Research Article

Optimisation of Driver's Traffic Literacy Evaluation Index from the Perspective of Information Contribution Sensitivity

Lingzhi Wang[1] and Kang Tian [ID] [2]

[1]*School of Mechanical and Electrical Engineering, Guangxi Science & Technology Normal University, Laibin, Guangxi, China*
[2]*School of Management and Economics, North China University of Water Resources and Electric Power, Zhengzhou, Henan, China*

Correspondence should be addressed to Kang Tian; tiankang@stu.ncwu.edu.cn

The practice has proven that relying solely on large-scale transportation facilities cannot fundamentally alleviate urban transportation problems. Since the motor vehicle drivers are the main participants of transportation, they should improve their knowledge of transportation. Moreover, the drivers should equally cope with transportation problems. This paper establishes an evaluation index system for traffic literacy of urban drivers. In addition, it proposes a method of information contribution sensitivity to optimise the index system. The main results and achievement of this paper include the following: (1) A traffic literacy evaluation index system including 13 evaluation indexes such as traffic rules and general knowledge of machinery has been constructed. (2) Based on the calculation results of the sensitivity of the information contribution, the first 10 indexes that satisfy the cumulative information contribution rate's value of greater than 90% are retained and 3 indexes with lower contribution rates are eliminated. This study provides a theoretical framework and basic methods to evaluate the traffic literacy of urban drivers.

1. Introduction

With the rapid development of urbanisation, the total demand for transportation and motor vehicles has continued to increase. However, road congestion is also becoming more serious, traffic accidents occur frequently, and violations of traffic regulations are continually occurring. According to estimates by the World Health Organization (WHO), about 1.35 million people die from road traffic injuries, which means that 3,700 people die from road traffic accidents every day (2018) [1]. Other studies have proved that human factors cause more than 90% of traffic accidents [2, 3]. The practice has proven that relying solely on large-scale transportation facilities cannot fundamentally alleviate urban transportation problems. As the main participants of transportation, motor vehicle drivers should improve their transportation literacy and jointly cope with transportation problems. To this end, this article attempts to establish and optimise a model for evaluating urban driver traffic literacy

to create a theoretical foundation to evaluate the traffic literacy of urban drivers.

Research on traffic literacy evaluation indexes at home and abroad is scarce, and most literature has focused on researching the factors that affect traffic accidents [4–6]. Most traffic accidents occur because traffic participants have a relatively poor understanding of safe traffic, and many scholars have evaluated their status by constructing safe traffic evaluation index systems. For example, Zhang et al. [7] took the status of local transportation system safety management as the evaluation object and divided the indexes that reflect safe traffic conditions into three categories, veto indexes, qualitative indexes, and quantitative indexes, to build safe traffic evaluation index systems. Guo et al. [8] constructed a rail transit safety evaluation index system model composed of 14 evaluation indexes from three aspects: the train's safety, the interface between the train and other systems, and the safety guarantee system. Scholars have carried out systematic research on the evaluation index

systems of green transportation [9, 10], intelligent transportation [11], and harmonious transportation [12]. Many studies have also been conducted on the impact of traffic safety, such as drivers' attitudes and behaviours towards traffic safety [13], the use of safety devices during driving [14], and drivers' traffic violations [15].

However, none of those abovementioned studies has been researched from the perspective of drivers' traffic literacy. Traffic literacy can better reflect a person's necessary driving qualities and gradually reduce the probability of traffic safety incidents under the joint influence of knowledge acquisition, skill mastery, safety awareness, and driving safety behaviour. At present, the concept of transportation literacy is still in the exploratory stage. Based on the existing literature analysis, this paper sorts out the factors that affect the driver's traffic literacy and uses an improved mathematical method to screen the indexes, hoping to lay a theoretical foundation for the further evaluation and improvement of the driver's traffic literacy.

Studying whether the evaluation index system of traffic literacy is reasonable will directly affect the evaluation results' scientificity. At present, research on the optimisation methods of evaluation indexes is relatively extensive. The principal component analysis method is often used to select the original indexes. For example, Tung and Lee [16] used principal component analysis to reduce the dimensionality of many enterprises' financial indexes based on the grey theory method. Zheng et al. [17] used the principal component analysis method to optimise the comprehensive evaluation index system of reservoirs after an earthquake, reduced 15 risk factors to two principal components, and eliminated redundant information indexes. A variety of other methods are also used to screen and optimise the original indexes. Liu et al. [18] conducted nonparametric Bayesian discrimination for the first round of screening for all credit indexes and nonparametric clustering for the second round of screening for retained credit indexes and provided a set of nonparametric methods for screening credit evaluation indexes with unknown index distributions. Xu et al. [19] used a combination of correlation analysis, frequency analysis, principal component analysis, grey correlation analysis, membership function analysis, cluster analysis, and stepwise regression analysis to complete the selection of drought resistance indexes. Zhu et al. [20] used the Memetic Algorithm to optimise the index parameters extracted by the 3D wavelet transform to obtain distinct and parsimonious feature sets and perform accurate classification. The main problems in the existing research are as follows. First, the indexes are screened and optimised using various research methods, the dimensions of the indexes cannot be reduced, and the original indexes have not changed. Second, the selected method can only optimise the index, but it cannot determine the index's weight after optimisation.

This paper establishes an index selection and weighting method based on the sensitivity of information contribution, which retains the significant and low information overlap indexes and weights the indexes according to the sensitivity of information contribution. First, through the definition of the concept of traffic literacy and by combining the factors that affect traffic literacy, the formation mechanism, the purpose of evaluation, etc., a traffic literacy evaluation index system was proposed, and a questionnaire was designed based on the initially established evaluation index system to obtain the original data. Second, the concept of the sensitivity of index information contribution, which is the sum of the difference between the main component and the cumulative contribution rate of the corresponding principal component variance, is proposed. Indexes with less sensitive information contribution are excluded; the retained indexes can reflect most of the original indexes' information. Finally, all indexes are weighted according to the proportion of each index's information contribution sensitivity to the sum of all indexes' information contribution sensitivities. The weight of the indexes reflects the relative information content of different indexes.

2. Theory

2.1. Definition of the Concept of Driver Traffic Literacy. By analysing the literature and drawing on previous research experience, we believe that the concept of literacy can be introduced to the study of driver traffic behaviour, and the current traffic problem can be regarded as a "human action." Therefore, the prerequisite for solving such problems is to improve the traffic action literacy of drivers, that is, their "traffic literacy." We draw lessons from the definition of literacy by Ritchhart [21] of Harvard University: an acquired behaviour pattern that includes multiple behaviours and is subjectively active. In the development process of a specific situation, these behaviours are dynamic and exceptional and must be combined with necessary abilities. Another definition of thinking literacy is that it is not merely a subjective desire or tendency to think critically in a specific situation. Simultaneously, it is necessary to form habits to use skills or actively believe and choose to use their abilities [22].

Traffic literacy is a kind of professional literacy with practical significance. It refers to the traffic behaviours or tendencies that traffic participants gradually develop in long-term driving activities and the awareness, attitude, and control ability to drive activities. It mainly refers to a comprehensive quality that people gradually accumulate due to coping with various road traffic conditions, the awareness of traffic, the relationship between people and the traffic environment, and the treatment of traffic conditions by individuals. It is the sum of specific transportation knowledge and experience, reasonable method skills, and people-oriented green awareness. The formation of traffic literacy begins with the grasp of traffic knowledge by individuals and develops through the cultivation and formation of a healthy traffic awareness; eventually, the traffic knowledge is mastered, and a sound awareness of traffic safety is established and converted into a skill that is used to guide actions.

2.2. Basic Components of Driver Traffic Literacy. This part draws on previous studies on driver prevention of traffic accidents, combined with the author's research experience,

and explores the factors that affect drivers' traffic literacy levels from four dimensions: knowledge, awareness, skills, and behaviour.

2.2.1. Driver's Traffic Knowledge. Some studies believe that changes in knowledge will reduce traffic safety accidents [23, 24]. Driver's traffic knowledge means that traffic participants need to master the corresponding rules, such as traffic rules, mechanical common sense, and knowledge of laws and regulations. The first task of traffic literacy is to make the road participants understand their environment to determine the appropriate driving means accurately. According to an analysis of statistical data from a United Nations survey in 2016, the fatality rate of traffic accidents in developed countries was less than 4%, and the death toll was 1.2–1.7 people per 10,000 vehicles, while the fatality rate in China was as high as 22%, and the death toll was approximately 3.3 people per 10,000 vehicles. Both of China's evaluation indexes are higher than those of developed countries. Most of the causes of accidents are the driver's insufficient traffic experience and noncompliance with traffic laws [25, 26]. In today's rapidly developing traffic environment, mastering sufficient traffic knowledge and experience will lay the foundation for driving in traffic. For example, only by understanding the road signs' information can the driver know the road conditions they are driving on. Studies have proved that a better understanding of traffic signs will promote good traffic behaviour [27] so that it will not be easy to conflict with other traffic participants and avoid unnecessary disputes.

2.2.2. Driver's Traffic Awareness. Driver traffic awareness is an inherent extension of traffic literacy, reflecting the driver's moral cultivation and reflecting how people treat others and deal with the traffic environment. A cautious driving attitude should be formed, and a correct road traffic concept should be established, mainly in terms of safety awareness, kindness to others, values, and situation foresight. Changing people's attitudes towards traffic laws is crucial in preventing traffic accidents [28]. When drivers have strong traffic risk perception capabilities, they will take the initiative to take certain protective traffic behaviours [29]. For traffic drivers, safety and equality need to be considered in establishing traffic awareness [30, 31], and the main emphasis is on traffic safety awareness. Values are also the main representation of the level of traffic awareness. They give the driver a subjective judgment, drive behaviour standards, and shape their driving behaviour [32–34]. In recent years, personal moral issues related to transportation have gradually attracted people's attention [35–37]. The concept of traffic ethics will affect traffic participants' consciousness to comply with laws and regulations and determine whether they can correctly view the position of traffic participants in the transportation society and their relationships with other participants. Correct traffic concepts and attitudes should lead to the establishment of the concepts of "safety first" and "treat others" and the further formation of an attitude of "driving cautiously," "obeying orders," and "being polite to others."

2.2.3. Driver's Traffic Skills. Driving is a complex task that relies on different skills [38]. The perception of traffic skills can affect self-regulation behaviours during driving and prevent unnecessary driving behaviours [39]. Traffic skills are a further manifestation of traffic awareness and a specific means to reflect traffic knowledge. It is divided into two dimensions: perception of motor skills and safety skills [40]. The driver's traffic skills can transform the knowledge he already knows into skills, be proficient in manipulating the vehicle, and take timely action in response to sudden road conditions. Skills are the prominent ability to make correct judgments and operations based on knowledge and experience. If the driver overestimates his driving skill level, potential hazards will occur [41]. By investigating the status of people involved in traffic accidents, it was found that participants with relatively low skills accounted for a relatively high proportion of the accident group [42]. Only transforming traffic knowledge into a driving ability and gradually forming traffic skills that can be directly used in manipulating vehicles and then positively intervening in driving behaviour will reduce driving safety incidents. Some studies have also proved that skills are closely related to behaviour and accidents [43, 44].

2.2.4. Driver's Traffic Behaviour. Traffic knowledge, traffic awareness, and traffic skills are all directly established at the traffic participants' level, which indirectly affects drivers' traffic literacy level. Driver traffic behaviour is aimed at the driver's actual action level, which is the most direct reflection of driver traffic literacy. Studies have shown that traffic accidents' leading cause is the driver's improper behaviour (76.1%) [45]. The driver's traffic behaviour is a process of continuously receiving, analysing, and responding to the surrounding environment and changes. The external environment's quality may increase the probability of violations [46]. For example, when drivers believe that the external environment is normal, they will often show more dangerous driving behaviours [47].

On the contrary, the driver cannot be affected by the external environment, make certain self-management behaviours, and safely control the vehicle, effectively reducing the possibility of traffic accidents. As a kind of cognitive behaviour, safe and civilised behaviour can reduce driving aggression caused by angry and risky driving behaviours [48, 49]. Therefore, focusing on cultivating drivers' safe and civilised behaviour will directly affect every link of the driving process and reduce traffic accidents.

2.3. Construction of the Driver Traffic Literacy Index System. The construction of a driver traffic literacy evaluation system is a multi-index and multilevel comprehensive evaluation problem, which contains more content, involves a broader range, and is more complicated. There are many problems related to transportation literacy, and the corresponding influencing factors can be divided into dozens or hundreds of factors. For the convenience of research and the operability of the evaluation model, combined with the influencing factors, formation mechanism, evaluation purpose,

and index selection principles of traffic literacy, the traffic literacy evaluation index system is constructed according to the four dimensions of knowledge, awareness, skills, and behaviour. There are 13 indexes in the specific subjective index layer, including traffic rules, common sense of machinery, knowledge of laws and regulations, safety awareness, kindness to others, values, situation foresight, vehicle control, precautionary measures, emergency measures, self-management behaviour, driving control behaviour, and safe and civilised behaviour, as shown in Table 1.

3. Material and Empirical Analysis

3.1. Data Sources and Analysis. Based on the Likert five-level scale, this study designed a questionnaire to assess "evaluation of traffic literacy of motor vehicle drivers" with a total of 17 questions. To ensure the data integrity of individual indexes, we consulted experts in related fields on the design ratio of questionnaire questions. Finally, it is determined that the four indexes of traffic rules, safety awareness, vehicle control, and self-management behaviour each correspond to 2 questions, and the other indexes correspond to 1 question. The survey respondents selected persons with driving experience within the administrative area of Zhengzhou City and issued a total of 550 questionnaires to eliminate complete questionnaires (for example, the online questionnaire has a short response time, and more than 80% of the questions are answered for the same option; the questionnaire is not completed completely). Finally, 393 valid questionnaires were obtained, and the sample efficiency was 71.45%. The preliminary analysis of the questionnaire data shows that the Cronbach's α coefficient of the questionnaire is 0.821, which indicates that the overall questionnaire has good reliability. Through the KMO test on the questionnaire data, the questionnaire's KMO value was 0.854, and the significance p value of the Bartlett sphere test is less than 0.05. The cumulative variance contribution rate of the common factor was 63.311%. Each entry's load value on a common factor was greater than 0.4, and the load values of other common factors were below 0.4, indicating that the questionnaire for traffic literacy of motor vehicle drivers has a higher validity.

3.2. Empirical Analysis Results

3.2.1. Screening of Indexes Based on Information Contribution Sensitivity. According to the data collected from the questionnaire survey, the data of each index are first standardized to obtain a standardized matrix Z, and the standardized matrix is solved for the correlation coefficient matrix R:

$$R = \left[r_{ij} \right]_{13 \times 13} = X^T X \tag{1}$$

as shown in Table 2.

The correlation coefficient matrix R is brought into the formula $|R - \lambda_i E_n| = 0$, where E_n is a n-order identity matrix,

and the eigenvalue λ_i is obtained. The obtained eigenvalue λ_i is brought into the formula $\omega_i = \lambda_i / \sum_{i=1}^{n} \lambda_i$, and the variance contribution ratio of principal component Z_i to ω_i is calculated (Z_i is the i-th principal component, $i = 1, 2, \ldots, k$, and k is the number of retained principal components). ω_i is the proportion of the i-th principal component Z_i explaining the total variation of all 13 original indexes and reflecting the proportion of the information content of the i-th principal component Z_i that occupies the information content of all indexes. The larger this value is, the more the original information of the main component Z_i is carried by $X_1, X_2, \ldots, X_{13}$.

Based on the variance contribution rate of each principal component, the proportion of the sum of the information content of each principal component in the former k to the information content of all original indexes is calculated, that is, the cumulative variance contribution rate $U_k = \sum_{i=1}^{k} \omega_i$. The cumulative variance contribution ratios of the first k principal components are arranged from the largest to the smallest. In general, when the eigenvalues of the indexes are greater than 1 and the cumulative variance contribution rate exceeds 60%, these principal components contain the main information of most measurement indexes [50]. In this study, if the first three principal components' cumulative variance contribution rate is retained, the first three principal components with the largest variance contribution ratio are retained. The calculation results are shown in Table 3.

The eigenvector p_i^T that is orthogonally unitized by the correlation coefficient matrix R is obtained from the basic solution system of the following linear equations with the formula $(R - \lambda_i E_n)x = 0$. The initial matrix and eigenvalues formed by all the data are brought into the formula to obtain the eigenvectors of the three principal components. The calculation results of the orthogonalization of the eigenvectors to the absolute value are shown in Table 4.

The main information of the original index is expressed by a few principal components Z_i, and its expression formula is as follows:

$$Z_i = p_{i1}X_1 + p_{i2}X_2 + \cdots p_{ij}X_j + \cdots p_{in}X_n. \tag{2}$$

Based on this result, the sensitivity α_{ij} of the i-th principal component affected by the size change of the j-th index is calculated as follows:

$$\alpha_{ij} = \left| \frac{Z_i^* - Z_i}{X_j^* - X_j} \right| = \left| p_{ij} \right|. \tag{3}$$

In this paper, the result of the difference operation is approximated to the orthogonalization of the eigenvectors to determine the absolute value. The calculated data are shown in Table 4.

The sensitivity β_{ij} of the information of all original indexes through the i-th principal component, which is affected by the change of the size of the j-th index and the information contribution sensitivity β_j of the fourth index, is calculated.

TABLE 1: Structure of the evaluation indexes for transportation literacy.

Evaluation goals	Evaluation index	Main connotation
Traffic literacy X	Traffic rules X_1	To maintain road traffic order, prevent and reduce traffic accidents, protect personal safety, protect the property and other legitimate rights and interests of citizens, legal persons, and other organisations, and improve traffic efficiency and other related rules.
	Knowledge of laws and regulations X_2	Knowledge of road traffic safety-related laws, administrative regulations, and departmental rules and regulations.
	Mechanical common sense X_3	Understand the vehicle's basic structure and be proficient in its correct operation and each component's performance.
	Safety consciousness X_4	In production activities, a state of alertness and alertness to the external environment may cause harm to the driver.
	Values X_5	Values, which are acquired via the dominant social context and the unique experiences of the person, can result in an action, giving it direction and emotional intensity while also designating standards for judging and justifying action.
	Treat others well X_6	Drivers are always grateful for the unexpected things that happen during driving, and they have more understanding and tolerance.
	Situation foresight X_7	In driving, grasp possible future situations and make scientific predictions on complex problems.
	Vehicle control X_8	The driver drives the vehicle through the steering system and the steering wheels' direction (straight or corner). When exposed to external disturbances (uneven roads, crosswinds, cargo, or passengers being eccentrically loaded), the vehicle can resist interference and maintain everyday driving.
	Precaution X_9	The driver takes response measures to eliminate potential emergencies or other potentially undesirable emergencies.
	Emergency measures X_{10}	The handling method is adopted when an emergency occurs, which mainly includes the handling method.
	Driving control behaviour X_{11}	The behaviours of controlling vehicle operation and monitoring the driving environment include driving control operation sensitivity, driving control activity intensity, and driving control state stability.
	Self-management behaviour X_{12}	Self-teaching and restraint. The driver's self-management of goals, thoughts, psychology, and behaviour during driving.
	Safe civilised behaviour X_{13}	Drivers drive in a safe and civilised driving life and can calmly face complicated traffic conditions, to avoid illegal behaviours.

$$\beta_{ij} = \omega_i \left| \frac{Z_i^* - Z_i}{X_j^* - X_j} \right| = \omega_i \left| p_{ij} \right|,$$

$$\beta_j = \sum_{i=1}^k \omega_i \left| \frac{Z_i^* - Z_i}{X_j^* - X_j} \right| = \sum_{i=1}^k \omega_i \left| p_{ij} \right|, \qquad (4)$$

β_j reflects the degree of influence of index X_j on the evaluation results. The greater the value of β_j, the more important the index X_j. Indexes with a higher contribution sensitivity to the overall evaluation are retained. The calculation results are shown in Table 4.

Based on the calculations of the above model, indexes with a low sensitivity of information contribution are eliminated, and the obtained values of β_j ($j = 1, 2, \ldots, 13$) are arranged in order from large to small. The ratio γ_m of the sum of the β_j values of the top m indexes to the sum of all 13 indexes β_j indicates the information volume of the selected indexes for all indexes, which is called the sensitivity of the cumulative information contribution. The calculation formula is

$$\gamma_m = \frac{\sum_{j=1}^m \beta_j}{\sum_{j=1}^{13} \beta_j}. \qquad (5)$$

In the principal component analysis theory, when the cumulative information contribution sensitivity reaches 70% ~ 90%, the principal components can reflect most of the information of all the original indexes. Based on this, to ensure the maximum information contribution and prevent the omission of information from individual indexes, the first m indexes that meet the value of the cumulative information contribution rate γ_m at a level of 90% or greater are selected and retained. The specific calculation data are shown in Table 5. The cumulative information contribution sensitivity of the 10th line is 90.00%. Therefore, the first 9 indexes are retained, and the 3 indexes with lower contribution rates such as X_6, X_3, and X_{12} are excluded.

3.2.2. Index Weighting Based on Information Contribution Sensitivity.
The core idea of index weighting is to divide the sensitivity of each index's information contribution by the sum of the sensitivity of the information contribution of all indexes. The formula is

$$w_r = \frac{\beta_r}{\sum_{j=1}^n \beta_j}, \ (r = 1, 2, \ldots, n). \qquad (6)$$

This article presents the weighting results based on index selection, as shown in Table 5. It should be noted that after the index selection is completed, the problems corresponding to the elimination index shall be deleted, and the reserved indexes shall be reempowered. The specific process is not shown in detail.

TABLE 2: Correlation coefficient matrix of the original index.

Index	X_1	X_2	X_3	X_4	X_5	$\cdots$	X_{13}
X_1	1.0000	0.457	0.612	0.526	0.320	$\cdots$	0.222
X_2	0.457	1.000	0.589	0.527	0.275	$\cdots$	0.127
X_3	0.612	0.589	1.000	0.628	0.387	$\cdots$	0.237
X_4	0.526	0.447	0.527	1.000	0.628	$\cdots$	0.234
X_5	0.320	0.275	0.387	0.628	1.000	$\cdots$	0.218
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
X_{13}	0.222	0.127	0.237	0.234	0.218	$\cdots$	1.000

TABLE 3: Characteristic values and contribution rates of principal components.

Number/item	Eigenvalues	Variance contribution rate	Cumulative variance contribution rate
	λ_i	ω_i (%)	U_k (%)
1	6.697	51.518	51.518
2	1.173	9.025	60.543
3	1.074	7.494	68.037
4	0.839	6.455	74.492
5	0.608	4.680	79.172
6	0.531	4.084	83.256
7	0.469	3.605	86.861
8	0.395	3.035	89.896
9	0.345	2.655	92.551
10	0.329	2.528	95.078
11	0.264	2.033	97.112
12	0.243	1.871	98.983
13	0.132	1.017	100.000

4. Discussion

The influencing factors of driver's traffic literacy are discussed from four dimensions through the analysis of the existing literature. Literacy is a collection of preferences, attitudes, intentions, and the related ability to reflect preferences in a specific way [51]. Therefore, we believe that the driver's literacy should include knowledge, awareness, skills, and behaviour. These four dimensions comprehensively reflect the driver's overall quality in the entire driving process from basic theory to behaviour implementation. Based on these four dimensions, the representative indexes in each size (such as traffic knowledge including traffic rules, laws, and regulations) are further screened out. The driver's traffic literacy level can be evaluated more scientifically and comprehensively. Government departments or organisations can also take some targeted measures based on these indexes to guide drivers to improve their traffic literacy continuously. Implementing some positive measures will help reduce the occurrence of traffic accidents, make urban traffic more orderly, and meet the needs of social and economic development and people's lives.

The rationality of indexes directly affects the results of the evaluation. In many studies, relying on indexes' relative importance can only reflect the importance of the amount of information reflected by an index relative to the evaluation results [52–55]. However, in the era of big data, the dimensions of index sets presented by different evaluation systems are becoming more and more complex, and there will inevitably be information overlap between indexes. Screening indexes based on relative importance cannot determine the collinearity between indexes and whether

there is an overlap of information. Some scholars have adopted principal component dimensionality reduction methods to reduce information overlap [56, 57], but only using the size of the load factor cannot effectively reflect the information content of the index and cannot determine the weight of the index. From the perspective of information contribution sensitivity, this study uses improved principal component analysis methods to prioritize the retention of indexes with greater information contribution sensitivity. The research results ensure that the retained evaluation indexes carry more information from the original data set and achieve a low degree of information overlap between the indexes, guaranteeing the rationality of the evaluation system and at the same time getting the weight of each index.

The research results obtained by using this research method show that the knowledge of laws and regulations in the traffic knowledge, the kindness to others in the traffic awareness, and the driving control behaviour in the traffic behaviour are deleted. These three indexes carry a small amount of information (information contribution rates are 4.32%, 3.1%, and 2.23%) and overlap with the amount of information carried by other indexes. For example, the "traffic rules" in traffic knowledge will include part of the knowledge of traffic laws and regulations, which will lead to overlap of information; another example is that there is an inevitable overlap of information between the indexes "be kind to others" and "values." Kaçan et al. [34] believe that traffic values are obtained through dominant social background and unique personal experience. The direction and emotional intensity of behaviour can be given, and standards can be specified to judge and prove the rationality of actions. A driver with good traffic values will reasonably control the

TABLE 4: The results of orthogonal normalization of the first three principal component eigenvectors to determine the absolute values.

Serial number	Index	Eigenvector orthogonal normalization to determine the absolute value			Information contribution sensitivity
		$|p_{1j}|$	$|p_{2j}|$	$|p_{3j}|$	β_j
1	X_1	0.2280	0.5124	0.0231	0.1654
2	X_2	0.3917	0.1167	0.0328	0.2148
3	X_3	0.0996	0.0876	0.0342	0.0618
4	X_4	0.3678	0.2321	0.0239	0.2122
5	X_5	0.6317	0.4582	0.0625	0.3715
6	X_6	0.1565	0.0287	0.0375	0.0860
7	X_7	0.2302	0.5372	0.0096	0.1678
8	X_8	0.1289	0.2220	0.1862	0.1004
9	X_9	0.1537	0.1769	0.6955	0.1473
10	X_{10}	0.1748	0.2200	0.6737	0.1604
11	X_{11}	0.1772	0.1047	0.1287	0.1104
12	X_{12}	0.0896	0.0066	0.0484	0.0504
13	X_{13}	0.2502	0.1513	0.0033	0.1428

TABLE 5: Index screening and weighting based on cumulative information contribution sensitivity.

Serial number (1)	Index (2)	Metrics are sorted by the value of β_j	Cumulative information contribution sensitivity γ_m	Retained and removed indexes	Weights
1	X_1	X_5 (0.3715)	18.66%	Retained X_5	0.0831
2	X_2	X_2 (0.2148)	29.44%	Retained X_2	0.1079
3	X_3	X_4 (0.2122)	40.10%	Retained X_4	0.0310
4	X_4	X_7 (0.1678)	48.53%	Retained X_7	0.1066
5	X_5	X_1 (0.1654)	56.84%	Retained X_1	0.1866
6	X_6	X_{10} (0.1604)	64.89%	Retained X_{10}	0.0432
7	X_7	X_9 (0.1473)	72.29%	Retained X_9	0.0843
8	X_8	X_{13} (0.1428)	79.46%	Retained X_{13}	0.0504
9	X_9	X_{11} (0.1104)	85.00%	Retained X_{11}	0.0740
10	X_{10}	X_8 (0.1004)	90.05%	Retained X_8	0.0806
11	X_{11}	X_6 (0.086)	94.37%	Removed X_6	0.0554
12	X_{12}	X_3 (0.0618)	97.47%	Removed X_3	0.0253
13	X_{13}	X_{12} (0.0504)	100.00%	Removed X_{12}	0.0717

Note. The weights in the last column correspond to the indexes in the second column.

implementation of his own emotions and behaviours in the traffic interaction with others, take the initiative to treat others kindly, and effectively avoid traffic injuries. As a subjective behaviour of the driver, driving control behaviour occurs during the entire driving process. However, as the number of vehicles on the road gradually increases, the degree of automation is getting higher and higher [58], and different countries and regions have aligned their driving licenses. The standards for examinations have gradually increased, and the driver's driving control knowledge and skills have been improved in driving training [59, 60], making the driver more instinctively focused on behaviour in the actual driving process. As a result, this index's impact on traffic literacy is relatively low during the investigation process.

The research results show that the weights of the three mechanical knowledge indexes, safety awareness, and values are relatively high, all greater than 0.1. "Mechanical knowledge" can better reflect the driver's understanding of the vehicle, master the driving tool's performance and operation instructions, and enhance the interaction between the driver and the vehicle information [61], which guarantees the driver a prerequisite for safe driving. Safety

awareness and values belong to traffic awareness. Studies have shown that changing people's attitudes towards traffic is essential to prevent traffic accidents. When drivers have a solid ability to perceive traffic risks, they will take the initiative to take certain protective behaviours [28]. Schwartz [62] believes that values are universal, but their importance varies from person to person and is a dynamically changing emotional state. Values exist in the individual at different levels, thereby affecting the individual's real-life behaviour [63]. When applied to the driving environment, they interact with their knowledge reserves and master skills, thereby affecting their driving behaviour. Driving behaviour as a direct factor that affects the driver's traffic literacy does not show a greater weight, which may be related to the behaviour as an actor in the driver's daily driving activities and has not attracted the driver's attention.

5. Conclusions

Through an analysis and induction, a traffic literacy evaluation index system was constructed based on the concept of traffic literacy. This system includes thirteen indexes, such as safety awareness, traffic rules, vehicle control, emergency

measures, being kind to others, values, driving control behaviour, situation foresight, common sense regarding machinery, precautionary measures, knowledge of laws and regulations, self-management behaviour, and safe and civilised behaviour. Through combining various texts, this article summarizes the indexes that can comprehensively reflect the level of driver traffic literacy and lay a specific theoretical basis for further research on the evaluation index system of driver traffic literacy.

The research method proposed in this paper excludes the indexes with overlapping information. During the index screening process, the concept of information contribution sensitivity was proposed. Its value is obtained by calculating the sum of the difference operation result of the retained principal component to an index and the cumulative contribution rate of the principal component variance corresponding to this index. Each index is weighted by the ratio of the information contribution sensitivity of one index to the sum of the information contribution sensitivity of all indexes, so the index's weight can genuinely reflect the corresponding index's information content. It overcomes the shortcomings that existing research cannot use the principal component analysis method to complete the empowerment and makes the weights of various indexes more objective and expands scientific methods other than subjective empowerment.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

References

[1] Y Üzümcüoğlu, T Özkan, C Wu, and H Zhang, "Traffic climate and driver behaviors: the moderating role of driving skills in Turkey and China," *Journal of Safety Research*, vol. 75, pp. 87–98, 2020.

[2] L. S. Nangana, B. Monga, N. R. Ngatu, E. P. Mbelambela, L. H. Mbutshu, and K. F. Malonga, "Frequency, causes and human impact of motor vehicle-related road traffic accident (RTA) in Lubumbashi, Democratic Republic of Congo," *Environmental Health and Preventive Medicine*, vol. 21, no. 5, pp. 350–355, 2016.

[3] K. Rumar, "The role of perceptual and cognitive filters in observed behavior," *Human Behavior and Traffic Safety*, Springer, Boston, MA, USA, pp. 151–170, 1985.

[4] H. Lu, X. F. Xi, W. C. Yang, and C. Y. Hu, "Cause analysis of traffic accidents in plateau and mountain highway environment," *Journal of Chinese Safety Science*, vol. 29, no. 05, pp. 44–49, 2019, in Chinese.

[5] Z. Yan, X. Lu, and W. Hu, "Analysis of factors affecting traffic accident severity based on heteroskedasticity ordinal Logit," in *ICTE 2019*, pp. 422–435, American Society of Civil Engineers, Reston, VA, USA, 2020.

[6] T. O. Nævestad, R. O. Phillips, and B. Elvebakk, "Traffic accidents triggered by drivers at work–A survey and analysis of contributing factors," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 34, no. 8, pp. 94–107, 2015.

[7] Y. Zhang, Z. W. Chen, and Q. S. Zhang, "Building of assessment index system of safe transport," *Journal of Transportation Research*, vol. 1, no. 6, pp. 8–13, 2015, in Chinese.

[8] Z. Guo, X. Shang, and H. Li, "AHP-based safety assessment model for rail transit system," *Zhong Guo Tie Dao Ke Xue*, vol. 32, no. 3, pp. 123–125, 2011.

[9] G. X. Liu, ""Research on evaluation method and index system of green transportation in small cities," China science and technology association, ministry of transport of the people's Republic of China, Chinese academy of engineering," in *Proceedings of the 2019 World Transportation Conference (Part 2)*, pp. 820–830, China Highway Society, 2019, in Chinese.

[10] P. Y. Long and C. N. Gao, "Study on evaluation index system of green city traffic based on tourism development," *Technology of Highway and Transport*, vol. 33, no. 3, pp. 116–120+125, 2017.

[11] Y. X. Yu, X. C. Wang, H. Zhang, and X. Chen, "Reconfiguration DEA's optimal in ITS evaluation," *Journal of Shandong Jiaotong University*, vol. 18, no. 1, pp. 17–21, 2010.

[12] J. J. Fan, "Construction and empirical analysis of Beijing harmonious transportation evaluation index system," PHD thesis, Beijing Jiaotong University, Beijing, China, 2010.

[13] Y.-H. Huang, P.-L. P. Rau, B. Zhang, and M. Roetting, "Chinese truck drivers' attitudes toward feedback by technology: A quantitative approach," *Accident Analysis & Prevention*, vol. 40, no. 4, pp. 1553–1562, 2008.

[14] Y.-H. Huang, W. Zhang, L. Murphy, G. Shi, and Y. Lin, "Attitudes and behavior of Chinese drivers regarding seatbelt use," *Accident Analysis & Prevention*, vol. 43, no. 3, pp. 889–897, 2011.

[15] G. Zhang, K. K. W. Yau, and X. Gong, "Traffic violations in Guangdong Province of China: Speeding and drunk driving," *Accident Analysis & Prevention*, vol. 64, pp. 30–40, 2014.

[16] C.-T. Tung and Y.-J. Lee, "A novel approach to construct grey principal component analysis evaluation model," *Expert Systems with Applications*, vol. 36, no. 3, pp. 5916–5920, 2009.

[17] H. Y. Zheng, J. B. Sheng, X. H. Peng, and D. W. Yang, "Earth-rock dam risk consequence's comprehensive evaluation under drought condition," *Procedia Earth and Planetary Science*, vol. 5, pp. 237–240, 2012.

[18] Y. M. Liu, Z. J. Li, and W. Yin, "Credit index selection model based on Bayesian discriminant and cluster analysis under non-parameters," *Statistics & Decisions*, vol. 22, no. 5–10, in Chinese, 2018.

[19] Y. P. Xu, Y. D. Pan, Q. D. Liu et al., "Drought resistance identification and drought resistance indexes screening of barley resources at mature period," *Acta Agronomica Sinica*, vol. 46, no. 3, pp. 448–461, 2019.

[20] Z. Zhu, S. Jia, S. He, Y. Sun, Z. Ji, and L. Shen, "Three-dimensional Gabor feature extraction for hyperspectral imagery classification using a memetic framework," *Information Sciences*, vol. 298, pp. 274–287, 2015.

[21] R. Ritchhart, *Intellectual Character: What it Is, Why it Matters, and How to Get it*, Academic Press, John Wiley & Sons, San Francisco, CA, USA, 2004.

[22] S. P. Norris, "Testing for the disposition to think critically," *Informal Logic*, vol. 14, no. 2, pp. 157–164, 1992.

[23] S. Miccoli, G. Giraldi, A. Boccia, and G. La Torre, "School teachers' knowledge, attitudes and behaviors towards road safety: results from a multicenter cross-sectional study in Italy," *Annali di Igiene: Medicina Preventiva e di Comunita*, vol. 24, no. 4, pp. 289–299, 2012.

[24] R. Mirzaei, N. Hafezi-Nejad, M. Sadegh Sabagh et al., "Dominant role of drivers' attitude in prevention of road traffic crashes: A study on knowledge, attitude, and practice of drivers in Iran," *Accident Analysis & Prevention*, vol. 66, pp. 36–42, 2014.

[25] D. Shinar and R. Compton, "Aggressive driving: an observational study of driver, vehicle, and situational variables," *Accident Analysis & Prevention*, vol. 36, no. 3, pp. 429–437, 2004.

[26] M. A. Machin and K. S. Sankey, "Relationships between young drivers' personality characteristics, risk perceptions, and driving behaviour," *Accident Analysis & Prevention*, vol. 40, no. 2, pp. 541–547, 2008.

[27] P. Hardini and E. W. Indriyati, "Pengetahuan Dan Pengaruhnya Terhadap Perilaku Berlalu Lintas; Tinjauan Terhadap Pelaku Lalu Lintas Usia Remaja Di Smk Ypt 1 Purbalingga," *Journal of Indonesia Road Safety*, vol. 1, no. 3, pp. 138–146, 2018.

[28] L. M. Martinussen and C. G. Prato, "Facilitating improved road safety based on increased knowledge about driving behaviour and profiling sub-groups of drivers," PhD thesis, Technical University of Denmark, Denmark, Europe, 2013.

[29] H. A. Deery, "Hazard and risk perception among young novice drivers," *Journal of Safety Research*, vol. 30, no. 4, pp. 225–236, 1999.

[30] H. Safarpour, D. Khorasani-Zavareh, and R. Mohammadi, "The common road safety approaches: a scoping review and thematic analysis," *Chinese Journal of Traumatology*, vol. 23, no. 2, pp. 113–121, 2020.

[31] F. Di Ciommo and Y. Shiftan, "Transport equity analysis," *Transport Reviews*, vol. 37, no. 2, pp. 139–151, 2017.

[32] S. H. Schwartz, "Beyond individualism/collectivism: new cultural dimensions of values," in *Individualism and Collectivism: Theory, Method, and Applications*, U. Kim, H. C. Triandis, Ç. Kâğitçibaşi, S.-C. Choi, and G. Yoon, Eds., pp. 85–119, Sage Publications, Inc, Thousand Oaks, CA, USA, 1994.

[33] T. Özkan and T. Lajunen, "Person and environment: traffic culture," in *Handbook of Traffic Psychology*, pp. 179–192, Academic Press, Middle East Technical University, Ankara, Turkey, 2011.

[34] B. Kaçan, G. Fındık, Y. Üzümcüoğlu et al., "Driver profiles based on values and traffic safety climate and their relationships with driver behaviors," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 64, pp. 246–259, 2019.

[35] D. Husak, "Vehicles and Crashes," *Social Theory and Practice*, vol. 30, no. 3, pp. 351–370, 2004.

[36] S. O. Hansson, "Making road traffic safer: reply to Ori," *Philosophical Papers*, vol. 43, no. 3, pp. 365–375, 2014.

[37] M. Ori, "Why not road ethics?" *Theoria*, vol. 86, no. 3, pp. 389–412, 2020.

[38] M. Hatakka, E. Keskinen, N. P. Gregersen, A. Glad, and K. Hernetkoski, "From control of the vehicle to personal self-control; broadening the perspectives to driver education," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 5, no. 3, pp. 201–215, 2002.

[39] A. Siren and A. Meng, "Older drivers' self-assessed driving skills, driving-related stress and self-regulation in traffic," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 17, pp. 88–97, 2013.

[40] T. Lajunen and H. Summala, "Driving experience, personality, and skill and safety-motive dimensions in drivers' self-assessments," *Personality and Individual Differences*, vol. 19, no. 3, pp. 307–318, 1995.

[41] F. P. McKenna and M. S. Horswill, "Risk taking from the participant's perspective: the case of driving and accident risk," *Health Psychology*, vol. 25, no. 2, pp. 163–170, 2006.

[42] T. Pan and R. F. Wang, "Based on the traffic quality of drivers to the city's traffic safety management research," *Journal of Technical Economics & Management*, vol. 2, pp. 76–78, 2007, in Chinese.

[43] L. M. Martinussen, M. Møller, and C. G. Prato, "Assessing the relationship between the driver behavior questionnaire and the driver skill inventory: revealing sub-groups of drivers," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 26, pp. 82–91, 2014.

[44] Y Üzümcüoğlu, T Özkan, C Wu, and H Zhang, "Traffic climate and driver behaviors: the moderating role of driving skills in Turkey and China," *Journal of Safety Research*, vol. 75, pp. 87–98, 2020.

[45] A. A. Redhwan and A. J. Karim, "Knowledge, attitude and practice towards road traffic regulations among university students, Malaysia," *IIUM Medical Journal Malaysia*, vol. 9, no. 2, 2010.

[46] W. Chu, C. Wu, C. Atombo, H. Zhang, and T. Özkan, "Traffic climate, driver behaviour, and accidents involvement in China," *Accident Analysis & Prevention*, vol. 122, pp. 119–126, 2019.

[47] T. Gehlert, C. Hagemeister, and T. Özkan, "Traffic safety climate attitudes of road users in Germany," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 26, pp. 326–336, 2014.

[48] J. L. Deffenbacher, "A review of interventions for the reduction of driving anger," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 42, pp. 411–421, 2016.

[49] S. Q. Shen, "The associated factors and psychological intervention of driving anger and aggression for plateau military truck drivers east," PhD thesis, China Normal University, Shanghai, China, 2013.

[50] L. B. Wang, *Multivariate Statistical Analysis: Model Cases and Application of SPSS*, Economic Science Press, Beijing, China, 2010, in Chinese.

[51] G. Salomon, *Interaction of Media, Cognition, and Learning*, Psychology Press, London, UK, 1994.

[52] M. Kazemi, "Partial correlation screening for varying coefficient models," *Journal of Mathematical Modeling*, vol. 8, no. 4, pp. 363–376, 2020.

[53] D. Fouskakis, G. Petrakos, and I. Rotous, "A Bayesian longitudinal model for quantifying students' preferences regarding teaching quality indicators," *Metron*, vol. 78, no. 2, pp. 255–270, 2020.

[54] J. Rezaei, W. S. van Roekel, and L. Tavasszy, "Measuring the relative importance of the logistics performance index indicators using Best Worst Method," *Transport Policy*, vol. 68, pp. 158–169, 2018.

[55] W. N. K. Wan Ahmad, J. Rezaei, S. Sadaghiani, and L. A. Tavasszy, "Evaluation of the external forces affecting the sustainability of oil and gas supply chain using Best Worst Method," *Journal of Cleaner Production*, vol. 153, pp. 242–252, 2017.

[56] H Uğuz, "A hybrid system based on information gain and principal component analysis for the classification of transcranial Doppler signals," *Computer Methods and Programs in Biomedicine*, vol. 107, no. 3, pp. 598–609, 2012.

[57] S.-F. Chen, S. Wang, and C.-Y. Chen, "A simulation study using EFA and CFA programs based the impact of missing data on test dimensionality," *Expert Systems with Applications*, vol. 39, no. 4, pp. 4026–4031, 2012.

[58] P. A. Hancock, T. Kajaks, J. K. Caird et al., "Challenges to human drivers in increasingly automated vehicles," *Human Factors: The Journal of the Human Factors and Ergonomics Society*, vol. 62, no. 2, pp. 310–328, 2020.

[59] V. Beanland, N. Goode, P. M. Salmon, and M. G. Lenné, "Is there a case for driver training? A review of the efficacy of pre- and post-licence driver training," *Safety Science*, vol. 51, no. 1, pp. 127–137, 2013.

[60] A. F. Williams, "Graduated driver licensing (GDL) in the United States in 2016: a literature review and commentary," *Journal of Safety Research*, vol. 63, pp. 29–41, 2017.

[61] J. Koo, J. Kwac, W. Ju, M. Steinert, L. Leifer, and C. Nass, "Why did my car just do that? Explaining semi-autonomous driving actions to improve driver understanding, trust, and performance," *International Journal on Interactive Design and Manufacturing (IJIDeM)*, vol. 9, no. 4, pp. 269–275, 2015.

[62] S. H. Schwartz, "Universals in the content and structure of values: theoretical advances and empirical tests in 20 countries," *Advances in Experimental Social Psychology*, vol. 25, pp. 1–65, 1992.

[63] E. Skimina, J. Cieciuch, S. H. Schwartz, E. Davidov, and R. Algesheimer, "Testing the circular structure and importance hierarchy of value states in real-time behaviors," *Journal of Research in Personality*, vol. 74, pp. 42–49, 2018.