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Comparative Analysis of Motorcyclist Visibility using Wearable Reflective Gear: Enhancing Safety and Visibility for Motorcyclists

Nur Hazwani Mokhtar[1,*], Mizah Ramli[1], Noor Faradila Paiman[2], Zulhaidi Mohd Jawi[2], Matsuura Yoshifusa[3]

[1] Faculty of Mechanical Technology and Engineering, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia
[2] Malaysian Institute of Road Safety Research, 43000 Kajang, Selangor, Malaysia
[3] Yokohama National University, 79-1 Tokiwadai, Hodogaya, Yokohama, Kanagawa 240-8501, Japan

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ABSTRACT

This research paper discusses the problem of motorcycle visibility in low light conditions and at night, as evidenced by fatal accident statistics from various countries. The paper compares the visibility of reflective clothes by taking the driver's reaction time. The paper begins by discussing statistics from Great Britain, Asia, and Brazil, as well as reflective and fluorescent jackets and fabrics used to develop reflective jackets. The paper continues to discuss supplemental lighting systems, electroluminescent panels, and types of reflective clothing. The paper then discusses a survey distributed to 102 respondents to determine the most critical factors for motorcyclists. Following this, the paper discusses the design of three samples of motorcyclist jackets and the experiment conducted to assess the visibilities of the different samples of reflective clothing. The paper concludes that Jacket C (full Retroglo) was the most visible, followed by Jacket B (Fluorescent & Retroglo) jacket and Jacket A (black jacket).

1. Introduction

Motorcycles contribute to nearly half of the annual road fatalities in Malaysia [8]. Motorcyclist visibility is a critical factor in motorcycle safety, as it directly affects the ability of other road users to see and react to motorcyclists on the road. Several factors contribute to motorcyclist visibility, including the design of the motorcycle, the use of reflective gear and materials, and the positioning of the motorcyclist on the road [3,7]. In Malaysia, motorcyclist visibility has been a significant issue contributing to motorcycle accidents on the road. According to a recent study by the Malaysian Institute of Road Safety Research, it was discovered that a substantial number of motorcycle accidents were attributed to poor motorcyclist visibility. The researchers noted that motorcyclist visibility is the prime cause in 65% of motorcycle-to-car crashes, with particular importance being placed on the front of the vehicle. Additionally, the study highlighted that the lack of reflective gear and improper positioning of motorcyclists on the road were common factors in these accidents. The

* *Corresponding author*
E-mail address: nurhazwani@utem.edu.my

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study reported that approximately 40% of motorcycle accidents in Malaysia were due to inadequate motorcyclist visibility. This emphasizes the critical need for interventions and measures to improve motorcyclist road visibility [2,5,6].

To gain a deeper understanding of motorcyclist visibility, exploring various measures that can enhance it is important. This includes studying the effectiveness of different types of reflective gear, analyzing the impact of motorcycle design modifications, and considering the influence of road infrastructure on motorcyclist visibility. While previous studies have highlighted mixed results regarding the effectiveness of reflective gear, it is crucial to continue researching and implementing interventions to improve motorcyclist visibility. Based on the mentioned sources, it is evident that motorcyclist visibility plays a crucial role in motorcycle safety. Improving motorcyclist visibility can significantly reduce the risk of accidents and enhance overall road safety [1,11,13].

Furthermore, conducting field studies and experiments to evaluate the effectiveness of different visibility enhancement measures in real-world conditions would provide valuable insights for developing evidence-based strategies. By addressing the multifaceted nature of motorcyclist visibility and implementing a holistic approach that combines education, regulations, infrastructure improvements, and technological advancements, we can strive towards significantly reducing motorcycle accidents attributed to poor motorcyclist visibility. This comprehensive approach will benefit motorcyclists and improve road safety for all road users [1,10,11]. This study's objective is to survey 102 motorcyclists to identify key factors deemed necessary for motorcycle visibility and compare the effectiveness of reflective clothing in enhancing motorcycle visibility.

2. Methodology

2.1 Market Survey and Motorcyclist Visibility

To attain the study objectives, we conducted a comprehensive market survey and engaged in product development. The survey was structured into two main sections, with the first section dedicated to collecting demographic data. This section comprises three key questions addressing age, gender, and possession of a license.

The second section, Section 2, primarily focuses on enhancing the jacket product. Within this section, there are nine sets of questions, each designed to elicit valuable insights. Respondents are prompted to provide ratings on a scale of five, ranging from the least important to the most important aspects related to jacket improvement. This detailed approach ensures a nuanced understanding of user preferences and priorities in the enhancement of the product.

2.2 Experimental Setup

According to the survey results, one of the prioritized specifications is night visibility. This study utilized four distinct samples, as outlined in Table 1. These samples include a reflective helmet, a retroglo jacket, a combination of fluorescent and retroglo jackets (denoted as V), and a conventional black jacket (denoted as X). The selection of these samples was based on their widespread usage among motorcyclists in Malaysia, their affordability, and their ready availability. Each sample serves a specific purpose: V represents the combination of a fluorescent and retroglo jacket, X is a standard black cotton jacket, Y is a retroglo jacket, and Z is a reflective helmet. The fluorescent material incorporated in the experiment is composed of a phosphor that emits visible light and absorbs ultraviolet radiation. On the other hand, the retroglo material is crafted from high-refractive glass beads laminated to a polyester film [4].

This diverse selection of samples, chosen due to their prevalence in the Malaysian motorcycling community, ensures that the experiment reflects real-world conditions and provides valuable insights into the night visibility effectiveness of different safety gear options. In the Visibility Experiment, four variables of Jacket V, X, Y and Helmet Z were used to determine the level of visibility at four different times: daytime, twilight, and nighttime with and without light.

Table 1
Wearable reflective gear

Name	Jacket V	Jacket X	Jacket Y	Helmet Z
Image				
	Fluorescent and retroreflective jacket	Black cotton jacket	Retroreflective jacket	Reflective helmet

In the initial phase of the experiment, visibility levels will be captured at four different time frames: daytime, twilight, nighttime without artificial lighting, and nighttime with artificial lighting. The horizontal distance from the camera and light sources to Jacket V, X, Y and Helmet Z will be maintained at 5 meters. The subsequent scenario focuses on a motorcycle setting, aiming to determine the driver's reaction time in recognizing the visibility of a motorcyclist. For this phase, motorcyclists will be outfitted with Jacket A, B, C and Helmet at distances of 60 meters, 80 meters, and 100 meters, as illustrated in Figure 1. Ten participants aged between 20 and 25 years will be involved in this experiment.

The stationary car will have its driver positioned to look at point O as in Figure 1, situated 20 meters from the car. The reaction time measurement begins as the motorcyclist enters the main road from junctions A, B and C, maintaining a constant speed of 10 km/h until the driver recognizes the motorcyclist. The experiment will be repeated three times for robust data collection. The vehicles used in this experiment are a Perodua Kancil for the car and a Yamaha Lagenda for the motorcycle. The motorcycle will have its lights turned off, while the car's lights will be turned on, creating a controlled environment to assess the driver's reaction time under specific conditions. This comprehensive setup aims to provide valuable insights into the effectiveness of different safety gear configurations and visibility scenarios in real-world driving situations.

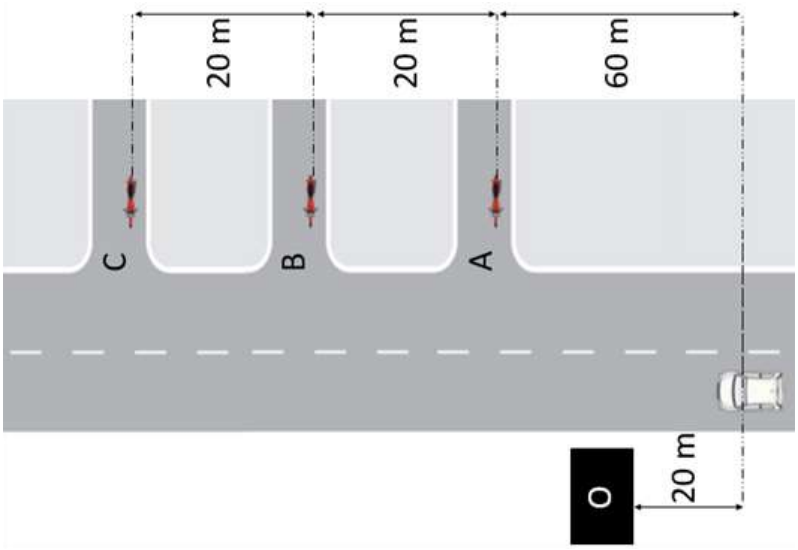

Fig. 1. Test condition

3. Results

3.1 Experimental Setup

The survey is filled with 102 respondents *via* Google Forms and distributed through social media, as summarized in Table 2. The survey consists of two sections. The first section is demographic data. It has three questions: age, gender and type of license. Sections 2 focus more on jacket improvement. In Section 2, there are nine sets of questions. Each question will reflect a five-rating number from least important to most important. The data from the survey is provided in Table 2. The result in Figure 2 displays that the highest priority and most important specifications are safety, waterproof, fast dry, and easy to wear, while the lowest is fashionable and referring to Eq. (1). The survey result reveals that the top three specifications were night visibility, safety and weatherproof. However, the fashionable specification is unpopular. In other words, motorcyclists prioritize safety over fashionable jackets. (Table 3).

$$\text{Specification weight} = \frac{(total\ rating\ 4\ and\ 5)}{total\ respondent} \times 5 \quad (1)$$

Table 2
Demographic data obtained from a survey (n = 102)

Demographic aspect		Percent %
Age group	13-18	2
	19-59	95.1
	60 and above	2.9
Gender	Male	77.5
	Female	22.5
License	Motorcycle	6.9
	Car	29.4
	Motorcycle and car	62.7
	Others	1

Table 3
Specification of total rating, rank, and weighting

Specification	Rate 4 and 5	Rank	Weighting
Safety	99	1	5
Night visibility	96	2	5
Weatherproof	96	2	5
Easy to wear	92	3	5
Fast dry	92	3	5
Brightness	90	4	4
Affordable price	86	5	4
Washable	75	6	4
Fashionable	48	7	2

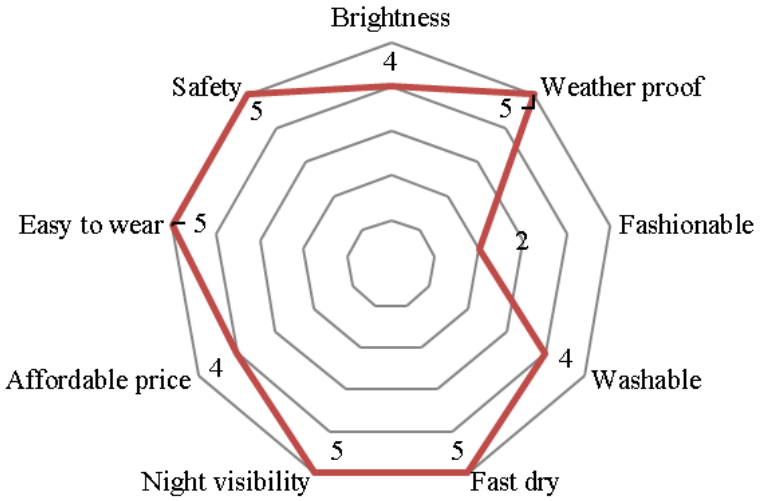

Fig. 2. Weighing specification

3.2 Visibility Experiment

In this experiment, four variables of Jacket V, X, Y and Helmet Z were used to determine the level of visibility at four different times: daytime, twilight and nighttime with and without light. The illustration in Table 4 was captured from a horizontal distance of 5 m. The results demonstrate different results in different light conditions. During the daytime, all the samples are easily seen like the other objects. During twilight, all the samples start looking fuzzily and not clear except the jacket that has fluorescent material, Jacket V, since the material of fluorescent itself absorbs the light and gives out a brighter color [9]. During the nighttime time, without light, all the jackets and helmets look vague. However, with a light source, Jacket X radiates brighter than the other jackets and helmets since the retroreflective surface is designed to give feedback towards the light source, like a mirror. The findings are similar to a study by Tyrrell *et al.,* [12] where 100% of the respondents recognize the pedestrian wearing retroreflective material. The reflective helmet is still functional. However, it does not perform well like the retroreflective material jacket, just like the fluorescent jacket.

The reaction time for recognising motorcyclist visibility was discussed. The results of the reaction time in motorcycle scenario with distance 60 m, 80 m and 100 m as shown in Figure 5 (Table 6), Figure 6 (Table 7) and Figure 7 (Table 8) respectively. According to Figures 5 to 7 where the x axis represents participant while y axis represents reaction time, the highest reaction time is Jacket X followed by Helmet Z, Jacket Y and Jacket V. The graph trend in reaction time at distance 60m is clear and can be differentiated according to type of jacket and helmet. However, as the distance increase to 100 m,

the reaction time for Jacket v and Jacket Y are indistinguishable. The minimum time to recognize motorcyclist visibility is 0.29 sec at 60 m distance for Jacket V while the maximum distance detect at 100 m is 3.02 s for Jacket X. The results show that the reflective material on Jacket V is the best among others. Even the average reaction time increase as the distance increase, Jacket V is still on its best perform as long as the driver can recognize the existence of motorcyclist that wear the jacket even though the driver does not look directly to the motorcyclist during the experiment. Low reaction time, interpreted to high visibility of motorcyclist and it is easier for driver to detect motorcyclist especially during low light condition (Table 5).

Table 4
Visibility

Day time	Twilight
	
Nighttime without light	**Nighttime with light**
	

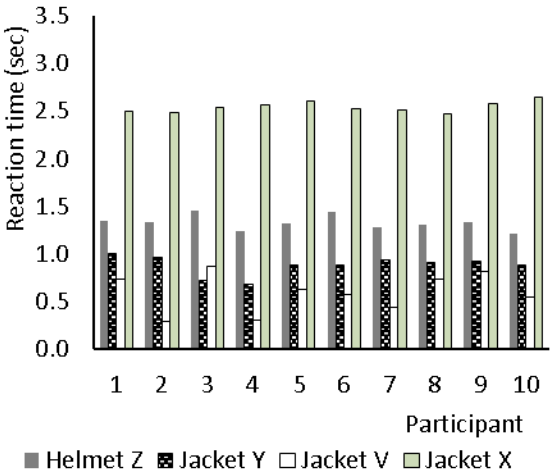

Fig. 5. 60 m

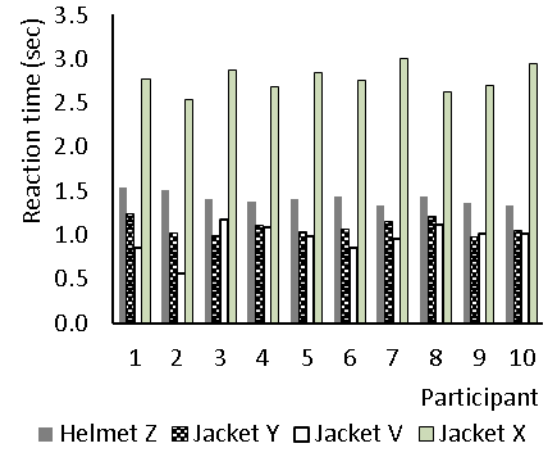

Fig. 6. 80 m

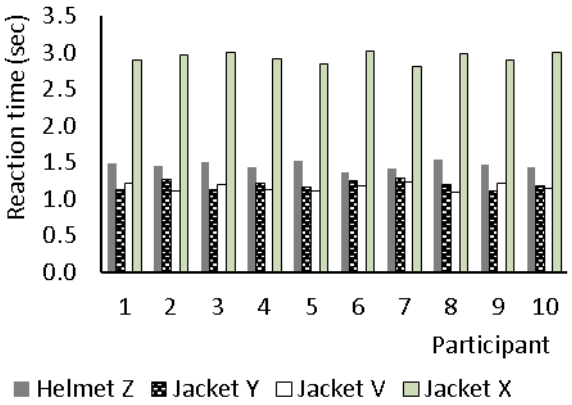

Fig. 7. 100 m

Table 5
Anova

Distance	Anova Result	
60 m	[F(3, 36) = 487.0, p = 3.4946E-29]	Significantly difference
80 m	[F(3, 36) =427.369, p = 3.4946E-29]	Significantly difference
100 m	[F(3, 36) =1999.5, p = 4.46252632330012E-40]	Significantly difference

Table 6
F-Test and T-Test result for 60m

60 m			
Pair	F-Test	T-Test (two tail)	
V vs X	Unequal Variances	t(10)=2.2,P<0.0005	SD
V vs Y	Unequal Variances	t(13)=2.2,P>0.0005	NSD
V vs Z	Unequal Variances	t(11)=2.2,P<0.0005	SD
X vs Y	Equal Variances	t(18)=2.1,P<0.0005	SD
X vs Z	Equal Variances	t(18)=2.1,P<0.0005	SD
Y vs Z	Equal Variances	t(18)=2.1,P<0.0005	SD

Table 7
F-Test and T-Test result for 80m

80 m			
Pair	F-Test	T-Test (two tail)	
V vs X	Equal Variances	t(18)=2.1,P<0.0005	SD
V vs Y	Unequal Variances	t(13)=2.2,P>0.0005	NSD
V vs Z	Unequal Variances	t(12)=2.2,P<0.0005	SD
X vs Y	Equal Variances	t(18)=2.1,P<0.0005	SD
X vs Z	Unequal Variances	t(13)=2.2,P<0.0005	SD
Y vs Z	Equal Variances	t(18)=2.1,P<0.0005	SD

Table 8
F-Test and T-Test result for 100m

100 m			
Pair	F-Test	T-Test (two tail)	
V vs X	Unequal Variances	t(16)=2.1,P<0.0005	SD
V vs Y	Unequal Variances	t(18)=2.1,P>0.0005	NSD
V vs Z	Equal Variances	t(18)=2.1,P<0.0005	SD
X vs Y	Equal Variances	t(18)=2.1,P<0.0005	SD
X vs Z	Unequal Variances	t(18)=2.1,P<0.0005	SD
Y vs Z	Equal Variances	t(18)=2.1,P<0.0005	SD

4. Conclusions

Motorcyclist safety depends heavily on being seen, especially at night. This study compared different reflective gear for nighttime visibility. A survey revealed safety, night visibility and weatherproofing as top priorities for jackets, while fashion was less important. An experiment then tested four samples: a jacket with both fluorescent and retroreflective materials, a plain black jacket, a solely retroreflective jacket, and a reflective helmet. In daylight, all were easily seen. At twilight, the fluorescent jacket shone brightest. In darkness, headlights illuminated the retroreflective jacket and helmet best, while the plain jacket remained lost in the shadows. Overall, combining fluorescent and retroreflective materials in a jacket maximizes visibility in all lighting conditions, while purely retroreflective gear excels at night with headlights. Future research could explore integrating other visibility technologies into motorcycle gear for even greater safety.

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