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Research Paper

How to choose Hazard perception test scenarios in Rapid bus transit routes? A ranking study

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Abstract

Traffic safety and behavioral studies have long been critical areas of focus in urban transportation research. Among behavioral studies, hazard perception in driving has been identified as a key factor in reducing road accidents and improving overall traffic safety. In recent years, with the rise in accident statistics, hazard perception models have gained significant attention and are increasingly being implemented across various countries. This study explores the prioritization of hazards using the MABAC (Multi-Attributive Border Approximation Area Comparison) method for application in hazard perception test scenarios, alongside examining the factors influencing hazard perception among city bus drivers. To achieve this, drivers operating on one of Tehran's busiest and most accident-prone bus routes, specifically the Khavaran-Azadi route, were analyzed. The findings reveal that the crossing of motorcyclists and pedestrians into bus lanes is the highest-priority hazard to be incorporated into hazard perception tests for bus drivers. The results of this research can be applied to enhance hazard perception and prediction tests for city bus drivers, improve driver evaluation and training programs, and increase the safety of dedicated bus lanes.

Keywords: Hazard perception, BRT, Hazards in route, Ranking

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1. Introduction

Car dependency has led to increased traffic, delays, and environmental pollution, highlighting the need for sustainable solutions such as transit-oriented development (TOD) and complete street designs (Mirzahossein et al., 2023). Iran ranks 65th among 183 countries, with an estimated road traffic accident mortality rate of 15.22 deaths per 100,000 people. This ranking is considered unfavorable, necessitating strategic planning and collaboration among relevant executive bodies to address the issue. Road traffic casualties in Iran are among the top five causes of mortality. Consequently, this issue has been prioritized in the country's development plans, with authorities urged to implement necessary measures to reduce casualties and accidents. Therefore, the government must prioritize mechanisms aimed at decreasing fatalities from road accidents. The importance of obtaining accurate and timely statistics cannot be overstated, as decisions and actions must be based on these data to evaluate the current situation and implement appropriate measures (Statistical Research and Training Center, 2023). Annually, road traffic crashes result in approximately 1.19 million fatalities worldwide. Additionally, between 20 and 50 million people suffer non-fatal injuries, many of which lead to disabilities. Road traffic injuries are the leading cause of death among children and young adults aged 5 to 29 years. Approximately two-thirds of road traffic fatalities occur among individuals of working age, specifically between 18 and 59 years. Moreover, males are three times more likely to die in road crashes than females (World Health Organization, 2023). The economic impact of road traffic injuries is profound, affecting individuals, their families, and national economies. These economic losses stem from treatment costs, lost productivity due to death or disability, and the need for family members to take time off work or school to care for the injured. In many countries, road traffic accidents account for approximately 3% of their gross domestic product. Shinar and Miller, through accident analysis, demonstrated that the vast majority of accidents are attributable to human errors (Cox et al., 2016; Shinar, 2017). Similarly, Borowsky and colleagues concluded that human factors play a significant role in 95% of accidents, with driver behavior being the most prominent factor (Borowsky et al., 2010). Research indicates that psychological issues faced by drivers and aspects related to their perception should be prioritized in traffic safety studies (Sheikholeslami et al., 2023). One crucial human factor in accidents is hazard perception, which refers to the ability to recognize hazards in a timely manner. Hazard perception has been recognized as a critical factor in traffic safety research over the past two decades and has recently been incorporated into driving license tests (Kabir & Roy, 2023).

2. Literature Review

Hazard perception in driving refers to a driver's ability to anticipate potentially dangerous situations on roads and highways. This skill has been a subject of research for over five decades. It is typically assessed through computer-based hazard perception tests and is associated with both retrospective and prospective accident risks. It is also linked to key risk factors, including inattention, fatigue, alcohol consumption, speed choice, and age-related declines. Moreover, hazard perception can distinguish between high-risk and low-risk driver groups. However, acquiring this skill seems to require decades of driving experience, prompting the question of whether it is feasible and practical to accelerate this learning process through targeted assessment and training to improve traffic safety. Evidence indicates that, unlike most driver training and assessment interventions, hazard perception testing and training can effectively reduce the risk of accidents. For example, the inclusion of a hazard perception test in the driver licensing process in Britain has been estimated to reduce the overall road accident rate by up to 11.3% in the year following the test (Horswill, 2016).

In a 2020 study by Leandro et al., titled 'A Cross-Cultural Comparison of Visual Search Strategies and Response Times of Drivers in a Road Hazard Perception Test,' road hazard perception was identified as the most critical higher-order cognitive skill linked to traffic accident involvement. Regional cultures and social norms governing acceptable behaviors can influence how drivers interpret traffic situations, thereby affecting their ability to accurately identify hazards. This study aims to compare hazard perception skills across four European countries—Ukraine, Italy, Spain, and Sweden—which differ in traffic cultures, risk mitigation policies, and fatal crash rates. We developed a static hazard perception test featuring driving scenes with varying levels of braking capability, during which drivers' gaze was recorded. During the test, drivers were asked to indicate whether they would brake or continue driving. Multilevel models showed that the level of braking capability in the scenes, including road hazards, influenced drivers' behavior. As braking capability increased, drivers' response times improved, and their gaze entropy decreased, suggesting a more irregular visual search pattern. Country of origin significantly affected these outcomes, with Ukrainian drivers responding the fastest and Swedish drivers the slowest. In all countries, the reduction in response time was less noticeable among experienced drivers. Spanish drivers exhibited the most structured visual search strategy, while Italian drivers showed the most consistent approach. These findings indicate that road hazard perception is culturally influenced, with factors such as traffic conditions and laws impacting response times and visual search strategies. Our results also highlight the feasibility of a multi-modal assessment method for large-scale testing of road hazard perception, offering valuable insights into how different traffic cultures shape driving behavior (Di Stasi et al., 2020).

In a 2021 study by Crundall et al., titled 'Assessing Young Drivers with Hazard Perception, Hazard Prediction, and Theory Questions,' researchers developed a new hazard test using high-quality computer animations that featured ten hazards. Sixty learner drivers and sixty experienced drivers participated in either a hazard perception test (requiring timely responses to hazards) or a hazard prediction test (where the screen was obscured, and participants had to predict the next event after a hazard began). Recent studies have shown that the prediction test format using naturalistic film outperforms the hazard perception format. However, no study has replicated this effect using computer-animated materials of similar quality to those in the official UK hazard perception test. The new test also incorporated eleven theory questions designed to assess drivers' knowledge of road rules. The results showed that both test types effectively distinguished between learner and experienced driver groups. Theory question scores were similar across both groups, suggesting that learners were well-prepared, while experienced drivers may have encountered issues like memory decline or transcription errors. Interestingly, playing driving-related video games was negatively correlated with hazard perception performance but showed no correlation with hazard prediction scores. Certain hazards were better suited to either the prediction or perception test format, indicating the potential for a future combined test integrating both methods (Crundall et al., 2021). In the study by Brusky et al., the focus was on the relationship between age, skill, and hazard perception in driving, specifically exploring how age and driving experience influence hazard detection abilities. Previous studies on hazard perception have shown that young, inexperienced drivers exhibit greater deficiencies in hazard perception compared to experienced drivers. However, it remains unclear whether this skill diminishes with age. In this study, twenty-one inexperienced drivers, nineteen experienced drivers, and sixteen older experienced drivers watched six hazard perception films while connected to an eye-tracking system and were asked to identify hazardous situations. Overall, both experienced and older experienced drivers showed similar hazard detection skills, consistently identifying potentially dangerous scenarios (e.g., approaching intersections or roadside pedestrians), while inexperienced drivers paid less attention to these critical situations. Additionally, when approaching T-junctions, older and experienced drivers focused more on the right side of the road, while inexperienced drivers focused on the straight path, overlooking potential vehicles at the intersection. This study suggests that driving experience improves drivers' awareness of potential hazards and guides their eye movements toward areas where risks may arise (Borowsky et al., 2010).

Young male drivers demonstrate lower hazard perception skills than older, more experienced drivers and frequently overestimate their abilities in hazardous situations. These factors contribute to their higher involvement in traffic accidents. This study, based on a sample of 63 drivers aged 18 to 24, compares the consistency of hazard perception skills measured by both objective and subjective criteria, highlighting the relationship between these measures. The study examined both visible and hidden hazards. Objective criteria for assessing hazard perception skills included response times and eye movements during simulated driving. Subjective criteria were based on self-reported data from the Hazard Perception Questionnaire, the Driver Skill Inventory, and the Brief Sensation Seeking Scale. The results show that drivers who respond quickly to hazards score higher on subjective measures of hazard perception skill and perform better in visible hazard conditions, though this does not apply to hidden hazards. Eye movement analysis supports this finding, showing that timely responses to hazards are associated with higher hazard perception skills, especially among young drivers, who find it more challenging to detect hidden hazards. Drivers who respond promptly recognize hazards more quickly and exhibit more fixations, though they tend to focus less on the hazards themselves. In contrast, non-responders show delayed initial fixations and fewer, but longer, fixations on the hazard. Interestingly, high-sensation-seeking drivers tend to respond quickly to visible hazards, suggesting that sensation seeking does not impair hazard perception skills when hazards are apparent. To improve hazard perception skills among young drivers, the study recommends targeted training, particularly for hazards requiring advanced perception skills (Ābele et al., 2018). Research has shown that modifying hazard characteristics, such as size, color, and contrast with the environment, can significantly affect hazard perception (Asadamraji et al., 2022). Various methods are available for selecting hazards in hazard perception tests, including engineering judgment, conventional multi-criteria decision-making methods (Asadamraji, 2022), economics-based approaches, and new hybrid methods (Asadamraji et al., 2024). This study focuses on ranking hazards on dedicated urban bus lanes to incorporate them into the design of a hazard perception test. Key aspects of test design include identifying critical scenarios and ranking the primary hazards associated with dedicated urban bus lanes. This step is essential to ensure that subsequent stages of test design effectively address these factors.
speeding.

3. Methodology

Multi-Criteria Decision Making (MCDM) methods are widely used in various managerial fields and human decision-making processes. In multi-criteria decision-making problems, each alternative can be characterized by a set of criteria. These criteria may be either qualitative or quantitative. The Analytic Hierarchy Process (AHP) is regarded as one of the most recent, effective, and straightforward methods in multi-criteria decision-making. Additionally, it is employed to address a wide range of decision-making problems (Zavadskas & Turskis, 2010a). It offers a robust technique for presenting performance metrics and the desirability of various options in relation to the optimal scenario. Furthermore, it is relatively easy to apply in risk management contexts (Rani et al., 2022; Sihombing et al., 2021; Zhu et al., 2023). The findings demonstrated that prioritizing public transport resulted in significant improvements, underscoring the need for cultural adaptation in Tehran's urban environment (Abolfathi et al., 2022). This study aims to rank and select the optimal alternatives in a multi-criteria decision-making (MCDM) problem. Various MCDM methods, such as MABAC (Asadamraji, 2023)., TOPSIS, VIKOR, and SAW, have been reviewed and compared. Each method employs a distinct approach to evaluate alternatives and compute scores. The MABAC method was chosen as the primary approach in this research due to its enhanced capability to manage uncertain data and its straightforward computational process. MABAC operates by measuring the distance of alternatives from a border approximation area, effectively identifying and ranking the most optimal options. To justify the selection of the MABAC method and compare it with other widely-used MCDM methods, the table 1 outlines the key differences:

Table 1. Comparison of Multi-Criteria Decision-Making (MCDM) Methods

Comparison Criteria	MABAC	TOPSIS	VIKOR	SAW
Main Objective	Ranking based on distance from border approximation area	Ranking based on distance from ideal solutions	Ranking based on relative distance from best and worst options	Weighted sum of criterion scores
Core Concept	Distance from the border approximation area	Distance from positive and negative ideal solutions	Relative closeness to the ideal solution	Sum of weighted criteria
Data Type	Quantitative and qualitative (normalization required)	Quantitative and qualitative (normalization required)	Quantitative and qualitative (normalization required)	Quantitative and qualitative (normalization required)
Criteria Scaling	Normalization required	Normalization required	Normalization required	Normalization required
Criteria Weighting	Required (subjective and objective)	Required (subjective and objective)	Required (subjective and objective)	Required (subjective and objective)
Computational Complexity	High (multiple calculation steps)	Moderate	High (multiple calculation steps)	Low
Sensitivity to Criteria Weights	High	High	High	High
Applications	Multi-criteria decision making, project management	Risk management, supplier selection	Strategic and critical decision making	Simple decision-making scenarios
Handling Uncertainty	High (better for ambiguous data)	Moderate	High	Low

Comparison Criteria	MABAC	TOPSIS	VIKOR	SAW
Final Output	Full ranking of alternatives	Full ranking of alternatives	Full ranking with compromise solutions	Full ranking of alternatives
Group Decision Making Suitability	Suitable	Suitable	Highly suitable (for conflicting criteria)	Suitable

This study marks the first application of the MABAC method to prioritize hazard scenarios for incorporation into a hazard perception driving test. The research process consists of the following stages:

The MABAC method is a novel multicriteria decision-making approach that evaluates alternatives based on their distance from a border approximation area, offering a systematic framework for complex decision-making processes (Božanić, Pamučar, & Karović, 2016).

In the first step Forming initial decision matrix (X). It is performed the evaluation of m alternatives by n criteria. The alternatives are presented with the vectors Ai = $(x_{i1}, x_{i2},\ldots, x_{i1})$, where xij is the value of the i alternative by j criterion (i = 1, 2,..., m ; j = 1, 2,...,n).

$$X = \begin{array}{c} \\ A_1 \\ A_2 \\ \cdots \\ A_m \end{array} \begin{array}{c} \begin{matrix} C_1 & C_2 & \cdots & C_n \end{matrix} \\ \begin{bmatrix} t_{11} & t_{12} & \cdots & t_{1n} \\ t_{11} & t_{22} & \cdots & t_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ t_{1m} & t_{2m} & \cdots & t_{mn} \end{bmatrix} \end{array} \tag{1}$$

where m is the alternative number, n is total number of criteria.

Normalization of initial matrix (X) elements.

$$X = \begin{array}{c} \\ A_1 \\ A_2 \\ \cdots \\ A_m \end{array} \begin{array}{c} \begin{matrix} C_1 & C_2 & \cdots & C_n \end{matrix} \\ \begin{bmatrix} t_{11} & t_{12} & \cdots & t_{1n} \\ t_{11} & t_{22} & \cdots & t_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ t_{1m} & t_{2m} & \cdots & t_{mn} \end{bmatrix} \end{array} \tag{2}$$

Elements of normalized matrix (N) are obtained by applying the expression:

a) For benefit-type criteria

$$t_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \tag{3}$$

b) For cost-type criteria

$$t_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+} \tag{4}$$

where X_{ij}, X_i^+ and X_i^- present the elements of initial decision matrix (X), wherein X_i^+ and X_i^+ are defined as follows:

X_i^+ = max $(x_1, x_2, \ldots, x_m)$ represents maximum values of the observed criterion by alternatives.

X_i^- = min $(x_1, x_2, \ldots, x_m)$ represents minimal values of the observed criterion by alternatives.

Calculation of weighted matrix (V) elements.

$$V = \begin{bmatrix} V_{11} & V_{12} & \cdots & V_{1n} \\ V_{21} & V_{22} & \cdots & V_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ V_{1m} & V_{2m} & \cdots & V_{mn} \end{bmatrix} \tag{5}$$

Weighted matrix (V) elements are calculated based on the expression (6):

$$V_{ij} = W_{ij}\, t_{ij} + W_i \tag{6}$$

where tij presents the elements of normalized matrix (N), wi presents weight coefficients of criteria. By applying the expression (6) it is obtained the weighted matrix V, which can also be written as follows:

$$V = \begin{bmatrix} w_i t_{11} + w_1 & w_2 t_{12} + w_2 & \cdots & w_n t_{1n} + w_n \\ w_i t_{21} + w_1 & w_2 t_{22} + w_2 & \cdots & w_n t_{2n} + w_n \\ \cdots & \cdots & \cdots & \cdots \\ w_1 t_{m1} + w_1 & w_2 t_{m2} + w_2 & \cdots & w_n t_{mn} + w_n \end{bmatrix} \tag{7}$$

where n presents total number of criteria, m presents total alternatives number.

Determination of border approximate area matrix (G). The border approximate area for every criterion is defined according to the expression (8):

$$g_i = \left[\prod_{j=1}^{m} v_{ij}\right]^{1/m} \tag{8}$$

where v_{ij} presents weighted matrix elements (V), m presents total alternatives number.

After calculating the values g_i by criteria, it is formed the matrix of border approximate area G (9) in the form n x 1 (n presents total number of criteria by which is performed the selection of the alternatives offered).

$$\begin{array}{cccc} & C_1 & C_2 \quad \dots & C_n \\ G = [& g_1 & g_1 \quad \cdots & g_i\ ] \end{array} \qquad (9)$$

Calculation of matrix elements of alternative distance from the border approximate area (Q):

$$Q = \begin{bmatrix} q_{11} & q_{12} & \cdots & q_{1n} \\ q_{21} & q_{22} & \cdots & q_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ q_{1m} & q_{2m} & \cdots & q_{mn} \end{bmatrix} \qquad (10)$$

The alternative distance from the approximate border area (q_{ij}) is determined as the difference of weighted matrix elements (V) and the values of border approximate area (G):

$$Q = V – G \qquad (11)$$

which can be written in another way:

$$Q = \begin{bmatrix} v_{11} - g_1 & v_{11} - g_1 & \cdots & v_{1n} - g_n \\ v_{21} - g_1 & v_{22} - g_2 & \cdots & v_{2n} - g_n \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1} - g_1 & v_{m2} - g_2 & \cdots & v_{mn} - g_n \end{bmatrix} \qquad (12)$$

where g_i presents the border approximate area for the C_i criterion, v_{ij} presents weighted matrix elements (V), n presents the number of criteria, m presents the alternatives number.The alternative Ai can belong to the border approximate area (G), upper approximate area (G^+) or lower approximate area (G^-), i.e., $A_i \in \{G \vee G^+ \vee G^-\}$. The upper approximate area (G^+) presents the area where the ideal alternative is located (A^+), while the lower approximate area (G^-) presents the area where the anti-ideal alternative is located (A^-) (Figure 1).

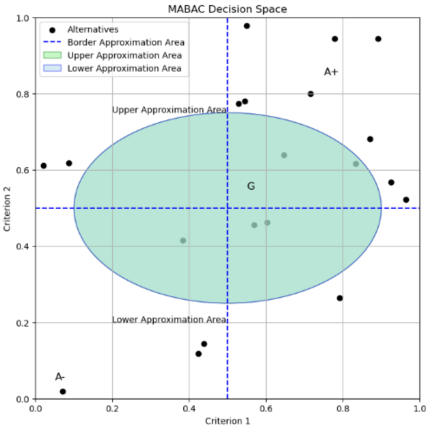

Figure 1. Display of upper (G+), lower (G-) and border (G) approximate area

Belonging of the alternative A_i to the approximate area (G, G^+ or G^-) is determined based on the expression (13):

$$A_i \in \begin{cases} G^+ & if\ q_{ij} > 0 \\ G & if\ q_{ij} = 0 \\ G^- & if\ q_{ij} < 0 \end{cases} \qquad (13)$$

In order to be selected as the best one from the set, the alternative Ai should belong to the upper approximate area (G^+) by as many criteria as possible.

For instance, if the alternative Ai belongs to upper approximate area by 5 criteria (out of total of 6 criteria), and by one criterion it belongs to lower approximate area (G^-), this means that according to 5 criteria it is close or equal to the ideal alternative, but by one criterion it is close or equal to the anti-ideal alternative. A higher value $g_i \in G^+$shows that the alternative A_i is closer to the ideal alternative, while a smaller value $g_i \in G^-$ shows that the alternative Ai is closer to the anti-ideal alternative.

Ranking alternatives. The calculation of the values of criteria functions by alternatives (14) is obtained as the sum of the alternatives distances from the border approximate area (q_i). Summing the matrix elements Q by lines are obtained final values of criteria function of alternatives:

$$s_i = \sum_{j=1}^{n} q_{ij}\ , j = 1,2, \dots , n, i = 1,2, \dots , m \qquad (14)$$

where n presents the number of criteria, m presents the number of alternatives.

4. Results

To validate the proposed model, after establishing the ranking pattern using the MABAC method, the next step involved analyzing hazards along the dedicated routes of urban express buses. This phase focused on Tehran's urban express bus routes, and based on data from the bus company, the route from Khavaran Terminal to Azadi Terminal was chosen for the study. Initially, the Shannon entropy method was applied to identify and weight the criteria. The selected criteria were the number of accidents, violations, and observed hazards. As indicated in Table 2, the number of observed hazards had higher values, resulting in greater weight allocation. Additionally, all criteria were treated as benefit-type and assigned a positive sign. Following this, the number of accidents and related violations were ranked. The reported data included field visits and information collected by traffic surveillance cameras along the specified route over a one-month period.In the second step of this method, a decision matrix was constructed. This matrix is used to evaluate the available options in the problem. In this matrix, the rows represent the options, and the columns represent the research criteria, with each cell of the matrix indicating the evaluation of each option against each criterion. As shown in Table 3, options such as motorcycle crossings, pedestrian crossings, vertical signs and boards installed in inappropriate locations, lateral vehicle passage in access areas, longitudinal vehicle passage, animal crossings, road narrowing, head-on BRT bus collisions, stationary obstacles on the route, bus station frontage, discontinuity of road separators, road construction activities, signal-controlled intersections, police-controlled metal gates, and bicycle crossings were considered. Additionally, the number of hazards, accidents, and related violations were collected as research criteria and incorporated into the decision matrix.

- The ideal value for positive criteria is defined as the highest recorded value, while for negative criteria, it is set as the lowest recorded value.
- This step involves transforming the normalized matrix into a weighted normalized matrix, where the weight of each criterion is multiplied by the corresponding values in the normalized matrix.
- In this step, the desirability of each option is determined. The results for the desirability of each option are presented in Table 4.
- The base point vector and matrix G are calculated in this step. The details of these calculations are provided in Table 5.
- Finally, the final score for each option is calculated based on the sum of its distances. These scores are displayed in Table 6, and the final ranking of the options is illustrated in Figure 2.

Table 2. Weighting criteria using Shannon entropy method

criteria	Number of violations	The number of accidents	The number of observed hazards
w_j	0.287	0.332	**0.381**
sign	+	+	+

Table 3. Decision Matrix Between BRT Routes Risks and Related Criteria

Hazard/Criteria	Number of Observed Hazards	Number of Related Accidents	Number of Related Violations
Motorcyclist passing	1123	6	1201
Pedestrian crossing	712	55	355
Vertical signs and boards in inappropriate locations	4	2	2
Lateral vehicle passage in access areas	127	4	10
Lengthwise vehicle passage	33	4	25
Animal crossings	2	1	4
Narrowing	3	5	3
BRT bus head-on	72	8	11
Stationary obstacle on the path	13	7	1
Bus station frontage	6	3	2

Hazard/Criteria	Number of Observed Hazards	Number of Related Accidents	Number of Related Violations
Discontinuity of path separators	11	2	10
Road construction	5	9	6
Signal-controlled intersections	7	5	19
Metal gates controlled by the police	15	4	5
Cyclists	12	6	2
Disabled individuals	3	5	4
Total	2148	126	1660

Table 4. Determining the Ideal Value for Criteria

Ideal Value	Number of Hazards Observed	Number of Related Accidents	Number of Related Violations
Highest Value	1123	55	1201
Lowest Value	2	2	1

Table 5. Comparison Between the Exact Solver and the Proposed Hybrid Approach

Criteria	Number of Hazards Observed	Number of Related Accidents	Number of Related Violations
Motorcyclist passing	0/575	0/363	0/760
Pedestrian crossing	0/469	0/665	0/492
Vertical signs and boards in inappropriate locations	0/288	0/332	0/380
Lateral vehicle passage in access areas	0/319	0/351	0/383
Lengthwise vehicle passage	0/295	0/351	0/388
Animal crossings	0/287	0/332	0/380
Narrowing	0/288	0/332	0/380
BRT bus head-on	0/305	0/338	0/383
Stationary obstacle on the path	0/290	0/338	0/380
Bus station frontage	0/288	0/338	0/381
Discontinuity of path separators	0/290	0/332	0/383
Road construction	0/288	0/332	0/380
Signal-controlled intersections	0/289	0/332	0/386
Metal gates controlled by the police	0/291	0/332	0/380
Cyclists	0/290	0/332	0/380
Disabled individuals	0/288	0/332	0/380

Table 6. GEOMEAN and Gi Values for Observed Hazards, Related Accidents, and Violations

Criteria	Number of Hazards Observed	Number of Related Accidents	Number of Related Violations
GEOMEAN	0/314	0/353	0/405
Gi	0/111	0/138	0/180

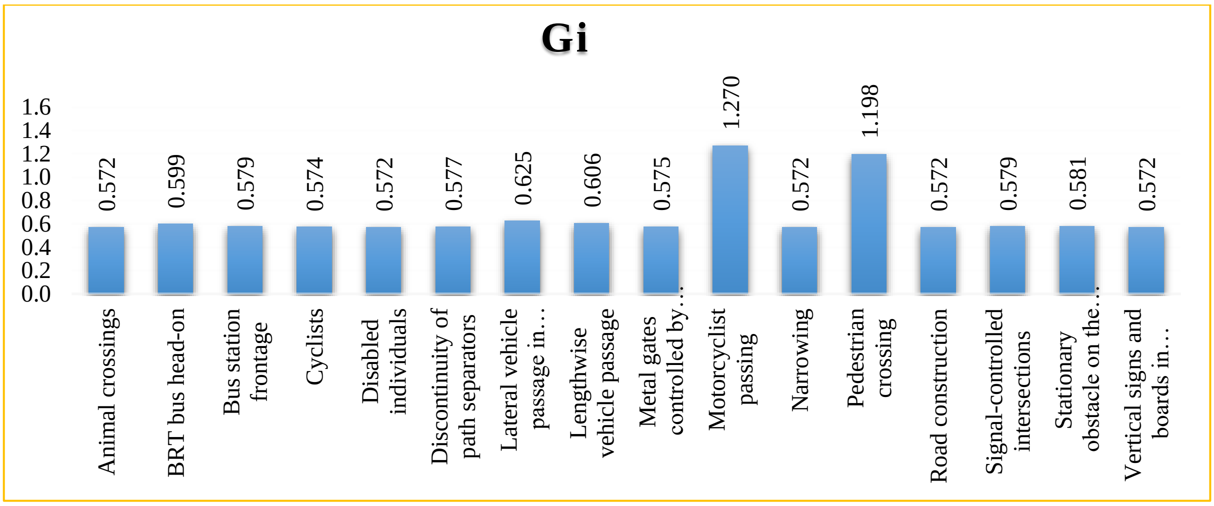

Figure 2. Ranking of Hazard Scenarios for Implementation in the Urban Rapid Transit Bus Driver Hazard Perception Test

As shown in Figure 2, the rankings from one to sixteen are assigned as follows:

1. Motorcyclist passing
2. Pedestrian crossing
3. Lateral vehicle passage in access areas
4. Lengthwise vehicle passage
5. BRT bus head-on
6. Stationary obstacle on the path
7. Bus station frontage
8. Signal-controlled intersections
9. Discontinuity of path separators
10. Metal gates controlled by the police
11. Cyclists
12. Road construction
13. Vertical signs and boards in inappropriate locations
14. Narrowing
15. Disabled individuals
16. Animal crossings

5. Conclusion

The interaction between humans and computers fundamentally lies at the intersection of computer science and behavioral sciences. This relationship and inclination between humans and computers occur through an interface that includes both software and hardware. More precisely, this field involves the design, implementation, and evaluation of interactive computational systems for human use in studying significant phenomena around them. Hazard perception and prediction tests are also constructed using this approach and have been extensively studied. Furthermore, these tests, designed for general education, provide urban bus drivers with a tool to gain sufficient understanding of potentially hazardous traffic situations, especially if theoretical training has not adequately captured their attention. As previously mentioned, one of the key factors affecting safety is the contribution of human error. Therefore, if drivers maintain proper behavior while driving, even if the road's geometric design is flawed or the vehicle has technical deficiencies, the driver's behavior can mitigate the severity of accidents or even prevent them altogether. In this study, for the purpose of designing a hazard perception test specific to urban bus drivers, hazard scenarios were evaluated based on three criteria: the number of accidents, the number of violations, and the number of observed hazards, using the MABAC ranking technique. Accordingly, the top three hazards included motorcyclist passing, pedestrian crossing, and head-on bus collisions, while discontinuities in path separators and animal crossings received lower rankings. Based on this hazard ranking, a hazard perception test was designed for urban bus drivers. The results of this study can be utilized in training and hazard perception tests for urban bus drivers, while municipalities can use them to enhance safety and identify hazards on dedicated bus lanes.

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