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Effects of Energy Drink Types on Male and Female Drivers in an Effort to Reduce Drowsiness While Driving

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Abstract. *Energy drinks* are stimulants that men or women generally use to handle sleepiness while driving with sleep deprivation. There is no study about energy drink's effect on gender. This study aims to learn about energy drinks in different genders while driving with sleep deprivation. Research is done using a laboratory approach using a driving simulator. Ten men and ten women were participants (21 ± 0.95 years). Participants were asked to drive for 90 minutes, and before driving the simulator, participants drank coconut water or Kratingdeng based on the planned order. PVT measured awareness before and after participants used the simulator. Dependent variables measured are mean RT, %minor lapses, and mean 1/RT. EEG evaluated sleepiness during the driving session. Based on ANOVA, energy drinks did not influence mean RT (p-value = 0,088), mean 1/RT (p-value= 0,058), %minor lapses (p-value =0,571), and EEG (p-value = 0,348). Meanwhile, EEG measured sleepiness and was only influenced by gender (p-value = 0,048). Based on the test, there is no difference between the two energy drinks. It is caused by an energy drink's material that gives the body the same stimulant level. There is a difference in Mean 1/RT between gender and energy drinks. It is caused by composition such as potassium in coconut water or taurine and caffeine in Kratingdeng. The research shows that energy drinks do not influence awareness and sleepiness while driving for 90 minutes. However, energy drinks give different results in awareness of different genders.

Keywords: Sleepiness, Gender, Energy Drinks, Monotone

INTRODUCTION

There are several modes of transportation known in Indonesia. One mode of transportation that is widely used is island transportation. Land transportation with the most active users is motorized vehicles. The type of active motor vehicle widely used is passenger cars, which have 15,592,419 cars. The high number of vehicles is accompanied by an accident rate that has continued to grow yearly since 2017 (BPS, 2020). Based on the data displayed, it can be seen that an increase in the number of accidents occurs every year. Several factors cause motor vehicle accidents.

However, the most influential factor is the state of the driver or motorists at the time of the accident. Fatigue is the cause of accidents. Fatigue, as described by Williamson et al. (2011), can have an effect on the human body in the form of fatigue and drowsiness. Several factors can cause fatigue. These are circadian rhythm, homeostatic, and occupational factors (Williamson et al., 2011). Van Dongen (2005) explains that fatigue experienced by everyone can affect a person's performance level in doing work. The weakening of a person's cognitive abilities from one period to another indicates a decrease in performance.

This theory is reinforced by studies conducted by Galliaud, Taillard, Sagaspe, Valtat, Bioulac, and Philip (2008), which proved the effects of fatigue for each individual using EEG (*Electroencephalography*). There are two main factors of fatigue: sleeping sickness and demographics. Demographic factors such as age, gender, marital status, socio-economic status, and race can provide different levels of fatigue for each group as well as individuals (Di Millia, Smolensky, Costa, Howarth, Ohayon, and Philip, 2011).

To overcome fatigue and drowsiness, a solution is needed, one of which is to use stimulants. Stimulants are one type of drug that can increase the speed of sending information between the body and the brain. That way, a person will feel more alert, refreshed, and energized (Sproule & Marshman, 1998). One stimulant that can overcome fatigue and sleepiness levels is energy drinks. Based on the U.S. *Food and Drug Administration*, the caffeine content in energy drinks (80 mg-300 mg) is higher than in coffee (60 mg-150mg) (Smolensky et al., 2011).

Higher caffeine can give a faster and longer wakefulness effect, especially for driving. It is caffeine and a mixture of other ingredients such as taurine, vitamin B, and ginseng. The higher caffeine content and mixture of other ingredients encourage drivers to use energy drinks as stimulants. Studies conducted by Saku et al. (2020) found that 75% of 132 drivers used energy drinks, and 78% of those drivers used them to improve driveability.

The study was conducted based on concerns about the effects of fatigue and sleepiness on sleep-deprived motorists. The primary purpose of this study was to determine the effect of energy drink types on sleepiness and alertness of car drivers on different genders and determine the best type of energy drink for men and women. The gap to conduct this study is based on previous research where there was no in-depth research on the effects of sex and energy drinks on a person's fatigue level, especially when driving in conditions of sleep deprivation.

The variables used will be presented in figure 1.

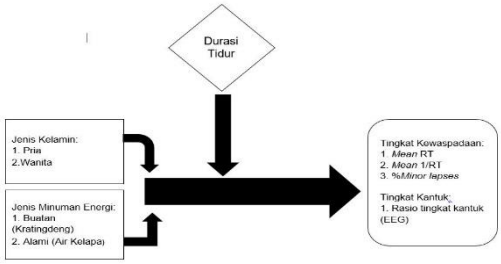

Figure 1. Conceptual Model of Research
Energy Drinks and Gender to Drowsiness

Based on this conceptual model, there are research questions about what type of energy drink affects gender and which energy drink has the best effect in reducing sleepiness for men and / or women. To be able to answer this question, the purpose of the study was set to determine the effect of this type of energy drink on different genders.

METHOD

In this study, the experimental design used was a *mix design subject*. The model was used in this research because the implementation of the research contains the properties of the *within-subject* and *between-subject* models simultaneously. The *within-subject* aspect is represented by the type of energy drink while the *between-subject* aspect is represented by gender. The experimental design can be seen in table I.

Table 1. Mixed Design research design

Types of Energy Drinks		Gender	
Kratingdaeng	P1,P2,..,P20	Man	P1,P2,..,P10
Coconut Water	P1,P2,..,P20	Woman	P11,P12,..,P20

In this study, participants were limited to those aged between 21 and 29 years, which is the age with the highest risk of accidents Regev, Rolison, J and Moutari (2018). Selected participants could only sleep for 4 hours the night before the experiment. This is based on a National *Sleep Foundation* survey, which found that drivers who sleep less than 5 hours will experience drowsiness while driving. Participants drove for 90 minutes and underwent *a Psychomotor Vigilance Test* (PVT). The driving duration is based on a study conducted by Hyodo, S., Yoshii,

T., Satoshi, M., & Hirotoshi, S.(2017), which states that motorists experience a decrease in alertness characterized by a change in speed after driving in the range of 60 to 90 minutes. Before PVP testing and driving, participants consumed 250 ml of energy drinks. After the driving activity was over, participants again conducted PVP testing. In measurements using EEG used algorithms (θ+α)/β (Jap, Lal, Fischer, Bekiaris, 2009). %change of Mean *Reaction Time* (*Mean* RT), 1/RT, and %*Minorlapse* will be used for PVT. The following timeline of research activities is shown in Figure 2.

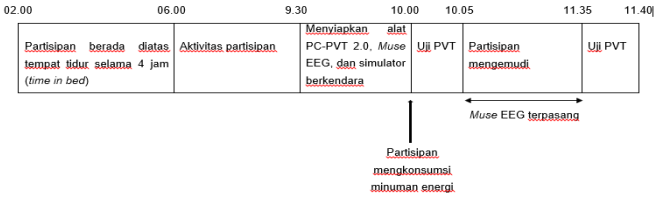

Figure 2. Experiment timeline

In providing treatment or treatment to participants used *counterbalancing*. This technique is used to avoid the *order effect*. Martin (2008) states that the *order effect* occurs when participants respond to a level of treatment that can be influenced by the level of treatment that has been given to the participant. The type of *counterbalancing* used in the conduct of this experiment is *Latin Square*.

DISCUSSION

PVP and EEG data were collected for statistical testing using *Mixed ANOVA*. In the implementation of the research, *a pilot study* was carried out first to be able to find out the number of participants needed. Here is *Cohen's equation d* used to obtain the number of participants. Based on *cohen's table d* (Maxwell &; Delaney, 2004). The following calculations use *Cohen's method d*.

$$\boldsymbol{d} = \frac{\mu_{max} - \mu_{min}}{\sigma_{\varepsilon}} \quad \text{(Pers.III-1)}$$

$$\boldsymbol{\sigma_{\varepsilon}} = \frac{\sigma_m}{f} \quad \text{(Pers.III-2)}$$

$$\boldsymbol{\sigma_m} = \sqrt{\frac{\sum(\mu_j - \mu)^2}{a}} - \sqrt{\frac{\sum \alpha_j^2}{a}} \quad \text{(Pers.III-3)}$$

Information:
d = effect size
μ_j = average test results
μ = average of μ_j
σ_ε = square root of the population *within cell error variance*
σ_m = standard deviation of population mean
μ_{max} = Maximum average value of group population
μ_{min} = Group population minimum average value

Using equation III.1, equation III.2, and equation III.3 and using *60%* power of statistics, the *effect size* value is 1.2. Using *the Cohen's d* table, a minimum sample size of 10 participants was obtained. This value is obtained by interpolating the minimum sample results (N) for *50% power of statistics: d = 1.00 N = 9 and d = 1.25 N = 7 with interpolation results of 7.4 and 80% power* of statistics: d = 1.00 N = 17 *and d = 1.25 N = 12 with interpolation results of* 13. To get the value of N at 60% power of statistics, *it is necessary to interpolate between* the power of statistics 50% d = 1.2 N = 7.4 ≈ 8 with the power *of statistics 80% d = 1.2 N* = 13. From the interpolation, N = 9.6666 was obtained ≈ from 10 participants. The number 10 participants were used for both *between-subject* groups: men and women. That way, the total number of participants needed is 20, divided into ten female and ten male participants. After the study, the following are the results of PVP testing of all pesetas from the two energy drinks studied.

Table 2. PVP Data Recapitulation

Participants	T1 Man (Coconut Water)		
	Mean RT	1/RT	%MinorLapse
	%Change	%Change	%Change
1	-8,003	2,513	-47,913
2	5,757	-4,996	0,962
3	6,303	-5,004	19,994
4	1,341	-0,437	13,625
5	8,585	-4,153	182,329
6	-0,388	-1,18	145,324
7	-9,234	-6,437	-24,997
8	5,526	-0,056	104,619
9	28,057	-16,893	126,944
10	9,845	-6,43	90,208
Participants	T2 Man (Kratingdeng)		
	Mean RT	1/RT	%MinorLapse
	%Change	%Change	%Change
1	3,745	-6,687	6,516
2	2,775	-0,112	150,92
3	8,076	-3,805	206,485

4	-9,65	8,304	0
5	-27,857	37,161	-81,224
6	-16,196	11,206	12,745
7	-4,114	9,856	-8,167
8	-9,223	7,261	-21,482
9	-1,332	3,843	-37,446
10	-5,313	6,12	-35,945
Participants	T1 Woman (Coconut Water)		
	Mean RT	1/RT	%MinorLapse
	%Change	%Change	%Change
11	19,03	-15,163	117,868
12	10,607	-11,743	-100
13	-13,141	10,118	-2,068
14	-4,411	-1,486	-74,488
15	-5,593	5,339	-34,549
16	-10,344	9,285	-64,583
17	-0,556	1,159	8,341
18	2,871	-1,889	112,513
19	-9,383	4,16	-41,18
20	-1,009	-0,839	66,667
Participants	T2 Woman (Kratingdeng)		
	Mean RT	1/RT	%MinorLapse
	%Change	%Change	%Change
11	4,174	-4,92	19,892
12	-6,149	4,731	-69,526
13	0,414	1,134	0
14	2,786	-2,084	59,995
15	-12,133	8,628	-61,43
16	-3,852	2,597	4,356
17	-3,691	-5,779	-25
18	-13,403	13,841	-38,8
19	21,59	-15,949	90,557
20	17,463	-5,922	113,629

The PVP data is obtained from the comparison or % change between the initial test and the final test of each participant. Not only PVP, this study also used EEG as a measurement tool. The following is a recapitulation of measurement results using EEG.

Table 3. EEG Data Recapitulation

T1 (Coconut Water)			
Man		Woman	
Participants	Rasio EEG	Participants	Rasio EEG
1	2,036	1	2,183
2	2,016	2	1,993
3	1,983	3	2,151
4	2,059	4	2,161
5	1,967	5	2,006
6	1,959	6	1,993
7	1,681	7	2,068
8	2,06	8	2,07
9	2,023	9	1,958
10	1,928	10	1,926
T2 (Kratingdaeng)			
Man		Woman	
Participants	Rasio EEG	Participants	Rasio EEG
1	1,909	1	2,075
2	1,972	2	2,046
3	1,945	3	2,193
4	1,884	4	1,992
5	2,049	5	1,919
6	1,481	6	1,912
7	2,019	7	1,888
8	1,827	8	1,96
9	1,976	9	1,955
10	2,202	10	2,185

The data that has been collected and recapitulated is then processed as a process in getting answers to research questions. The data that has been collected is processed to determine the effect of the independent variable on the dependent variable. Data processing is carried out using *mixed ANOVA testing*. In fulfilling the assumptions of ANOVA testing, data normality testing and data homogeneity testing are carried out.

Normality Test

Before conducting an influence test using *Mixed ANOVA,* there are conditions that need to be met, one of which is the data normality test.

Test data normality using the *Shapiro-Wilk method* because the number of data is less than 50. The following in Table III.6 displays the results of the data normality test.

Hypothesis tested:

H_0 : Normal distributed residual standard data

H_1 : Residual standard data is not normally distributed

The following is a recapitulation of the data normality test.

Table 4. Data Normality Recapitulation

Normality Test			
Shapiro-Wilk			
Tested Data	Statistics	df	Sig.
Mean RT Man-Coconut water	0,903	10	0,235
Mean RT Male-Kratingdeng	0,951	10	0,679
Mean RT Women-Water Coconut	0,929	10	0,439
Mean RT Kratingdeng's women	0,92	10	0,355
1/RT Man-Coconut water	0,875	10	0,115
1/*RT* Male-Kratingdeng	0,828	10	0,03*
1/RT Women-Water Coconut	0,924	10	0,395
1/RT Kratingdeng's women	0,981	10	0,97
%Minor Lapse Man-Coconut water	0,942	10	0,576
%Minor Lapse Male-Kratingdeng	0,811	10	0,2
%Minor Lapse Women-Water Coconut	0,919	10	0,345
%Minor Lapse Kratingdeng's women	0,946	10	0,623
Male-Coconut Water sleepiness ratio	0,735	10	0,002*
Male-Kratingdeng sleepiness ratio	0,875	10	0,115
Woman-Coconut Water sleepiness rate ratio	0,923	10	0,386
Female-Kratingdeng sleepiness ratio	0,891	10	0,176

Based on the test, there are 2 groups of data that are not normally distributed. The data is data on the ratio of male sleepiness to coconut water and a value of 1 / RT for men with kratingdeng. Although the two data are not normally distributed, they can still be used to test the effect of *mixed ANOVA.* This is supported by research conducted by Schmider et al. (2010) who said that the ANOVA test is not sensitive or is not affected by the normality of the data tested.

Homogeneity Test

After conducting the normality test, the data homogeneity test was then carried out. This homogeneity test is carried out to test whether the data to be tested *mixed ANOVA* has the same variance or not. Homogeneity testing is carried out using the Levene homogeneity method. The following homogeneity test results are shown in Table III.7.

Hypothesis tested:

H_0 : Data has the same variance (homogeneous)

H_1 : Data does not have the same variance (not homogeneous)

The following is a recapitulation table of testing the homogeneity of research data.

Table 5. Recapitulation of Homogeneity Test

Homogenitas		
Indicator	Coconut Water (*p-value)*	Kratingdeng (*p-value)*
Mean RT	0,922	0,802
1/RT	0,232	0,787
%Minor Lapse	0,68	0,51
Drowsiness ratio	0,848	0,514

Based on Table 5 there is no inhomogeneous data. This is because all data tested have a *p-value* greater than 0.05. Therefore all tested data fail to reject H_0 or the data has the same variance value.

Uji *Mixed ANOVA*

After conducting the normality test and homogeneity test, the next step is to conduct an influence test using *mixed ANOVA*. The *mixed ANOVA* test was conducted to determine the effect of independent variables such as gender, type of energy drink, and the interaction between the type of energy drink and gender on the dependent variable in the form of measurement indicators such as *Mean* RT, 1 / RT, %*Minor lapse*, and sleepiness ratio based on EEG. The following in Table III.8 are shown the results of *mixed ANOVA testing*.

Hypothesis tested:

H_0 : There was no significant average difference between the indicators between sex and the type of energy drink.

H_1 : There were significant average differences between indicators between sex and type of energy drink.

The following is a recapitulation table of statistical *mixed ANOVA test results*.

Table 6. Mixed ANOVA test

Mixed ANOVA			
Indicator	*P-Value*		
	Gender	Types of Energy Drinks	Type of Energy Drink*Gender
Mean RT	0,92	0,088	0,226
1/RT	0,539	0,058	0,049*
%Minor Lapse	0,111	0,571	0,348
Drowsiness ratio	0,048*	0,348	0,942

Description: *: significance on α=0.05

Table 6 shows two indicators that have averages that differ significantly between groups. The two indicators are 1/RT and the ratio of sleepiness level, which has a *p-value* smaller than 0.05. For indicator 1/RT, there was a significant average difference between the interaction group of energy drink type and sex. For the sleepiness ratio indicator, there is a significant average difference in the sex-independent variable. As for other indicators such as *Mean* RT, %*minorlapse*, the ratio of sleepiness by type of energy drink, and the interaction between energy drinks and gender, 1/RT based on the type of energy drink and gender did not have a significant average difference.

Testing was not continued *post-hoc* testing because this study only considered two factors, namely gender, with each factor having only two levels: coconut water and kratingdeng. In the mixed *ANOVA test results*, it can be seen that there are independent variables that have a significant influence on the indicator. The independent variable that significantly influences the interaction variable between sex and energy drinks on the average reaction speed in 1 second can be referred to as the *mean* 1 / RT and the sex variable to the ratio of sleepiness. Based on the *mixed ANOVA* test, the independent variable of interaction between sex and energy drinks on *a mean* of 1/RT has a *p-value* or significance of 0.049.

The value is smaller than 0.05, so the test results reject the null hypothesis and accept the alternative hypothesis, meaning there is a significant difference. The interaction variable is a variable to determine whether the effect of the sex variable on the *mean* 1 / RT is influenced by the effect of energy drinks. Based on *the mixed ANOVA test*, it is known that there is an influence between the effects of the two independent variables. The results of *the mixed ANOVA* test only showed that gender and energy drink variables influenced each other. The effect in question is the percentage change value of *Mean* 1 / RT male and female sex influenced by energy drink variables and vice versa.

Another independent variable that exerts an influence is the sex-to-sleepiness ratio. The ratio of sleepiness levels is the result of brain wave calculations recorded using EEG and processed using algorithms found by Jap et al. (2009). Three brain waves are used, namely Theta, Alpha, and Beta waves, which are then calculated using the equation $(\theta + \alpha) / \beta$. Based on this equation, a person's sleepiness level can be known. If the calculation result of the three waves is less than one, then the person is not sleepy, while if the calculation result is more than 1, then the person is in a sleepy condition (Jap et al., 2009).

Based on the results of mixed ANOVA testing, *it can be seen that the sex-independent variable influences the ratio of sleepiness, where the p-value of the ANOVA* test results has a

value of 0.048. The null hypothesis is rejected with test results below 0.05, and alternative hypotheses are accepted. To support this, see Figure C.1 in Appendix C, where the blue line represents the man with coconut water, and the red line represents the man with the majority kratingdeng below the yellow and gray line representing the female sex in both energy drinks. A study on the physiological differences between the sexes supports this statement.

In research, Wimer & Levant (2013) states there are differences in sex performance. The study found that men respond better than women. In the results of testing the ratio of other levels of sleepiness, the free variable of energy drinks does not affect the value of the level of sleepiness, and there is no influence between independent variables. Based on this, the level of sleepiness is only influenced by gender but ignores which type of energy drink has a better effect.

Two dependent variables are not affected by all independent variables. The two variables are *Mean* RT and *%Minorlapses*. The *independent variable did not affect the mean RT* variable, indicating that the magnitude of the change in reaction time for different sexes using different energy drinks had no difference. The test results are supported by Dykiert & Der (2012) research. In the study, it was found that there was no difference in reaction time between the sexes. Another independent variable that had no influence was the type of energy drink. Based on the results of *mixed ANOVA* testing, both energy drinks provide the exact change in reaction time results.

This can be due to the period of giving energy drinks with PVP testing that is too short so that the maximum effect of energy drinks is less. It takes at least 30 minutes for artificial energy drinks such as kratingdeng and coconut water to affect the body (Erdmann et al., 2021). Another bound variable not affected by the independent variable is the *% of Minorlapses change*. Based on this, it is known that participants tend to have similar %*minorlapse* changes. This is because there is the same *minor lapse* limit tolerance for more than 500 milliseconds of circumstances. This can cause participants to have a reaction time smaller than 500 milliseconds.

The mixed *ANOVA* results showed no difference between the two energy drinks, namely coconut water and kratingdeng. There are two main factors: the two types of energy drinks have no difference. The first factor is the content possessed by both energy drinks. On paper, artificial energy drinks represented by kratingdeng can provide more stimulants to drivers than coconut water. However, the content of coconut water, such as potassium, sodium, and other minerals along with protein, can provide the same stimulant to the body (Pathiranage et al., 2017).

Although there is a difference in content between coconut water and kratingdeng, the body still gets the same level of stimulants. This is to the results of research conducted where the

mixed *ANOVA* value shows no significant difference between coconut water and kratingdeng at the level of alertness and a person's sleepiness level. The second factor is the period between consuming energy drinks and conducting experimental activities. In this study, participants immediately carried out activities after consuming energy drinks. This can cause participants to engage in activities before energy drinks can have an effect. This factor can significantly influence experimental activities, primarily when participants conduct PVP testing before driving activities. The results obtained show no difference between the two types of energy drinks. While it cannot determine which energy drink is best, some contributions can be made.

CONCLUSION

The conclusions drawn are answers to research questions formulated at the beginning of the study. The advice in question is a suggestion for similar research in the future based on research that has been carried out. Two conclusions can be drawn. First, based on the results obtained from research, it is known that energy drinks can have different effects on a person's reaction speed in different sexes. This is based on the analysis of the *mixed ANOVA* results of *the Mean* 1/RT indicator. The results of *ANOVA* indicators show that gender and energy drinks affect a person's reaction speed. Thus, the speed of reaction in different sexes can be affected by energy drinks. However, for the level of sleepiness, only differences in different sexes were based on the results of the ratio of sleepiness levels. Men have a lower level of sleepiness compared to women. Second, there is no difference in the effect of giving encouragement or stimulants to the body between the two types of energy drinks. Therefore, coconut water and kratingdeng are equally suitable for encouraging or stimulating the human body.

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