample conditions based on dependent variables before and after the experiment. The description of each dependent variable is explained as follows.

a) Age / *Dob*

According to Lawther & Griffin [20], children aged 6 to 7 years started to experience MS, with symptoms peaking around ages 9 to 10 years. These symptoms began to disappear when the children reached 15 years old, and the tendency to experience MS decreased into adolescence and adulthood. Given that most passengers on the ship were between 24 and 40 years old and had traveled by ship at least once, this research focused on passengers aged 15 to 40 years. This age range was selected because the selection represented a group with lower tendency for MS and was commonly found among ship passengers.

b) Blood pressure / *Krvni pritisak*

N. Sugita *et al.* [21] investigated effect of visually-induced motion sickness (VIMS) by analyzing causal coherence functions

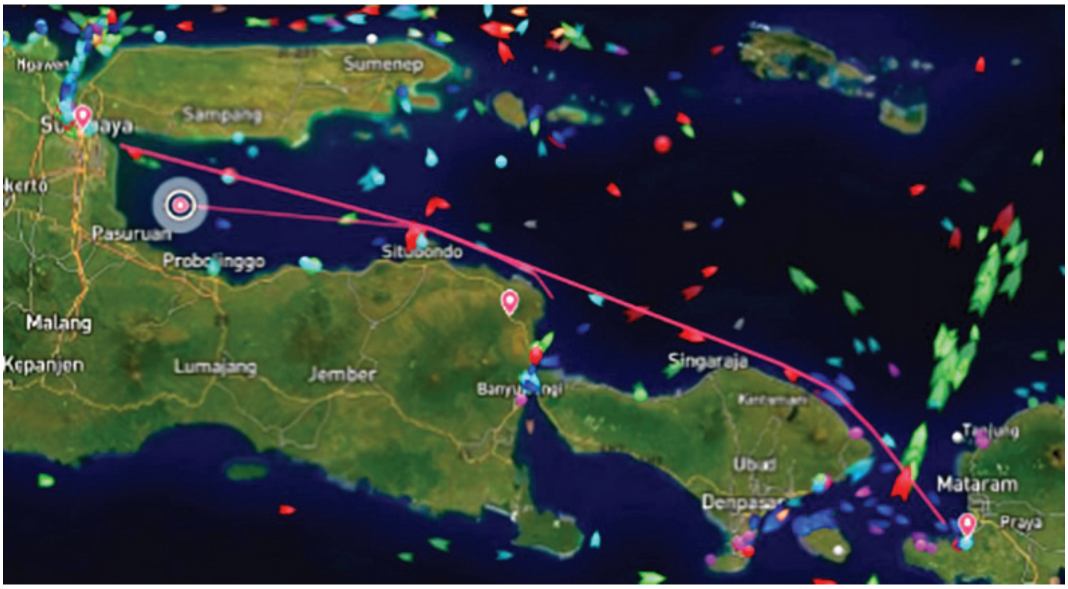

Figure 2 Ship Route during the experiment
Slika 2. Ruta broda za vrijeme eksperimenta

between blood pressure and other variables. This research found significant differences in both traditional and causal coherence functions between individuals who experienced MS and healthy people. The relationship between cardiovascular system indices, such as heart rate and blood pressure, changes due to alteration in autonomic nervous activity caused by visual stimulation. The coherence function between blood pressure and heart rate along with two causal coherence functions showed the total linearity of the cardiovascular system. This process showed that blood pressure was an important dependent variable in assessing MS. Following this discussion, blood pressure should be measured before and after using HMD VR.

c) Medication factor / *Učinak lijekova*

Susceptibility to MS was influenced by the consumption of alcohol and the use of relief tablets. Previous research showed that alcohol, as signified by Blood Alcohol Concentration (BAC) had a negative relationship with the severity of MS. Additionally, [12] stated that participants in the experiment should avoid taking MS relief tablets, as the tablets were used to prevent MS and thereby reduced the severity of symptoms during travel.

3.2.3. Independent Variables / *Neovisne varijable*

VR model incorporated three variables including image quality (clear and blurry), visual intervention with color tones, and passengers' positions as shown in Figure 3. Following the discussion, these variables were tested on ship passengers participating in this research. The data collected via Sickness Simulator Questionnaire (SSQ) was then tested using three methods, namely ANOVA Multiway, Multiple Linear Regression, and paired t-test.

The samples for this research were collected from passengers onboarding a passenger ship sailing from Tanjung Perak Port to Gili Mas Port in Lombok. All criteria mentioned were then interpreted into standards that were met by all participants in the following manner.

1. Male and female with age between 15 to 40 years,
2. In good health, with no history of recurrent headaches, visual impairment, and ear dysfunction,
3. Experienced in using VR no more than twice in one year,
4. Abstinence from alcohol less than 2 hours before the ship sailed and were free from the influence of alcohol,
5. Abstinence from MS relief tablets.

All participants should be willing to participate in experiments in various conditions. Due to the difficulty

Table 1 Review of sample condition before and after the *experiment*
Tablica 1. Pregled stanja uzorka prije i nakon eksperimenta

Gender	N	Age (Year) Mean ± SD	Medication	Blood Pressure-mmHg (Mean ± SD)			
				Before Using HMD		After Using HMD	
				Systolic	Diastolic	Systolic	Diastolic
Male	12	28.92 ± 7.35	None	115.50 ± 32.25	78.92 ± 23.37	118.06 ± 30.66	80.21 ± 25.09
Female	12	25.33 ± 4.99	None	103.20 ±30.05	75.22 ± 20.89	107.42 ± 29.50	79.08 ± 22.33

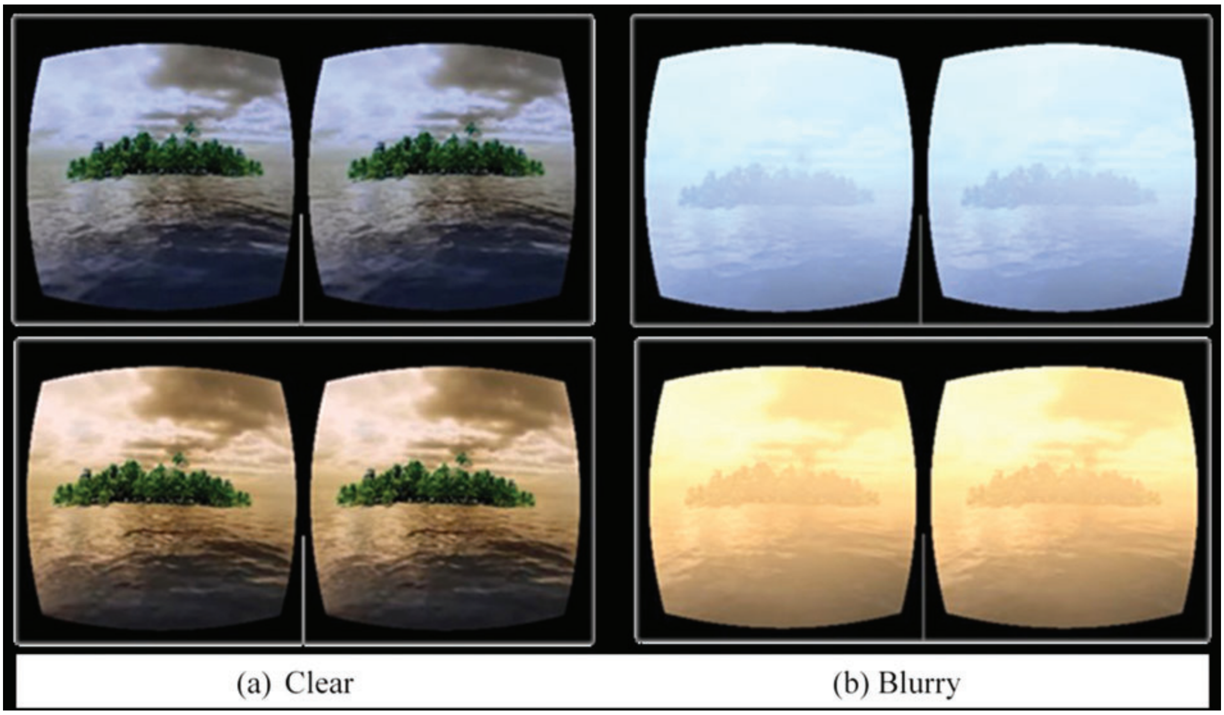

Figure 3 VR Model
Slika 3. Model virtualne stvarnosti

during finding participants that met these requirements, the experiment was designed to include three samples in each group, following Least Significant Difference (LSD) Formula [22].

3.3. Sickness Simulator Questionnaire SSQ / *Upitnik o simulatoru bolesti*

The research used SSQ because it effectively captured subjective experiences of MS without requiring participants to vomit. This method was useful when handling small sample sizes such as passengers prone to vomiting. MS symptoms often resembled typical MS, but effects of simulator sickness were generally milder and less severe among exposed populations. SSQ templates developed by Kennedy, et al. classified tissue disorders across several dimensions, including nausea, oculomotor, and disorientation [23].

Table 2 Independent variables of the experiment
Tablica 2. Neovisne varijable eksperimenta

Image Quality	Color Type	Passengers Position	Number of Subjects
Clear	Cold Tone	Inside	3
		Outside	3
	Warm Tone	Inside	3
		Outside	3
Blurry	Cold Tone	Inside	3
		Outside	3
	Warm Tone	Inside	3
		Outside	3

Table 3 showed how to calculate MS symptoms results for Nausea (N), Oculomotor (O), Disorientation (D), and the resulting Total Score. The results of the reduction between symptoms before and after VR was used produced the final score on SSQ.

Table 3 Sickness Simulator Questionnaire (SSQ)
Tablica 3. Upitnik o simulatoru bolesti

SSQ symptoms	Nauseous (N)	Oculomotor (O)	Disorientation (D)
Malaise	o	o	
Fatigue		o	
Headache		o	
Eye strain		o	
Difficulty focusing		o	o
Increased salivation	o		
Perspire	o		
Nauseous	o		o
Difficulty concentrating	o	o	
Heavy head			o
Blurred vision		o	o
Dizziness (open) eyes)			o
Dizziness (closed) eyes)			o
Vertigo			o
Stomachache	o		
Burps	o		
Total	{1}	{2}	{3}

Table 4 Equations for calculating the SSQ Component Value
Tablica 4. Jednadžbe za izračun SSQ vrijednost komponente

SSQ components	Equation
Nauseous	{1} x 9.54
Oculomotor	{2} x 7.58
Disorientation	{3} x 13.92
Total Score	{{1} + {2} + {3}} x 3.74

3.4. Experimental Data / *Eksperimentalni podaci*

Table 5 showed the experiment procedure used to obtain data that was conducted on passengers of the ship.

Table 5 Experiment Activity and Duration
Tablica 5. Aktivnost eksperimenta i trajanje

No.	Activity	Duration
1.	Asking passengers to join the experiment	5 minutes
2.	Filling in personal data and declaration of consent following the experiment	5 minutes
3.	Explaining SSQ before starting the experiment	5 minutes
4.	Attaching HMD to participants and playing one-play created virtual design videos	14 minutes
5.	Participants who had experimented took a short break and were later asked to fill out SSQ	5 minutes
6.	Giving souvenirs to the subject	2 minutes

3.5. Statistical Data Analysis / *Statistički podaci i analiza*

Several statistical tests were conducted to determine the relationship between each variable and symptoms of MS experienced by passengers using HMD VR. Although the main statistical test was three-way ANOVA, other methods such as Wilcoxon test and multiple linear regression were also used to validate the result of ANOVA.

3.5.1. Analysis of Variance (ANOVA) / *Analiza varijacija*

Three-way ANOVA was used due to the presence of three independent variables. This method was used to determine whether the various criteria tested influenced the desired results.

Performing three-way ANOVA required preliminary tests to validate the sample data. This research used three classic assumption tests, namely normality test, homogeneity test, and independence test. The samples were independent and randomly selected from each population or data group. When the assumption test was satisfied, ANOVA was then performed. Moreover, the results of ANOVA analysis showed whether there was a significant change in symptoms of MS before and after using VR. The classic assumption tests that were met included the following,

a) Normality Test

The examination was conducted to determine when the data obtained was normally distributed. The basis for decision-making was,

- Significant or probability > 0.05, then the data was normally distributed.
- Significant or probability < 0.05, then the data was not normally distributed.

b) Homogeneity Test

The examination aimed to explore whether the sample group had the same variance. The basis for decision-making for this test included the following.

- Significant or probability > 0.05, then the Hypothesis was accepted (H0)
- Significant or probability < 0.05, then the Hypothesis was not accepted (H1)

c) Independence Test

This examination aimed to determine the correlation among the experimental data. Additionally, experimental data should not have a significant correlation with other data to be independent. In this ANOVA test, the following calculation formula was used.

$$JKT = \sum_{i=1}^{r}\sum_{j=1}^{c} x_{ij}^2 - \frac{T_{..}^2}{rc} \quad (1)$$

$$JKB = \frac{\sum_{i=1}^{r} T_i^2}{c} - \frac{T_{..}^2}{rc} \quad (2)$$

$$JKK = \frac{\sum_{j=1}^{c} j^2}{r} - \frac{T_{..}^2}{rc} \quad (3)$$

$$JKG = JKT - JKB - JKK \quad (4)$$

where:

JKT : Total Squared Sum

JKB : sum of squares of rows

JKK : sum of squares of columns

JKG : sum of squares error

3.5.2. Wilcoxon / *Wilcoxon*

This analysis was part of a nonparametric test, which did not require normally distributed data. In addition, the test was conducted as a substitute for ANOVA analysis. Since the assumption of the parametric ANOVA test was not met, the nonparametric test was performed. The results of this test determined whether there was a significant difference between the independent variables on SSQ. Relating to the analysis, the formula of Wilcoxon test was as follows.

$$Z = \frac{J - \mu J}{\sigma J} = \frac{J - \frac{n(n+1)}{4}}{\sqrt{\frac{n(n+1)(2n+1)}{24}}} \quad (5)$$

where:

Z : Wilcoxon z-test

J : Small number of levels

μJ : Average value

σJ : Standard deviation value

n : number of samples

The basis for decision-making for Wilcoxon test was as follows.

- When the value of Asymp. Sig. (2-tailed) < 0.05, then the Hypothesis was accepted (H_0)
- When the value of Asymp. Sig. (2-tailed) > 0.05, then the hypothesis was not rejected (H_1)

3.5.3. Multiple Linear Regression / *Višestruka linearna regresija*

Multiple linear regression was used when the number of independent variables or predictor variables was more than one. During this process, the analysis produced values from both F-test and t-test. F-test was used to analyze the collective effect of independent variables on dependent variable, while t-test was used to determine the partial effect of each independent variable on dependent variable. The multiple linear regression model was represented by the following equation.

$$Y = \alpha + \beta_1 X_2 + \beta_2 X_2 + \beta_n X_n + e \quad (6)$$

where:

Y : Dependent variable or response variable

X : Independent variable or predictor variable

α : Constant

β : Slope or Coefficient estimate

The basic assumption tests that were met in Multiple Linear Regression analysis included the following.

a) Multicollinearity Test

This analysis showed a perfect linear relationship between some or all the variables that explained regression model. The basis for decision-making for the test included the following.

Based on tolerance value

- Tolerance > 0.10 = No Multicollinearity occurred
- Tolerance < 0.10 = Multicollinearity occurred

Based on the variance inflation factor (VIF) value

- VIF > 10.00 = No Multicollinearity occurred
- VIF < 10.00 = Multicollinearity occurred

b) Autocorrelation Test

This test was part of the classical assumption test aimed to determine the correlation of confounding errors in period t with previous period t-1 in linear regression model. When correlation was detected in the data, it was referred to as an autocorrelation problem in the analysis data. The basis for decision-making in the analysis included the following statements.

- When d < dL or d > 4-dL then the Hypothesis was rejected (H_1), and there was autocorrelation.
- When dU < d < 4-dU then the Hypothesis was accepted (H_0), and there was no autocorrelation.
- When dL < d < dU or 4-dU < d < 4-dL, this implied that there was no conclusion.

c) Normality Test

Normality test was performed to determine the data distribution in this research. When the data was abnormally distributed, linear regression method could not be applied because the prerequisites of the classical assumption test were not met. Following this process, two methods were used for this test, namely Kolmogorov-Smirnov test for samples more than 50 and Shapiro-Wilk test for samples less than 50. Since the data in this research was less than 30, normality test was conducted using the Shapiro-Wilk test.

d) Homoscedasticity Test

Homoscedasticity test aimed to determine any deviation from the classical assumption of heteroscedasticity, which referred to the presence of variance inequality in residuals across all observations in regression model. Glejser test method was used in this research as the method provided more accurate results compared to plot test which could cause bias. The examination was conducted by regressing independent variable on its absolute residual value of dependent variable.

3.5.4. Paired T-test / *Upareni T-test*

Paired t-test was used to compare two samples from the same subject in different treatments. This model analyzed differences before and after treatment, allowing the model to be a common method to assess the effectiveness of treatment. The efficiency was shown by the changes in the average values before and after the treatment [24]. Moreover, Paired t-test included parametric tests, showing that assumptions should be met.

The paired t-test in this investigation had the following hypothesis.

- $H_0 : \mu_1 = \mu_2$ (There was no significant difference in subjects to the treatment given)
- $H_0 : \mu_1 \neq \mu_2$ (There were significant differences in subjects with the treatment given)

The test statistics in this research included the following equation.

$$t_{hit} = \frac{\bar{D}}{\frac{SD}{\sqrt{n}}} \quad (7)$$

$$SD = \sqrt{var} \quad (8)$$

$$var = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2 \quad (9)$$

where,

t_{hit} = Calculated value,

$\bar{D}$ = average difference between measurements 1 and 2

SD = standard deviation difference between measurements 1 and 2

var = variance (s^2)

n = number of samples

4. RESULT AND DISCUSSION / *Rezultati i rasprava*

4.1. Classical Assumption Test / *Klasični test procjene*

Classical assumption test was a prerequisite in statistical analysis to ensure the validity of the model. This examination was essential in ANOVA and Multiple Linear Regression analysis, where assumption test was conducted before proceeding with the analysis. The results of the experiments were analyzed to determine whether the data met the criteria. The explanation of some classical assumption tests was as follows.

a) Normality Test

Normality Test was used to determine whether the data was normally distributed. This assumption was evaluated using two methods, namely Kolmogorov-Smirnov test for sample size greater than 50 and Shapiro Wilk test for data samples less than 50.

The results of residual normality and normality tests using Shapiro Wilk method in SPSS showed (significance value) Sig. = 0.687 and 0.127. Since Sig. > 0.05, the data in this experiment was considered normally distributed.

Table 6 Normality Test Comparison
Tablica 6. Usporedba testa normalnosti

Assumption Test Name	Analysis	Sig.
Residual Normality	Multiple Linear Regression	0.687
Normality	ANOVA & Paired t-test	0.127

b) Homogeneity Test

Homogeneity test aimed to determine whether the variation of some data from the population had the same variance. The assumption was accepted when the variance of several populations was equal or homogeneous. The basis for decision-making in this test was based on Sig. at mean > 0.05, then the data was considered homogeneous.

Table 7 Homogeneity Test Results on Color Type Variables
Tablica 7. Rezultati testa homogenosti na varijable vrsta boje

	Levene Statistic	Sig.
Based on Mean	3.722	0.014
Based on Median	0.600	0.747
Based on Median and with adjusted df	0.600	0.741

When Sig. < 0.05, the result showed that the variance of data from all variables was not equal or homogeneous. Although Homogeneity assumption test of data variance was not met, ANOVA test was still conducted, because the number of samples in this experiment was balanced. Therefore, conducting independence test was performed during the investigation.

c) Independence Test

Independence test in this research was conducted as a parametric test for independent comparison. Following this discussion, an independent sample in the results produced data from different subjects.

Table 8 Independence Test Results
Tablica 8. Neovisni rezultati testa

Variable	F	Sig. (2 tailed)
Image Quality	0.420	0.474
Color Type	0.379	0.012
Passengers Position	1.252	0.000

Sig. (2-tailed) value of image quality variable > 0.05 and the color type as well as position variables of passengers < 0.05. The values showed that there was no difference between SSQ score and image quality variable, but there was a difference between variable color type and position of passengers.

Table 9 Descriptive Statistics on Independent Variables
Tablica 9. Opisna statistika neovisnih varijabli

Variable	Criterion	N	Mean
Image Quality	Clear	12	87.740
	Blurry	12	161.797
Color Type	Cold Tone	12	3.421
	Warm Tone	12	246.115
Passengers Position	Inside	12	305.525
	Outside	12	-55.988

The lower average value on independent variable shown in the Table implied that the factors had a better potential to reduce MS symptoms.

Since some assumption tests such as homogeneity test and independence test were not satisfied, ANOVA analysis was not proceeded. The analysis was performed using a nonparametric Wilcoxon test, which did not rely on assumption tests and was used to compare more general groups.

d) Multicollinearity Test

Multicollinearity test was conducted to determine whether there was a correlation between independent variables in regression model.

Table 10 Multicollinearity Test Results
Tablica 10. Rezultati testa višebojne linearnosti

Variable	Sig.	Collinearity Statistics	
		Tolerance	VIF
Image Quality	0.104	1.000	1.000
Color Type	0.000	1.000	1.000
Passengers Position	0.000	1.000	1.000

The test results showed the value of tolerance > 0.10 and value of VIF < 10.00, implying that non-multicollinearity was met. This process implied the data did not experience multicollinearity problems.

e) Autocorrelation Test (Durbin Watson)

This test was represented using Durbin Watson values which were one method for evaluating autocorrelation. According to the decision-making criteria, non-autocorrelation was satisfied when dL < d < 4-dU.

Table 11 Durbin Watson Autocorrelation Test Results

Tablica 11. Rezultati Durbin Watsonova autokorelacijskog testa

R Square	Adjusted R Square	Durbin Watson
0.837	0.813	2.272

To determine dU and dL values, Durbin Watson Tables were used. For sample size N of twenty-four, and three number of independent variables (k), dL and dU values were 1.101 and 1.656. In this research, Durbin Watson value obtained was 2.272, hence, the data did not experience autocorrelation problems.

f) Homoscedasticity Test

The working principle of Glejser test was to progress independent variables to absolute residual values or ABS_RES. In this research, homoscedasticity was satisfied when Sig. > 0,05.

Table 12 Homoscedasticity Test Results

Tablica 12. Rezultati testa homogenosti varijacija

Variable	t	Sig.
Image Quality	-0.058	0.954
Color Type	2.287	0.333
Passengers Position	1.268	0.219

At the value of Sig., image quality variable = 0.954, color type variable = 0.333, and position variable = 0.219. All variables showed homogeneous symptoms with Sig. > 0.05, implying the data satisfied the assumption of homoscedasticity.

4.2. Results / *Rezultati*

After performing all assumption tests and results showed that all conditions were passed, parametric statistical tests of Multiple Linear Regression, Paired t-test, and Wilcoxon nonparametric statistical tests were conducted.

Table 13 F-Test Results

Tablica 13. Rezultati testa

Type	Df	F	Sig.
Regression	3	34.304	0.000
Residuals	20		

The Table showed that at Sig., 0.000 < 0.05 in F-test trigger. Therefore, independent variable simultaneously contributed to the influence on dependent variable of MSsymp toms.

Table 14 T-test Results

Tablica 14. Rezultati T-testa

Variable	t	Sig.
Image Quality	1.701	0.104
Color Type	5.574	0.000
Passengers Position	-8.303	0.000

In the results of the t-test, image quality value = 0.104 greater than 0.05, signifying that image quality did not have a significant effect on SSQ score. Consequently, the values of color type and position are both 0.000, which was less than 0.05. This result showed both color type and passengers position had a significant effect on SSQ score as MS symptoms was measured.

Table 15 Coefficient of Determination Test Result

Tablica 15. Koeficijent određivanja rezultata testa

R	R Square	Adjusted R Square
0.915	0.837	0.813

The results of coefficient of determination test were represented by R Square value, which was 83.7%. This result implied the independent variable simultaneously contributed to the influence of dependent variable of MS symptoms by 83.7%. The remaining 16.3% was influenced by other variables not included in this equation or variables not studied.

Table 16 Paired T-test Analysis Results

Tablica 16. Upareni rezultati T-testa

T	Sig. (2-tailed)
-2.479	0.021

Sig. (2-tailed) values were 0.021 < 0.05 in paired t-test analysis. This result was interpreted that H_0 was rejected and H_1 was accepted. Consequently, there was a significant difference between before and after getting intervention for the treatment.

Table 17 Wilcoxon Analysis Results

Tablica 17. Rezultati Wilcoxon analize

	SSQ
Z	-2.201
Asymp. Sig. (2-tailed)	0.028

During analysis of Wilcoxon, which was a nonparametric statistical method, Asymp. Sig. (2-tailed) value was 0.028 < 0.05. Therefore, the result showed that H_0 was accepted signifying a difference between before and after getting intervention for the treatment.

5. CONCLUSIONS / *Zaključci*

In conclusion, after analyzing the data and discussing the impact of using VR on symŽptoms of MS in the previous section, the following deductions were obtained.

1. According to the results of the analysis using Wilcoxon method, Multiple Linear Regression, and Paired t-test, the outcomes showed that there was a significant difference between before and after receiving treatment intervention using VR. This process signified visual intervention in the form of color type and passengers position influenced symptoms of MS. Moreover, the use of visual intervention with cold tone colors and showing external environmental conditions tended to reduce MS symptoms.
2. R Square value obtained from coefficient of determination test in multiple linear regression analysis was 83.7%. This result showed that the independent variables simultaneously contributed to symptoms of MS.
3. The results of image quality factor did not show a significant influence on symptoms of MS. These outcomes were obtained during partial regression coefficient test (t-test) which produced Sig. exceeding alpha 5%.
4. The outcomes of color type factor showed a significant influence on MS symptoms. These results were achieved when t test produced Sig. less than 5% alpha. During independence test for the color type variable, the average

value of warm colors (Warm Tone) was greater than cold colors (Cold Tone). Therefore, the values signified this color intervention could worsen symptoms of MS.

5. The results of position factor of passengers implied a significant influence on symptoms of MS. These results were achieved when t-test produced a significant value of less than 5% alpha. During independence test for position variable of passengers, the average value for the passengers positioned outside was greater than those positioned inside. Therefore, the investigation showed that the passengers' position outside could relieve symptoms of MS.
6. Future works could add more variables to the experiment to capture other possibilities that affect the effectivity of VR to reduce the symptoms of motion sickness. For example, the effect of ships dimension, voyage distance of the ships, as well as the duration of the experiment could also be further investigated.

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