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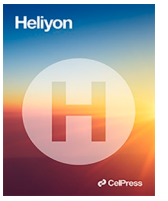

Research article

Understanding level of Chinese traffic signage among children aged 7–11 years: A pilot study

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ABSTRACT

Road traffic injuries are one of the main causes of death among children. In recent years, the incidence and casualty rates of traffic accidents have increased year by year, which is a major challenge faced by safety organizations and governments in various countries, especially in developing countries. Among them, correct understanding of road traffic signs is a factor in reducing accidents. Therefore, identifying traffic signs has become an important indicator of road safety education. This study aimed to understand the understanding level of existing road traffic signs among Chinese children aged 7–11. 30 children aged 7–11 from Guangzhou participated in this study.

The working title "Traffic Signage understanding Test questionnaire" was used as the tool for data collection. The questionnaire measured three aspects of child road users' understanding, including verbal label, action and consequences. Three experts in child psychology and cognition reviewed the questionnaire and validated its face and content. The survey results show that compared with actions and consequences, children have a lower understanding of verbal labels of signs, but overall, most children understand traffic signs incorrectly or do not understand them. This is statistically significant in reducing China's road traffic casualty rate. It is also recommended to design traffic signs that are suitable for children to understand.

1. Introduction

Researchers and governments are increasingly acknowledging that the comprehension of signs is a crucial factor to consider when designing signage. Studies indicate that the pathway from symbols to behaviour has two overarching processes: comprehension and decision-making [1]. Which means for a signature to be effective, it is crucial that it is both perceived and its intention is comprehended. Simultaneously, Wogalter conducted a study on safety signs and suggested that a prevalent approach to prompt individuals about hazardous and injury-prone behaviours is to display signage [2]. The effectiveness of warning signage for these reasons is contingent, to some extent, on how the audience perceives and understands the intended message. The level of comprehension, whether it is high or poor, significantly affects the personal safety of the target population [3–5] as well as social and economic investment [6]. The degree of comprehension of a signage is a crucial determinant for designers and government organizations when determining whether to utilise the signage.

Traffic signage plays a vital part in safeguarding the essential interests of individuals using the road [7]. Thus, the comprehension of

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traffic signage is crucial. Traffic signs have a direct or indirect impact on the frequency of traffic accident injuries by avoiding and minimising risky behaviours and situations. They serve as an essential precaution to reduce unintentional injuries [8]. Traffic Signage often communicates meaningful information using visual symbols and graphics, assisting in directing, regulating, and alerting individuals who are using the road [9,10]. Traffic signage play a substantial role in establishing a more secure setting for automobiles, bikers, and pedestrians [11]. Research conducted by Huang indicates that the presence of traffic safety signs on the road significantly impacts pedestrian walking safety and the likelihood of road traffic accidents [12]. Consequently, this has an impact on the way pedestrians walk and behave [13]. Consequently, the incorrect use or the presence of traffic signs that are challenging to comprehend can result in road traffic collisions [14,15]. Due to the influence of cultural and other factors, it is necessary to differentiate and independently study the comprehension of children's traffic signals in China from other locations, since this affects the effectiveness of intervention strategies aimed at preventing accidents involving children [16].

It should also be noted that a significant proportion of studies (91.4 %) primarily examine vehicle drivers [17]. According to the World Health Organization (WHO) in 2018, drivers make up just 64 % of all individuals using the road. However, there is a lack of study in the existing literature that specifically examines the involvement of other road users, such as pedestrians, which is the same goes for children's role as road users. Prior study indicates that safety signage mostly focusses on adults 18, with little consideration given to children's cognitive abilities [19]. Less attention has been paid to traffic signage for children [20]. While children are indeed a target audience for traffic signage, their comprehension of these signage remains uncertain. Children's comprehension of signage and their preferences for design vary from those of adults [18,21,22]. This particularly is true for children with limited education and who are not constrained by social norms or standards [23]. Research on traffic signs specifically designed for children under the age of 11 is limited [24]. Addressing child injuries should be a fundamental aspect of all efforts aimed at improving child mortality and morbidity rates, as well as the overall well-being of children, both nationally and globally. It is crucial to give priority to policies and strategies aimed at minimising accidental traffic injuries in all age categories, with special emphasis on children [25]. Simultaneously, Han have found that the current research on Chinese children's traffic signs is still in its early stages [26]. Annually, around 18,500 children below the age of 14 lose their lives in road traffic accidents in China. Additionally, roughly 10 % of children experience at least one road traffic injury per year [27].

Consequently, the objective of this study was to ascertain the extent of children's comprehension of Chinese traffic signs, specifically focusing on 8 pedestrian traffic signs in vicinity of schools. The study involved children who were given three comprehension level test questionnaires. These questionnaires assessed their grasp of three aspects of traffic signage: verbal label, action, and consequence. This method can thoroughly evaluate children's understanding of traffic signs. Given the research gaps in the literature, false matching rate, and "don't know" rate of signs were also considered. Each question not only provides a "right" and "wrong" option, but also provides a "don't know" option, which is also one of the novelties of the study. If the absence of opinion is acknowledged as a plausible scenario, then may be justifications for incorporating it as a distinct choice [28]. Especially with children, when a child responds with "yes" or "no," they may be giving an answer even if they don't actually know the answer [29]. Assessing the three aspects of traffic signage could help researchers in gauging children's comprehension of the various aspects of traffic signage. The findings of this study will offer valuable information for the development of traffic signage, taking into account the viewpoint of children.

2. Methodology

2.1. Study design and setting

The Study will employ the probability sampling approach to choose the specific location with a high incidence of traffic accidents, namely the urban-rural fringe of Huadu District in Guangzhou. Probability samples are considered the most reliable and accurate method for sampling. They are crucial for guaranteeing that the study results can be applied to the entire target population. Additionally, probability sampling allows for generalisation to the population indicated by the sampling frame [30]. Quantitative study will employ simple random sampling, where each individual in the population has an equal probability of being chosen for inclusion in the sample. In this approach, both the internal and external validity are significantly high, making it straightforward to analyse the data [30].

2.2. Sampling approach

Participants and guardians expressed their interest in the survey through the paper version of the project information sheet and confirmed whether each participant could participate in the study; all participants and guardians provided a consent form. For the sample size of pilot study, Johanson and Brooks proposed that a representative participant of 30 interested groups is a reasonable minimum recommendation for pilot studies aimed at preliminary investigation or scale development [31]. Sampling within the range of 10–30 has several practical benefits, such as simplicity, convenience of computation, and the capacity to test hypotheses [32,33]. Additionally, a sample size of $N = 30$ is often regarded as the minimal need for bootstrap confidence intervals [34]. Based on the selection criteria, 30 children aged 7–11 years were selected as subjects of the study, with 6 children in each age group participating. These populations provide a comprehensive understanding of the issues researchers are trying to explore in their studies.

2.3. Instruments

This study used the close-ended questionnaire -"Traffic Signage understanding Test questionnaire". The questionnaire is divided into three parts. The first part involves the understanding level of the verbal labels of traffic signage, the second part involves the understanding level of the actions of traffic signage, and the third part involves the understanding level of the consequences of traffic signage. This kind of questionnaire design yield results that facilitate statistical data and grading, thereby improving scoring accuracy [35]. There are fixed reference standards, in this study is Traffic sign standard of the People's Republic of China, the correct meaning of all signs will be specified [36], which improves the objectivity of the scoring process [37]. In addition, utilizing a close-ended questionnaire can be beneficial for children aged 7–11 as it allows them to avoid losing points as a result of their limited spelling, grammar, or writing skills [38]. And the reliability and validity of the data results have also increased since the age of 7, and the reliability of the data has already been quite good between the ages of 8 and 11 [39,40].

'right/wrong' questions will be employed in questionnaire. Since it can maximize the acquisition of information. All children choose to answer "yes/no" questions when they can choose the type of the test question [41,42]. And participants' errors can well explain the reason why signage are misunderstood [43]. While children aged 7–12 have also developed the ability to refuse to interfere with information [44].

To minimize guesswork, habitual selection of the second option in children, to determine and assess the adverse effects of minor variations in options on data gathering, this research will employ a modified True/False questionnaire developed by Lesch and McDevitt, That is: Each question in the questionnaire is accompanied by a symbol and a response, and participants are required to judge the accuracy of the answer [43]. In a subsequent inquiry, the identical symbol will be linked with a plausible yet incorrect distractor, and once more, participants must ascertain the accuracy of the distractor. A sign might be deemed as "comprehended" if the participant acknowledges the accurate response and dismisses all inaccurate responses [45,46].

2.4. Validity and reliability

The validity of the questionnaire was verified through Delphi method. Three experts from child psychology, early childhood education and children cognitive behavioural therapy validated the questionnaire.

Table 1
Eight traffic signage and corresponding numbers in the questionnaire.

No.	Traffic signage
A1	
A2	
A3	
A4	
A5	
A6	
A7	
A8	

Before doing the actual testing, the Delphi method will be used. This is due to the results of first the Delphi method to achieve construct validity [47]. Utilizing a mixed methods approach in which panellists rate inclusion questions and provide qualitative responses allows for thorough feedback and consideration of each question raised. Studies by Adams, Taylor and Woodcock all recommend using a 75 % agreement level when determining consensus [48–50]. In this study, consensus was set at 75 % or higher agreement.

The Delphi method was used to obtain how to guide and introduce children before starting the questionnaire to ensure that they are able to respond based on their own thoughts and ideas. Simultaneously, three experts thoroughly examined the terminology and sentences in the questionnaire to guarantee that the research participants could accurately comprehend all the Chinese characters present in the questionnaire. Investigators are requesting the assistance of specialists [51] or laypeople to assess the questionnaire's validity [52]. This assessment will involve assessing the tool's grammar, syntax, organisation, appropriateness, and establishing its logical consistency.

2.5. Procedures

Prior to commencing the questionnaire, a concise introduction will be provided. Hox and Borgers claimed that providing concise and informative introduction material and training can enhance the dependability and accuracy of study findings [53]. Prior to children commencing the questionnaire, the facilitator will explicitly emphasise that all responses will be acknowledged, and there are no objectively correct or incorrect answers. Therefore, the children are encouraged to answer based on their own individual judgements. An expert researcher skilled at engaging with children act as a facilitator for the questionnaire portion.

3. Data collection and analysis

Data were collected using a structured online questionnaire Star, which was collected during September 2023. IBM Statistical Package for the Social Sciences (SPSS) version 26 was used to analyse the data for this study. The study included descriptive and inferential statistical analyses. For ease of reading, a simple bar chart is used to illustrate how often respondents answered the questions. And use numbers to correspond to each traffic signage. Table 1 shows the eight traffic signage and corresponding numbers in the questionnaire.

Before conducting data analysis, data inspection and anomaly search will be performed. It includes three steps of filtering and cleaning data: checking for errors, identifying errors in the data files, and repairing any errors found in the data files.

3.1. Assess normality

The Kolmogorov-Smirnov test can use sample data to infer whether the sample from the population obeys the normal distribution theory. It is a goodness-of-fit testing method. Its advantage is that as a non-parametric method, it is robust and does not depend on the position of the mean, and has a wide scope of application. Therefore, this article uses the K–S test to test the normal distribution of the questionnaire on traffic sign actions to determine whether each question obeys the normal distribution. Table 2 below shows the test of

Table 2
The Kolmogorov-Smirnov test of various traffic signage at different ages.

Question number	P	Decision
A1-1	1.000	Keep the null hypothesis
A2-1	0.799	Keep the null hypothesis
A3-1	0.388	Keep the null hypothesis
A4-1	1.000	Keep the null hypothesis
A5-1	1.000	Keep the null hypothesis
A6-1	0.998	Keep the null hypothesis
A7-1	1.000	Keep the null hypothesis
A8-1	0.952	Keep the null hypothesis
A1-2	0.998	Keep the null hypothesis
A2-2	1.000	Keep the null hypothesis
A3-2	1.000	Keep the null hypothesis
A4-2	1.000	Keep the null hypothesis
A5-2	0.998	Keep the null hypothesis
A6-2	1.000	Keep the null hypothesis
A7-2	0.998	Keep the null hypothesis
A8-2	1.000	Keep the null hypothesis
A1-3	1.000	Keep the null hypothesis
A2-3	1.000	Keep the null hypothesis
A3-3	0.952	Keep the null hypothesis
A4-3	0.998	Keep the null hypothesis
A5-3	1.000	Keep the null hypothesis
A6-3	0.586	Keep the null hypothesis
A7-3	1.000	Keep the null hypothesis
A8-3	1.000	Keep the null hypothesis

various traffic signage at different ages.

Overall, using age as a grouping variable, it is divided into two groups (age7-9, age10-11). It can be seen that the significance level of each question is greater than 0.05, which indicates that each question obeys a normal distribution as a whole.

4. Results

The results will be discussed separately according to the three parts of the measurement tool, including verbal label, action and consequences. Eight traffic signs related to children were tested in three parts, and each questionnaire included 24 multiple-choice questions. The three options for each multiple-choice question are true, wrong, and don't know, which correspond to children fully understanding the sign action (choosing the correct answer and eliminating interfering options), matching the sign with an incorrect behaviour, and being unsure whether the sign matches the action (Don't know the answer). Table 3 shows the reliability coefficient of the instrument.

4.1. Traffic signage understanding test questionnaire-verbal label

Among the comprehension levels of verbal labels, only A4 and A7 reached a complete understanding level of more than 40 %, with A4's understanding level being 40 % and A7's 53.33 %. In the A4 sign, although 70 % of children could exclude one of the distractor options, which is "No pedestrians or non-motor vehicles", 63.33 % of children could also match the correct option to the sign, leaving 40 % of children were unable to exclude the distractor options "No pedestrians or bicycles". In the A7 sign, more than half of the children were completely unable to distinguish between the three options correctly or incorrectly. Therefore, more than 50 % of the children matched each option with the sign, among which Also included were the two distractor options "No playing and chasing" and "No running", which children considered to be the correct verbal label for the sign. The complete understanding level of the remaining 6 signs is all lower than 30 %, among which A1, A2 and A3 only have a complete understanding level of 10 %. In the A1 sign, 80 % of the children matched the sign with the distractor option "Watch out pedestrians" and 70 % with another distractor option "Pedestrian access only", resulting in a completely correct understanding rate of only 10 % of the A1 sign. Similarly, there is the A2 sign. Although the correct verbal label of the sign is "Footbridge", 80 % of the children still think that the correct verbal label of the sign is "Upward stairs". Similarly, the two distractor options marked A3 are also easily mistaken by children as correct matching objects. The complete understanding rate of 8 traffic signage of verbal label as shown in Fig. 1.

When it comes to matching signs with wrong behaviours, there are three signs with an error matching rate higher than 50 %, including 52.22 % for A1, and 53.33 % for A3 and A5. Even the lowest false match rate is as high as 25.56 %. Overall, among the three options in each sign, which is one correct answer and two distractor options, most children easily match distractor options and signage, thereby increasing the false match rate. To be more specific, children matched the distractor option "Upward stairs" with the A2 sign up to 80 % of the time, which was the highest rate of false matches overall. At the same time, there are 4 distractor options with an error rate of 70 %, including pedestrian access only in A1, "bus stop" in A2, and "Shared space for pedestrians and bicycles" in A5, and "Watch out for" in A6 cars". At the same time, there are also 4 options with a false matching rate higher than 60 %. In A3, 66.67 % of children mistook "Bus parking area" in A3 as the correct sign verbal label instead of "School bus stop". At the same time, the two distractor options "No running" and "Children prohibited" in A8 were mistaken by children as the correct verbal labels of the signs, with false matching rates of 63.33 % and 60 %. Among them, the correct option "Crosswalk" with the A1 sign has the lowest false matching rate, with only 6.67 % of children choosing it incorrectly. As depicted in Fig. 2.

For the "don't know" option, children chose "don't know" 88 times, accounting for 12.22 % of the total answers. Among them, the A3 mark has the highest frequency of "don't know" at 29 %, followed by the A4 mark at 16.67 %. The lowest is 6.67 %, which is the A7 mark. When looking at each option separately, one of the distractor options "No pedestrians or bicycles" in A4 has the highest frequency of not knowing, reaching 26.67 %. At the same time, 23.33 % of children did not know whether "exit" was the correct verbal label for A2. The same unknown frequency occurs simultaneously with the correct option "school bus stop" in A3. The unknown frequency of the four options is between 15 % and 20 %, including the correct selection of A4 "Separate spaces for non-motor vehicles and pedestrians", and the two distractor options of A3, which is "Bus stop" and " Bus parking area", 20 % and 16.67 % of children were unable to judge whether the two distractor options were the correct verbal labels for the sign. As for the A6's distractor option "No cars", the same 16.67 % of children did not know whether this option was correct. Among them, the flag selection "don't know" has the lowest frequency of 3.33 %, which is the correct option of A5, and the two distractor options of A7 are "No playing and chasing" and "No running". The "don't know" rate of 8 traffic signage of verbal label as shown in Fig. 3.

Table 3
Reliability coefficient of the instrument.

	Cronbach Alpha
Traffic Signage understanding Test questionnaire-verbal label	0.936
Traffic Signage understanding Test questionnaire-action	0.784
Traffic Signage understanding Test questionnaire-consequences	0.729
Total Average Reliability Coefficient	0.816

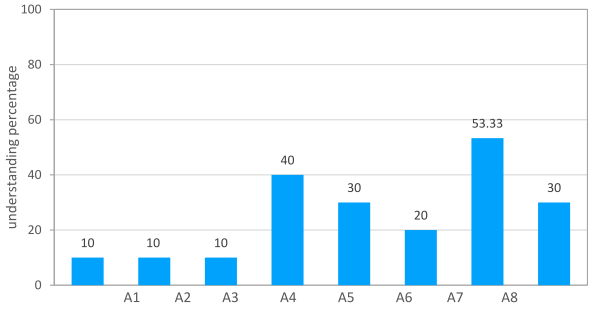

Fig. 1. Complete understanding level of traffic signage verbal label.

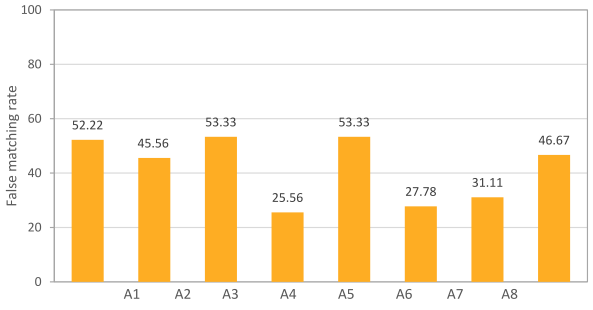

Fig. 2. False matching rate of traffic signage verbal label.

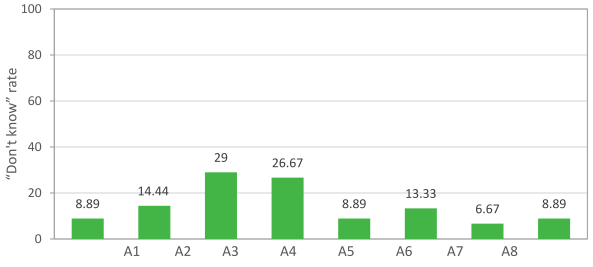

Fig. 3. "don't know" rate of traffic signage verbal label.

4.2. Traffic signage understanding test questionnaire-action

Children were less likely to correctly match signs with the actions they should perform after seeing the signs, and to exclude interfering options. Among the eight signs, A7 has the highest level of complete understanding, but only 46.67 %. Among them, A8 and A1 have the lowest complete understanding levels, which are 20.00 % and 23.33 % respectively. This is because in A8, although more than 50 % of children can match "A8" with "Pedestrians are not allowed to enter", more than 60 % of children can also match "A8" with "Pedestrians are not allowed to enter". Run on this road" and "Children are not allowed to enter" are matched, which means that

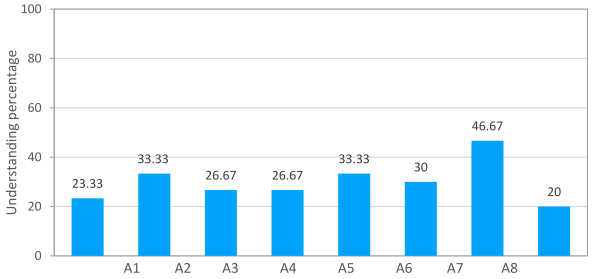

Fig. 4. Complete understanding level of traffic signage action.

most children cannot fully understand the correct meaning and action of the A7 expression. The same problem also occurs in A1. 80 % of the children can choose the correct action of the sign, but cannot eliminate the interference items. More than 40 % of the children still match the sign with "Only pedestrians can use this road". The complete understanding rate of 8 traffic signage of action as shown in Fig. 4.

Children aged 7–11 chose Don't know answer 118 times in the action questionnaire, accounting for 16.38 % of the total answers. Among them, children chose "Don't know" the least in A1, at 8.89 %. It was also the only sign among all signs with less than 10 % of "Don't know" answers. A5 and A6 are the two signs with the most "don't know" choices, both higher than 20 %, 21.11 % and 20 % respectively. The frequency of selecting "don't know" among the remaining signs ranged from 10 % to 20 %. As indicated in Fig. 5.

At the same time, when statistically analysing based on the correct options and d distractor options, it can be seen that the frequency of children's "don't know" about certain options is particularly high. Among the correct matches of each sign, A4, A7 and A8 have relatively high "don't know" frequencies, all 23.33 %, that is, children do not know whether the correct action matches the sign. Among the distractor options, the "don't know" frequency of two distractor options exceeded 25 %. Including children's ignorance of "This road is only accessible to pedestrians and bicycles" in A5, the frequency of which is as high as 30 %. For A2, the unknown frequency of "Pedestrians need to use upward stairs to reach the exit" is as high as 26.67 %. That is, for partially flagged options, the reason children are unable to select the correct option while excluding the incorrect option is due to not knowing whether the option is correct.

When the analysis was based on whether children matched signs with incorrect behaviours, the incorrect matching rate for all signs except A7 and A5 was higher than 40 %. Among them, the A3 and A4 marks have the highest error rate, which is 43.33 %. According to the frequency of incorrect matching of each option, children's incorrect judgment rate for the correct option of A5 is as high as 53.33 %, that is, children think "Non-motor vehicles and pedestrians can share this road", which is the correct action, is not match with A5 signage. The false matching rate of 8 traffic signage of action as shown in Fig. 6.

For most distractor options, children mistook the distractor options for the correct signage action. For example, for the A8 sign with the highest frequency, 63.33 % of children considered "Children are not allowed to enter" as the correct A8 action, rather than the correct "Pedestrians are not allowed to enter". At the same time, among the distractor options in A1, A2, A3, A4, and A6, more than 50 % of children matched them as the correct options. For example, in A3, 56.57 % of the children believed that "Students need to wait for the bus here" is the correct action of the A3 sign, rather than "Students need to wait for the school bus here". And in A4, 53.33 % of children thought that the bicycle pictogram in the sign only indicated Cyclists, not Non-motor vehicles, and therefore matched the wrong distractor option with the sign.

4.3. *Traffic signage understanding test questionnaire-consequences*

Children's level of complete understanding of the consequences of noncompliance signage was relatively high, with five signs having a level of complete understanding above 50 %. Among them, the A8 mark reached 60 %. More than half of the children could match the correct answer "Being struck and injured by motor vehicles" with the mark and exclude the two distractor options. And the second A7 logo, 56.67 % of children can fully understand this logo. The lowest complete understanding rate occurred at the A2 sign. Although 26.67 % of the children could clarify the correct consequences of not following the sign, only 16.67 % of the children could eliminate the wrong distractor options. The complete understanding levels of the remaining two signs are both below 40 %, which are 23.33 % for A3 and 33.33 % for A4. As depicted in Fig. 7.

For the frequency of match signage to wrong consequences, all signs are above 25 %. The highest among them is the A2 mark, with the frequency of incorrect matching reaching 48.89 %. Among the remaining flags, 4 flags have a false match rate higher than 30 %, and 3 flags have a false match rate between 25 % and 30 %. When looking at the different options in the questionnaire separately, one of the distractor options in A2 had the highest false match rate. 73.33 % of children believed that failure to comply with this sign would lead to a fall down, rather than the correct traffic accidents and injuries. There are also two options with an incorrect matching rate higher than 60 % in the correct options, namely the A2 and A4 marks. In the A2 sign, 63.33 % of the children believed that traffic accidents and injuries were not the consequences of not complying with the sign, and in the A4 sign, the same 63.33 % of children

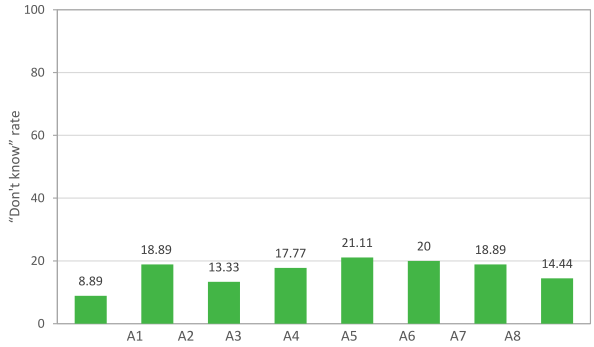

Fig. 5. "don't know" rate of traffic signage action.

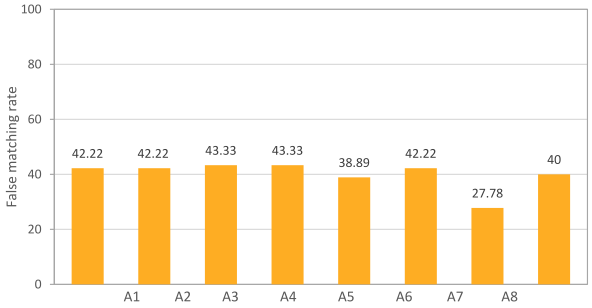

Fig. 6. False matching rate of traffic signage action.

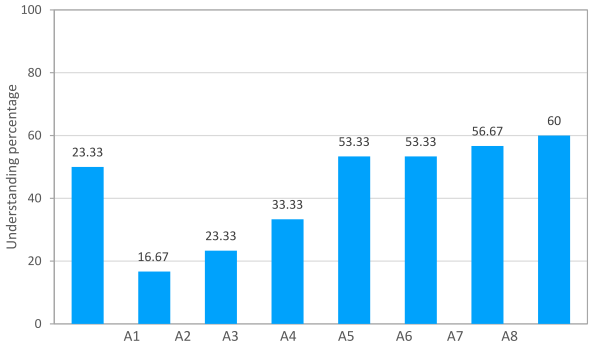

Fig. 7. Complete understanding level of traffic signage consequences.

judged the correct options as wrong consequences. 43.33 % of children mistakenly believed that the distractor option "Being struck and injured by motor and non-motor vehicles" on the A6 sign was the correct consequence. The lowest false match rate occurred in the distractor option "Enter the tunnel" marked A2, with only 10 % of children considering it the correct consequence. The false matching rate of 8 traffic signage of conesquences as shown in Fig. 8.

The frequency of choosing the "don't know" option is relatively low in the consequences questionnaire. Only the frequency of "don't know" with the A3 mark is higher than 20 %, and the rest are between 5 % and 20 %. The lowest unknown frequency occurs in the A7 and A8 logos, both at 6.67 %. However, the frequency of not knowing increased when all options were analysed separately. Among them, as before, the most frequently unknown correct options appear in A3, and 36.67 % of children do not know whether not following the A3 sign will cause Cannot catch the school bus. and the A2 flag's distractor options "Enter the tunnel". There are 4 distractor options selected between 20 % and 30 % of the "don't know" frequency, which are all distractor options for A1, A3 and A4, which is "fall down" and "slipped on the road". Frequency lower than 5 % of "don't know" option There are 5 options, namely correct options for A3 and A8, and distractor options for A6, A7 and A8. The "don't know" rate of 8 traffic signage of consequences as shown in Fig. 9.

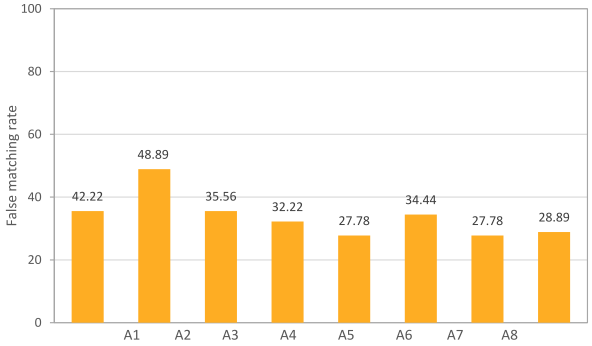

Fig. 8. False matching rate of traffic signage consequences.

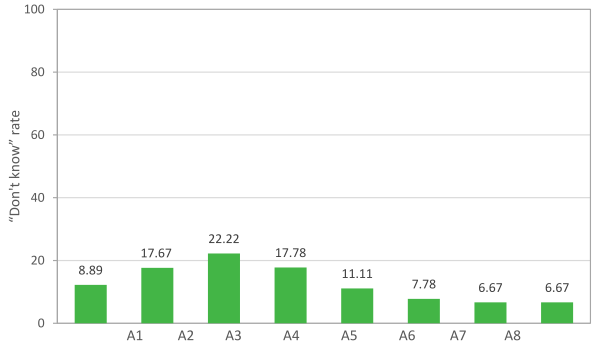

Fig. 9. "don't know" rate of traffic signage consequences.

4.4. Comparison summary

When the three different aspects, which are verbal labels, actions and consequences, are uniformly summarized and the data are compared, it is clear that children have different levels of understanding of different aspects of the sign.

Overall, children had the highest level of complete understanding of the consequences of labels, at 43.33 %, while the lowest level was for verbal labels, which was less than 30 %. Since children can fully understand the signs only if they fully understand all three aspects of the signs, therefore, only 25.38 % of children can fully understand the 8 traffic signs related to them. When each sign is analysed separately, A1, A2 and A3 have the lowest level of complete understanding, at only 10 %. The highest level of understanding is the A7 sign, with 46.67 % of children being able to accept correct answers from the three aspects of the sign and eliminate incorrect options. Comprehension levels for the remaining signs ranged from 15 % to 30 %. The complete understanding rate of 8 traffic signage of three aspects as shown in Fig. 10.

Comparing the three understanding aspects of each sign, similar to the overall data, the comprehension level of the consequences of most signs is higher than that of verbal labels and actions. The A4 mark has the highest understanding level for verbal labels, followed by consequences. At the same time, the difference is the A2 sign. 33.33 % of children can fully understand the actions of the A2 sign, but only 16.67 % understand the consequences. As indicated in Fig. 11.

Judging from the data on the overall wrong matching rate of signs, children have the highest frequency of matching signage to wrong verbal label, while the wrong matching rate of consequences is the lowest. To be more specific, except for A6 and A4, all other marks are the same as verbal label, which has the highest false matching rate. On the contrary, A4 and A6 have the lowest false matching rate of verbal label, and the highest false matching rate of action. At the same time, the error matching rate of verbal labels and consequences in the A5 logo has the largest difference, up to 25.55 %. The false matching rate of 8 traffic signage of three aspects as shown in Fig. 12.

Relatively speaking, children chose the "don't know" option relatively less frequently. Overall, the frequency of "don't know" in action is the highest, while the frequency of "consequences" is the lowest, both below 20 %. According to the signs, the verbal label "don't know" in A3 has the highest frequency, and only one aspect of this sign is higher than 25 %. The frequency of "don't know" among the remaining signs ranged from 6 % to 23 %. As indicated in Fig. 13.

5. Discussion

The findings of this study indicate that children between the ages of 7 and 11 have a limited comprehension of prescribe pedestrian traffic signs. The data obtained from all survey respondents indicated a deficiency in comprehension among children aged 7–11 regarding the eight pedestrian traffic signs currently implemented in school zones. Even the sign with the most advanced comprehension level (A7, watch out for children) only scored 46.47 %.

The quantitative findings of this study align with previous research on children's comprehension of traffic signs. Several studies have indicated that children between the ages of 7 and 15, who are enrolled in primary and secondary schools, exhibit a rather poor level of accuracy when it comes to recognising established traffic signs. Specifically, the understanding and recognition rate was found to be just 67.92 % of traffic signage according to Zhao's research [54]. The existing design of traffic signage for children in public spaces is inadequate and lacks clarity. This could be attributed to the fact that the design of the majority of children's safety warnings does not take into account the cognitive thinking features of children and strays totally from addressing specific warning objects. The study conducted by Easterby and Hakiel similarly observed similar levels of comprehension data as those found in this study [55]. Despite the relaxation of the comprehension norms, the test marks only reached a maximum comprehension level of 50 %. The evaluation performed by Zhong and Chan likewise yielded similar research findings. Those between the ages of 6 and 11 had a diminished comprehension of traffic signs in comparison to those aged 12 and older. It is possible that the current traffic signage is created by adults without considering the specific requirements and preferences of children [56–58]. Nevertheless, the literature does not provide a precise comprehension level for each traffic sign among various age groups. This gap in knowledge presents an opportunity for further research.

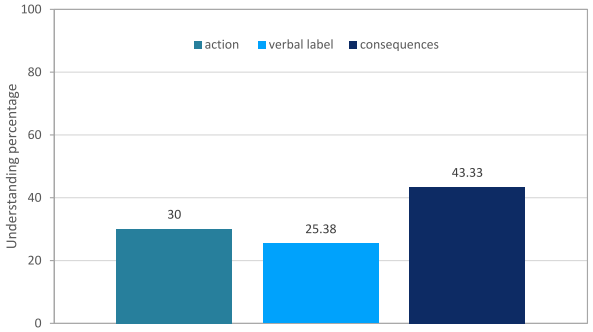

Fig. 10. Complete understanding level of traffic signage among three aspects.

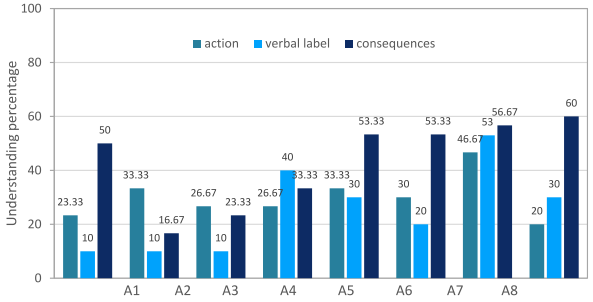

Fig. 11. Complete understanding level of each traffic signage among three aspects.

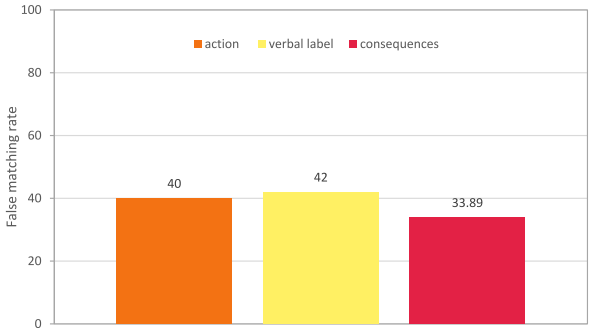

Fig. 12. False matching rate of traffic signage among three aspects.

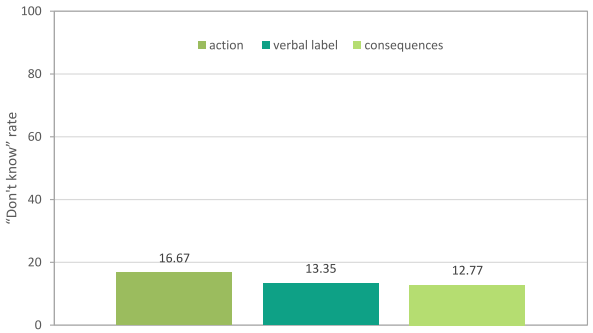

Fig. 13. "Don't know" rate of traffic signage among three aspects.

A further finding in this study reveals that approximately 14.26 % of children explicitly expressed their lack of knowledge regarding the definition of a prescribed pedestrian sign. When a child responds with "yes" or "no," it is possible that they are giving an answer without actually knowing the correct response [59–61]. Still, in every prior study, whether employing questionnaires or interviews, researchers mandated that the questioned children elucidate the signs, and subsequently assessed the children's comprehension level of the signs based on the accuracy of their explanations, does not offer children the option of don't know. Hence, by including the "don't know" option in the comprehension level test questionnaire, we can assess not only the children's understanding level and error matching rate, but also the rate at which they indicate "don't know". This aspect is one of the innovative aspects of this study on children's traffic signs.

6. Limitation and future suggestion

Despite the many strengths of this study, I would want to highlight few drawbacks. One significant constraint is that the pilot study only had 30 participants. Therefore, I cannot assert that the sample obtained accurately represents the entire population of 7-11-year-old children in Guangzhou. Hence, the extent to which the findings of this study may be applied to other contexts or populations is restricted [62]. Another limitation of this study is the lack of behavioural testing [63,64]. It was inconclusive if the children's behaviour after seeing the signs aligned with their responses to the questionnaire. According to Kalsher and Wogalter, future evaluations of traffic signs for children should not just take place in classrooms but should also include behavioural testing to determine the extent to which these signage truly influence children's behaviour on the road [64]. Within this particular framework, the issue of evaluating behavioural tests for detecting traffic signage in children holds significant importance. Meanwhile, given that this study only considered age and geography as personal factors, future research will focus on investigating the correlation between children's personal factors and their levels of understanding traffic signs. The amount of signage understanding in children is influenced by various personal characteristics, such as family education [65], familiarity with signals [66], and education level [67,68] (Duarte et al., 2014; Dowse & Ehlers, 2001).

7. Conclusion

This study explored the understanding levels of existing traffic signs among Chinese children aged 7–11 years. This study shows that a significant proportion of traffic signs are not fully understood by children. According to International Organization for Standardization (ISO), 67 % understanding level and The American National Standards Institute (ANSI)'s 85 % understanding level is considered acceptable, the understanding level of the existing eight traffic signs has not reached an acceptable level for children. Overall, children had relatively high levels of understanding of the consequences of not complying with signs, but low levels of understanding of the verbal labels of signs. Another conclusion is that the type of signage and children's age also affects children's level of understanding.

The following recommendations are made based on the research results:

(1) Traffic signs should be designed specifically for children.
(2) Child-centred traffic sign design needs to be carried out according to the type of sign.

Data availability statement

Data included in article/supp. material/referenced in article.

CRediT authorship contribution statement

Qingjun Han: Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation. **Noorhayati Saad:** Writing – review & editing, Supervision, Conceptualization. **Kamarudzaman Bin Isa:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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