Design of Drivers' Hazard Perception Context Test

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Abstract: Driver behavior is influenced by external factors (e.g., road, vehicle, driver supervision and control measures) and latencies (e.g., driver's inherent cognition, behavioral intention and driving technique). Studies have shown that the driver's reactive capability of hazard perception is positively correlated with the total running time, and effective training can improve the delay of hazard perception. This study referred to the practice of advanced countries, such as the UK and Australia, recorded videos of physical hazardous context on roads, and invited professional driving instructors to assist in evaluating hazard perception test. When a hazardous context occurred in the test video, the research subjects were asked to click the mouse immediately as a reaction, and the computer recorded the subject's reaction time to determine the score interval of primary hazards in the test video. When the primary hazards were determined, the mouse clicking time distribution of primary hazards was tested. This study assumed the mouse clicking time distribution to be normal distribution, and used two common methods of normality test, Kolmogorov-Smirnov test and Shapiro-Wilk test. The normal distribution diagram was divided into five equal parts according to the occurrence to end of hazards in the score interval, given 1~5 points as the marking standard of hazard perception test.

Keywords: Hazard; Hazard Perception; Context Test

1. INTRODUCTION

Driver behavior is influenced by external factors (e.g., road, vehicle, driver supervision and control measures) and latencies (e.g., driver's inherent cognition, behavioral intention and driving technique). Studies have shown that the reactive capability of hazard perception is positively correlated with total running time. The novice drivers are less sensitive to accidents than the experienced drivers (Borowsky, 2010); the experienced drivers perceive hazards much faster than the novice drivers; the young drivers are likely to underrate the risk of accidents in different hazardous conditions, as well as overrate their technique. When driving, the young drivers are more willing to take risks than the experienced drivers; the young drivers' hazard perception reaction time is longer than the experienced drivers'; the hazard perception reaction capability of the drivers who have had accidents is better than that of the drivers who have not had a crash (Deery,1999). As a result of these factors, the novice drivers have a relatively high ratio of accidents. Fortunately, the delay of hazard perception can be improved effectively by training. The statistical data of accidents have indicated that the risk of accidents of novice drivers decreases rapidly after several months of the attainment of driver's license, because the novice drivers have learned the techniques related to hazard perception and safe driving in this period.

The existing driver training content and mode in Taiwan need improvement on the safe driving concept and skill content. At present, the driving training for driving test in Taiwan is performed by various training institutes affiliated with Directorate General of Highway, Ministry of Transportation and Communications, private driving training classes and self-practice. The training courses for drivers are divided into written test and skill test. In terms of training for written test, the government lists the required six major fields of written test for the driving training classes, including driving ethics, driving principles and methods, accident prevention and handling (including safe driving), highway code, automobile construction and repair, first aid knowledge. The legal total time of written test teaching is 20 hours. In terms of skill test course, according to regulations, anyone joining a driving training institute must receive a five weeks' intensive driving training. If one learns driving by himself, he shall practice by himself for more than three months after he obtains a learner's license. The road driving must be carried out according to the road and time designated by local police, and the process shall be watched by a driver who possesses the driver's license of the learning car type, but the practice hours and content have not yet been specified. In terms of written test, the driving trainees joining the driving training institutes can enroll for the written test of the supervision unit. The self-practicers can take part in the written examination of the supervision unit individually, the test is held in the written examination room specified by the supervision unit. The written examination involves problems related to traffic laws and driving ethics, including 40 true/false questions and choice questions, 2.5 points per question, the passing grade is 85 points.

In terms of skill test, the trainees of the driving training classes are tested according to whether their driving training classes are qualified for supervisor dispatch. If a driving training class is qualified, the examination is carried out at its site; if a driving training class is not qualified, the trainees and the self-practicers shall be tested at the site of the supervision unit. The test items include stability test when gear changed, reverse the car into a garage, parallel roadside parking, run forward and backward on a curve, go up and down a hill, railroad crossing, forked road intersection and other technical items (e.g. start, throttle control, brake operation, etc.), scored by the supervisor. The score shall be deducted according to the standard of deduction of points in the case of traffic violation or touching roadside pipelines. The passing standard of skill test is 70 points. A person passing the written test and skill test can obtain a driver's license.

The existing driver training content and mode in Taiwan should still be enhanced on the safe driving concept and skill content. At present, the driving test in the training area is very different from the driving environment on real road, and the test is rather easy. In addition, the existing training is mostly presented in written or briefing form, so that the drivers can hardly react and feed back. For the drivers' safe driving knowledge, the training course of driving test should be modified to cultivate Taiwan's novice drivers a good driving habit, so as to reduce the traffic accidents. At present, several countries have begun to develop or use new test modes to bring more advanced cognitive function into the test. For example, the UK has included the Hazard Perception Test in the items of the driving subject test in order to test the hazard perception of the drivers. In the UK, about 3,600 people die from traffic accidents annually. The results of the test have proved that the strategies enhancing the hazard perception ability have positive influence on reducing the accidents. By accumulating experience, the accident rate of novice drivers decreases sharply after 12 months (Sagberg & Bjørnskau, 2006). This finding is a considerable reference for promoting relevant policies in Taiwan.

2. LITERATURE REVIEW

According to many studies, of all the different components of driving skills, only hazard perception has been found to relate to accidents involvement. This ability is mainly derived from the ability in situation awareness (SA)(Simon et al., 2004). For example, in some traffic conditions, it is probably required to vary the speed or direction to avoid hazards, namely, to use some driving skills, such as road condition scanning, to choose a safe driving headway or appropriate speed. The driving ability coinciding with favorable expected result can be obtained by early planning and effective implementation. At present, the studies related to hazard perception have several important topics, including dispute about methodology, testing reliability and validity, practicing automatic function and training effectiveness and evaluation. The data from literatures about related topics are analyzed below.

1) **Relationship between accidents involvement and hazard perception :** The relevance between the theoretical basis of hazard perception and traffic accidents has been debated. Some argue that the presently described correlation is beyond the actual state, because some factors may be statistically significant, but are not significant factors, or some factors may be statistically insignificant and have not been published. This topic is a very important issue for the road safety decision makers or researchers. Elander et al. (1993) reviewed correlations between accident rates over consecutive time periods, and found that its relevance to the correlation variables measuring accidents was very low. French et al. (1993) found that the coefficient of correlation between the accident rates in the past three years and in the next year was only 0.13. Such a low correlation may be resulted from underrating the relevance to other variables. The traffic accidents have three characteristics: a) the occurrence of an accident is not homogeneous; b) the occurrence of an accident is usually resulted from interaction among many factors; c) the accidents are of rare events. According to statistics, a driver has a traffic accident about every 10 years on an average, in other words, 90% of drivers do not have an accident within a year. Therefore, in order to obtain correct information about accidents, a large amount of samples are required for analysis and estimation. In addition, even if the accident data have considerable errors, a large proportion of light accident data may be excluded in the police reports, and the amount of exposure of each driver is also influential. Maycock & Lockwood (1993) suggested that the probability of accident would increase with the mileage of a vehicle, but should not be regarded as dangerous driving. Even if the mileage is controlled, other variables can be influential; for example, the accident risk of driving on busy roads in urban area or night driving may be higher than that of other simple road conditions or non-night driving (Elander, 1993). Therefore, it is necessary to adopt large samples or to screen samples beforehand for research. Hunter (1997) indicated that significance or insignificance was merely the number of samples. Cohen (1992) classified effective samples and found that although the coefficient of correlation between the hazard perception and the occurrence rate of accidents was not high, and it was of great importance, because the traditional method calculating the correlation coefficient had not considered the distribution.
2) **Analysis of validity of hazard perception test:** As the hazard perception is correlated with the occurrence of accidents, it is found in the observation on different levels of drivers, such as novice drivers who just attain a driver's license, experienced drivers and expert drivers, the hazard perception ability can be improved by experiencing and learning. However, in terms of the hazard perception test, is the test in any form (foot operated or hand pressed) identical with the true

environment? How is the validity of hazard perception test (this part concerns whether the hazard perception test result can be regarded as a capability index of hazard perception)? Many studies have tested the validity of hazard perception test, and found that it was similar to actual situation. Mills et al. (1998) found that the instructors of novice drivers performed better than novice drivers in the number of hazards detected or in the reaction time. The attentive, safe and well skilled trainees with good capability of foreseeing situation also performed well in the hazard perception test. Renge (1998) found that the coefficient of correlation between the real road condition and the risk in the video scene was 0.94. The experienced driver detected more hazards than the novice, and the validity of their test difference was good. The statistical comparison of Mckenna (1991) showed that the drivers with over ten years' driving experience perceived hazards significantly faster than the drivers with less than three years' experience. Although some studies have proposed different opinions (Underwood, 2002), the test results of hazardous scenes derived from real accidents without beforehand selection showed that there is also significant difference between them. Another major problem is the puzzle resulted from the influence of driving experience and age. Groeger & Chapman (1996) fixed the age and compared different accumulated mileages, and found that the driver having a mileage of 40,000km reacted faster than the driver having a mileage of 10,000km, and they reacted faster than the drivers of the same age without driving experience. Therefore, the experience should be the major factor influencing the hazard perception. The age has no influence, and the hazard perception test reflects the driving situation in the real world to some extent. The studies of its correlation with accidents also specifically indicate their relationship.

3) **Analysis of reliability of hazard perception test:** Many hazard perception test results are regarded as low reliability and low internal consistency, so the predictive ability is limited. For example, Catchpole et al. (2001) found that the internal consistency of hazard perception test was only 0.27. However, not all the hazard perception test results are in this manner. For example, the internal consistency of the hazard perception test of Horswill & Helman (2003) was 0.68. The hazardous conditions are defined according to different consideration criteria in different tests, so there are differences. The reliability of test can be improved effectively by increasing physical scenes and test units and redesigning the operation guide and good user interface (Catchpole et al., 2001).
4) **Practice automation effect of hazard perception :** Many theories suggest that the technical action of capability should be forecast, with continuous development, less and less cognitive resource will be used for operation, and the problem solving model should be regularized and automated gradually. However, Mckenna & Farrand (1999) found that the experienced drivers needed more retention to complete the hazard perception of the same degree, and they would not react automatically though they practiced. However, Groeger (2000) argued that the experienced drivers had more extensive perception of the traffic context in non-hazardous conditions, so they visualized hazardous conditions faster. Therefore, the experienced drivers did not have to concentrate too much on the hazard perception in their memory, but they handle it more efficiently than the novice. If the hazard perception can be further regularized and automated by practice, an experienced driver can be less disturbed than the novice in the second hazard perception test, because he can finish the same action without too many cognitive resources.

5) **Response bias and hazard perception test:** The difference in the threshold of individual's reaction to hazards may also result in error in score. Farrand & Mckenna (2004) found that using different instructions to change the error in the driver's reaction time could change the test score. Stanislaw & Todorov (1999) used traditional method and theory of signal detection and calculated the error and sensitivity according to the number of correct and wrong reactions to stimulation. They indicated that if the error of reaction influenced the score significantly, it should not be the important mechanism determining the driver's hazard perception ability. However, Derry (1999) indicated even if the difference in some hazard perception ability might result in the error of reaction, it should not be a matter influencing the traffic safety. If a driver regards some non-hazardous conditions as hazards, he can be a safe driver, independent of the perception ability, meanwhile, the less the driver perceives the road risk, the more likely is an accident to happen.
6) **Driver assessment:** Hazard perception tests are now part of driver licensing in the UK and Australia. There is some evidence that separate hazard perception tests for different road user groups such as motorcyclists could be of use. At present, this test has been applied to practice gradually to evaluate the driving ability of drivers. Many studies have found and proved the correlation between the hazard perception ability and accidents and the effect of specifically designed training procedures. These conclusions can help to enhancing road traffic safety, especially to remedying the limit of traditional driving test which cannot predict whether the subjects are likely to have traffic accidents effectively (Sheppard et al., 1973).

The "safe driving" behavior and "hazard perception" ability can reduce the probability of traffic accidents effectively. By enhancing the hazard perception ability, the hazardous behaviors which may cause traffic events in the driving process can be noticed beforehand and preventive measures against hazards can be taken, so as to protect the driver and other road users. This study designs a hazard perception ability test platform by training and referring to the systems of advanced countries abroad, hoping to enhance the drivers' hazard perception ability to strengthen traffic safety, everybody can be an expert safeguarding traffic safety by enhancing the hazard perception ability.

3. CONTEXT TEST DESIGN

Recent studies on hazard perception test can be divided into static hazard perception test, driving simulator and dynamic hazard perception test. The first test mode is static hazard perception test, static picture or text test questions are provided for the subjects, and the subjects are required to indicate the conflict points which may cause traffic accidents, or to determine whether the event is probable to cause hazards. The second test mode uses driving simulator to train and test drivers, the simulator is used to design controllable environment and hazardous conditions to know the observation on the subjects' driving behaviors in the driving simulator. Although using driving simulator for driving training has many advantages, its cost is high, common people cannot practice at home. The third test mode uses visualization for hazard perception test, watches the video scenes simulating actual driving context, and keeps tracking the change in hazardous conditions, so as to simulate the driving context of operating steering wheel. Various traffic scenes are displayed on the screen in video mode by using customized software. Whenever the subject detects these immediate risks, he must click the mouse immediately as confirmation. When the mouse is clicked, the software sounds to let the subject be aware of the click, and the click record is stored in the computer system.

The advantages of hazard perception test in static mode are low cost and easy performance, but the test is carried out only by static pictures, it is quite different from real road conditions, little helpful to real road driving. The advantage of using driving simulator as hazard perception test tool is that it is similar to real road environment, when the subject perceives a hazard on the simulator screen, he can use the equipments equipped for the simulator to brake and shift gear immediately similar to driving reactions on real road. However, the driving simulator is very expensive, it is difficult to be extensively popularized. Therefore, some advanced countries such as the UK and Australia use dynamic road running videos for hazard perception test at present. The dynamic real vehicle video for test has approximate conditions to real road driving as the driving simulator does, its cost is relatively low, but it spends much time on gathering appropriate real vehicle videos as test library material. The hazard perception test can be carried out by using customized software and the presently popular PC.

The test mode in this study uses visualization for experimental survey, so as to view the video scene simulating real driving context, and to keep tracking the change in road conditions, so that the subject simulates the driving context of operating steering wheel. Various traffic context scenes are displayed on the screen in video mode, the video contains some appropriate reactions such as braking, blowing horn or changing lanes. Whenever the subject detects an immediate event, he must click the mouse immediately as confirmation, and the click record is stored in the computer system.

1) Principle of context design: This study refers to the practice of advanced countries abroad, hoping to design a testing tool, assisting the trainee drivers with safe driving. The test question design concept is based on safe and responsible driving standard as a basis of learning driving process. The purpose is to teach driving skill, knowledge and cognition by structurization to cultivate safe drivers, namely, using a series of learning and training course to cultivate drivers: a. knowledge and cognition of safe driving theory; b. applying related knowledge and cognition to practical driving situation; c. cautious and careful driving behavior, detecting hazardous conditions instantly and taking appropriate reaction. Therefore, the principle of hazard perception test context design in this study is described below:

- The hazard perception test should consist of technologies evaluating the driver's hazard perception.
- The hazard perception test should distinguish the basic difference between individuals in the hazard perception technology, not simply reflecting the timing difference.
- The hazardous context design should present relatively real driving situation.
- The introduction to the hazard perception test should clearly acquaint the subject with the due reactions to hazardous conditions in the test.
- The hazard perception test should be able to identify inappropriate reaction.

2) Hazard perception test context cases : The test videos are taken in the exterior or interior of a car applicable to the driver's angle, as the driver's sight line is likely to be distracted by the windshield (e.g. raindrop, rag, leaves, reflection, etc.), the camera is mounted inside the car and should be close to the driver's sight line, the user can implement proper real-time handling in the true environment, so that the user can be more adapted to the real driving context. This study mounted a high

definition camera and a driving recorder respectively in front of the driver's seat close to the driver's sight line, so as to simulate the real view of the driver, and then the car ran on different roads, such as country roads, urban arterials and so on, the driving recorder recorded data. The following test video example helps the driver know the driving on a busy road, there is a cyclist in the right front of the lane, and then there is a truck parking on the right hand side ahead in the lane. When the driver approaches to the cyclist, the cyclist is about to move in the lane to avoid the truck ahead, the cyclist turns his head to check the rear situation (as shown in Figure 1), at this moment, the driver must slow down to protect the cyclist.

The length of each hazard perception test question is 60 seconds, there is a five-second countdown before the video begins, and each video may have several potential risks. Only one principal risk is planned at present, and more than two major risks can be planned. The potential risks include the pedestrians who may crash into the lane, cyclists, vehicles with lighting stoplights and so on, the time of occurrence of risk is calculated from the occurrence of risk to the end of risk, the potential risk should be perceived and reacted to as soon as it occurs in principle, perception and response delay may result in collision.

As stated above, each video may have several risky events, how to test and score them is the key task of this study. At present, there are two essentials, the first essential is the visible and perceptible potential risk after the driver's reaction time. The second one is the final opportunity of reaction of the subject in safe conditions. Namely, the period from the moment when the driver visually perceives these potential risky events to the driver taking corresponding reaction safely considering the safe distance is the qualified reaction range. As long as taking appropriate reactions, such as braking, slowdown, changing lanes and so on in this period, unnecessary accidents can be avoided. The time length of safe range varies with the potential risky events in this period.

Figure 1. Potential risk of cyclist dodging the front truck

The recorded videos were reviewed, the picture fragments of risky conditions in the running process were selected, and one-minute videos were edited out as test items. There were 33 picture fragments prepared, and then relevant experts and scholars reviewed the "hazard perception relevance" and "video test question quality", and screened out 20 picture fragments as test questions of this experiment. The main risk items and risk intervals of various test items are listed in Table 1.

Table 1 Main risk items and risk intervals of various test questions

Test question code	Main risk item	Risk interval (sec)	Risk duration
A-1	Medial island gap risk	15.23~18.30	3.07 secs
A-2	Risk of left-hand turning motorcycle at three-way intersection	33.67~37.20	3.54 secs
A-3	Risk of dodging roadside double parking violation	12.30~18.00	5.7 secs
A-4	Risk of lateral vehicles at intersection with flashing yellow lamp	24.00~28.33	4.33 secs
A-5	Risk of roadblocks in roadside construction area	26.00~30.50	4.5 secs
A-6	Risk of roadside vehicles merging into traffic flow	45.00~48.00	3 secs
A-7	Risk of roadside pedestrians facing lane to cross lane	56.00~60:00	4 secs
A-8	Risk of pedestrians rushing out of the rear side of queuing vehicles for red light	44:00~47.50	3.5 secs
A-9	Risk of motorcyclists pushing motorcycles crossing crosswalk	43.00~46.30	3.3 secs
A-10	Risk of freeway system interchange crossing channelizing line	14.67~18.00	3.33 secs
B-1	Risk of reverse running trailer	36.00~46.76	10.70 secs
B-2	Risk of motorcycle dragging vehicle into lane	42.10~49.67	7.57 secs
B-3	Risk of coming vehicles at an alley entrance	38.60~41.67	3.07 secs
B-4	Risk of difference of radius between inner wheels of buses	34.50~37.50	3 secs
B-5	Risk of lateral motorcycles when yellow lamp is flashing	22.50~26.50	4 secs
B-6	Risk of left motorcycles at three-way intersection	42.00~48.50	6.5 secs
B-7	Risk of roadside starting motorcycles	48.60~49.67	1.07 secs
B-8	Parking lot exit risk	41.17~42.17	1 sec
B-9	Risk of double parking and turning round	18.00~21.00	3 secs
B-10	Risk of pedestrians and motorcycles in downtown alleys	33.00~37.00	4 secs

Table 1 shows various edited questions have different main risk items and risk intervals. In terms of the question content, the risk of left-hand turning motorcycle at three-way intersection of Question A-2 is taken as an example and described below. There is no sign at the three-way intersection, there are cyclists or vehicles turning right or turning left to enter the opposite lane in succession in the distance. In the place nearby the three-way intersection, a motorcyclist appears at the intersection, turning left directly without any deceleration. At this point, the driver shall tread on the brake pedal to slow down, so as to avoid crashing into the motorcyclist. The schematic diagram of score intervals is shown in Figure 2.

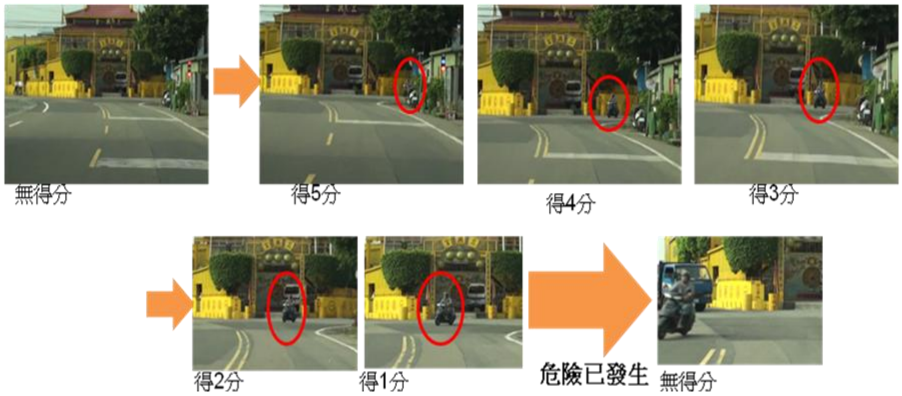

Figure 2 Risk of left-hand turning motorcycle at three-way intersection

4. TEST MARKING STANDARD

1) **Major risk determination:**

This study gathered the videos of different hazardous contexts, and screened out 20 test questions about "hazard perception relevance" and "video test question quality". The test items of 20 test questions are shown in Table 1 of previous section. The professional instructors of Hsinchu Safety-Educational Center and Training Institute, Directorate General of Highway, M.O.T.C were invited to assist in screening the video test questions, and they were asked to click the mouse immediately as reaction (it may be braking or turning steering wheel in real situation) when they saw risks in videos, such as a laterally emergent motorcycle, a vehicle with lighting turn signal to change lanes, a vehicle turning around at intersection and so on, so as to know the time of reaction of professional instructors to risks, and to further determine the score interval of major risks in the test videos, this is the "expert validity". Each time when the mouse was clicked, the time points of clicks were recorded by computer program. After the instructors saw and clicked all the test videos, this study ranked the clicking time of various professional instructors, and then all the clicking time was made into a histogram taking every second as a class boundary, and then the most frequently and the second most frequently clicked intervals could be found, so as to find out the time point of most frequent clicks, and the major risks in the test videos were compared. As shown in Figure 3, the horizontal axis is the second, the vertical axis is the clicking frequency of professional instructors, the clicking frequency increases since the 18th second, meaning a risk has occurred, as people have different reaction periods for risks, the peak occurs at the 20th second, meaning a majority of professional instructors find a risk and react somewhere about the time point.

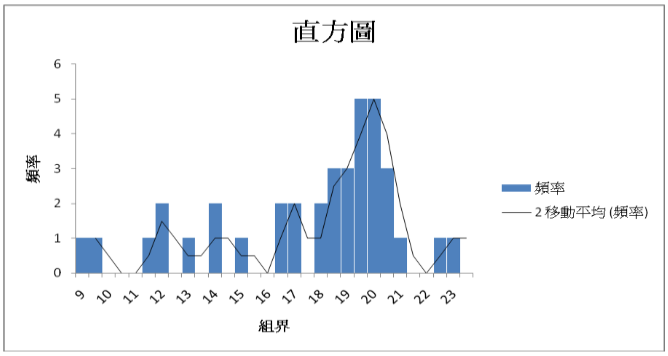

Figure 3 Risk clicking frequency diagram

2) Reaction time distribution test:

When the major risks are determined, the clicking time distribution of major risks of professional instructors is tested. This study assumes the clicking time distribution to be normal distribution, and uses the most used Kolmogorov-Smirnov test and Shapiro-Wilk test of normality test. The significance level provided by these two test methods is sig.p<0.05, then the null hypothesis is rejected, namely, the normality is rejected; sig.p>0.05 means conforming to normal distribution. The normal distribution test result of clicking time distribution of all the test videos of professional instructors is shown in Table 2 (there is no measuring data of test question A-10 due to software setting error). It is inferred from Table 2 that the clicking time of the tested instructors is mostly normal distribution.

The test result of test question A-2 in Table 1 is significance, when the major risk (motorcycle) in the video occurs, the minor risk (truck) occurs, so that there is another risk reaction in the period of 33.67~37.2 seconds from the occurrence to the end of major risk (as shown in Figure 4, Figure 5). In addition, the test result of test question B-2 is significance, there are 30 clicks in the score interval of 42.1~49.67 seconds (as shown in Figure 6), meaning multiple instructors click the mouse multiple times in the score interval, so that the test result is not normal distribution. The test questions B-3, B-5 and B-6 have similar situation.

Table 2 Normal distribution test of clicking time

Test question	Kolmogorov-Smirnov test			Shapiro-Wilk test		
	Statistics	DOF	Significance	Statistics	DOF	Significance
A-1	.095	13	.200	.965	13	.832
A-2	.220	25	.003	.863	25	**.003**
A-3	.136	18	.200	.930	18	.196
A-4	.169	17	.200	.931	17	.222
A-5	.110	18	.200	.978	18	.930
A-6	.181	22	.058	.935	22	.159
A-7	.176	19	.124	.955	19	.476
A-8	.155	12	.200	.940	12	.502
A-9	.153	9	.200	.945	9	.633
B-1	.085	48	.200	.961	48	.111
B-2	.186	30	.009	.906	30	**.012**
B-3	.185	27	.018	.841	27	**.001**
B-4	.177	14	.200	.902	14	.121
B-5	.283	25	.000	.728	25	**.000**
B-6	.136	46	.032	.944	46	**.028**
B-7	.213	14	.084	.884	14	.067
B-8	.250	8	.152	.761	8	**.011**
B-9	.127	18	.200	.985	18	.988
B-10	.100	36	.200	.970	36	.433

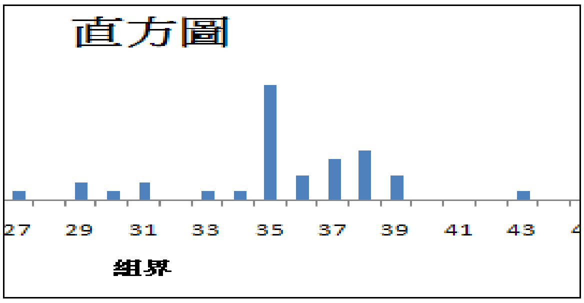

Figure 4 Time of occurrence of motorcycle as major risk during 33.67~37.2 seconds

Figure 5 Occurrence of major risk and other risk

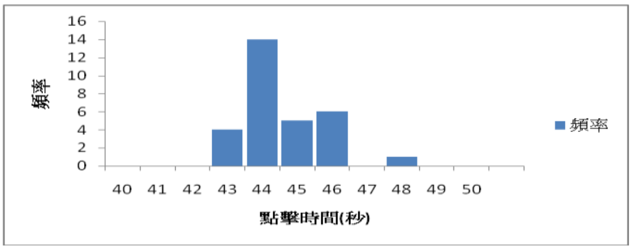

Figure 6 Test question B-2 clicking time histogram

Test question B-8 is tested as significance, so it is in the score interval of 41.17~42.17 seconds, as the period from the occurrence to the end of the risk is too short (only 1 second), there are merely eight clicks (as shown in Figure 7), so that the test result is not normal distribution.

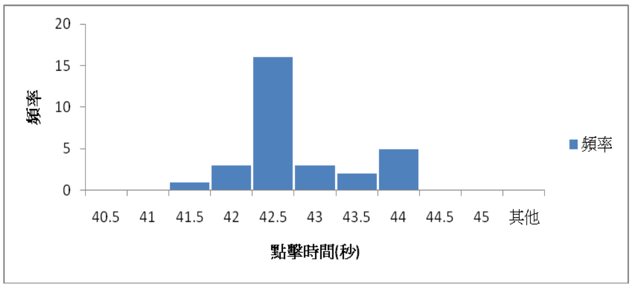

Figure 7 Test question B-8 clicking time histogram

3) Score scale conversion:

The score interval will divide the normal distribution into five equal parts according to the period from the occurrence to the end of risks (crossing motorcycle, vehicle with lighting turn signal or pedestrian to cross road), each part accounts for 20% of total area (as shown in Figure 7). The clicking time is divided into five equal parts according to the normalized normal distribution, and the first 20%, 40%, 60% and 80% of area are given 5, 4, 3 and 2 points respectively, after 80% to the risk end is given one point (as shown in Table 3). For example, the major risk occurs since 18.00 sec, and ends at 21.00 sec, the average is 19.49, the standard deviation is 0.147, the Z values corresponding to 20%, 40%, 60% and 80% area are converted, X_5=19.37, X_4=19.45, X_3=19.52, X_2=19.60, the final scoring standard is described below:

$$z_a = \frac{x_a - \mu}{\sigma}$$

1. 18.00~19.37 sec scores 5 points
2. 19.38~19.45 sec scores 4 points
3. 19.46~19.52 sec scores 3 points
4. 19.53~19.60 sec scores 2 points
5. 19.61~21 sec scores 1 point

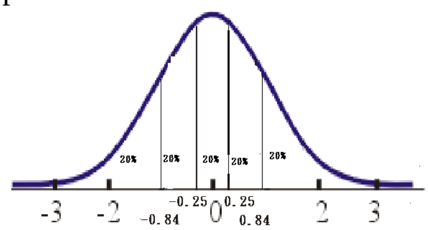

Figure 7 Z value of five equal parts of normalized normal distribution

Table 3 Scoring standard of test questions (unit: sec)

Test question	Commencement of risk	X_5	X_4	X_3	X_2	Risk end time	Risk duration
A-1	15.23	16.55	16.67	17.02	17.44	18.30	3.07
A-2	33.67	34.64	34.94	35.45	36.05	37.20	3.54
A-3	12.30	13.88	14.58	15.43	16.43	18.00	5.7
A-4	24.00	24.99	25.1	25.37	25.86	28.33	4.33
A-5	26.00	27.32	27.86	28.57	29.41	30.50	4.5
A-6	45.00	45.85	45.99	46.36	46.8	48.00	3
A-7	56.00	57.58	57.94	58.49	59.15	60:00	4
A-8	44:00	45.75	46.05	46.30	46.60	47.50	3.5
A-9	43.00	44.01	44.15	44.52	44.97	46.30	3.3
B-1	36.00	37.42	39.16	40.89	42.93	46.76	10.70
B-2	42.10	43.29	43.74	44.37	45.12	49.67	7.57
B-3	38.60	39.27	39.37	39.72	40.12	41.67	3.07
B-4	34.50	35.41	35.59	36.01	36.48	37.50	3
B-5	22.50	23.33	23.44	23.79	24.2	26.50	4
B-6	42.00	44.02	44.68	45.49	46.46	48.50	6.5
B-7	48.60	48.95	49.14	49.30	49.5	49.67	1.07
B-8	41.17	41.75	41.83	41.89	42.07	42.17	1
B-9	18.00	19.37	19.45	19.52	19.6	21.00	3
B-10	33.00	34.28	34.64	35.2	35.86	37.00	4

This study takes the persons who have passed the driving test for small passenger cars for the first time as research subjects, and designs training materials and related videos according to domestic and foreign safe driving cases, and collects the subjects' learning effect and evaluates the feasibility of developing a series of teaching material with the assistance of information output equipments. As this is a preliminary planning operation, laying emphasis on function planning and case analysis, the trial plan can be constructed and popularized gradually in the future, various probable problems and challenges will be known thoroughly by performing demonstration and application program, so as to propose a more complete training material which can be used as reference for adjusting the driving test system in the future.

5. CONCLUSIONS AND RECOMMENDATIONS

1) The driver behavior is mainly influenced by external factors (road, vehicle, driver supervision and control measures) and latencies (inherent cognition, behavioral intention and driving technique of driver), related studies show that the drivers' hazard perception ability is positively correlated with total running time, the delay of hazard perception can be improved by training.
2) This study refers to the practice of advanced countries such as the UK and Australia, and designs hazard perception test context videos according to the road traffic situation in Taiwan, and screens out 20 test questions for "hazard perception relevance" and "video test question quality", collects the subjects' reaction time with the assistance of information output equipments, and evaluates developing the marking standard of hazard perception test context.
3) This study invited the professional driving instructors to assist with hazard perception test evaluation, when a hazardous context occurred in the test video, the mouse was clicked immediately as reaction, and the computer recorded the subject's reaction time to analyze the subjects' reaction time frequency distribution of various context test videos, the score interval of primary hazard was determined according to the reaction time frequency distribution, and the major risk clicking time distribution was tested.
4) This study assumes the clicking time distribution to be normal distribution, and uses the most used Kolmogorov-Smirnov test and Shapiro-Wilk test of normality test, the score interval divides the normal distribution diagram into five equal parts according to the period from the occurrence to the end of hazard, each part accounts for 20% of total area, given 1~5 points respectively as the hazard perception test marking standard.
5) As the real road situation is very complex, the hazard perception test context types should conform to different probable hazardous conditions in real driving process, the main content should include hazard event in front of vehicle, sudden occurrence of something in the front of running direction, traffic situation in the opposing current and so on, they should be classified according to the traffic environments such as road type, time interval, weather condition and so on. It is suggested to collect and analyze the hazardous context data in large scale in the future, so as to construct more systematic hazard perception training material.
6) At present, a few countries have begun to develop or use new test modes, importing more advanced cognitive function into test. For example, the UK has formally brought Hazard Perception Test into one of two classes of test questions in driving subject test for hazard perception test. This practice is a considerable reference for

promoting relevant policies in Taiwan.

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