

Research Article

Driver-Related Factors Affecting Traffic-Sign Letter Height Preferences: A Regression-Based Study in Kut City, Iraq

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Article Info	Abstract
Article History	This study investigated driver-related factors affecting preferred traffic-sign letter height in Kut City, Iraq. A questionnaire survey was conducted with drivers of different vehicle types to examine the effects of age, gender, driving experience, and vehicle type on preferred letter height. The collected data were analysed using multiple regression to identify significant predictors of letter-height preference. The results showed that older drivers and heavy-vehicle drivers preferred larger traffic-sign letters. Specifically, the age groups 46–55 years ($B = 2.5$, $p = 0.02$) and 56–65 years ($B = 4.0$, $p = 0.001$), as well as lorry drivers ($B = 2.2$, $p = 0.005$) and bus drivers ($B = 1.8$, $p = 0.02$), were positive predictors of preferred letter height. Gender and driving experience were not statistically significant predictors after controlling for the other variables. Model validation was assessed using residual normality checks and multicollinearity diagnostics. The findings suggest that driver age and vehicle type should be considered when refining traffic-sign letter-height guidelines. However, because the study is based on self-reported preferences from one city, further field-based legibility testing is needed before the findings are generalised to wider traffic-sign design standards.
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1. Introduction

Road signs are an essential component of traffic management systems. They are designed to regulate, inform, and guide road users to drive safely and competently. They are classified into three main types: guide, regulatory, and warning signs. They are deployed for several important reasons. These include providing road network information for advanced time-planning, providing warning information for safety improvement, enhancing road capacity, and improving traffic flow [1]. To fulfil functions such as advising on restrictions, issuing instructions, and issuing warnings and orders, they involve a partial or complete combination of sentences, letters, symbols, and numbers [2, 3]. Distributing road signs appropriately across designated road sections is imperative to deliver the best safety advice to all road users. The precise and

timely identification of traffic signs by drivers is crucial if driving systems are to operate reliably and to enhance safety [4, 5].

Although previous studies have examined traffic-sign recognition, driver distraction, sign visibility, and road-safety outcomes, fewer studies have investigated how driver-related characteristics influence preferred traffic-sign letter height in local urban contexts. This gap is important because letter height affects legibility, reading distance, and driver response time, particularly for older drivers and drivers of heavy vehicles. Therefore, this study examines the effects of age, gender, driving experience, and vehicle type on preferred traffic-sign letter height among drivers in Kut City, Iraq. The study's contribution is to provide empirical evidence to support future refinements of traffic-sign letter-height guidelines, while acknowledging the need for field-based validation.

2. Literature Review

2.1. Traffic-Sign Legibility and Recognition

Road sign specifications can influence driver behaviour. For instance, Han, et al. [6] stated that road sign properties, such as height and location, can significantly affect a driver's behaviour. Other research has shown that specifications, such as colour, dimensions, and font size of road signs, may also influence drivers' attitudes [7]. Furthermore, driver distraction, one of the main contributory reasons for road accidents, should be taken into consideration regarding road safety implementation. For example, one safety concern arises when drivers are involved in multiple activities, defined as competing activities, when they should be driving safely [8]. Competing activities can be divided into driving-related tasks, such as obeying road signs, and non-driving-related tasks, such as texting on a mobile device while driving [9]. Thus, there is a need to consider drivers' attention and to prevent distractions. One factor that has increased driver distraction is the overload of information on road signs, which has been found to contribute to an increase in road accidents [10].

Several researchers have investigated road sign text and font recognition by utilising deep learning techniques [11-13], including convolutional neural networks (CNN) [14], support vector machines (SVM) [15], traffic sign recognition (TSR) systems [1], and multiscale cascaded R-CNNs [16]. To further enhance the safety of road users, another recognition approach has been developed that enables drivers to comprehend and recognise significant road signs, such as warning and guide signs [3]. Crucial considerations related to the text visualisation employed in designing traffic signs need to be considered.

For instance, due to the multicultural nature of populations in some regions, bilingual texts in traffic signs have been employed. In this case, problems related to the lack of spatial arrangement in bilingual texts may arise [17].

2.2. Driver Characteristics, Visibility Conditions, and Letter-Height Needs

A shortage of road signs can significantly contribute to road accidents [18, 19]. To reduce their numbers, researchers have examined the effectiveness of drivers who cross or drive equipped with the required road signs [20-22]. Multiple factors related to road signs can cause an increase in accident frequency. For example, a lack of road sign reflection increases the risk of traffic accidents [23]. In addition, the age of drivers can be considered a factor impacting the occurrence of road accidents. For example, Babić, et al. [24] noted that drivers aged 30 or younger are frequently involved in road accidents, particularly at night. Another factor is the unsystematic deployment of road signs in some zones, such as school areas, which can lead to road accidents and endanger young people's safety [25, 26].

Other research has examined extreme conditions and their effects on stopping sight distance. Ben-Ben-Edigbe [27] concluded that stopping sight distance is affected by dark roads, night-time conditions, and wet weather. Such conditions may reduce perception distance and increase braking and stopping distance. De Santos-Berbel and Castro [28] simulated and calibrated vehicle-headlight algorithms to estimate headlight sight distance and found that swivelling headlights can improve night-time visibility.

2.3. Research Gap

Existing studies have mainly focused on traffic-sign recognition technologies, general road-safety effects, sign visibility, and stopping sight distance. However, limited evidence is available on how driver-related variables, such as age, gender, driving experience, and vehicle type, influence preferred traffic-sign letter height in Iraqi urban contexts. In addition, many existing sign design approaches rely primarily on physical and geometric factors, while driver preferences and perceptions are less frequently incorporated. This study addresses this gap by using survey-based data and regression analysis to examine the relationship between driver characteristics and preferred traffic-sign letter height in Kut City.

3. Methodology

This study used a questionnaire-based survey and multiple regression analysis to examine how driver-related characteristics affect preferred traffic-sign letter height. The study was conducted in Kut City, Iraq,

and focused on drivers of five vehicle categories: passenger cars, sport utility vehicles, lorries, buses, and motorcycles. The dependent variable was preferred traffic-sign letter height, while the independent variables were age group, gender, driving experience, and vehicle type. The methodology consisted of questionnaire design, participant recruitment, data collection, variable coding, regression modelling, and model validation.

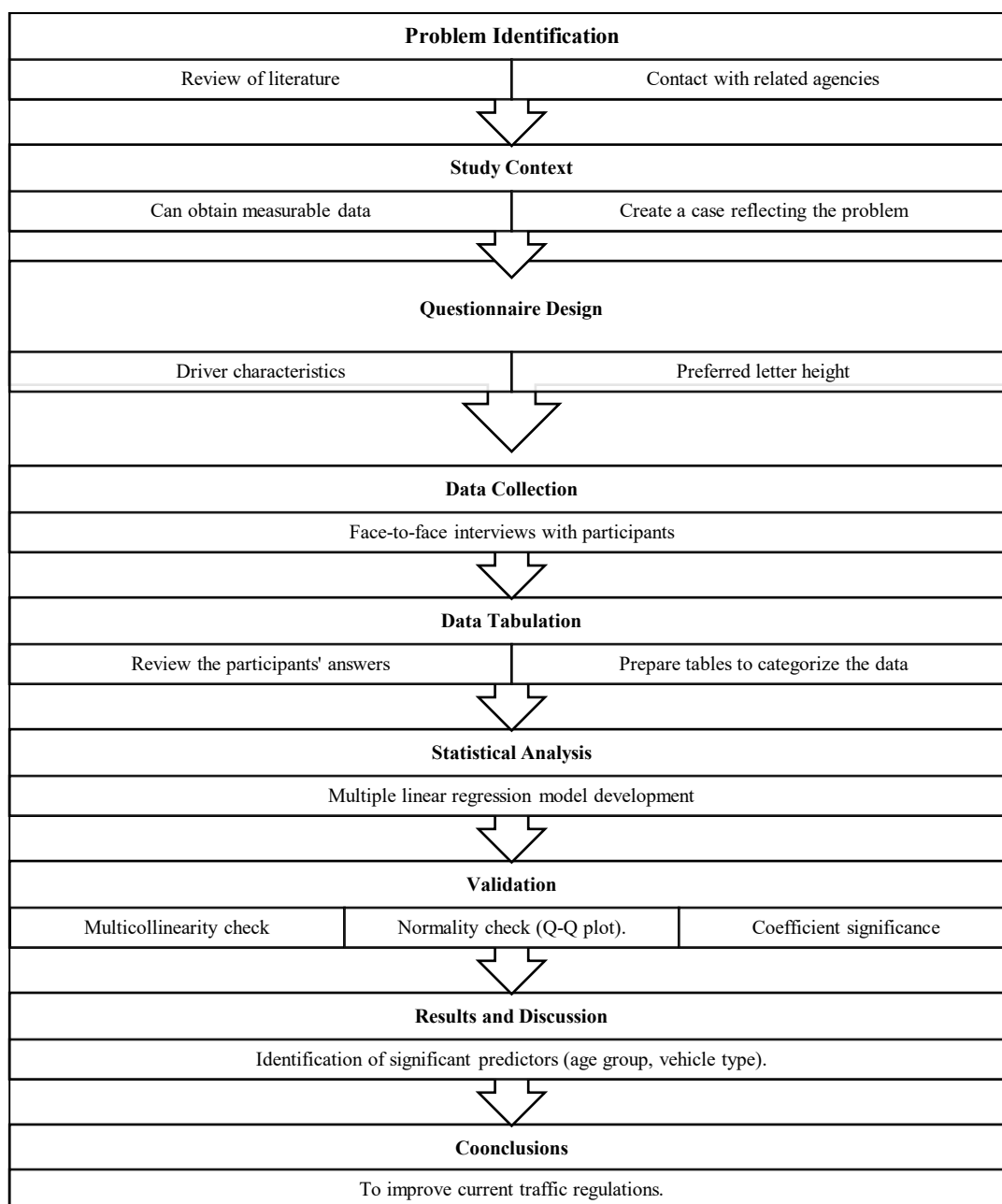


Figure 1. Methodology chart of the study

The final dataset included 200 valid responses. This sample size was considered adequate for the regression model because the analysis included 13 predictor terms, and common regression guidance recommends at least 10–15 observations per predictor. With 200 valid responses, the study provided

approximately 15 observations per predictor term, supporting the stability of the regression estimates. Participants were recruited through face-to-face interviews with drivers in Kut City. The sample included drivers from five vehicle categories: passenger cars, SUVs, lorries, buses, and motorcycles. Gender representation was balanced as far as possible to reduce gender-related bias in the model coefficients.

3.1. Data Collection

The questionnaire consisted of two parts. The first part collected driver-related information, including gender, age group, driving experience, and vehicle type. The second part asked participants to indicate their preferred traffic-sign letter height. Participants were shown traffic-sign examples with fixed letter-height alternatives ranging from 12 to 22 cm. The sign examples were presented under good viewing conditions and typical urban design-distance assumptions. Participants selected the letter height they considered most legible and appropriate for urban traffic signs. All questionnaires were completed individually through face-to-face interviews.

3.2. Variable Coding

The dependent variable was preferred traffic-sign letter height, measured in centimetres. Age group, gender, driving experience, and vehicle type were treated as categorical independent variables in the regression model. Dummy coding was used for the regression analysis. The reference categories were age 18–25 years, male gender, less than one year of driving experience, and passenger car. The remaining categories were compared with these reference categories. For the exploratory correlation matrix only, age group and driving experience were coded ordinally. Vehicle type was not treated as a naturally ordinal variable in the regression model because it represents nominal categories; therefore, any correlation involving vehicle type should be interpreted cautiously.

3.3. Data Analysis

Multiple linear regression was used to examine the effects of driver-related characteristics on preferred traffic-sign letter height. The dependent variable was preferred letter height in centimetres. The independent variables were age group, gender, driving experience, and vehicle type. Because these predictors were categorical, dummy variables were used in the regression model. Model fit was assessed using the F-statistic, p-value, R^2 , and adjusted R^2 . Regression coefficients were reported as unstandardised coefficients (B), with standard errors and p-values. Model assumptions were checked using residual normality diagnostics and variance inflation factor (VIF) values for multicollinearity. Residual normality

was assessed using the Shapiro-Wilk test and Q-Q plot. All statistical analyses were conducted using Microsoft Excel.

4. Results and Discussion

4.1. Descriptive Analysis

The collected data followed a normal distribution, with an average preferred letter height of 16.7 cm (standard deviation 1.9 cm), and the driver's preferred letter height, by age, ranged from 12 to 22 cm (see Figure 2).

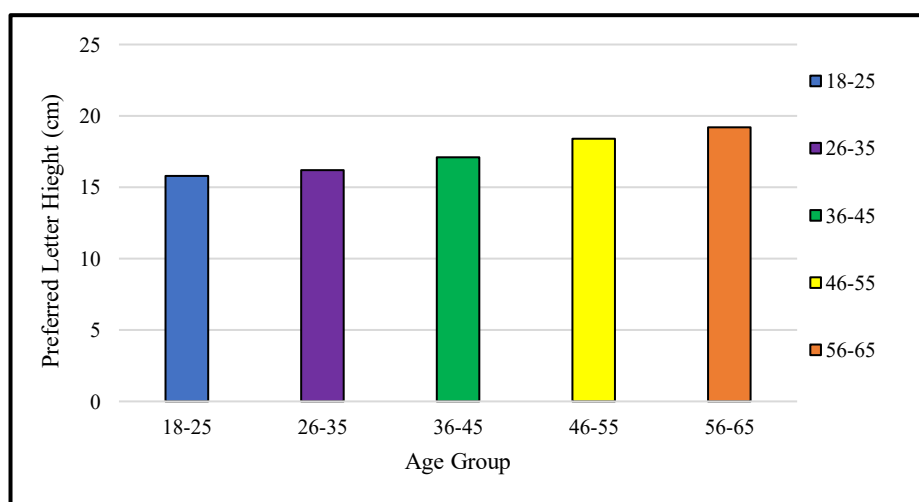


Figure 2. Age group versus preferred traffic-sign letter height

Male and female participants selected similar preferred traffic-sign letter heights, with an average value of approximately 16.7 cm for both groups, as shown in Figure 3.

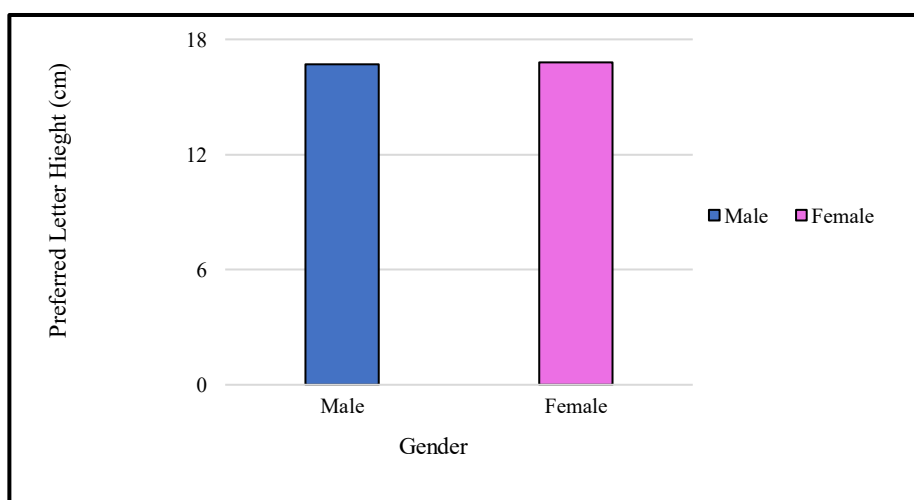


Figure 3. Gender versus preferred letter height

The effects of driving experience on preferred letter height are shown in Figure 4, where the height gradually increases with years of driving experience. The increase in preferred letter height across driving-

experience categories may partly reflect the association between driving experience and age. However, after controlling for age, driving experience was not a statistically significant independent predictor.

Vehicle type also affected drivers' choices, as shown in Figure 5. Passenger-car drivers selected a smaller preferred letter height, averaging 16.3 cm, whereas bus and lorry drivers selected larger preferred letter heights, averaging approximately 17.4 cm. SUV drivers and motorcycle riders selected average preferred letter heights of approximately 16.3-16.8 cm. This pattern may be related to differences in driver eye height, vehicle size, and required viewing distance; however, this interpretation should be confirmed through field-based visibility testing.

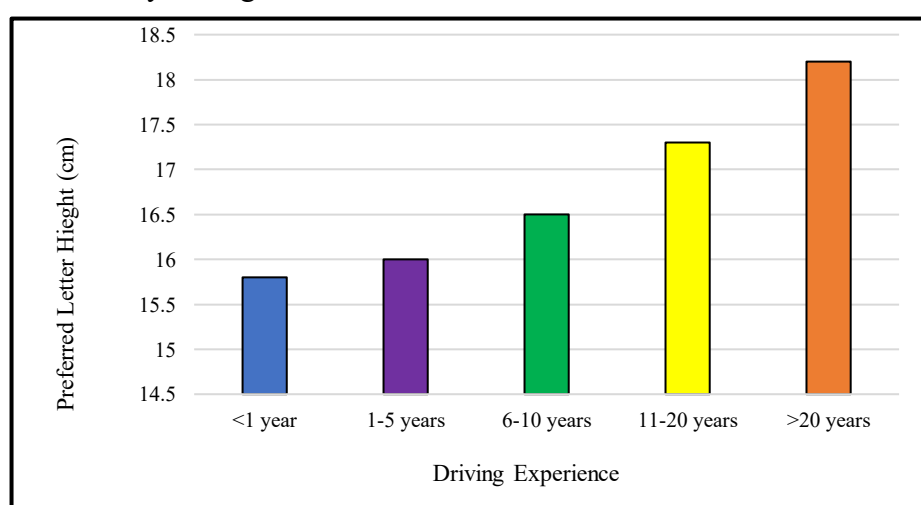


Figure 4. Driving experience versus preferred traffic-sign letter height

4.2. Exploratory Correlation Analysis

Table 1 presents an exploratory correlation matrix between preferred traffic-sign letter height and the selected driver-related variables. Because some variables are categorical or ordinal, especially gender and vehicle type, Pearson correlations should be interpreted cautiously and should not be treated as causal evidence. The regression model provides the main inferential analysis, as the categorical variables were dummy-coded.

Driving experience is also moderately positively correlated with preferred letter size (Pearson's $r = 0.13$). This indicates that the most experienced drivers are the oldest, and both groups prefer larger letter size. But driving experience and age group are positively correlated ($+0.23$), indicating that older drivers have driven their cars for many more years than younger drivers.

Vehicle type was treated as a categorical variable in the regression model, with passenger cars used as the reference category. In the exploratory correlation matrix only, vehicle types were coded numerically

to provide a preliminary descriptive association. Therefore, the correlation between vehicle type and preferred letter height should be interpreted cautiously.

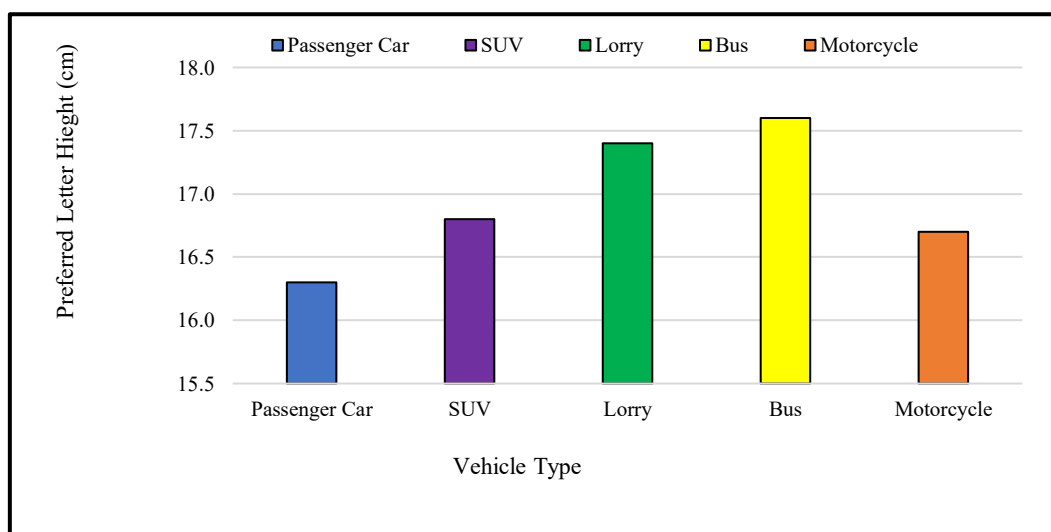


Figure 5. Vehicle type versus preferred traffic-sign letter height

Gender shows a weaker correlation than the other independent variables (Pearson $r = 0.07$), indicating no linear relationship between gender (male or female) and letter size preference.

Table 1. Exploratory correlation matrix for driver-related variables and preferred traffic-sign letter height

	Age Group	Gender	Driving Experience	Vehicle Type	Preferred Letter Height
Age Group	1.00	-0.05	0.23	-0.12	0.17
Gender	-0.05	1.00	-0.24	-0.24	0.07
Driving Experience	0.23	-0.24	1.00	0.20	0.13
Vehicle Type	-0.12	-0.24	0.20	1.00	0.16
Preferred Letter Height	0.17	0.07	0.13	0.16	1.00

4.3. Multiple Regression Analysis

The baseline was selected as the 18-to-25-year-old male group with less than one year of driving experience and passenger cars. The other independent variables were then compared to the baseline.

The multiple regression model was statistically significant, $F(13,186) = 8.0$, $p < 0.001$, indicating that the independent variables jointly explained a significant proportion of variation in preferred traffic-sign letter height. The model produced an R^2 value of 0.34 and an adjusted R^2 value of 0.30, meaning that approximately 30–34% of the variation in preferred letter height was explained by the selected driver-related variables.

Table 2 shows that age group and vehicle type were statistically significant predictors of preferred traffic-sign letter height, whereas gender and driving experience were not statistically significant after controlling for the other variables. Drivers aged 46–55 years and 56–65 years preferred larger letter heights than drivers aged 18–25 years. Lorry and bus drivers also preferred larger letter heights than passenger-car drivers.

Table 2. Multiple regression results for preferred traffic-sign letter height

Predictor	Coefficient (B)	SE	p-value
Intercept (baseline driver)	10.5	0.8	< 0.001
Age 26–35	-0.8	0.9	0.38
Age 36–45	1.2	1	0.24
Age 46–55	2.5	1.1	0.02 *
Age 56–65	4	1.2	0.001 **
Female (vs Male)	0.5	0.5	0.31
Experience 1–5 yrs	-0.3	0.7	0.68
Experience 6–10 yrs	0.6	0.8	0.45
Experience 11–20 yrs	1	0.9	0.27
Experience >20 yrs	1.5	1.1	0.17
Vehicle: SUV	0.6	0.7	0.4
Vehicle: Lorry	2.2	0.8	0.005 **
Vehicle: Bus	1.8	0.8	0.02 *
Vehicle: Motorcycle	0.4	0.9	0.66

Note: B = unstandardised regression coefficient; SE = standard error; * $p < 0.05$; ** $p < 0.01$. The reference categories were age 18–25 years, male gender, less than one year of driving experience, and passenger car.

4.4. Model Validation

Table 3. Regression diagnostic tests

Diagnostic	Result	Interpretation
Shapiro-Wilk test	W = 0.98, p = 0.07	Residuals are approximately normally distributed
Maximum VIF	2.10	No serious multicollinearity
Q-Q plot	Approximate linear pattern	Supports residual normality

Figure 6 presents the regression coefficients with 95% confidence intervals. The confidence intervals for the 46–55 and 56–65 age groups did not cross zero, indicating statistically significant positive effects on preferred letter height. The confidence intervals for bus and lorry drivers also did not cross zero, indicating significant positive effects compared with passenger-car drivers. In contrast, the confidence

intervals for gender and driving-experience categories crossed zero, suggesting that these variables were not statistically significant predictors in the model.

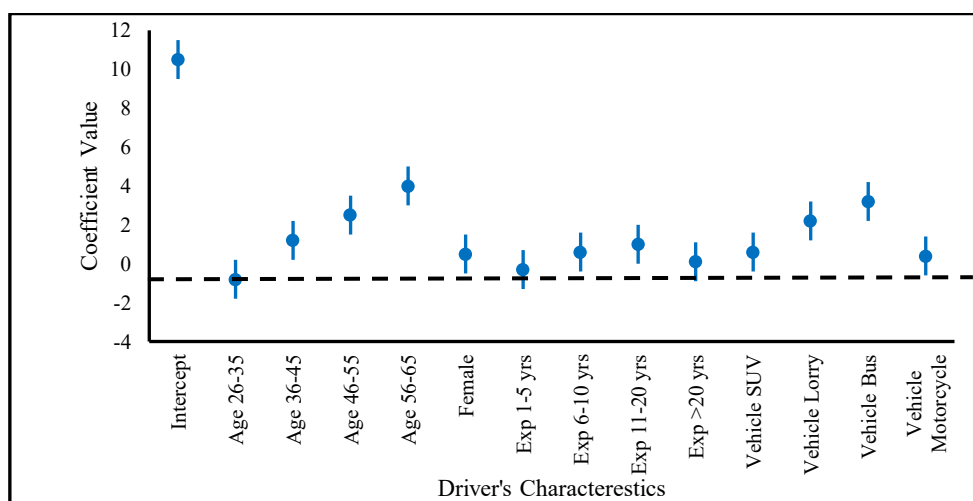


Figure 6. Coefficients plotted at a 95% confidence level

The Q-Q plot in Figure 7 suggests that the residuals were approximately normally distributed, although minor deviations from the reference line were observed. This visual assessment is consistent with the Shapiro-Wilk result reported in Table 3.

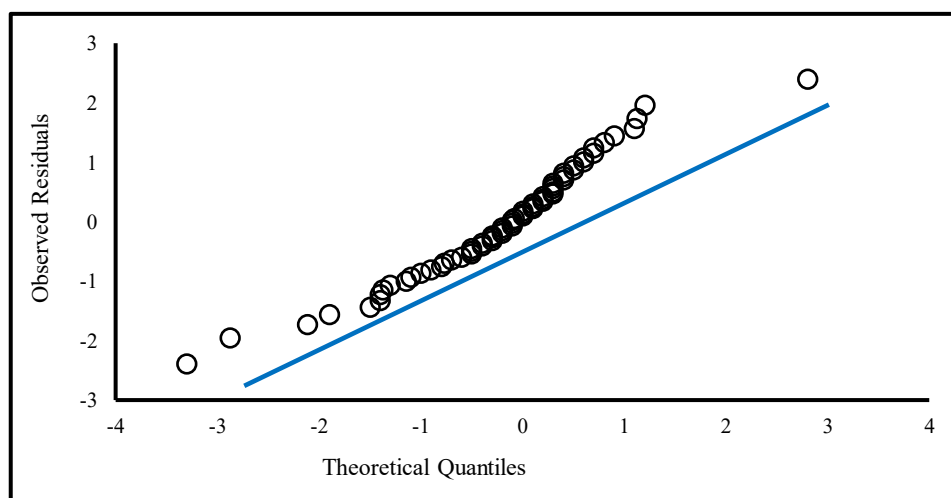


Figure 7. Plot of the residuals of the regression model

5. Conclusion

This study examined the influence of driver-related characteristics on preferred traffic-sign letter height in Kut City. The regression results indicated that age and vehicle type were the strongest predictors of preferred letter height. Drivers aged 46–65 years and drivers of heavy vehicles, particularly lorries and buses, preferred larger letter heights than younger drivers and passenger-car drivers. In contrast, gender and driving experience were not statistically significant predictors after controlling for the other variables.

These findings suggest that driver age and vehicle type should be considered in future refinements of traffic-sign letter-height guidelines. However, the results should be interpreted cautiously because the study relied on self-reported preferences from one city and did not directly test real-world legibility performance, night-time visibility, different sign designs, or driving behaviour. Future research should use larger, more diverse samples, field-based visibility tests, and experimental sign-reading tasks before generalising the findings to broader traffic-sign design standards.

Data Availability Statement: All data generated or analysed during this study are included in this article. Additional supporting survey data are available from the corresponding author upon reasonable request.

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Declaration of Competing Interest: The authors declare that they have no known competing interests.

Research Involving Human/Animal Participants: This study involved questionnaire-based responses from drivers in Kut City. No medical, biological, or experimental intervention was conducted on human participants, and no animal subjects were involved in this study.

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