Hazard perception test development for Lithuanian drivers

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Hazard perception test development for Lithuanian drivers

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ABSTRACT

Hazard perception tests may not be transferable between different countries, due to differences in traffic culture and infrastructure. Therefore, different instruments might be necessary for assessing hazard perception in various countries. The aim of the current study was to develop the Lithuanian hazard perception test based on static traffic images and test its psychometric properties. Thirty-four experienced drivers participated in a pilot study, and 125 drivers with diverse driving experience took part in the main study. The final test contained 27 static traffic scenes and the participants were asked to respond if they saw a hazard or not. Results demonstrated that the test has satisfactory internal consistency and test-retest reliability. It differentiated between inexperienced and experienced drivers, and between those experienced drivers who had less than three or more than three crashes in their driving history. The test has sufficient psychometric properties for research; still further development is needed in order to apply it for individual testing and decisions about licence provision.

1. Introduction

Road traffic crashes remain serious public health concern all over the world because of 1.25 million of deaths each year [1]. Within the EU, Lithuania takes the fourth highest place by road crash mortality rates [2]. This country might be described by some disadvantages in road traffic system: significant fluctuations of mortality and injury rates in the last decade that are difficult to explain; non-persistent policy in safety management; old car fleet; no graduate driving licensing; high share of alcohol-related road fatalities; poor attitudes of inh,abitants towards investments into road safety [2–5].

Despite successful investments into the traffic since its membership in the EU by 2007, additional efforts to enhance road safety in Lithuania are thus needed. Researchers and practitioners worldwide acknowledge the need of evidence based on modern psychological or educational means that would enhance safe behaviour on the road [6,7]. In this study, we present the Lithuanian version of a hazard perception test, which could be one of the tools for improving road safety.

Many psychological factors are reported as having influence upon road safety. Some of these are transient like driver distraction while talking to a mobile phone [8,9], whereas some more or less stable properties of the individual, like sensation-seeking, attitudes or driving skills [10–12]. Among these, hazard perception is acknowledged as an important factor contributing to crash involvement [13–15]. This ability might be of great value in traffic safety promotion as it is thought to be relatively easily influenced during training [16–18].

Hazard perception is defined as ability to perceive, anticipate and respond to situations in traffic which have a high probability to lead to a crash (e.g. Crundall et al. [19]). This ability is related to driving experience, but it is also influenced by age, cognitive functions, and physiological responses [16,20–22]. Hazard perception tests have been developed for testing this skill, and some countries (like UK, Netherlands, and Australia) have included it in driver's licensing [6,23,24]. European Union Directive (Directive 91/439/EEC on driving licenses) recommends using hazard perception measurement in driver training and testing [25]. Unfortunately, there is no appropriate tool to deal with hazard perception testing in Lithuania.

There are some doubts if hazard perception tests are transferable between different countries, due to differences in legislations, traffic culture, and infrastructure [26,27]. Despite the traffic legislation is rather consistent across European countries, including Lithuania (e.g. EU Directive 2008/96/EC), research data suggested that differences in traffic safety perception and driving behaviour are more a cultural or infrastructural issue. When comparing driving behaviour across 41 countries from all over the world, it was found that traffic violations were related to the developmental status of the country [28]. Differences in road traffic risk perceptions were disclosed in the samples of inhabitants from Norway, Russia, and India [29]. Similarly, empirical data showed that behavioural situations can be interpreted differently even in the countries from same geographical region [30]. Cultural differences can influence what is seen as normal or acceptable behaviour, and thus change the drivers' interpretation of the situation. Differences in perception of traffic safety climate were obtained in young drivers' samples in

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Lithuania, Turkey, and Germany [31]. Lesch, Rau, Zhao, Liu [32] and Lim et al. [27,33] revealed that hazard is perceived not equally across cultures with different thresholds for what constitutes a hazard, therefore different instrument might be necessary for assessing hazard perception in developed and developing countries. Consequently, common practice in the field is to create country-specific measurement tools based on the assumption that methodology itself is cross-culturally transferable, whereas, the road environment familiarity should be sustained.

Several types of hazard perception tests are employed worldwide. Video-based series of dynamic roadway scenes are frequently used in many hazard perception tests [26,34,35]. Still images are another widely used way to assess hazard perception [36,37]. The performance in a driving simulator is perceived as an indicator of hazard perception as well [38,39]. Also, self-reports have been used [36,40]. Scialfa et al. [36] reported some advantages of using still images, like unambiguousness of stimuli, lower cost of development and administration, efficiency in time and stimuli number, etc. Based on this, computer-presented still images were chosen for Lithuanian version of hazard perception test.

The validation of tests is based on an assumption that a good test produces results predicted by the underlying theory. First, a hazard perception test should differentiate between inexperienced and experienced drivers, because hazard perception is a learned skill [36,40]. Second, a hazard perception test should be able to identify drivers with a high and low crash involvement, because good hazard perception skills should decrease crash risk [41].

The aim of the current study was to develop the Lithuanian hazard perception test, which does not currently exist, based on static traffic images and test its criteria and construct validity and psychometric properties (internal consistency and test-retest reliability) among Lithuanian drivers. Based on previous literature it was expected that driving experience [35,42–44] and having no history of crashes [26,41] were positively related to hazard perception abilities, and there would be no gender differences in hazard perception [17,45].

2. Method

2.1. Participants

The study used a convenience sample of 159 drivers in total. Thirty-four experienced drivers (driving experience more than two years when full licence is acquired; 23 males, 11 females; age M = 37.03 years, SD = 13.84) participated in the pilot stage where face and content validity of the developed hazard perception test was examined. One hundred twenty-five drivers (70 males, 55 females; age M = 31.89 years, SD = 12.15; driving experience M = 11.49 years, SD = 10.45) participated in the main study. They were recruited via advertisements or personal invitations from different areas of Lithuania, although Kaunas region (the second largest city of Lithuania) was mostly represented in the sample. Three groups of drivers were classified when analysing the results: 32 novice drivers (14 males, 18 females; less than two years of driving experience), 65 experienced drivers having two or less crashes in driving history (37 males, 28 females; driving experience M = 13.88 years, SD = 10.26), and 28 experienced drivers with the record of more than three traffic crashes based on self-report (19 males, nine females; driving experience M = 17.54 years, SD = 8.86). Part of this sample (30 drivers, 18 males, and 12 females) participated in the test-retest study with the interval of three weeks between tests. No statistically significant differences in gender, age or driving experience in this retest sub-sample were found when compared to the rest of the participants.

Oral informed consent was obtained from each participant and no reward for participation was offered.

2.2. Materials, apparatus and test construction

The development of the Lithuanian Hazard perception test (HPT-LIT) was conducted in a series of stages: description of the situations and hazard types to be represented in the test; collecting photos with diverse traffic scenes; expert evaluations of images to be included in the tool; pilot study of the face and content validity of the hazard perception test. The intention was to design a short, convenient, cost efficient and user-friendly tool.

First, detailed driving scenarios were prepared based on the literature [36,44,46] and driving legislation in Lithuania. The scenarios involved different traffic participants (vehicles, pedestrians, cyclers, etc.) and potential hazards (Table 1). Potential traffic hazards were defined to be situations in which the driver must take some unplanned evasive action to avoid the hazard (usually a collision).

Typical circumstances of traffic conditions in Lithuania were considered when preparing stimulus for the test in order to develop the new nationally valid instrument. There is a right-hand traffic in Lithuania; therefore, all pictures were taken from driving in the right lane perspective. Traffic is less intensive due to lower number of population (less than three million inhabitants), less-crowded and smaller towns (the largest town has c. 550 thousand inhabitants) when compared with other European countries [47]. Despite increasing investments into traffic infrastructure, the technical quality of urban and rural roads is still quite unsatisfactory. Road deficiencies and traffic intensity are seen clearly in test materials. Also, specific types of public transport may be recognized. Only buses and trolleybuses are available for public travelling, no trams or trains are operating in the towns. Weather conditions typical to Lithuanian climate are captured in pictures. There are about 38% of rainy and cloudy days per year in Lithuania. Heavy rain and snow was avoided in stimulus to exclude weather conditions as primary hazard, focusing more on objects and traffic participants. Low light is used as a context of driving situation at least in a half of images. Finally, most prevalent crash types were considered when developing the HPT-LIT test. Eighty-two percent of people killed in road crashes are pedestrians and car occupants in Lithuania and this rate is significantly higher than in other countries that have developed and adopted hazard perception tests, like UK and the Netherlands [47]. Because bicycling is not very common in Lithuania, less images with bicyclist operating on

Table 1
A list of driving scenarios for hazard perception test.

Scenarios	Number of scenes included
In the distance of 25–45 m vehicle in front is turning right	2
In the distance of 25–45 m vehicle in front is turning left	2
In the distance of 25–45 m vehicle in front is breaking	2
In the distance of 25–45 m vehicle in front is parking	2
In the distance of 25–45 m vehicle in front is merging into the lane of observer	2
In the distance of 25–45 m vehicle from the opposite lane is turning left	4
In the distance of 25–45 m vehicle is approaching observer's vehicle head-on	1
In the distance of 25–45 m pedestrian is crossing or about to cross the street at the zebra	4
In the distance of 25–45 m pedestrian is crossing the street at the carriageway	2
In the distance of 25–45 m vehicle is parked at the roadside	1
In the distance of 25–45 m bicyclist is driving in observer's lane	1
In the distance of 25–45 m the road construction is proceeding	1
In the distance of 25–45 m the object is left on the road	1
In the distance of 25–45 m vehicle in first lane is turning right, while observer is going in the second lane (no hazard)	1
In the distance of 25–45 m vehicle from opposite lane is turning right (no hazard)	1
In the distance of 100–150 m vehicle is merging from the right bystreet in the town (no hazard)	1

the road were included, more attention on pedestrians' participation in the traffic was paid. These characteristics impacted the currents study's method putting efforts in making the stimuli as familiar for participants as possible. It is assumed that familiarity of environment can influence the judgement of hazard [32].

Then real-world driving scenes where photographed using digital Nikon D3100 DSLR Camera with 18–55 mm lens. Images represented urban, rural, residential and freeway environment usually encountered by drivers. For safety reasons, photos were taken by a passenger sitting on the right front seat, but otherwise the photos replicated "driver's eye" view (see Fig. 1).

Fifty-five initial images were selected by researchers as representing earlier described scenarios, one third of them did not contain potential hazards (18 photos) and others (37 photos) were treated as containing potential traffic hazards. Safe scenes were included in the test based on earlier research experience. Scialfa et al. [44] recommended using such images so that the participants would not adopt tendency to answer 'yes' every time.

The prepared photos were presented to observers during the pilot study with the help of MS Office Power Point software on 17-in. LCD desktop monitor of portable notebook. The resolution of 1280 × 1024 and viewing distance of approximately 50 cm was used. Each photo was presented for three seconds (such time is sufficient to perceive and make a judgement about the stimuli) [46]. Face and content validity of the initial 55-images version of HPT-LIT were analysed in the pilot study.

First, four driving instructors as traffic safety experts were invited to evaluate the content of the photos and their potential to measure hazard perception. All of them were males working for different driving schools across Lithuania no less than five years. The instructors were sampled on voluntary basis. No other than being driving instructor inclusion criterion was used. Driving instructors were asked to look at the images as long as they needed, and then they were asked to evaluate if the scene had a potential hazard giving the "yes/ no" answer. In case of a positive answer, they were asked to describe the hazard in more detail.

Fig. 1. Examples of the photos with potential traffic hazards.

Thirty-four experienced drivers in the pilot study were asked to evaluate the potential hazard in each photo. They were presented with such instruction: "These photos present different traffic scenes. Please look carefully at each photo, imagine that you are a driver participating in this situation, and decide if there is a potential hazard or not. The potential traffic hazard is a situation in which the driver must take unplanned evasive actions to avoid the hazard. You will be permitted to watch at each image for three seconds". The total number of correct answers for each participant was calculated and used as a hazard perception score.

Only those scenes that were rated by all driving instructors (100%) and implementers of the study as having potential hazard were included in the final version of the HPT-LIT. These scenes were evaluated by 86.7% of drivers in the pilot sample as having a potential hazard, showing the good face and content validity of the test [34]. Three photos without potential traffic hazard were included as well. Therefore, the final version of the instrument contained 27 static images presenting diverse traffic situations that were used in the main study.

2.3. Procedure

Participants of the main study were tested in a single session that took approximately 30 min. After a detailed explanation about the study, an oral informed consent was obtained. Participants completed the demographic questionnaire with questions about their gender, age, driving experience, driving exposure, traffic crashes and offences. Then they were presented with the Lithuanian version of hazard perception test HPT-LIT composed of 27 static images. Images were presented on a 17-in. LCD desktop monitor of portable notebook with a resolution of 1280 × 1024, viewing distance of approximately 50 cm. Each photo was presented for three seconds; the instruction was the same as in the pilot study. The answers of each participant were recorded by the researcher, they were coded as follows: true – potential hazard is detected, false – potential hazard is not detected, or hazard reported when it is absent in the stimuli (Table 2). The total number of correct answers for each participant was calculated, the higher score showing better skills in hazard perception (Eq. 1).

$$HPT\ score = \sum_{i=1}^{n} a_i \tag{1}$$

Eq. (1) Calculation of the Hazard Perception Test (HPT) score. For each photo (1 to i) the answer *a* was transformed to one if correct, and zero if incorrect (see the confusion matrix at Table 2).

3. Results

3.1. Internal consistency

Internal consistency of the test was assessed using Cronbach Alpha coefficient. In the main sample of this study Cronbach Alpha was 0.77, which indicates a satisfactory internal consistency of the scale, sufficient for group comparisons in scientific research [48]. Corrected item-total correlations were within or above the acceptable range of 0.15 and

Table 2
Confusion matrix for transforming 'yes' and 'no' answers for the calculation of the HPT score.

		Stimulus	
	a	Hazard	No hazard
Answer	'yes'	1	0
	'no'	0	1

0.50 [49] except for three items which had very low correlations with total of the score. Still, removal of those three items did not change the score of internal consistency; therefore, all pictures were included in the final version of hazard perception test HPT-LIT.

The same Cronbach Alpha score of 0.77 was obtained in the smaller sample which was specifically recruited for test-retest reliability. It remained stable in both testing periods (in the first and subsequent testing).

3.2. Test-retest reliability

Reliability of the HPT-LIT was assessed following test-retest procedure. The same group of participants was approached twice in the period of three-four weeks. Participants were not provided with any feedback after the first measurement and they had no specific opportunity to practice hazard perception skills. The Pearson correlation between the total test score of the first and the second testing was 0.836. Based on the high correlation [50] between test and retest assessments it can be concluded that repeated answers to hazard perception tasks were stable. HPT-LIT is a reliable tool for hazard perception assessment.

3.3. Criteria validity

To evaluate the validity of HPT-LIT several types of validity were investigated. Criteria validity was tested by the hazard perception skills differences in drivers with two or less traffic crashes and drivers with three or more traffic crashes during the driving history. Previous research has shown that drivers with a history of more than three crashes are less able to recognize hazards on the road [41], thus the cut-off of three crashes was chosen in this study. Typically, criteria validity is supposed to be demonstrated by correlating new test scores with the scores of already recognized test in the field [51], but there is no existing hazard perception test in Lithuania yet, therefore, is was chosen to compare HPT-LIT scores of drivers with different crash history. The data was calculated only in the group of experienced drivers ($N = 93$) as none of the inexperienced drivers reported having three or more crashes in their driving history. The results of current study showed that drivers with a history of less than three crashes scored higher on HPT-LIT than drivers who reported more crashes during their driving history (Table 3). Thus, data confirmed that drivers who have been involved in no or just in a couple of crashes have better skills of hazard perception.

3.4. Construct validity

The construct validity was assessed by measuring the relationship among HPT-LIT scores, driving experience, and gender. Results of the current study showed that drivers with less than two years of driving experience scored significantly lower in HPT-LIT compared with drivers with more than two years of driving experience (Table 3). In line with expectations male and female drivers of this sample did not differ in the scores of HPT-LIT.

Table 3
Comparison of HPT-LIT scores in drivers with and without crash history, experienced and inexperienced drivers, and across the gender.

	N	Mean	Std. deviation	t	df	p	Cohen's d
Crash history (for experienced drivers)							
Less than three crashes	65	20.51	3.713	9.278	91	<0.001	0.27
Three and more crashes	28	13.32	2.625				
Driving experience							
Inexperienced	32	15.00	3.742	−4.054	67.936	<0.001	0.43
Experienced	93	18.34	4.754				
Gender							
Male	70	17.53	4.880	0.108	119.076	0.914	–
Female	55	17.44	4.586				

3.5. Predicting crashes with HPT-LIT

The scores of HPT-LIT, driving experience, number of crashes, gender are visualized in Fig. 2. Three quasi-poisson models were fitted to predict the crash involvement in the whole data. The first model included only driving experience and the intercept. The second added HPT sum, and the third also gender (Table 4). Driving experience and HPT score were significant predictors in all the models ($p < 0.001$), but gender was not ($p = 0.157$). Model 2 had a significantly lower residual deviance than Model 1 (203.12 vs. 244.66, deviance = 41.54, $F(1,122) = 27.382$, $p < 0.001$). For Model 3 the decrease in the residual deviance compared to Model 2 was not significant (200.00 vs. 203.12, deviance = 3.12, $F(1,121) = 2.083$, $p = 0.152$).

The modelling results show that drivers with more experience had more crashes in the whole sample. This is expected, because more experience means also more exposure. After controlling the driving experience, higher scores in HPT-LIT predicted lower crash involvement.

4. Discussion

Researchers and practitioners suggest including hazard perception measurement in formal driving licensing [44,52] as this ability might predict crash involvement and road safety. Because hazard perception tests can be sensitive to cultural or legislative differences, each country

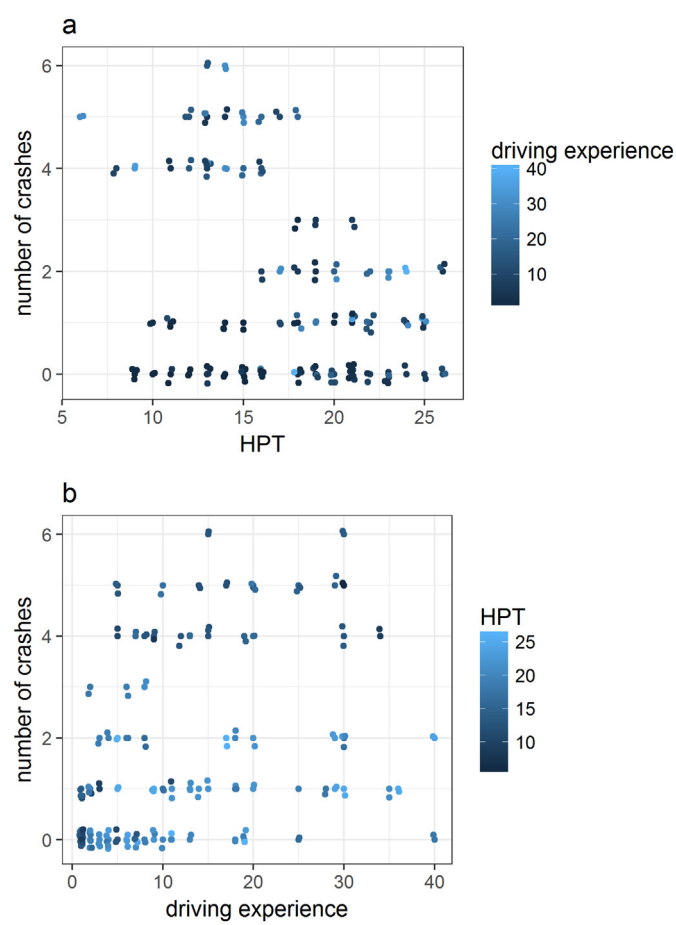

Fig. 2. Visualization of the data. a) HPT score (x-axis), number of crashes (y-axis), driving experience in years (colour), b) driving experience in years (x-axis), number of crashes (y-axis), HPT score (colour). Jitter is added to make the overlapping data points distinguishable.

Table 4
Parameter estimates and their standard errors (in parentheses) of the quasi-poisson models.

	Model 1	Model 2	Model 3
Intercept	−0.1321 (0.1718)	1.3987 (0.3163)*	1.5200 (0.3225)*
Driving experience	0.0400 (0.0084) *	0.0438 (0.0074)*	0.0424 (0.0075)*
HPT score		−0.0956 (0.0183)*	−0.0955 (0.0181)*
Gender (female)			−0.2688 (0.1886)

* $p < 0.001$.

has to validate its own testing instrument. The internal consistency of newly developed HPT-LIT was 0.77. This score is similar to ones found in other studies, e.g. Scialfa et al. [44] reported the coefficient 0.75 for hazard perception test using dynamic video-scenes, Greyson, Sexton [51] reported scores of internal consistencies from 0.69 to 0.86. Some tests reached more sound reliability scores necessary for individual testing, but usually they were using the higher number of stimulus (for example, 91 items in Wetton et al. [24]) or more specified skills of hazard perception (e.g., trajectory prediction or hazard classification judgements in Wetton et al. [41]). In respect to the internal consistency HPT-LIT can be regarded as suitable for research purposes. The test also showed a satisfactory test-retest reliability.

Poorer hazard perception skills are often measured among novice drivers when compared to more experienced ones [35,43,44]. At the group level, the newly developed HPT-LIT was able to differentiate between inexperienced and experienced drivers. This suggests that the test has the potential to capture deficiencies in hazard perception that is related to novice drivers' inexperience, inefficient scanning of driving environment, and poorer recognition of the hazard due to a low number of past exposures to it [6,51].

The possibility to differentiate drivers with and without crash involvement history was used as a validity measurement as well. Data of the current study revealed that drivers with three and more crashes in the driving history scored lower in hazard perception test than those with a history of less or no crashes. The finding is in line with the results of previous studies [15,26,41] confirming that some variation in crash risk is explained by poorer hazard perception skills.

The results did not show gender differences in hazard perception which is in line with previous research [17]. This also suggests that the test is a valid measure of hazards perception skills. Of course, the relatively small sample requires being cautious in such conclusion, but absolute mean hazard perception values of males and females differed just 0.11, so it would be difficult to expect a statistically significant difference even if the sample would be bigger. Therefore, data of the study evidenced that scores of HPT-LIT were related to driving experience in expected way but were unrelated to drivers' gender.

4.1. Limitations and future directions

The current HP test required drivers only indicate if the stimulus had a hazard or not. While such question has been often used in hazard perception tests, it can be asked if it measures specifically driver's ability to identify hazards, rather than driver's risk estimate for the situation [53]. For example, a busy urban street can be estimated to be riskier in than a rural road, which may lead the driver to respond 'yes' even though he/she did not identify any particular hazard. Alternative test formats based on Endsley's (1995) model of situation awareness (SA) have been proposed to address this [54]. For example, asking drivers to point out and/or name the hazard can help to ensure that they are responding to a hazard and not to the overall situation and asking them to predict what will happen next can more directly measure the ability to anticipate hazards [26]. However, these processes can influence the responses also in simple yes/no format. The advantage of asking only for yes/no responses, however, is that the test is simple and easy to comprehend and rate.

When validating a new research instrument, common practice is to correlate their results with known scales measuring the same construct. We were not able to implement such validation strategy because there is no other method for testing hazard perception skills in Lithuania. The sample size was relatively small and based on convenience sampling. Prospective self-report data on crash history might be biased due to social desirability or other confounding variables [15]. Due to small sample size there was no possibility in this study to differentiate drivers who were or were not at fault for crashes. It might be expected that drivers at fault for crashes have even poorer hazard perception skills. Taken this into account future studies would be able to report more solid evidence for external validity of current instrument.

In order to use the test in driver training and the licensing process the internal consistency of HPT-LIT must be increased. Based on the literature two useful alternatives may be considered: increased number of test inter-related items usually leads to higher reliability [35,51], and differentiation of specific hazard perception skills and their measurement might be beneficial [41]. Additionally, validity arguments should be obtained in other vulnerable samples of drivers, like learner and older drivers, who probably have poorer hazard perception skills [36]. Some criterion validity testing attempts by using other valid instruments created in other countries could be implemented. Although cultural suitability of any other hazard perception test requires cautiousness, we invite other researchers to address this issue in further studies. Similar test tasks and test administration procedures should be followed in both instruments [43]. Also, similarity of driving environment, especially in terms of right-hand vs. left-hand traffic, has to be ensured. Tests, which probe situation awareness (presence of elements, interpretation of the situation, and prediction of what will happen next) [54], may be more cultural-independent alternatives for tests which requires drivers to evaluate the level of hazardousness [33,43].

5. Conclusion

The newly developed Lithuanian hazard perception test (HPT-LIT) based on static images was tested. Results demonstrated that the 27-item tool has a satisfactory internal consistency and test-retest reliability. At group level, the test is also able to differentiate between inexperienced and experienced drivers, and between those experienced drivers who had less than three or more than three crashes in their driving history. After controlling the driving experience, higher scores in the test predicted lower crash involvement. In other words, the test has sufficient psychometric properties for research; still further development is needed in order to apply it for individual testing and decisions about licence provision. Cultural specificity of the test should be explored in future studies, especially that might be useful for countries with low-medium traffic density and high rates of road traffic fatalities.

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