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DRIVER RESPONSE AND REACTION ON SHARP CURVED ROADS TO THE USE OF WHITE AND YELLOW HEAD LAMPS

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ABSTRACT

Nowadays, with the increase in mobility and traffic intensity, it is essential to continuously improve driving safety technology. Driving safety is a primary concern as mobility increases and road networks continue to develop. In constantly changing and challenging road environments, such as winding roads, vehicle lighting factors become key to ensuring that drivers can respond quickly and accurately to emerging situations. Vehicle lights, particularly white and yellow headlamps, play an important role in providing adequate illumination to improve driver visibility on winding road conditions. The study uses a qualitative method, involving simulation analysis of driving on sharp curves and collecting interview data from experienced and professional drivers. The collected data is analyzed using the SWOT analysis method. Based on the findings, yellow headlamps are positioned in Quadrant I, at coordinates (0.53 and 0.75). This indicates that the use of yellow headlamps can be implemented effectively. Meanwhile, white headlamps are located in Quadrant II, at coordinates (-0.11 and 0.20). This shows that the use of yellow headlamps can be applied, albeit with internal considerations.

Keywords: response; safety; sharp curve; white headlamp, yellow headlamp

INTRODUCTION

Traffic accidents are one of the leading causes of injury and death worldwide. With increasing mobility and traffic intensity, it is crucial to continuously improve technologies for driving safety. Driving safety has become a major concern in this modern era, where mobility is rising and road networks are constantly expanding. In frequently changing and challenging road environments, such as winding roads, vehicle lighting factors play a key role in ensuring drivers can respond quickly and accurately to emerging situations. Vehicle lights, particularly white and yellow headlamps, are essential in providing adequate illumination to enhance driver visibility in winding road environments. When navigating winding roads, drivers face various challenges, including sharp curves, elevation changes, and limited visibility. Proper lighting can help reduce the risk of accidents and enable drivers to navigate roads more safely and efficiently. White and yellow headlamps are two commonly used types of vehicle lights, each with different characteristics and advantages. White headlamps are characterized by brighter and sharper illumination, while yellow headlamps provide softer and more comfortable lighting for the eyes. Comparing their performance in winding road conditions can offer valuable insights into the effectiveness of each lamp type in improving driving safety.

The more limited perspective at night highlights the importance of adequate road lighting and proper use of vehicle lamps to help extend drivers' visibility and enhance road safety. At night, drivers' visibility on sharp curves becomes critically important due to limited light from vehicle lamps and road illumination. Sharp curves tend to obscure drivers' views of what lies around the bend. In such situations, drivers must rely on vehicle lighting and road illumination to see the curves ahead. This study is also relevant to the development of advanced vehicle lighting technologies. The automotive industry continues to innovate by developing more sophisticated and efficient lighting systems, such as LED lights and adaptive headlights. However, despite the potential safety improvements offered by these technologies, debates persist regarding the relative advantages of white and yellow headlamps under certain conditions, particularly in winding road environments. Based on the aforementioned points, the researcher aims to conduct a study titled "Analysis of White and Yellow Head Lamps: A Comparison of Driver Response and Reaction on Sharp Curved Roads." This research is expected to help reduce the number of accidents on sharp curved terrains by providing recommendations on the appropriate type of vehicle headlamp. It also serves as a reference for future research development

METHOD

The research method employed in this study is a qualitative method. It involves conducting driving simulations and in-depth interviews with respondents. The interviews are conducted with drivers to understand their perceptions regarding the use of white and yellow headlamps on sharp curved roads and to identify the challenges faced by drivers when navigating sharp curves at night. After collecting data from simulations and interviews, the data will be analyzed using the SWOT analysis to determine its quadrant position. Based on recommendations for the number of respondents in interview methods, 15 respondents will be involved (Patton, M. Q: 2001 and Bonnie Nastasi: 2015).

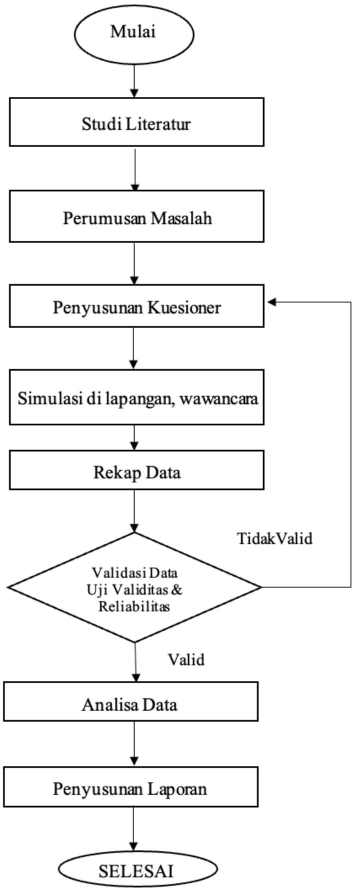

Figure 1. Research Process Flowchart

RESULT AND DISCUSSION

The driving simulation activity aims to understand the driving experience of drivers when using yellow and white headlights at night on sharp curved roads.

Table 1.
Driving Simulation

Description	Implementation
Driving Simulation	Conducting driving simulations with 15 drivers regarding the use of white and yellow headlamps. The researcher sits beside the driver while the vehicle is driven on the road. - Condition 1: The driver operates the vehicle using a white headlamp at night, while encountering vehicles with either white or yellow headlamps coming from the opposite direction on sharp curved roads - Condition 2: The driver operates the vehicle using a yellow headlamp at night, while encountering vehicles with either white or yellow headlamps coming from the opposite direction on sharp curved roads.
Interview with Drivers	While driving the vehicle, the researcher conducted direct interviews with the drivers regarding their driving experience in the two conditions - Condition 1: The driver operates the vehicle using a white headlamp at night, while encountering vehicles with either white or yellow headlamps coming from the opposite direction on sharp curved roads. - Condition 2: The driver operates the vehicle using a yellow headlamp at night, while encountering vehicles with either white or yellow headlamps coming from the opposite direction on sharp curved roads

Here is the documentation of the driver's driving simulation, as shown in Figures 2 and 3

Figure 2. Driver operating the vehicle using a yellow headlamp at night on a sharp curve

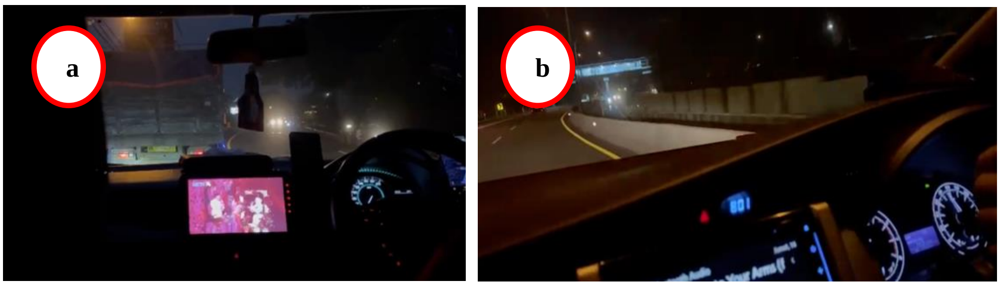

Figure 3. Driver operating the vehicle using a white headlamp at night on a sharp curve

Table 2.
Weighting of Internal Factor Analysis (IFAS) for White Headlamp – Strengths and Weakness

IFAS - STRENGHT & WEAKNESS				
Conditions				
	White Headlamp	Weight (a)	Rating (b)	Score (axb)
Strenght	Clearer and Brighter Illumination: Provides higher visibility, especially in dark conditions or when visibility is limited.	0,06	3	0,19
	Efficiency in Normal Conditions: Suitable for roads with minimal ambient lighting	0,06	3	0,19
	Modern Light Quality: White light technology (such as LED or HID) is often more energy-efficient and durable compared to yellow lights.	0,06	3	0,19
	Enhancing Vehicle Aesthetics: White headlights are often associated with modern vehicles	0,13	3,5	0,44
Sub Total Strenght				1,00
Weakness	Less Effective in Bad Weather Conditions: White light tends to reflect off particles like fog, heavy rain, or dust, reducing visibility and creating glare for the driver	0,19	2	0,38
	Higher Glare for Other Road Users: The high intensity of white light can cause glare for oncoming drivers, especially on sharp curves.	0,19	2	0,38
	Less Optimal in Low Contrast Environments: In areas with varying lighting (such as curves with tree shadows or tunnels), white lights can create extreme contrast differences, making it difficult for drivers to adapt.	0,13	1,5	0,19
	Higher Replacement Costs: White light technologies such as HID or LED are generally more expensive to replace compared to yellow halogen lights.	0,19	1,5	0,28
Sub Total Weakness				1,22

Table 3.
Weighting of Internal Factor Analysis (IFAS) for Yellow Headlamp – Strengths and Weakness

IFAS - STRENGHT & WEAKNESS				
Conditions				
	Yellow Headlamp	Weight (a)	Rating (b)	Score (axb)
Strenght	Ability to Penetrate Fog, Rain, and Dust: Yellow lights have a longer wavelength, making them more effective in penetrating poor weather conditions such as fog, heavy rain, or thick dust on sharp curved roads.	0,18	4	0,71
	Reducing Glare for Other Drivers: The intensity of yellow light tends to be softer, reducing the risk of blinding other drivers...	0,12	3,5	0,41
	Support for Safety: Yellow light provides better contrast in low-visibility environments, helping drivers stay alert in dangerous areas like sharp curves.	0,12	3,5	0,41
	Effectiveness for Challenging Terrain: Yellow lights are effective for challenging terrains, such as mountain roads or long-distance transport routes	0,12	3,5	0,41
Sub Total Strenght				1,94
Weakness	Less Bright Light: Provides lower visibility compared to white lights, especially in normal weather conditions.	0,12	2	0,24

	Limited Illumination Range: Yellow lights cannot reach as far as white lights, which is a disadvantage on curves with long sight distances.	0,12	2	0,24
	Less Efficient in Urban Areas with Adequate Lighting: In areas with artificial lighting, such as streetlights, yellow lights appear less effective compared to white lights.	0,12	2	0,24
	Aesthetic Appeal: Yellow lights are often considered outdated, making them less appealing to users of modern vehicles..	0,06	1,5	0,09
	Subtotal Weakness			0,88

Table 3.
Weighting of External Factor Analysis (EFAS) for White Headlamp – Opportunities & Threats

EFAS - OPPORTUNITY & THREATS				
	Conditions			
	White Headlamp	Weight (a)	Rating (b)	Score (axb)
OPPORTUNITY	Innovation in Automotive Lighting Technology: Advances in technology, such as LED and laser lights, can improve the efficiency and performance of white headlamps, making them more reliable even in extreme conditions.	0,08	4	0,32
	Market Demand for Modern Vehicles: Trends in modern vehicles that prioritize design and performance create opportunities for white headlamps to become the preferred choice due to their aesthetics and high performance.	0,08	4	0,32
	Development of Road Infrastructure: The addition of facilities such as reflective markers and smart signs can enhance the effectiveness of white headlamps on sharp curves.	0,08	4	0,32
	Regulations Supporting Road Safety: Governments may promote the use of brighter and more energy-efficient lighting technologies to improve traffic safety in accident-prone areas.	0,08	4	0,32
	Public Awareness of Driving Safety: Growing awareness of the importance of visibility while driving opens opportunities for the use of white headlamps to support safer journeys.	0,08	4	0,32
	Sub Total Opportunity			1,60
THREATS	Disruption from Adverse Weather Conditions: White lights tend to reflect off fog, heavy rain, or dust, reducing visibility and causing glare for drivers.	0,12	2	0,24
	Competition with New Lighting Technologies: Alternatives such as adaptive headlights or multi-spectrum lights pose a threat to conventional white headlamps by offering more flexible performance.	0,12	2	0,24
	Strict Traffic Safety Regulations: Rules limiting high-intensity lights that may dazzle other road users could restrict the use of certain white headlamps.	0,12	2	0,24
	Awareness of Glare Impact: Complaints from other drivers about glare caused by white lights may shift preferences toward more user-friendly lighting options.	0,12	2	0,24
	Dependence on Adequate Road Infrastructure: The effectiveness of white headlamps may decrease if roads lack reflective markers or signs that enhance additional visibility.	0,12	2	0,24
	Sub Total Threats			1,20

Table 4.
Weighting of External Factor Analysis (EFAS) for Yellow Headlamp – Opportunities & Threats

EFAS - OPPORTUNITY & THREATS				
Conditions				
	Yellow Headlamp	Weight (a)	Rating (b)	Score (axb)
OPPORTUNITY	Demand for Vehicles in Nighttime and Adverse Weather Conditions: Regions with extreme weather such as fog, heavy rain, or dust provide opportunities to maximize the use of yellow headlamps.	0,13	4	0,50
	Regulations in Specific Regions: Some countries or areas mandate the use of yellow lights on vehicles for certain conditions, creating opportunities for wider adoption.	0,13	4	0,50
	Market for Commercial and Specialized Vehicles: Vehicles such as buses, trucks, or heavy equipment that frequently operate in harsh terrain or adverse weather conditions have a greater need for yellow lights.	0,13	4	0,50
	Collaboration with the Transportation Industry: Partnerships with vehicle manufacturers or transportation operators to integrate yellow lights as standard features in their operational vehicles.	0,13	4	0,50
	Increasing Focus on Rural and Mountainous Roads: The development of road infrastructure in remote areas, which often experience extreme weather, can drive demand for yellow headlamps.	0,08	4	0,33
Sub Total Opportunity				2,33
THREATS	Competition with Modern White Lights: White lights are often considered more attractive in terms of aesthetics and performance, causing yellow lights to lose market share, especially among modern vehicle users.	0,08	2	0,17
	Changing Market Preferences: Many vehicle users prefer white lights as they are perceived to be brighter and more advanced, reducing the popularity of yellow lights.	0,08	2	0,17
	Misalignment with Technological Advancements: Traditional halogen-based yellow lights may be less efficient compared to LED or HID-based white lights, posing challenges from a technological perspective.	0,08	2	0,17
	Incompatibility with Urban Infrastructure: In areas with adequate street lighting, yellow lights may be seen as less effective, limiting their use in urban areas.	0,08	2	0,17
	Regulations Favoring Energy-Efficient Lighting: Yellow lights, which often use older technologies, may be replaced by modern, energy-efficient, and environmentally friendly lighting systems.	0,08	2	0,17
Sub Total Threats				0,83

The Internal Factor Analysis Summary (IFAS) Table for White Headlamps (S-W) represents the X-axis, and the External Factor Analysis Summary (EFAS) Table (O-T) represents the Y-axis

Formula Calculation:

X-axis : (Total *Strenght* – Total *Weakness*) / 2
: (1,00 – 1,22) / 2 = (- 0,11)

Y- axis : (Total *Opportunity* – Total *Treats*) / 2
: (1,60 – 1,20) / 2 = 0,20

The Internal Factor Analysis Summary (IFAS) Table for Yellow Headlamps (S-W) represents the X-axis, and the External Factor Analysis Summary (EFAS) Table (O-T) represents the Y-axis.

Formula Calculation:

X-axis : (Total *Strenght* – Total *Weakness*) / 2
: (1,94 – 0,88) / 2 = 0,53

Y- axis : (Total *Opportunity* – Total *Threats*) / 2
: (2,33 – 0,83) / 2 = 0,75

The diagram for the Yellow Headlamp is shown in Figure 4.

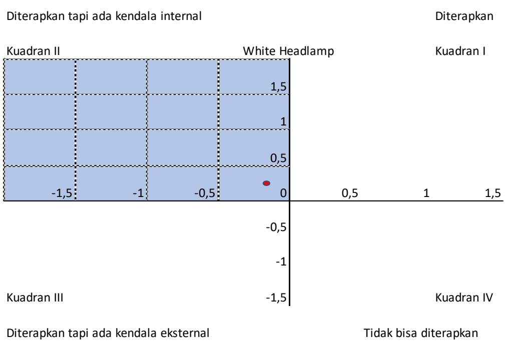

Figure 4. Quadrant for White Headlamp

Based on Figure 4, it can be seen that the IFAS and EFAS for White Headlamp are in Quadrant II, with coordinates at (-0.11) and 0.20. This indicates that the use of White Headlamp can be implemented with consideration of internal factors.

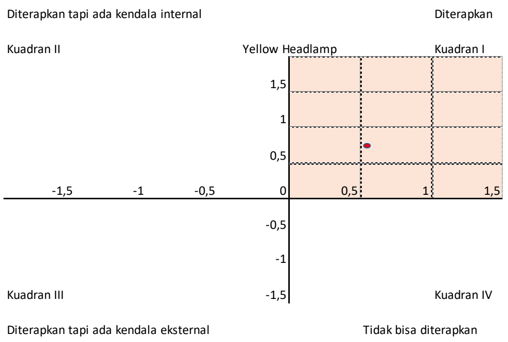

Figure 5. Quadrant for *Yellow Headlamp*

Based on Figure 5, it can be seen that the IFAS and EFAS for Yellow Headlamp are in Quadrant I, with coordinates at 0.53 and 0.75. This indicates that the use of Yellow Headlamp can be implemented without any significant considerations.

CONCLUSION

The conclusion of this study is that respondents prefer Yellow Headlamp over White Headlamp. The SWOT analysis shows that Yellow Headlamp is positioned in Quadrant I at coordinates 0.53 and 0.75. This indicates that the use of Yellow Headlamp can be implemented. Meanwhile, White Headlamp is in Quadrant II at coordinates (-0.11) and 0.20. This suggests that the use of White Headlamp can be implemented, but with internal considerations.

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