Risk Awareness, Driving Performance and Eye Movement Characteristics of Distracted Drivers

漫然運転ドライバーのリスク意識、運転パフォーマンス、眼球運動特性に関する研究

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ABSTRACT

According to the World Health Organization (WHO) report, the traffic accident is a severe threat to global health; and among all factors lead to accidents, the driver distraction is consistently a leading cause. According to the definition of National Highway Traffic Safety Administration (NHTSA), distracted driving is any activity that diverts attention from driving, including talking or texting on your phone, eating and drink, talking to people in your vehicle, fiddling with the stereo, entertainment of navigation system- anything that takes your attention away from the task of safe driving. with the development of technology, the cellphone related distraction is becoming more and more popular. Japan and China both have enacted laws and regulations to control distracted driving, but the result is not satisfactory. During 2019, the number of traffic accidents related to the use of cellphone 2,645, which is on the increase, in addition, when using a mobile phone, the fatal accident rate was about 2.1 times higher than when not using it. Unlike drunk driving and over speed, distracted driving is difficult to detect and monitor, relying on rigid rules to stop distracted driving has shown its limitations. It is necessary to focus on the drivers, to study their awareness toward distracted driving, then take measures to stop distracted driving fundamentally. The objectives of this thesis are:

1) Study on the driving awareness, try to figure out the drivers' attitude towards distracted driving, and what factors influence their attitude.

2) Study on the physiological reaction of distracted drivers, focus on the eye movement features and driving performance.

3) Compare the similarities and differences in the awareness of distracted driving behaviors and their driving behaviors between the drivers of the two countries, try to provide a new perspective for comprehensively improving traffic safety.

To achieve these targets, one simulation experiment and two questionnaire surveys were conducted.

In the simulation experiment, two secondary tasks (answer a call and text a message) were set. Each task included 3 difficulty levels (0-back, 1-back, 2-back), the driver's eye movement measures including fixation, blink, pupil size and speed data were collected. Firstly, the eye movement characteristics on different levels of secondary tasks were studied, then the novice drivers and experienced drivers are compared in detail. Results demonstrate a lack of experience makes the novice drivers shown a centralized visual area, longer fixation time and more blink cases. The driving performance, specifically, driving speed features are also analyzed, results shown the drivers are slow down when conducting secondary tasks. These are the contains of Chapter 3.

Chapter 4 focuses on attitude towards distracted driving of Chinese drivers, based on a questionnaire survey, the relations between attitude towards distracted driving and factors including driving awareness, quality of life (QOL), personal attributes were analyzed, and clarified the characteristics of each attitude group. Results show driving awareness and QOL status positively influence attitude towards distracted driving; being female, with an education career below than university graduation and not driving every day may have a correct attitude towards distracted driving.

The attitude towards distracted driving is strongly related to accident-related experience. The drivers with a correct attitude experienced less accident, less near accident, and fewer violations in the recent year.

In Chapter 5, to figure out the factors related to distracted driving's attitudes due to mobile phone use, based on the questionnaire survey, a structural equation model was built to explore the relationships. In this study, the drivers' attitudes towards specific behaviors with mobile phone use while driving are the objective, and driving style, social capital and specific distracted driving behaviors are explanatory variables. Results have shown, to build a healthy attitude towards distracted driving due to mobile phone use, governments and related organizations must boost social capital ownership and educate on common safety driving habits. As the first research focused on the effect of social capital and driving styles on distracted driving attitudes, this study proves that the TPB theory is effective when reverse applied.

Chapter 6 compared Japanese and Chinese drivers on attitudes toward distracted driving behaviors and discussed the possible reasons for the difference. The road safety environment between Japan and China are quite different. The accident of China shown the characteristics of high mortality and high severity. The attitude towards specific distracted behaviors, the social capital status, and other personal attributes were compared. Similar models were built to compare the influence degree of each explanatory variables, the parameters proved the models' validity. For Chinese drivers, the driving habits and social capital are connected to each other, and both influenced attitude towards distracted driving, and the attitude towards distracted driving is connected to the accident-related experience, gender and driving frequency are also shown significance influence on attitude towards distracted driving. For Japanese drivers, the driving habits and social capital are connected, but the social capital and gender shown no significant influence on distracted driving due to cellphone use; the influence of attitudes toward distracted driving are also shown no significant meaning.

Chapter 7 summarized the findings and possible applications of this thesis and discussed the plan. As stated above, this study was trying to figure-why drivers are addicted to distracted driving, what factors influencing their attitude towards distracted driving, and if they are distracted, what are the features of their eye movement and driving performance. The results of eye movement characteristics are hoped to apply to the technology of distraction detection devices. The comparison between novice drivers and experienced drivers throws light on education for the new drivers. The research about risk awareness toward distracted driving and comparison between Japan and China is beneficial to understand distracted driving and safety attitude in a comprehensive perceptive.

CONCENTS

Chapter 1 Introduction

1.1 Research background and application

1.1.1 Research background

The traffic accident is a severe threat to global health; the lives of approximately 1.35 million people are cut short due to a road traffic crash in 2016. Between 20 and 50 million more people suffer non-fatal injuries, with many incurring a disability because of their injury. Road traffic injury is now the leading cause of death for children and young adults aged 5-29 years, on average, road crashes cost countries 3% pf their gross domestic product (WHO) [1].

The road traffic system is a complex system composed of people, vehicles, and road environments. The instability or imbalance of any factors in the system has potential risks, leading to traffic accidents. Among the various causes of road traffic accidents, human-related factors are the main factors. Therefore, how to prevent and control the occurrence of traffic accidents from the driver's perspective has received widespread attention. During the driving process, in addition to the main driving tasks such as vehicle control and monitoring the road environment, the driver sometimes performs other tasks that are not related to driving. These activities become secondary driving tasks, such as making phone calls, sending and receiving text messages, etc. Driving subtasks will occupy the driver's visual resources, cognitive resources, and motion resources to varying degrees, and compete with the main driving tasks, thereby adversely affecting traffic safety.

Driver distraction is consistently demonstrated to be a leading cause of traffic crashes worldwide [2]. There is growing evidence that indicates that crashes resulting from distracted driving pose a significant road safety problem both nationally and internationally [3-4]. In many developed countries, the number of motor vehicle crashes has declined over the years, but crashes resulting from distracted driving are increasing significant morbidity and mortality.

According to NHTSA, 8% of fatal crashes, 15% of injury crashes, and 14%of all police-reported motor vehicle traffic crashes in 2018 were reported as distraction-affected crashes. 5% of all drivers involved in fatal crashes were reported as distracted at the time of the crashes. Eight percent of drivers 15 to 19 years old involved in fatal crashes were reported as distracted. This age group has the largest proportion of drivers who were distracted at the time of the fatal crashes.

There were 2628 fatal crashes that occurred on the U.S. roadways in 2018 that involved distraction (8% of all fatal crashes). These crashes involved 2688 distracted drivers since some crashes involved more than one distracted driver. The **Table 1-1** provides the information on crashes, drivers,

Table 1-1 Drivers Involved in Fatal Crashes, by Age Group, Distraction, and Cell Phone Use, 2018

	Total	Number	Percentage of total	Number	Percentage of distraction affected
Crashes	33654	2628	8%	349	13%
Drivers	51490	2688	5%	354	13%
Fatalities	36560	2841	8%	385	14%

Source: FARS 2018 ARF

and fatalities involved in distraction-affected crashes in 2018.

As shown in **Fig.1-1**, statistical data of the National Policy Agency of Japan[5], during 2019, the number of traffic accidents related to the use of cellphones was 1,065, which is on the increase, and many fatal accidents are occurring while using cellphone, the fatal accident rate (shown in **Fig. 1-2**) was about 2.1 times higher than when not using it.

Various countries have enacted laws and regulations to stop distracted driving, but unlike drunk driving or speed driving, distracted driving is difficult to monitor; relying on rigid rules to stop this behavior has little effect; we need to solve the distracted driving issue from a conscious level.

1.1.2 Why distracted driving is dangerous- the working mechanism

Scholars have successively proposed some theories to explain the influence mechanism of distracted driving behavior. Among those theories, Wickens' Multiple resource theory (MRT) [6] has been widely accepted. MRT theory assumes that the process of human information processing is a
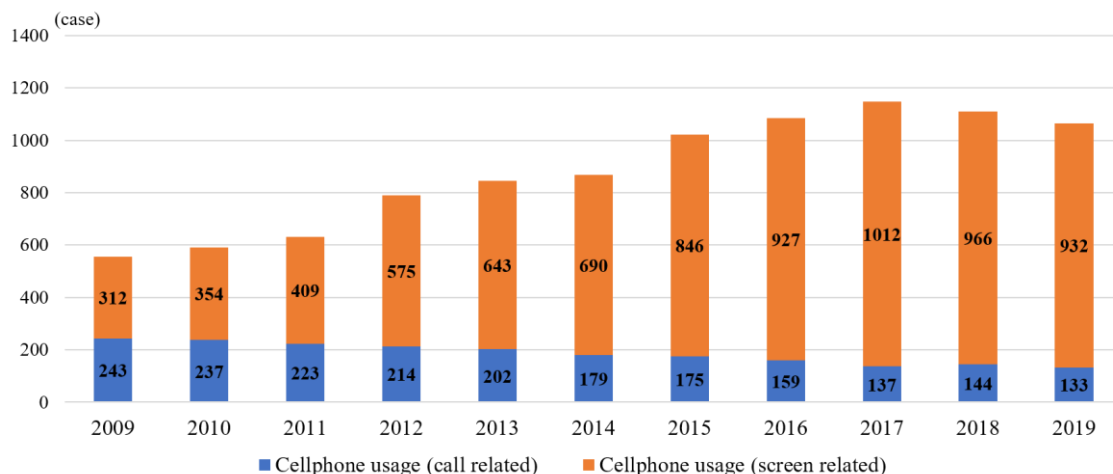
Fig.1-1 Status of traffic accidents related to the use of mobile phones (2009-2019)
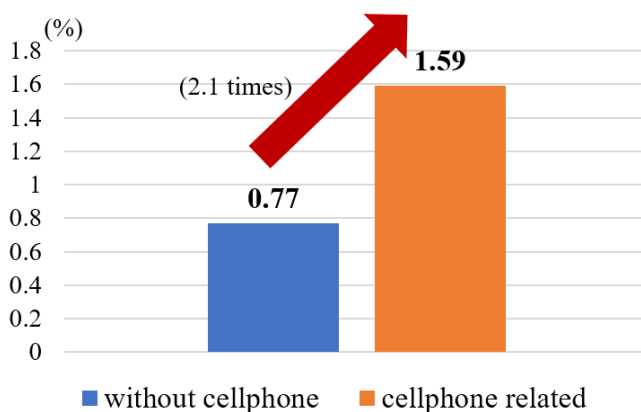
Fig.1-2 Fatal accident rate comparison (2019)

pool. The perceptual channel, code, and stage are the three dimensions of the cube, as shown in the **Fig.1-3**. As shown, the intuitive channel includes two levels of vision and hearing, the stage includes three levels of perception, cognition, and response, and the coding dimension is divided into two levels: spatial coding and speech coding. Humans process information in a serial manner, which means that only one task can be processed simultaneously. When two tasks have common needs in the same dimension or multiple dimensions, the two tasks will be competitive and affect the task's outcome.

1.1.3 Distracted driving types

There are four types of driver distraction:
1)Visual-looking at something other than the road; 2) Auditory- hearing something not related to driving; 3) Manual- manipulating something other than the steering wheel; 4) Cognitive- thinking about something other than driving. In actual driving, it is more common to combine several types of distractions, that is, comprehensive distractions, and different types of distractions have different effects on the driver.

In a research did two decades ago[7], the distraction types are shown in **Table 1-2**. Although cell phones were somewhat more prominent in these more recent data. Many more studies have been carried out focusing on individual sources of driver distraction, and in particular cellular telephones, vehicle navigation system, and other in-vehicle technologies.

Although nearly all countries and nations have illegalized mobile phone use in driving [8-9], many people still do so for many functions, such as reading or writing text, dialing or conversing in either handheld or hand-free modes, playing games, navigating, etc. According to an investigation by Oren Musicant et al.[10], phone calls and texting while driving are found to be the most common practice.
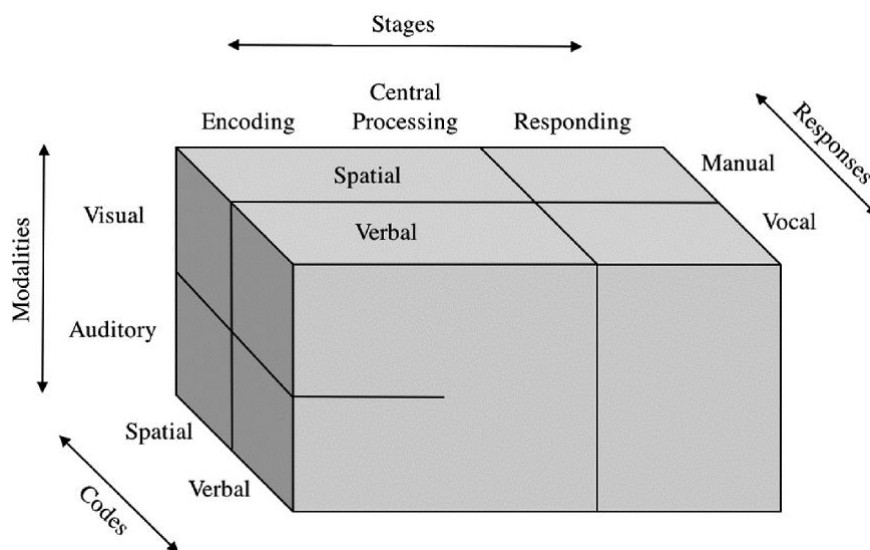
Fig.1-3 Wickens' s model of multi-resource theory

A large number of studies have shown that distraction seriously affects the driver's driving performance and visual detection ability, which is mainly reflected in the reduction of vehicle control capabilities 6) and increased driver response time7), reduce the visual perception and detection ability of the surrounding environment 8-11), and researches also turns out that distracted driving has related to specific accident types 12).

1.1.4 Research objectives and innovation points

With the popularization of smart in-vehicle devices and mobile internet terminals, drivers are more and more disturbed by external information during driving. More and more factors inducing distracted driving behavior pose serious challenges to traffic safety. The problem of distracted driving has become the focus of attention of domestic and foreign scholars. This study consists of two parts,

Table 1-2 Percentage distribution of specific driver distraction based on 1995-1999 National Crashworthiness Data system data

Source of distraction	% of drivers identified as distracted
Outside object, person, or event	29.4
Adjusting radio/cassette/cd	11.4
Other occupants	10.9
Moving object in vehicle	4.3
Using other device/ object brought into vehicle	2.9
Adjusting vehicle/climate controls	2.8
Eating and/ or driving	1.7
Using/dialing cellphone	1.5
Smoking related	0.9
Other distraction	25.6
Unknown distraction	8.6
Total	100

Source: Stutts et al. 2001

mainly to figure out two situations. One is what factors affect the driver's perception of distracted driving; the other is, what is the driver's eye movement behavior during distracted driving, what are the changes in driving performance. In this study, data were collected in two ways: the questionnaire survey and a simulated driving experiment. The questionnaire survey understands drivers' attitudes towards distracted driving, especially mobile phones, as well as personal attributes and driving-related energy. In the simulated driving experiment, two driving subtasks, namely mobile phone conversation and mobile phone text messaging, were set up to analyze and judge the characteristics of eye movements under distracting conditions. One of the two experimental methods is an invasive qualitative experimental method, and the other is a non-invasive quantitative experimental method. To summary up, the objectives of this thesis are

1) Study on the driving awareness, try to figure out the drivers' attitude towards distracted driving,

and what factors influence their attitude.

2) Study on the physiological reaction of distracted drivers, focus on the eye movement features and driving performance.

3) Compare the similarities and differences in the awareness of distracted driving behaviors and their driving behaviors between the drivers of the two countries, try to provide a new perspective for comprehensively improving traffic safety.

The research results of this paper can provide a theoretical basis for the formulation of traffic management measures and the study of distracted driving countermeasures and provide a scientific basis for onboard auxiliary equipment and autonomous driving technology. In the final section of this paper, the comparison between Japan and China is conducted, the driving pattern and perception difference are compared. It has important theoretical significance and practical application value, which are mainly reflected in the following aspect:

1. Provide a basis for understanding the status of distracted driving behaviors in different countries.

Through the questionnaire survey method, we surveyed distracted driving in Japan and China, learned about the factors affecting distracted driving attitudes and the differences in driving styles under different driving culture backgrounds, and systematically reduced distracted driving behaviors. It is essential to improve traffic safety.

2. Enriched research on theories related to distracted driving behavior.

Distracted driving behavior is an important part of unsafe driving behavior. The paper uses driving simulation experiments to study the influence of distracted driving on driving speed under normal conditions and the changes in eye movement indicators, revealing that distracted driving under different conditions is important for driving. The law of influence of performance. At the same time, this article refers to the TPB theory, innovatively introduces the social capital theory, studies the influence of social capital holdings on driving style, and better shapes the driving safety attitude.

3. Provides a perspective for the prevention and education of distracted driving.

Distracted driving behavior is an important cause of traffic accidents, and it shows the characteristics of younger age. In Chapter 4 of this article, a detailed comparison of young novice drivers' eye movement characteristics and experienced drivers during driving is useful for helping young drivers avoid accidents. It provides a new perspective to compensate for the impact of the lack of experience.

4. Enriched research methods related to distracted driving.

This research adopts two research methods: questionnaire survey and simulated driving, to systematically understand drivers' driving style with different distraction attitudes.

5. Provide a scientific basis for perfecting driving assistance system and distraction detection equipment.

In this study's simulated distracted driving experiment, two different distraction tasks were set up, telephone/text messages, and three difficulty levels were set for each distraction task. The effects of different levels of difficulty and different distraction categories on eye movement indicators were compared. The findings are useful for improve the driving assistance system and distraction monitoring equipment.

1.2 Research methods and technical routes

1.2.1 Research methods

This article combines traffic psychology, psychology, statistics, traffic simulation technology, and system engineering technology, adopts a research method combining invasive questionnaire surveys and non-invasive simulated driving, designed experimental methods and specific studies according to the research objects. Methods include:

1) Investigation method.

Use driver self-evaluation method and questionnaire method to investigate drivers' current driving behavior in Japan and China.

2) Driving simulation experiment method.

A distracted driving experiment was designed using the driving simulation experiment platform. The eye tracker was used to collect data to study the driver's eye movement index and speed index under normal and distracted driving conditions.

3) Statistical analysis methods.

There are many statistical analysis methods are used by SPSS and エクセル統計, in the simulation experiment, the Kruskal-Wallis text, independent t-text, residual analysis were conducted.

In the chapters based on questionnaire data, factor analysis, cluster analysis, logistic model and structural equation model were conducted.

1.2.2 Technical routes

Combined with the research content and research methods of this article, the technical route of the research is shown in the **Fig.1-4**.

1.3 Summary of this chapter

This chapter first gives the background of the thesis topic selection, expounds the purpose and significance of the research; then puts forward the research ideas and main contents of the thesis; finally formulates the research methods and technical routes.

This article takes distracted drivers as the research object. On the one hand, it studies their attitude towards distracted driving, and on the other hand, studies their eye movement characteristics and speed characteristics during distracted driving. This article is divided into 7 chapters; the specific content is as follows.

1) Introduction

This chapter expounded on the background of the thesis, the purpose and significance of the research，put forward the brief research and main content of the thesis, and formulated the research method and technical route.

2) Literature review

Organize and summarize the current research status of distracted driving behavior at home and abroad. This paper reviews the research status at home and abroad from several aspects such as the investigation method of distracted driving behavior and the influence of distracted driving on driving safety, and summarizes its research ideas, methods and results. On this basis, it summarizes and

discusses the deficiencies of current research, and puts forward the problems of this paper.

3) Study base on simulation experiment: the eye movement characteristics and driving performance of distracted drivers

In this chapter, the first is to have an overall grasp of the eye movement indicators and speed of distracted drivers, then, aiming at the social problem that the accident rate of novice drivers is higher than experienced drivers, the similarity and difference between novice and experienced drivers are analyzed.

4) Drivers' attitude towards distracted driving- Chinese drivers

In this chapter, Chinese drivers' attitude towards distracted driving are the objective, the quality of life (QOL) scale, driving behaviors, education career, gender and accident-related experience are been studied. A structural equalization modeling was built to explore the correlation between each variable.

5) Drivers' attitude towards distracted driving due to cellphone use- Japanese drivers

The Japanese drivers' attitude towards distracted driving due to cellphone use is been studied in this chapter, social capital, driving styles, and personal attributes are explanatory variables, the relationships and influence degree were also been studied.

6) The comparison between Japan and China on awareness toward distracted driving

Firstly, introduced the traffic situation, laws and regulations target at distracted driving, and experienced problems of Japan and China, then base on the questionnaire research, compared the similarities and difference of two countries on risk awareness towards distracted driving behaviors, and discussed the possible reasons.

7) Summary and discussion

This chapters summarized the conclusions of each chapter, and discussed the applications of this thesis, the plan of future research.
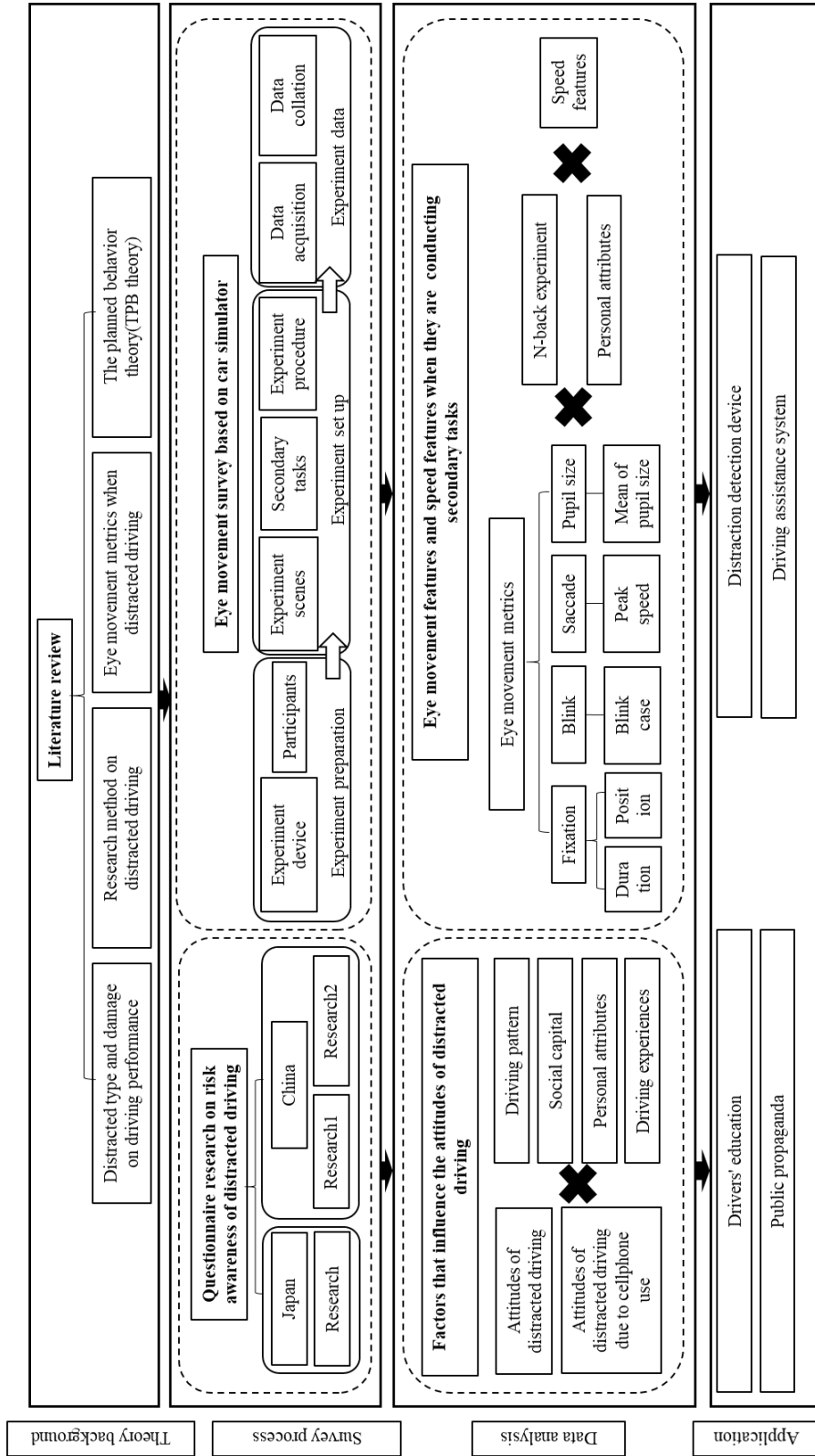
Fig.1-4 Technical routes

[Reference]

1. World Health Organization. Global status report on road safety 2018: Summary. No. WHO/NMH/NVI/18.20. World Health Organization, 2018.

2. Beanland, Vanessa, et al. Driver inattention and driver distraction in serious casualty crashes: Data from the Australian National Crash In-depth Study. Accident Analysis & Prevention Vol.54 pp.99-107, 2013.

3. Honda Masahide. Analysis of accidents caused by the use of mobile phones, etc[C]. Proceedings of the 18th Traffic Accident and Investigation Analysis Research Presentation.Tokyo: Institute for Traffic Accident Research and Data Analysis, 2015.

4. Distracted Driving 2016: DOT HS 812 517[R]. Washington DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 2018.

5. 国土交通省　令和 2 年国土交通白書,

   https://www8.cao.go.jp/koutu/taisaku/r02kou_haku/pdf/zenbun/1-1-1.pdf, 2021.1 Last read.

6. Wickens, C. D. Multiple resources and mental workload. Human factors, 50(3), 449-455, 2008.

7. Stutts, Jane C., Donald W. Reinfurt, Loren Staplin, and Eric Rodgman. The role of driver distraction in traffic crashes. 2001.

8. Rudisill T M, Zhu M. Hand-held cell phone use while driving legislation and observed driver behavior among population sub-groups in the United States. Bmc Public Health, Vol. 17, pp.437, 2017.

9. Sanbonmatsu D M, Strayer D L, Behrends A A, Ward N, & Watson J M. Why drivers use cell phones and support legislation to restrict this practice. Accident Analysis & Prevention, Vol. 92, pp.22-33, 2016.

10. Musicant O, Lotan T, Albert G Do we really need to use our smartphones while driving? Accid Anal Prev Vol.85, pp.13–21, 2015.

Chapter 2. Literature review

2.1 The influence of distracted driving on driving performance

2.1.1 The relationship between car accident and distracted driving with cellphone use

Many studies focused on the relationship between car accident and distracted driving with cellphone use.

McEvoy et al.[1] found drivers' use of a mobile phone up to 10 minutes before a crash was associated with a fourfold increased likelihood of crashing. Alghnam et al.[2] proved that using a cellphone while driving was associated with higher severity and prevalence of disability, in addition, using cellphone is associated with 44% higher odds of incurring a severe road traffic injury. Bakhit et al.[3] indicate that reaching for objects. Manipulation objects, reading, and cellphone texting are the highest crash risk factors among various secondary tasks.

2.1.2 The influence of distracted driving on driving performance

The influence of distracted driving on driving performance is summarized below.

Mansoureh et al.[4] found participants exhibited greater fluctuations in speed, changed lanes significantly more times, and deviated from the center of the road when they were distracted while driving. it is summarized that drivers reduced their speed by up to 33% while distracted with hands free/ voice command cellphone usage. The highest speed reduction happened on the local road when taking on/off clothing (50%), voice command texting (33%), and texting (29%). Morgenstern et al.[5] proved the drivers make speed adjustments while texting, the speed reduced more than 2km/h. Mian et al.[6] provide driving performance degrades significantly by reading text by a strong statistical sample base for driving distraction investigation on a driving simulator. They compared the regular and text-reading conditions, and found the distracted drivers increased their headway (20.7%), lance deviations (354%), total time of driving blind (352%), maximum duration of driving blind (87.6 per glance), driving blind incidents (170%), driving blind distance (337%) and significantly decreased lane change frequency (35.1%), however, reading text and braking aggressiveness are not related. Fitch et al. [7] proved that drivers' visual behavior was the most sensitive to change when using handheld cellphone, subtasks such as locating/ answering. Dialing, text messaging, browsing, and ending the call were all found to increase the mean percentage of total eyes off road times (TEORT). In contrast, the mean percentage TEORT significantly decreased when conversing on a handheld cellphone. Regarding longitudinal vehicle control, the mean speed standard deviation was found to significantly increase from baseline when ending both handheld and hands-free cellphone use (M=6.32km/h & M=4.96km/h, and M=5.19km/h & M=3.95km/h, respectively.)

2.1.3 The influence of distracted driving on eye movement measures

Eye-movement metrics are consistently reported to be among the best performing diagnostic metrics for measuring distraction [8-10], many researchers found with the cognitive load increases, the pupil diameter increase, the driver's gaze area will become narrower, the gaze point will be more concentrated on the middle area of road, and a shorter gaze duration will happen.

2.2 Drivers' attitude towards distracted driving

According to the research did by Liang and Lee[11], the visual and combined distraction both impaired vehicle control and hazard detection and resulted in frequent, long off-road glances. The combined distraction was less detrimental than visual distraction along. Cognitive distraction made steering less smooth but improved lane maintenance. Overall, visual distraction interferes with driving performance more than a cognitive distraction, and visual distraction dominates the performance decrements during combined distraction.

The research did by Bao et al.[12] found the spectral power analysis did show that cellphone use resulted in the different vehicle lateral control variations. Drivers had the bumpiest lane position keeping profiles during visual-manual tasks, featured by the largest average spectral power values and the greatest variation range when compared to the other two conditions. Baseline driving appeared to have the smoothest lateral controls. Older drivers were observed to have the highest lateral control variations among the three age groups when conducting visual-manual tasks, suggesting that they are less capable of controlling the wheels while engaging in secondary tasks that require both of their visual and manual inputs.

In the research did by Gershon et al.[13] found teens engaged in a potentially distracting secondary task in 58% of sampled road clips. The most prevalent types of secondary tasks were interaction with a passenger, talking/ singing (no passenger), external distraction, and texting/ dialing the cellphone.

2.3 The factors influence the distracted driving behaviors

Bakhit et al.[3] proved dangerous awareness of different secondary tasks is useful to avoid distracted driving. Recognized the effect of different secondary tasks on traffic safety in a real-world environment helps legislators enact laws that reduce crashes resulting from distracted driving, as well as enables government officials to make informed decisions regarding the allocation of available resources to reduce roadway crashes and improve traffic safety. Rupp et al.[14]' research consisted with these findings, they studied college-aged adults to examine the factors that influence both their risk perception of driving while distracted and how often they engage in distracting activities and situations while driving. They found a disassociation between individuals' perception of driving distraction risk and their engagement with the distraction. exposure, perceived knowledge of risks, fairness beliefs, and rating of perceived visual and cognitive demands was associated with risk perception. Conversely, risk-seeking traits, how voluntary the task was perceived, and previous exposure to a distraction influenced engagement.

In the research did by Sun et al.[15], Logistic regression model showed that the impact of using cell phone on driving safety varies depending on the characteristics of drivers, such as gender, age, driving experience, and use intensity. Additionally, the results indicated that the strong determinants of phone-related hazard are different from that of phone-related accidents. Regarding the drivers' perception of cell phone usage, there are two key findings. First, there is no explicit belief among the drivers about whether cell phone usage impairs driving safety regardless of the drivers' age, gender, driving education experience etc. Second, most of drivers have not realized that cell phone use while driving would increase their perception reaction time. Based on the analysis of these results,

implications of cell phone use on driving safety along with some safety countermeasures, such as selective bans and non-cell phone zones are discussed.

The research did by Bao et al.[12] proved secondary task engagement was more prevalent among those with primary vehicle access and when driving along. Social norms, friends' risky driving behaviors, and parental limitations were significantly associated with secondary task prevalence. In contrast, environmental attributes, including lighting and road surface conditions, were not associated with teens' engagement in secondary tasks. Gershon et al.[13] did a research focus on the prevalence and predictors on teens' distracted driving behavior, found teens are much easily to get involve into the distracted driving and experienced a poor control of their behaviors.

Pope et al. [16] found female adolescents were at two times greater odds of supporting a low against texting/ emailing while driving compared to male adolescents. Greater perceived threat to safety was associated with all three types of distracted driving legislation. Minimal association was found with peer influences.

Hill et al.[17] proved distracted driving is a highly prevalent behavior among college students who have higher confidence in their own driving skills and ability to multitask than they have in other drivers' abilities. Driver' self-efficacy for driving and multitasking in the car, coupled with a greater likelihood of having witnessed distracted driving behaviors in others, greatly increased the probability that a student would engage in distracted driving. most students felt that policies, such as laws impacting driving privilege and insurance rate increases, would influence their behavior.

Przepiorka et al.[18] did a research in Polish, found significant differences were found in all of the control beliefs for both handheld and hands-free cellphone use. composite measures of the behavioral and control beliefs were predictive of being a frequent handheld cellphone user.

2.4 Comprehensive review for research methods

The self-report survey method is widely used to investigate distracted driving behavior due to its simplicity, ease of operation, and low cost. However, this method may have driver's subjective prejudice, etc. Respondents may cater to investigators' wishes to conceal one's true thoughts. The roadside observation method can directly observe the actual driver behavior, and the cost is relatively low. However, due to the observer's limited time and energy, the distracted driving behavior that is out of sight or hidden cannot be completely observed. It is applicable when the vehicle is running at a low speed or when the vehicle is stopped. The driver's distracted behavior in a high-speed vehicle cannot be effectively observed, resulting in that the frequency of the observed distracted driving behavior is often lower than the actual frequency. Compared with other survey methods, the naturalistic driving studies (NDS) method is considered to be the best method for observing distracted driving behavior. It can monitor drivers throughout the entire process, better capture more concealed distracted driving behavior, and truly reflect distracted driving behavior. However, the NDS method still has some limitations. Firstly, the NDS method need to recruit the participants, the samples are limited; then, The installation, debugging and maintenance of equipment also requires a lot of investment in economic and manpower, which makes the NDS is the most expensive research method among all types. With the high development of VR technology, the validity is becoming better and better for the simulation methods. It is a safer way to monitor distracted drivers' driving behavior. Still, due to the phenomenon

of simulation sickness, not all drivers are suitable to participant in the simulator experiment. The advantage and disadvantages of each method are summarized in **Table 2-1**.

2.5 Shortcomings of existing research

Through the review and analysis of research trends at home and abroad, foreign scholars have achieved certain results in the field of distracted driving behavior. However, due to the wide variety of distracted driving behaviors, and it is difficult to predict, the current research still has many shortcomings, mainly Reflected in the following aspects.

1) Lack of quantitative research on the impact of distracted driving

Existing studies have analyzed the effects of different types of distracted driving on the driver's behavior, psychology, and body. Still, there is a lack of quantitative research on the same distracted behavior, for example, much research is about driving with cellphone use, but the cellphone use can be various by people, it is necessary to quantify the influence of specific behaviors.

2) Researched the attitude towards distracted driving, but did not understand which factors affect the attitude towards distracted driving

Many studies focus on the driver's attitude towards specific behaviors in distracted driving. For example, they compare the safety attitudes of using handheld and non-handheld communication devices, but they have not explored what factors affect these attitudes.

3) Most of research are only focused on safe driving attitudes under a single cultural

Table 2-1 Advantages and disadvantages of driver distraction behavior survey methods

Methods	Advantages	Disadvantages
Naturalistic driving studies	The accuracy of the data; precise information on usual driving behavior and performance as well as in the seconds preceding crashes and near-crash events	Cannot detect all types of cognitive distractions (or cognitive overload); high cost
Roadside observational studies	Gather a large sample size in a short time	The validity of data; an under-estimate of the frequency of distracted driving; The distracted driving behavior of the driver at high speed cannot be effectively observed
Self-report studies	Capture the motivations and reasons for engaging in distracted driving behavior	An underestimate of ones' actual behaviors due to social desirability biases, memory biases
Simulator studies	Safer to both drivers and experimenters; provides a scientifically method for studying effects on driving performance	The validity comparing to real simulator is doubtful; phenomenon of simulation sickness

background, lack of diversity

The current research stays at the level of a single country. The lack of comparison of different driving styles in different countries makes the research on mobile phone distracted driving relatively one-sided and not diverse.

2.6 The summary of this chapter

This chapter comprehensively reviews the current research status at home and abroad from four aspects: the investigation method of distracted driving behavior, the influence of distracted driving on driving safety, the attitude of distracted driving, and the policy of distracted driving. On this basis, it summarizes and discusses the deficiencies of existing research and puts forward the purpose of this article.

[Reference]

1. McEvoy, S. P., Stevenson, M. R., McCartt, A. T., Woodward, M., Haworth, C., Palamara, P., & Cercarelli, R. Role of mobile phones in motor vehicle crashes resulting in hospital attendance: a case-crossover study. bmj, 331(7514), 428, 2005.

2. Alghnam, S., Towhari, J., Alkelya, M., Alsaif, A., Alrowaily, M., Alrabeeah, F., & Albabtain, I.. The association between mobile phone use and severe traffic injuries: a case-control study from Saudi Arabia. International journal of environmental research and public health, 16(15), 2706, 2019.

3. Bakhit, P. R., Guo, B., & Ishak, S. Crash and near-crash risk assessment of distracted driving and engagement in secondary tasks: a naturalistic driving study. Transportation research record, 2672(38), 245-254, 2018.

4. Jeihani, M., Ahangari, S., Hassan Pour, A., Khadem, N., & Banerjee, S. Investigating the Impact of Distracted Driving among Different Socio-Demographic Groups, 2019.

5. Morgenstern, Tina, Lea Schott, and Josef F. Krems. "Do drivers reduce their speed when texting on highways? A replication study using European naturalistic driving data." Safety science 128, 104740, 2020.

6. Miah, Md Mintu. Effects of Reading Text While Driving Analysis of 200 Honolulu Taxi Drivers on a Vs500m Simulator. Diss. University of Hawai'i at Manoa, 2018.

7. Fitch, Gregory M., et al. The impact of hand-held and hands-free cell phone use on driving performance and safety-critical event risk. No. DOT HS 811 757. 2013.

8. Victor T W, Engström J, Harbluk J L. Distraction Assessment Methods Based on Visual Behavior and Event Detection[M]. Boca Raton, FL: CRC Press, 2008.

9. Victor T W, Harbluk J L, Engström J A. Sensitivity of eye-movement measures to in-vehicle task difficulty[J]. Transportation Research Part F: Traffic Psychology and Behaviour, 8(2): 167-190, 2005.

10. Horrey W J, Wickens C D, Consalus K P. Modeling drivers' visual attention allocation while interacting with in-vehicle technologies[J]. Journal of Experimental Psychology: Applied, 12(2): 67, 2006.

11. Lee, John, Jane Moeckli, Timothy Brown, Shannon Roberts, Trent Victor, Dawn Marshall, Chris Schwarz, and Eric Nadler. "Detection of driver distraction using vision-based algorithms." In Proc. 23rd Enhanced Safety Veh. Conf. 2013.

12. Bao, S., Guo, Z., Flannagan, C., Sullivan, J., Sayer, J. R., & LeBlanc, D. (2015). Distracted driving performance measures: Spectral power analysis. Transportation Research Record, 2518(1), 68-72.

13. Gershon, P., Zhu, C., Klauer, S. G., Dingus, T., & Simons-Morton, B. Teens' distracted driving behavior: Prevalence and predictors. Journal of safety research, 63, 157-161, 2017.

14. Rupp, Michael A., Marc D. Gentzler, and Janan A. Smither. Driving under the influence of distraction: examining dissociations between risk perception and engagement in distracted driving. Accident Analysis & Prevention 97,220-230,2016.

15. Sun, Dazhi, and Anxi Jia. "Impacts of cell phone use on driving safety and drivers' perception of risk." Journal of Modern Transportation 24.2, 145-152, 2016.

16. Pope, Caitlin N., Jessica H. Mirman, and Despina Stavrinos. "Adolescents' perspectives on distracted driving legislation." Journal of safety research 68 (2019): 173-179.

17. Hill, Linda, et al. "Prevalence of and attitudes about distracted driving in college students." Traffic injury prevention 16.4, 362-367, 2015.

18. Przepiorka, Aneta M., et al. "Do beliefs differ between frequent and infrequent hand-held and hands-free phone users while driving? A Polish study." Journal of Public Health 1-9, 2019.

Chapter 3. A study based on simulation experiment-eye movement characteristics and driving performance

This chapter studies the changes in eye movement measures (EMMs) and speed performance when the driver is in a distracted driving state. A driving simulator was used to providing the environment to get the speed data and behavior of using a cell phone for voice transmission (call) and text transmission (SMS) during driving, an eye tracker was used to collect data including fixation, blink and pupil size. Two types of distraction were set up with three difficulty levels, in the gap between each experiment, the participants were asked to rank the difficulty perception for each secondary task; at the end of all trials, the respondent requested to fill a questionnaire about cellphone usage while driving in daily life.

3.1 Introduction

As discussed before, the distraction type including visual distraction, manual distraction, cognitive distraction; at the same time, 90% of information was obtained by vison [1], so the visual characteristics of distracted driving are observed by many scientists. Results [2,3] show that visual distraction has a larger influence on driving behavior than manual distractions.

To be a safe driver, be able to control the vehicle and in accordance with traffic rules are not enough, plan the trip safely by understand the mode of transport, understand where risks may occur are also key abilities[4]. Skills such as con-trolling vehicles and following rules can be learned in educational schools but understanding the mode of transport and how to avoid risks are acquired through driving experience. It has been well established by studies and accident database from various countries that novice drivers are more frequently involved in traffic accidents than experienced drivers[5)-8)]. Newly licensed drivers are about eight times more likely to be involved in fatal crashes during their first six months than experienced drivers[9]. Meanwhile, there is a severely problem also result in significant morbidity and mortality, which is distracted driving, especially driving with cellphone use [10)-12)]. In USA, there are 3,166 people died because of distracted driving in 2017 alone[13]. In Japan, according to the government, the number of traffic accidents related cellphones usage during 2018 was 2,790, increased approximately 1.4 times in past five years, in comparison, the fatal accident data of using cellphone was about 2.1 times of that not using cellphone. Law restrictions on forbidden using cellphone have been implied in many countries but the results are far more from satisfied. A report from the center of disease baseline and prevention showed 69% of respondents used a mobile phone and 31% of respondents dealt with text messages or emails while driving at least once in the past 30 days in the united states[14], and in a research did in japan, about 36.5% of drivers admitted they are using cellphone while driving[15]. There is no accurate data of the use of mobile phones by novice and experienced drivers, but studies[4] have shown that young novice drivers are more likely than experienced ones to engage in the risky behavior such as driving with cellphone use. Visual information is of great importance when driving, the visual search of novice and experienced drivers have been studied for nearly 50 years[16]. Many researches shown [17-19] there was no significant difference in novice drivers' and ex-perienced drivers' horizontal visual search over low, medium and high driving demand situations; in contrast with the results of Mourant et.al[16], and Hills et al[17]'s. They

found that experienced driv-ers had significantly wider horizontal spread of search comparted to novice drivers. Unlike the horizontal spread, it is a conclusion that the novice drivers and experienced drivers have no differ-ence in vertical spread[17-18,21]. Case of fixations were also been studied, Konstantopoulos et al.[22] and Borowsky et al.[23] found there was no significant difference between the case of fixations made by experienced drivers and novice drivers. These findings of previous research have a number of implications for us to understand the difference between novice and experienced drivers, but far from enough, there is no conclusion of whether the visual spread is different between two groups; and the eye movement measures are not only fixation case, but also fixation duration, saccade peak speed, pupil size and blink case, whether two types of drivers share a similar feature on these measures are still need to be studied..

Given the situation that novice drivers are much easier to get involved into accidents comparing to experienced drivers; and a significant proportion of drivers using mobile phones while driving, figure out what are the effect of cellphone use on two types of drivers is quite necessary for improve the road safety.

The objectives of this study are

1) figure out the eye movement characteristics when conducing different types of secondary tasks, and when the secondary tasks are same, the influence of different level.

2) The specific difference between novice drivers and experienced drivers on eye movement measures when distracted.

3) The speed performance of distracted drivers when conducing secondary tasks.

3.2 Research method

3.2.1 Simulator experiment platform

The study was performed on a high-fidelity driving simulator. The simulator is QJ-4B1 with a six degrees of freedom motion, which manufactured by the OKTAL Company. A 180°front view of a display system is used to project the simulated environment, which located approximately 2 meters in front of the drivers. The driving simulator is shown in **Fig.3-1**. The simulator equipment offered a
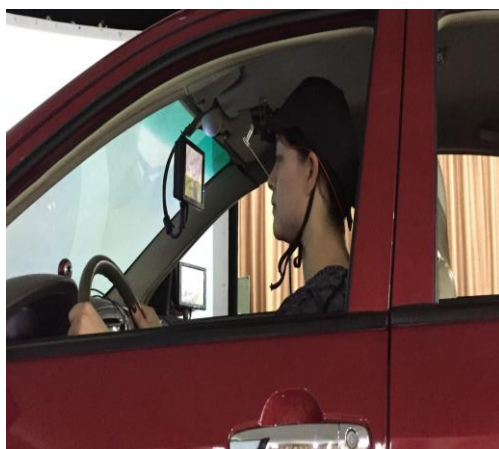
Fig.3-1 Driving simulator   **Fig.3-2** Eye-tracking device

three-lanes driving environment without other cars or pedestrians.

3.2.2 Eye-tracking equipment

This experiment's eye-tracking device is the Iview X HED eye tracker produced by German SMI (Senso Motoric Instruments). The eye tracker device is used to collect and record the driver's eye data during driving and the specific parameters of the eye tracking device, As shown in **Fig. 3-2**. BeGaze eye movement analysis software is used to analyze the driver's eye movement data. The basic parameters of Iview X HED is shown in Table **3-1**.

Table 3-1 Basic parameters of Iview X HED

Technical Parameters	Weight	Sampling frequency	Tracking angle	Resolution	Gaze point accuracy
Parameter value	450g	50hz	Horizontal angle: ±30° Vertical angle: ±25°	0.1°	0.5~1°

3.2.3 Subtask related device

To reduce the difference caused by unfamiliar equipment, all the distracting devices used by the subjects were their own mobile phones. To avoid other distractions, all mobile phones have shut the network function, only functions such as making calls and sending and receiving text messages can

Table 3-2 Subtask: N-back experiment

Item		Explanation	Stimulus					
Call	n=0	Heard	1	6	5	7	9	…
		Repeat	1	6	5	7	9	…
	n=1	Heard	1	6	5	7	9	…
		Repeat	-	1	6	5	7	…
	n=2	Heard	1	6	5	7	9	…
		Repeat	-	-	1	6	5	…
Text	n=0	Received	1	3	2	6	7	8
		Sent back	1	3	2	6	7	8
	n=1	Received	5+8=?		3+5=?		4+8=? …	
		Sent back	13		8		12	
	n=2	Received	14+39=?		24+56=?		19+42=	…
		Sent back	53		80		61	

be used. and before experiment, all participants understood the procedure clearly.

3.2.4 Secondary task setup

N-back working memory tasks were being used as the subtask in this experiment, during the driving, they need to answer a call, in 0-back experiment which is the most easily one, they will hear a series of randomly ordered auditory stimuli which is single digits from 0 to 9, and they react by repeat the number they heard immediately. In 1-back experiment, the number they heard is single digits from 0 to 9 but they need to take in and hold in memory each new number as it was presented and respond verbally with the number 1 position back in the presentation sequence. In 2-back experiment, they need to remember the number as well as repeated the number 2 position back in the presentation sequence. The difficulty increased from 0-back to 2-back experiment, the procedure is shown in **Table 3-2**. Text-set also including 3 levels of difficulties, the drivers will get a text-message when driving, in 0-back experiment, they repeated the number they received(0-back), in 1-back experiment, they answered the mathematical question of single digit addition such as 4+3=?(1-back), and in 2-back experiment, they answered a mathematical question of two digits addition, such as 27+48=?(2-back). After understood the subtask, all participants were asked to practice, only after a certain accuracy rate is reached can the experiment process begin.

3.2.5 Experiment program

The drivers were being required to driving in a simple three-lane road which is without any other kinds of road users such as cars, pedestrians. When the vehicle traveled to a certain position(position1), triggered a subtask, drivers need to complete the subtask while driving, after finishing the subtask, the driving keep go on, after reaching to a designated position(position2), one set of experiment is finished. Between each round of driving, the drivers were being asked to fill a questionnaire about the difficulty level of each subtask. One set of subtasks last for about 55 seconds, and to ensure the accuracy of the data, reduce the impact of cellphone connecting time, intercept a period of 35 s as analysis data. The schematic diagram is shown in **Fig.3-3**.

Besides the main driving task, among each round of experiment, the participants are being asked
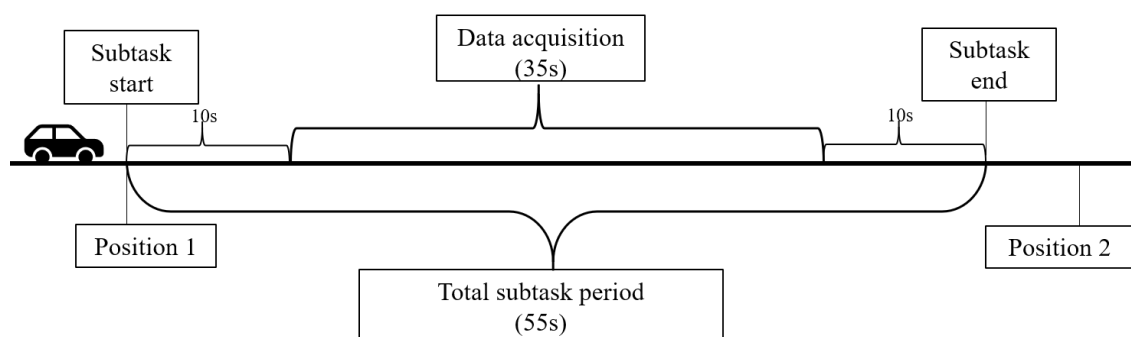
Fig.3-3 Experiment setup

to fulfill a short scale about the subtask difficulty, distraction degree.

The experimental process of this experiment is as follows: When the subjects arrive in the laboratory,

1) Read and sign an experimental informed consent form, in which there are clear experimental tasks, possible situations, and remuneration that can be received after completing the experiment.

2) The experimenter will explain the entire experiment process to the subjects and explain and train the driving tasks performed.

3) Participants fill in a questionnaire on basic personal information, social capital, driving patterns and distracted driving related items.

4) Under the experimenter's guidance, the subjects will perform adaptive driving to familiarize themselves with the simulated environment.

5) Before the experiment officially started, the subjects put on the eye tracker and calibrated the eye tracker using a five-point method

6)   In the formal experiment, the subjects completed at least 7 rounds of driving, including the control experiment, call 0-back, call 1-back, call 2-back and SMS 0-back, SMS 1-back, SMS 2-back, etc., and complete the corresponding driving tasks in the process.

7) Between each round of the experiment, a questionnaire about the of difficulty degree and distraction degree will be filled.

8) The participants receive the honorarium, and the trial ends.

During the experiment, if the subjects experience physical discomfort, the experiment can be terminated at any time. The experimental process is shown in the **Fig.3-4**. The experiment questionnaire included basic driver information, items related to distracted driving, driving habits, and the degree of distraction and difficulty of various distracting tasks. See the appendix for details.

3.2.6 Participants' information

A total of 33 drivers participated in the experiment, due to the data gather problem, 20 drivers' data was being analyzed, among them, experienced drivers were 12 and novice drivers were 8, the average age of experienced drivers is 38.25, standard is 13.10, novice drivers is 23.63, standard is 3.11,
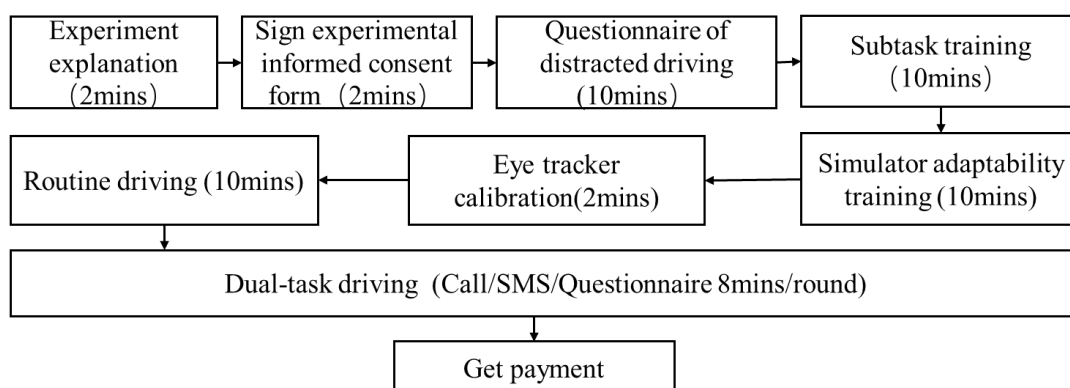
Fig.3-4 The experiment process

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the basic information of participants are shown in **Table 3-3**. All participants have a valid driver license and in good health condition, they are gathered through Wechat advertisements in Urumqi, and received financial compensation after experiment.

3.2.7 Eye movement measures

Eye movement measures were being analyzed including fixation, blink and saccade.

1) Fixation describes the transition of the eyes to a given area; in this experiment, the min duration is 80ms, the fixation range is horizontal from 0 to 752, vertical from 0 to 480. Due to the aging of the acquisition equipment, the fixation data that longer than 2s was removed.

2) Blink is a semi-autonomic rapid closing of the eyelid, the case where the pupil diameter is less than 1pixel, or the horizontal and vertical gaze position equals 0 is being taken as blink. Blink case and duration were being collected.

3) Pupil diameter enlarges proportionally with the mental load increase. Eye tracker collected the size of pupil when gazing, the data were divided into two sizes in horizontal and vertical directions. For the sake of simple calculation, the pupil size takes the average of the two direction when analyzing.

3.2.8 Speed performance

The average speed is analyzed among different groups. Similar with the eye data collection, the average speed of the distracted driving period is gathered and analyzed.

3.3 Eye movement features of distracted drivers

3.3.1 Fixation

In this section, the fixation case, fixation duration and fixation distribution of novice and experienced drivers are analyzed. Because when conducting the text secondary tasks, the fixation data will affect by many factors, so in this section, the fixation is focused on the period when conducting call related secondary tasks. Fig. x shows the fixation case of each round experiment, there is no

Table 3-3 Drivers' information

Item	Contains	Experienced Driver	Novice Driver
Gender	Male	10	5
	Female	2	3
Age	Below 30	3	8
	31 Above	9	0
Accident involvement	None	9	7
	Have	3	1
Driving frequency	Everyday	9	2
	Not Everyday	3	6

Kruskal-Wallis test
Chi-square value: 4.4847
P value:0.4819 ＊：P<0.05 ＊＊：P<0.01
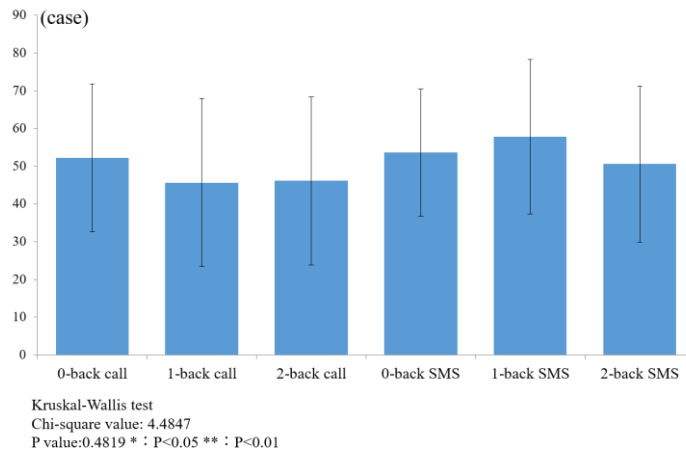
Fig.3-5 The average case on each experiment

Kruskal-Wallis test
Chi-square value: 10.6835
P value:0.0580 ＊：P<0.05 ＊＊：P<0.01
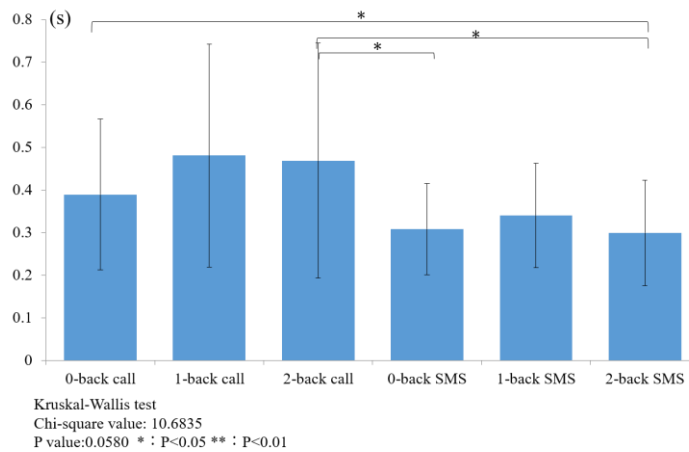
Fig.3-6 The average fixation duration on each experiment

significance between each difficulty level and type. **Fig.3-5** shows the average fixation time of each round, a Kruskal-Wallis test shows that the average fixation time of 0-back call is longer than 2-back SMS; 2-back call is longer than 2-back SMS, and 2-back call is longer than 0-back SMS. The total fixation time is also analyzed. The Kruskal-Wallis text show basically, the total fixation of n-back call experiments is longer than 0-back SMS experiments. And there is no significant difference among difficulty level in one type of experiment.

Fixation is a key measure to gather information and describe visual behavior, the fixation distribution is analyzed in detail shown in **Fig.3-8** and **Fig.3-9**. Divided the fixation by 0.2s, and research the distributions on each period, results show most of fixation are from 0.2s to 0.4s, then is less than 0.2s, with the difficulty increase, the longer gaze duration exists.

To figure out the fixation area distribution, divided the fixation in to five parts by divided the horizontal area equally. And the crossing analysis tests were conducted, results shown in **Fig.3-10**, with the difficulty increase, the visual shown a centralized tendency clearly.

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3.3.2 Blink

The blink case, average blink duration and total blink time of two types of distracted driving are gathered and analyzed in this section. Drivers blinked more times in 2-back SMS experiment than in 0-back call and 1-bak call experiment; the average blink time shows no significant difference among each experiment. result of total blink time shown the 2-back SMS cost longest time on blink, follows by 1-back SMS, and 0-back SMS, there is no significant difference between 2-back call and 0-back SMS, 1-back call and 1-back SMS; 0-back call and 2-back SMS, there is no difference among call related secondary tasks.
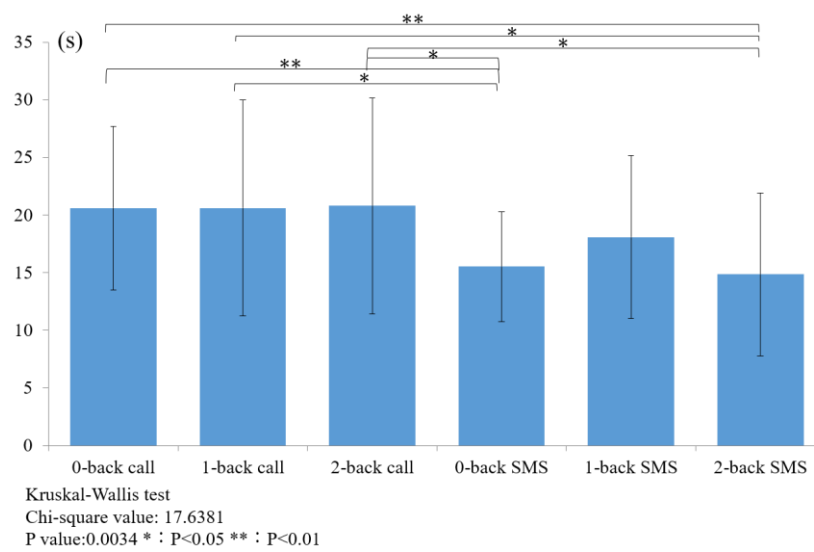
Fig.3-7 The total fixation duration on each experiment
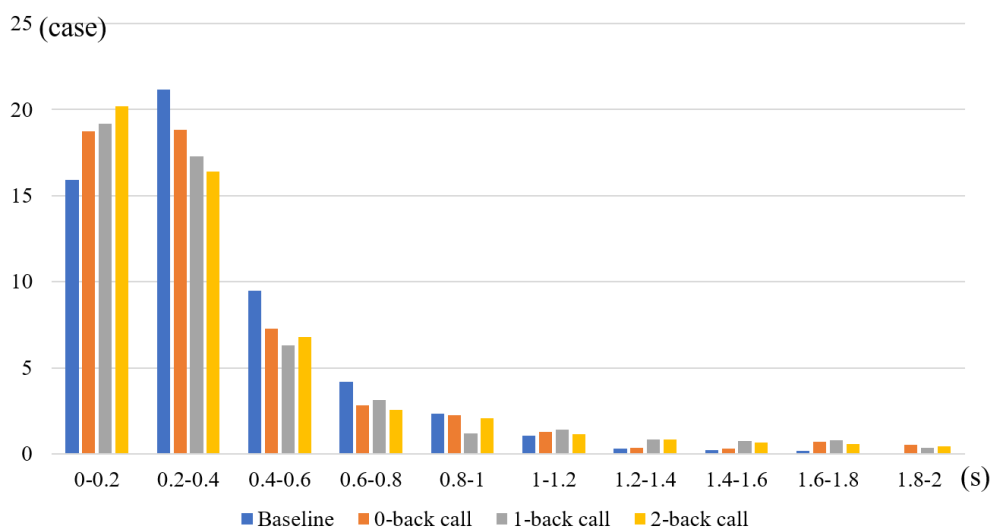
Fig.3-8 The fixation duration distribution on each time period

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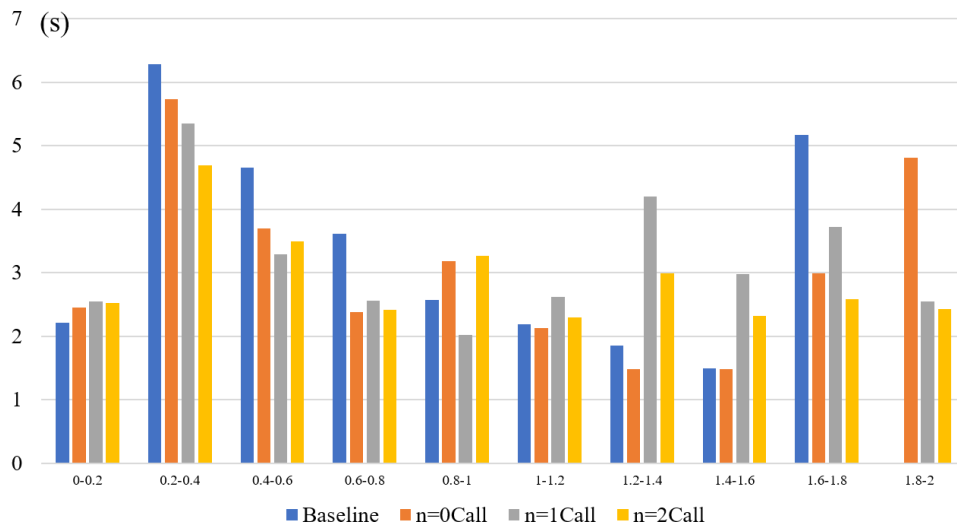
Fig.3-9 The total fixation duration distribution on each time period
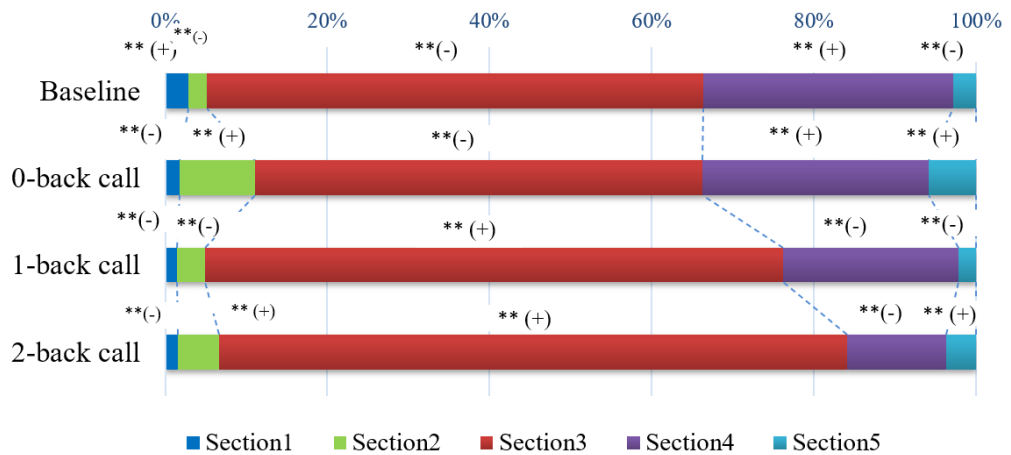
P value：0.0000　significance at 1%
Residual analysis of crosstab:　　**1%　*5%
 (+) High proportion　　(-) Low proportion

Fig.3-10 The fixation area distribution on each section
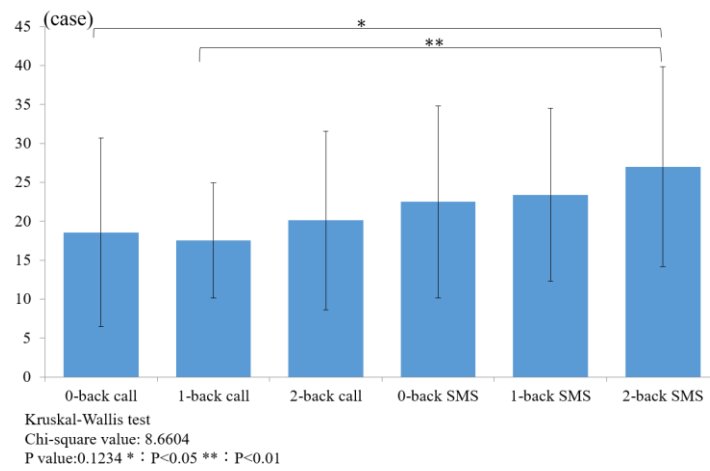
Fig.3-11 The blink case on experiment
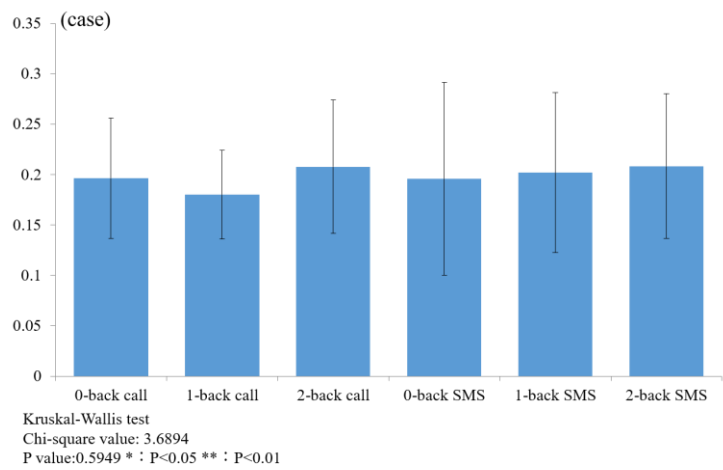
Fig.3-12 The average blink duration on experiment
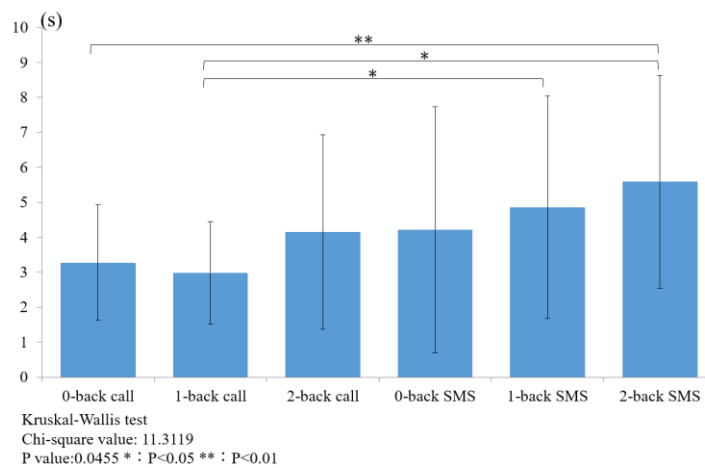
Fig.3-13 The total blink time on experiment

3.4 The comparison between novice drivers and experienced drivers when conducting secondary tasks

As discussed above, the novice drivers shown a larger possibility to get involved into car accidents, and in this section, we would like to figure out:

1) figure out the difference between novice drivers and experienced drivers when they are conducting subtasks
2) eye movement feature when conducting difficulty level of subtasks changes

3.4.1 Fixation

Fixation data including fixation case, total fixation time and area where the fixation located. In order to understand the gaze distribution, divided the gaze area into 6 parts, the division is shown in **Fig.3-14**. Making a comparison of the fixation time distribution on each section between novice and experienced groups, baseline experiment is shown in **Fig.3-15**; 1-back experiment is shown in **Fig.3-16**; 2-back experiment is shown in **Fig.3-17**. From these figures, we know section 3 takes the largest percentage of gaze area, the distribution on each part is similar between two groups. The total fixation time of experienced group is longer than novice group. The experienced group gazed right area more often than novice group.

Using chi-square test to analysis the gaze feature of novice group and experienced group among three types of driving, figure out the gaze case distribution on each section. The summary is shown in **Fig.3-18.** In baseline driving (p=0.0000, x^2=41.6977), there is no significance difference between novice and experienced group on section 1,2,3, novice group is longer in section 4, shorter in section 5 and 6 comparing to experienced group. When driving with a subtask, the drivers of novice group gaze at section 3 significantly longer than experienced group （1-back,2-back）. In 1-back experiment (p=0.0000, x^2=34.6495), the drivers of experienced group watched section 4 and 5 more than novice group. In 2-back experiment (p=0.0000, x^2=25.2877), the drivers of experienced group watched section 2 and 5 more than novice group.

X / Y	0-150	150-300	300-450	450-600	600-752
0-80	1	2	2	5	6
80-160	1	2	2	5	6
160-240	1	3	3	5	6
240-320	1	3	3	5	6
320-400	1	4	4	5	6
400-480	1	4	4	5	6

Fig.3-14 Fixation area distribution
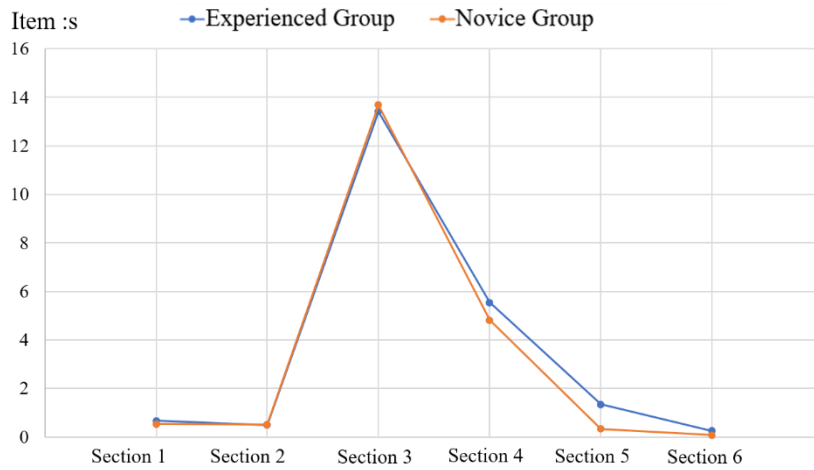
Fig.3-15 Fixation time distribution of baseline experiment
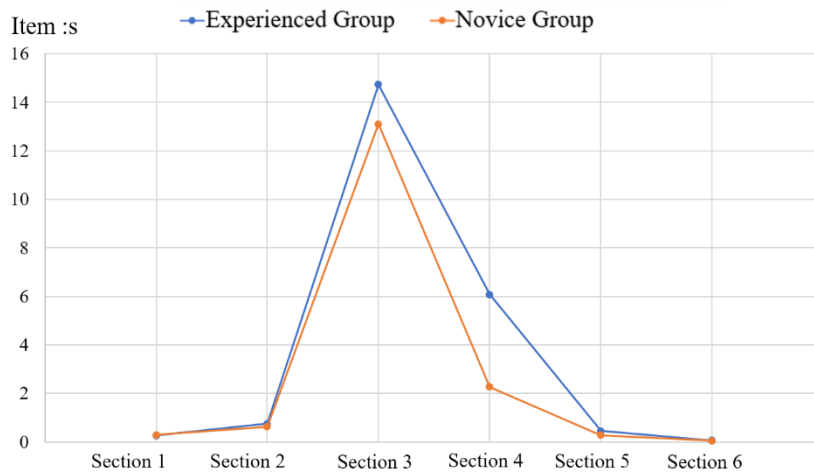
Fig.3-16 Fixation time distribution of 1-back call experiment
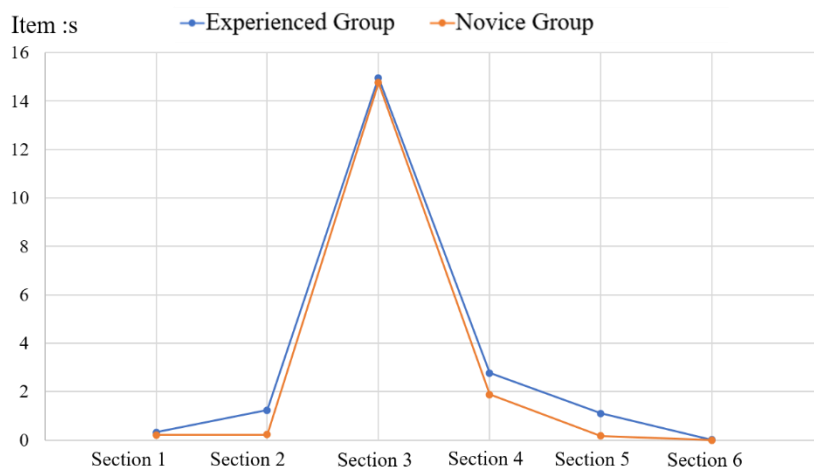
Fig.3-17 Fixation time distribution of baseline experiment

Residual analysis of crosstab: **1%   *5%
(+) High proportion   (-) Low proportion
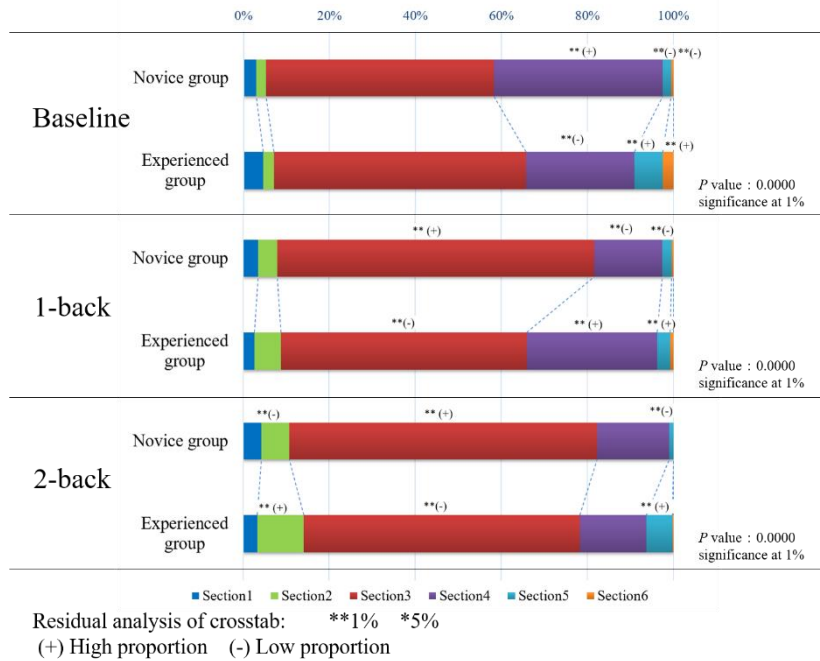
Fig. 3-18   Fixation case of two groups on different area division

3.4.2 Blink

Blink case and blink duration were also been gathered, shown in **Fig.3-19**.

In novice group, there are significant difference between baseline experiment and 1-back experiment (p=0.0014); baseline experiment and 2-back experiment(p<0.001).

In experienced group, as the Kraskar-Wallis test shown, there are significance difference between baseline and 2-back experiment(p<0.001).

Make a comparison between novice group and experienced group in same experiment, there is also a significant difference, the blink duration of novice group is longer than experienced group in all experiments and shown a significance difference in 1-back and 2-back experiment.
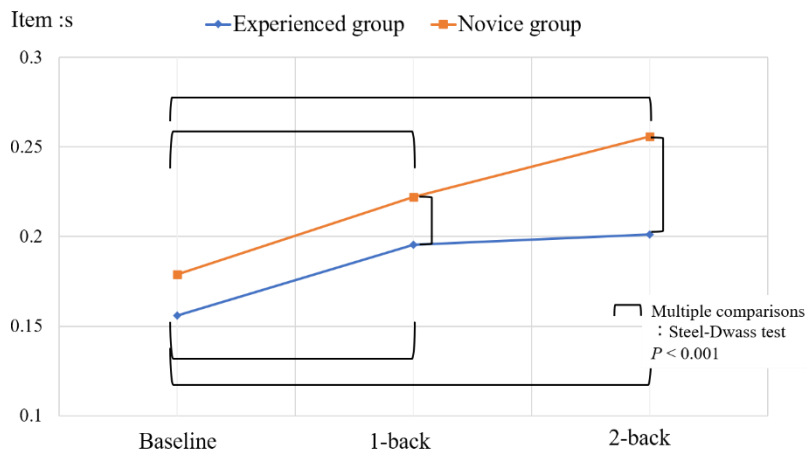
Fig.3-19 Blink duration of two groups on each experiment

3.4.3 Saccade

Saccade peak speed was been recorded; result shown in **Fig.3-20**. Among each experiment, there is a significant difference between novice and experienced group, the peak speed of novice group is larger than experienced drivers in every experiment($p<0.001$). In experienced group, the speed of baseline experiment is the fastest, there is significant difference between baseline experiment and 1-back experiment.
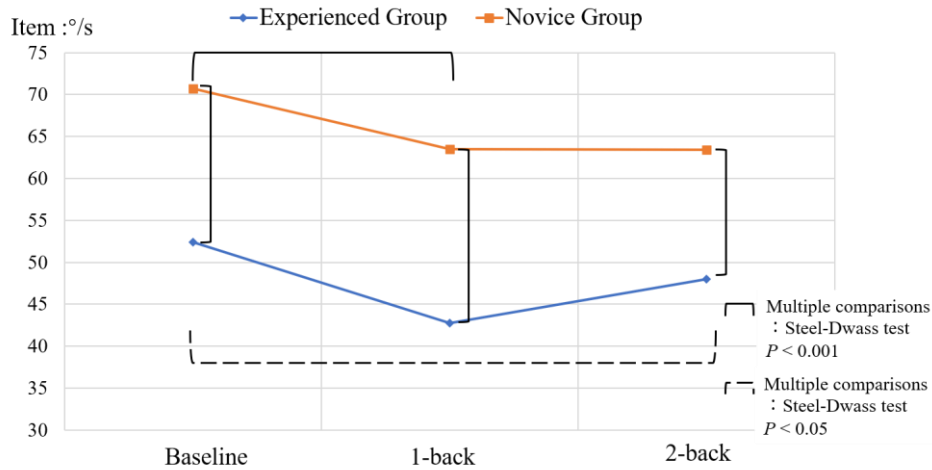
Fig.3-20 Saccade peak speed of two groups on each experiment

3.5 The speed performance of distracted drivers

The speed data was picked up as the same with the procedure of eye movement measures gathered. A total of 35 seconds speed data were analyzed. The drivers were divided into novice group and experienced group by the time they get their driving license. As shown in **Fig. 3-21.** Firstly, the
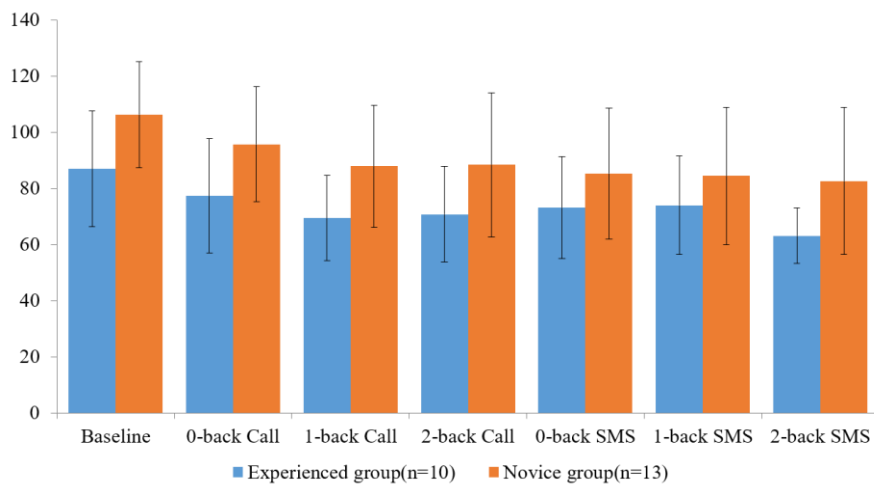
Fig. 3-21   Average speed of two groups on each experiment

experienced group have a slowly average speed comparing to novice group on every experiment; then both the novice group and experienced group experienced a decrease on speed from 0-back call to 2-back SMS. as for the comparison of standard deviation of speed, the novice drivers is unsteady comparing to experienced group.

3.6 The perceived distraction degree and perceived difficulty degree

In the gap between each set of experiment, there is a simple questionnaire, ask them to rank the difficulty degree from number 0-10 to each experiment, 0 is not distracted/ difficult at all and 10 is too distracted/most difficult to finish it.

3.6.1 The perceive distraction degree

The perceived distraction degree rank is, from the most distracted to the less distracted, 2-back SMS, 1-back SMS, 2-back call, 0-back SMS, 1-back call and 0-back call. The result is shown **Fig. 3-22**.

Kruskal-Wallis test
Chi-square value: 16.3624
P value:0.0059** ＊：P<0.05 ＊＊：P<0.01
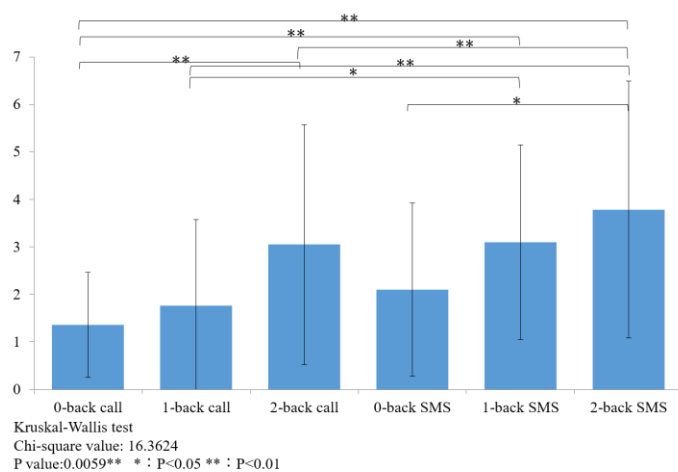
Fig. 3-22 The perceived distraction degree

Kruskal-Wallis test
Chi-square value: 16.3624
P value: P<0.001** ＊：P<0.05 ＊＊：P<0.01
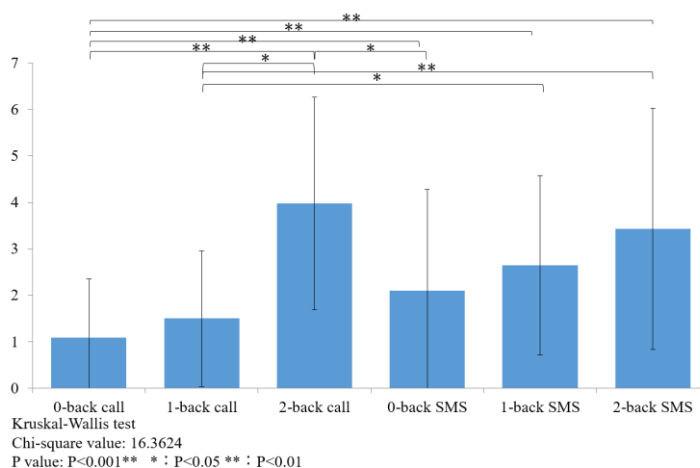
Fig. 3-23 The perceived difficulty degree

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3.6.2 The perceived difficulty degree

The perceived difficulty degree rank is, from the most difficult to the less difficult , 2-back call, 2-back SMS, 1-back SMS, 0-back SMS, 1-back call and 0-back call. The result is shown **Fig. 3-23**.

These two figures shown that the perceived distraction and difficulty are not the same, as the former research shown even the easiest 0-back SMS will make a stronger influence on eye movement measures and speed performance, it is concluded that the drivers may have a biased understanding about the distraction degree and difficulty degree of specific behaviors.

3.7 The summary of this chapter

In this study, the eye movement measures of novice and experienced drivers were being analyzed when conducting n-back experiments. The difference among each level of subtasks were also being compared. It is found that eye movement measures and difficulty of subtask is relevant when trying to differentiate between drivers with different levels of experience. Results are concluded in below.

1) Fixation: firstly, all drivers in both groups (experienced/novice) gazed at the middle area the most. Secondly, when the difficulty of subtask increase, the centralization of novice drivers is much severely than experienced drivers. The fixation distribution on each area were also been quantified. Unlike many studies separated the visual research into two dimensions, horizontal and vertical[17-21], in this study, the comparison is visual area, not only one dimension. Difference between novice drivers and experienced drivers are being found, this finding thrown a light in educate the new drivers, make them get the necessary visual search skills quickly. This finding is also useful for the driver assistance system to distinguish the driver's type, to make better driving assistance.

2) Blink: blink duration of two groups is getting longer with n-back experiment involvement, the time of novice is longer than experience group. Mayhew et a[124]'s result shown that blink duration is related to cognitive distraction degree. The result confirmed that even conducting same subtasks, the effect on cognitive for different drivers is different, the effect to novice drivers is larger than experienced drivers. Since blink has no benefit for information gathering, more blink time cause a decrease of gaze and glance behavior, which result in more exposures to danger.

3) Saccade: saccade peak speed is being studied, research have shown the saccade peak speed could be a useful diagnostic index for the assessment of operators' mental workload and attentional statet[25] as well as fatigue degree[26], As the mental workload increases, the saccade peak speed decreases, in this study, the peak speed of novice is slowly than the experienced, it means when driving at same situation, the driving takes more workload for novice drivers than experienced driver.

4) Pupil size: pupil size of novice group is larger than experienced group, there is no significant difference between each experiment in novice group; the baseline is smaller than 1-back and 2-back experiment in experienced group. Demberg et al. [27]'s results shown, pupil size and distraction degree are related, with distraction degree increase, the pupil size will be getting larger and larger. Similar with blink duration time, the distraction degree of novice drivers is more severely than experienced drivers when conducting same subtasks.

5) Speed performance:

This study provides that comparing to experienced drivers, the novice drivers have a more

centralized visual spread area, longer blink duration, faster saccade peak speed and larger pupil size. In a word, when conducting a same task, in same driving situation, the eye movement measures of novice drivers are different comparing to experienced drivers, the difference is not only the driving skills, but also in the working process of brain. In addition to providing more accurate information on educating novice drivers, it is hoped that these results can be used in the development of distraction monitoring devices and autonomous driving systems, just like Catalbas et al. [28]'s, Di et al. [29]'s and Vicente[30] 's research.

The present study has some methodological limitations should be taken into account. First, the samples of the study were small. Second, the data gathered by eye tracker is not include the head angle when driving, this disadvantage is hoping to be compensated by the simple driving environment, which all drivers do not need to change lanes or turn around, the rotation of head is negligible. Third, not all the eye movement measures are being analyzed, such as saccade average speed and average acceleration. In future, our study will increase the sample size, set up more precise experiment processes, and provide a more com-prehensive analysis of eye movement indictors.

[Reference]

1. Sivak M. The information that drivers use: is it indeed 90% visual? Perception, vol. 25, no. 9, pp. 1081-1089, 1996.

2. Carsten O, Brookhuis K. Issues arising from the HASTE experiments. Transportation Research Part F: Traffic Psychology and Behaviour, vol. 8, no. 2, pp. 191-196, 2005.

3. Angell L S, Auflick J, Austria P A, et al. Driver workload metrics task 2 final report. 2006.

4. Engström, I., Gregersen, N. P., Hernetkoski, K., Keskinen, E. and Nyberg, A.: Young novice driver education and training, literature review,A VTI-rapport, Vol. 491A. Linköping: Swedish National Road and Transport Research Institute, 2003.

5. Curry, A. E., Pfeiffer, M. R., Durbin, D. R., and Elliott, M. R. : Young driver crash rates by licensing age, driving experience, and license phase, Accident Analysis and Prevention, Vol. 80, pp. 243–250, 2015.

6. McCartt, A. T., Mayhew, D. R., Braitman, K. A., and Ferguson, S. A. et al. : Effects of age and experience on young driver crashes: review of recent literature, Traffic injury prevention, Vol. 10, No. 3, pp. 209–219, 2009.

7. Ulmer, R. G., Williams, A. F., and Preusser, D. F. : Crash involvements of 16-year-old drivers, Journal of Safety Research, Vol. 28, No. 2, pp. 97–103, 1997.

8. Mayhew, D. R., Simpson, H. M., and Pak, A. : Changes in collision rates among novice drivers during the first months of driving, Accident Analysis and Prevention, Vol. 35, No. 5, pp. 683–691, 2003.

9. National Research Council : Preventing teen motor crashes: contributions from the behavioral and social sciences: Workshop report, 2007.

10. Young, R.A., "Distracted Driving and Crash Risk," New England Journal of Medicine 370(16):1564, 2014.

11. Pickrell, T. M., Li, R., and KC, S. : Driver electronic device use in 2015 (Traffic Safety Facts Research Note. Report No. DOT HS 812 326), Washington, DC: National Highway Traffic Safety Administration, 2016.

12. National Highway Traffic Safety Administration : Traffic Safety Facts Research Note: Distracted Driving 2014, Washington, DC, United States: National Highway Traffic Safety Administration, 2016.

13. National Highway Traffic Safety Administration : Distracted Driving in Fatal Crashes, 2017, Washington DC: U.S. Department of Transportation, 2019.

14. Caird, J. K., Johnston, K. A., Willness, C. R., and Asbridge, M. et al. : A meta-analysis of the effects of texting on driving, Accident Analysis and Prevention, Vol. 71, pp. 311–318, 2014.

15. 本田正英 : 携帯電話等の使用が要因となる事故の分析，交通事故総合分析センター第 18 回交通事故・調査分析研究発表会論文集 ，2015.

16. Honda M. : Analysis of accidents caused by the use of mobile phones, etc, Proceedings of the 18th Traffic Accident and Investigation Analysis Research Presentation.Tokyo: Institute for Traffic Accident Research and Data Analysis, 2015.

17. Mourant, R.R., Rockwell, T.H., 1972. Strategies of visual search by novice and experienced drivers. Hum. Factors 14 (4), 325–335.

18. Bos, A.J., Ruscio, D., Cassavaugh, N.D., Lach, J., Gunaratne, P., Backs, R.W.: Comparison of novice and experienced drivers using the SEEV model to predict attention allocation at intersections during simulated driving. Proceedings of the Eighth International Driving Symposium on Human Factors in Driver Assessment, 2015.

19. Lehtonen, E., Lappi, O., Koirikivi, I., Summala, H.: Effect of driving experience on anticipatory look-ahead fixations in real curve driving. Accident Analysis and Prevention,70, 195–208. 2014.

20. Yeung, J.S., Wong, Y.D.: Effects of driver age and experience in abrupt-onset hazards. Accident Analysis and Prevention, 78, 110–117, 2015.

21. Hills, P.J., Thompson, C., Pake, J.M.: Detrimental effects of carryover of eye movement behaviour on hazard perception accuracy: effects of driver experience, difficulty of task, and hazardousness of road. Transp. Res. Part F Traffic Psychol. Behav. 58, 906–916, 2018.

22. Crundall, D., Underwood, G., Chapman, P.: Driving experience and the functional field of view. Perception 28 (9), 1075–1087, 1999.

23. Konstantopoulos, P., Chapman, P., Crundall, D.: Driver's visual attention as a function of driving experience and visibility. Using a driving simulator to explore drivers' eye movements in day, night and rain driving. Accident Analysis and Prevention, 42 (3), 827–834, 2010.

24. Borowsky, A., Oron-Gilad, T.: Exploring the effects of driving experience on hazard awareness and risk perception via real-time hazard identification, hazard classification, and rating tasks. Accident Analysis and Prevention, 59, 548–565,2013.

25. Mayhew, D. R., Robertson, R. D., Brown, S., and Vanlaar, W. : Driver distraction and hands-free texting while driving, 2013.

26. Di, Stasi.LL, Renner,R., Staehr,P. et al.: Saccadic peak velocity sensitivity to variations in mental workload. Accident Analysis and Prevention,81(4),413-417,2010.

27. Hirvonen, K., Puttonen, S., Gould, K., Korpela, and J. et al. : Improving the saccade peak velocity measurement for detecting fatigue, Journal of Neuroscience Methods, Vol. 187, No. 2, pp. 199–206, 2010.

28. Demberg, V., Sayeed, A., Mahr, A., and Müller, C. : Measuring linguistically-induced cognitive load during driving using the ConTRe task, Proceedings of the 5th international conference on automotive user interfaces and interactive vehicular applications, 2013.

29. Catalbas, M. C., Cegovnik, T., Sodnik, J., and Gulten, A. : Driver fatigue detection based on saccadic eye movements, 2017. 2017 10th International Conference on Electrical and Electronics Engineering (ELECO) : IEEE.

30. Di Stasi, L. L., Marchitto, M., Antolí, A., and Cañas Delgado, J. J. : Testing saccadic peak velocity as an index of operator mental workload: A partial overview, Human Factors and Ergonomics in Manufacturing and Service Industries (submitted for publication),2015.

31. Vicente, F., Huang, Z., Xiong, X., Torre, F. D. la, Zhang, W., & Levi, D.: Driver Gaze Tracking and Eyes Off the Road Detection System. IEEE Transactions on Intelligent Transportation Systems, 16(4), 2014–2027, 2015.

Chapter 4. Attitude towards distracted driving of Chinese drivers

In this chapter, the attitude towards distracted driving was discussed. For road safety, it is necessary to find out what factors affect the driver's attitude towards distracted driving. A questionnaire was designed to collect necessary data including attitudes towards many types of distracted driving behaviors, quality of life (QOL), driving awareness, personal attributes, and accident-related experiences of private car owners. A structural equation model (SEM) was established to estimate the correlation between the attitude towards distracted driving and the observed variables. The results show that driving awareness, QOL, personal attributes are related to the attitude towards distracted driving; QOL and driving awareness are correlated, and the attitude toward distracted driving is related to the accident experience. The result is beneficial for us to understand distracted driving and to improve road safety.

4.1 Introduction

The traffic accident is a severe threat to global health; the lives of approximately 1.35 million people are cut short due to a road traffic crash in 2016. More people suffer non-fatal injuries, with many incurring a disability because of their injury. Road traffic injury is now the leading cause of death for children and young adults aged 5-29 years [1].

Driver distraction is consistently demonstrated to be a leading cause of traffic crashes world-wide[2]. There is growing evidence that indicates that crashes resulting from distracted driving pose a significant road safety problem both nationally and internationally[3-4]. In many developed countries, the number of motor vehicle crashes has declined over the years but crashes resulting from distracted driving increase significant morbidity and mortality. In 2012, 3,328 people were killed on U.S. roadways in motor vehicle crashes reported to have involved distracted driving[5], six percent of all drivers in-volved in fatal crashes were reported as distracted at the time of the crash[1]. The total accident figure in Japan decreased year by year, but the cell phone-related distracted driving accident in-creased 1.6 times among five years from 2011-2016[4]. Various countries have enacted laws and regulations to stop distracted driving, but un-like drunk driving or speed driving, distracted driving is difficult to monitor. Relying on rigid rules to stop this behavior has little effect; we need to solve the distracted driving issue from the conscious level.

According to the planned theory (TPB) [6], attitude is directly linked to behavior, Areal and Carter et al. [7-8]'s researches is consistent with this theory. They found attitudes are an important predictor of distracted driving; all these findings proved that it is of great importance to understand driver's attitudes toward distracted driving to re-duce distracted driving behaviors.

Many scientists pay attention to this area, White et al.[9] found that drivers perceived using hands-free phones, eating, and drinking while driving as having a low-risk level, while grooming, making a call on a handheld phone, looking at a map, receiving a call on a handheld phone are highest among of risk. Titchener and Wong[10] found participants rating for reaching for an object as high risk, whereas accessories on other vehicles and shops on the sidewalk had the lowest perceived risk. Huemer and Vollrath[11] found that outside distracters were rated as dangerous by a majority of the participants. The different attitudes toward specific distracted driving behaviors were discussed in these research.

Understand the attitude towards distracted driving is not enough. Figure out what factors influence the attitude has practical significance to avoid distracted driving. Many research pieces are focused on this topic, they found whether a drive conducts a distracted behavior may be influenced by perceived knowledge of this behavior, fairness beliefs, and ratings of perceived visual and cognitive demands[12]. Personality measures are also a factor related to distracted behavior[13].

But the existing research has limitations. The research of attitudes toward distracted behaviors is not specific enough, especially not consider the different types of distracted driving by cellphone, and the distraction features among them. In addition, the research on the factors that affect the attitude toward distracted driving is not comprehensive enough, especially the correlation be-tween the influencing factors is not considered.

We are trying to fill these blanks. We build a questionnaire to inquire about the drivers' attitude towards distracted driving behaviors, driving awareness, quality of life (QOL)factors, and personal attributes, explore these factors 'relationship. And then, establish an SEM model to explore their internal connections and influence degree. This study hopes to be more clearly understand the influencing factors of attitude towards distracted driving and pointing out the direction for reducing distracted driving behavior.

4.2 Research outline

The respondents were those aged 20-65 who had a valid driver's license and drove more frequently than once a month. The contents of the questionnaire include gender, education, career, driving frequency, driving awareness, QOL, attitudes toward distracted behaviors. To ensure sufficient sample size, we conduct the online questionnaire survey twice; 564 responses were gathered in total. In order to ensure the effectiveness of the sample, the date was removed which not answered all the questions; or those who choose the same options for all questions, the final number of valid samples was 472, the research outline is shown in **Table 4.1**.

4.3 Participants' information

The basic information of the participants is shown in **Table 4.2**. 185 were women and 287 were men. Five age groups, 18-25 years is 5.72%, 26-35 accounted for 23.09%, 36-45 years old is 25.85%, 46-55 years old accounted for 30.93%, 56-65 years accounted for 14.41%; 46.2% of drivers drive every day; 49.8% of drivers with annual driving miles of less than 6000km, 33.1% of drivers with annual driving miles of less than 6000km, and drivers between 6000km and 12,000km accounted for 17.2%.

4.4 Attitude towards distracted driving

According to previous research, attitude towards distracted driving is a subjective mix of social and psychological factors that can influence individuals' behaviors and decision making[14]. For drivers, the attitude towards one possible dangerous behavior can be various and biased by age[12,15], gender[12], transportation mood, and many other factors. In this study, the attitude towards distracted driving is the objective variable and being analyzed.

Table 4-1 Questionnaire Research Outline

Method	Web Research
Research target	Adults with a driver's license
Research period	2019.7.1~4，2020.4.2~7
Sample	Total 564, Valid 472
Contains	Personal attributes
	Social capital scale
	Driving behaviors scale
	Risk perception of dangerous behavior
	Experience of accident

Table 4-2 Participants' information

Gender	Male	287(60.81%)
	Female	185(39.19%)
Age	18~25 years	27(5.72%)
	26~35 years	109(23.09%)
	36~45 years	122(25.85%)
	46~55 years	146(30.93%)
	56~65 years	68(14.41%)
Driving Frequency	Every day	218(46.19%)
	Not every day	254(53.81%)

4.4.1 Items of attitude towards distracted driving

The items are shown in **Fig.4.1**. The participants were asked to rank the dangerous degree of specific behaviors, from 1 to 5 points, in which 1 point means not dangerous, 5 points means dangerous. There are 9 items of distracted driving behaviors, the aggregate result has shown the participants take a different attitude towards these behaviors: playing mobile games are being regarded as the most dangerous behavior, follows by browsing the web and send/receive text messages; meanwhile, car equipment settings are regarded as the less dangerous behavior, follows by using a hands-free phone while driving.

4.4.2 Features of attitudes towards distracted driving

First, we conducted a factor analysis to grasp the commonalities in these items. Cronbach's α is 0.837, and the AMO value is 0.848, which indicates that the scale is trustful and the factor analysis is credible. The results of the factors are shown in **Table 4.3**, and the green color indicates the high value of the factor score.

Factor 1 is "sensitive to high demand distracting behaviors" because high-load factors are those that require high demand behaviors, such as playing mobile games, browsing the Internet, and sending and receiving text messages; factor 2 is "sensitive to low demand distracting behaviors", because compared to factor 1, the caused distractions of this factor is less, such as the use of hands-free phones, drinks, cigarettes and on-board equipment.
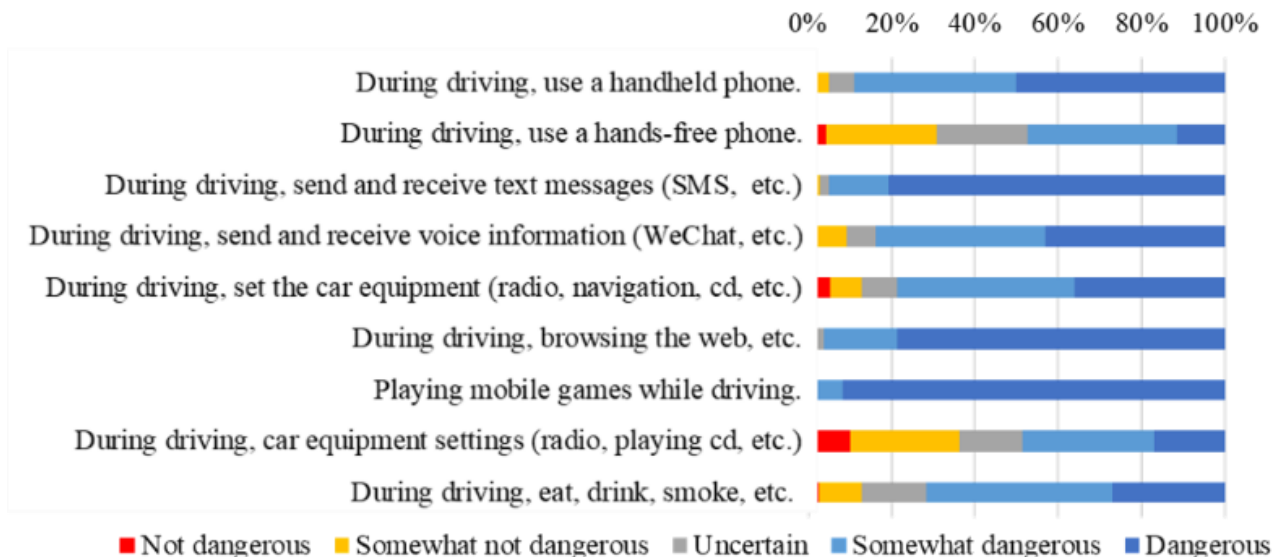
Fig.4-1 Aggregate results of attitude towards distracted driving

Based on the factor analysis to group the attitude towards distracted of participants, a cluster analysis was being conducted, the Ward method was used for cluster stratification, and the Square Euclidean Distance was used for the distance between groups. The participants have been di-vided into three groups. The average factor loads of each cluster are shown in **Table 4-4**. Depending on factor loads of each group named group 1 is "Attitude: incorrect group", group 2 is "Attitude: average group", and group 3 is "Attitude: correct group". Then, we confirmed the validity of the cluster analysis. When the normality test was performed on each cluster, the normality was not confirmed. Therefore, the difference in the mean value of the factor loads between the clusters was tested by the Kruskal-Wallis test. In addition, as a result of multiple comparisons by the Steel-Dwass test, a statistical difference was found at the 1% significance level among all the control groups, indicating the validity of the cluster.

Table 4-3 Factor analysis result of attitude towards distracted driving

Distracted behavior item	Factor1 Sensitive in high demand distraction	Factor2 Sensitive in low demand distraction
Playing mobile games while driving.	.862	.007
During driving, browsing the web, etc.	.837	.215
During driving, send and receive text messages (SMS, etc.)	.808	.270
During driving, use a hands-fr.ee phone.	.074	.743
During driving, eat, drink, smoke, etc.	.148	.720
During driving, car equipment settings (radio, playing cd, etc.)	.066	.684
During driving, use a handheld phone.	.476	.583
During driving, set the navigation.	.358	.545
During driving, send and receive voice information (WeChat, etc.)	.471	.514
Inherent quality	3.960	1.305
Contribution ratio	44.00%	14.50%
Cumulative contribution	44.00%	58.50%

Table 4-4 Average factor score of driving awareness clusters

No.1	Factor1 Sensitive in high demand distraction	Factor2 Sensitive in low demand distraction	n	Name
Cluster1	-1.67579	-0.69966	77	Attitude : incorrect
Cluster2	0.544643	-0.85334	161	Attitude : average
Cluster3	0.183865	0.820347	234	Attitude : correct

4.4.3 Relationships between attitude towards distracted driving and handheld cellphone use

We conduct independence and cluster analysis to analysis the attitudes towards distracted driving and experience of handheld cellphone use; the result is shown in **Fig.4-2**. The question is " have you ever use a handheld cellphone while driving ?" 338 out of 472 participants admitted they had used handheld cell-phone while driving, and the residual analysis showed, the drivers in the attitude incorrect and average group have a higher possibility used cellphone, and the drivers who belong to the attitude correct group have a higher possibility to have not used a hand-held cellphone while driving. These results confirmed that attitude is linked to behaviors; the drivers who regarded distracted driving is not dangerous are more likely to participate in distracted driving behavior.
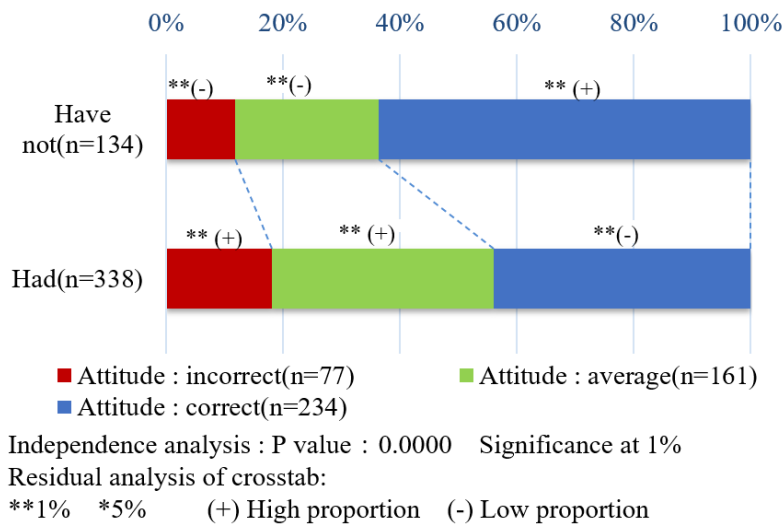
Independence analysis : P value : 0.0000   Significance at 1%
Residual analysis of crosstab:
**1%   *5%   (+) High proportion   (-) Low proportion
Fig. 4-2 The relationship between attitude towards distracted driving and hand-held cellphone use experience

4.5 Driving awareness

In this chapter, driving awareness is being summarized, and the participants were divided into groups by their characteristic of driving awareness. Driver awareness refers to the way people choose to drive or driving preference that have developed over time[16].

4.5.1 Driving awareness characteristics of participants

A scale consists of 9 items was being used to describe the drivers' driving awareness, each item uses a 5-rank from 1 point (disagree) to 5 points (agree), and the total score of those 9 questions (5 to 45 points) is calculated and measured. It is judged that the higher the score, the safer a respondent's drive, the aggregate results are shown in **Fig.4-3**.

Firstly, factor analysis was conducted. The factor analysis result is shown in **Table 4-5**. The Cronbach'sα is 0.819, and AMO value is 0.825, which means the scale and the result of factor analysis are re-liable.

Factor 1 is "care about other road users" due to the items are about pedestrians and cyclists, factor 2 is "accident prevention driving" because the items are about to prevent an accident; factor 3 named "stable driving" because the items are about driving steady and not speeding.

Subsequently, cluster analysis was performed using the factor scores obtained from the factor analysis. The Ward method was used for cluster stratification, and the Square Euclidean Distance was used for the distance between groups, and individuals were classified into 4 clusters. **Table 4-6** shows the average value and characteristics of the factor scores of each cluster.

In the first cluster, the "stable driving" axis is the lowest, the group name is "unstable driving group." The second cluster is named "safe driving group" because the three axes' average factor scores
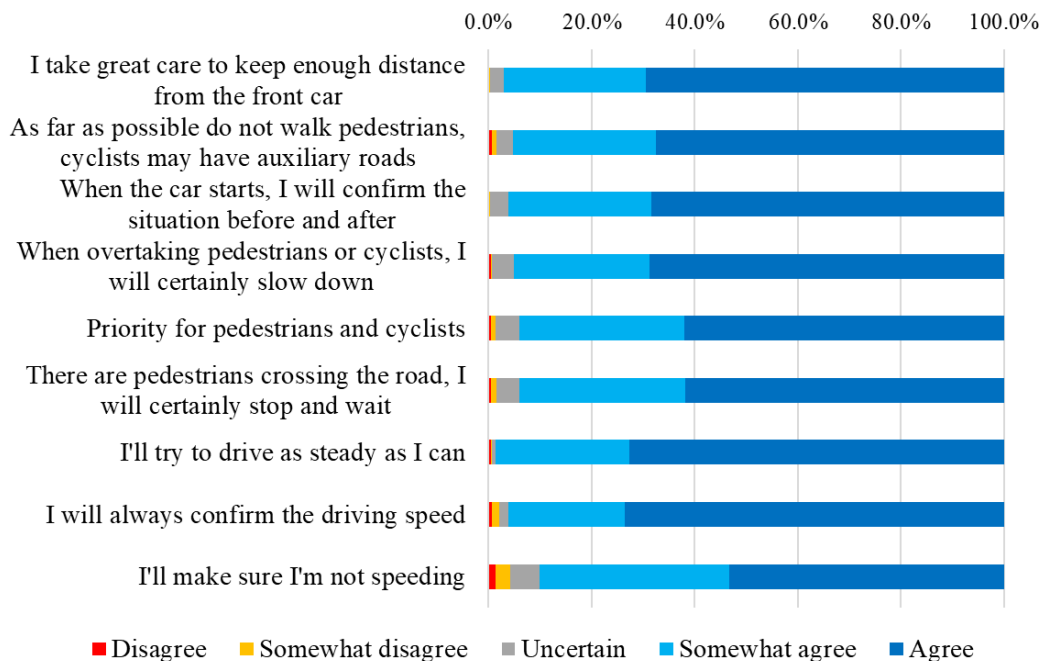
Fig. 4-3 Aggregate results of driving awareness

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are high, and the third cluster is the "self-centered driving group" because the "care about other road users" factor is lowest. The fourth cluster was rated "dangerous driving group" because this group is lowest in accident prevention driving factor, and other two factors are also at a low level.

4.5.2 The relationships between driving awareness characteristics and attitude towards distracted driving

In this section, the relationships between driving awareness and attitude towards distracted driving were analyzed. To understand the detailed relations, the independence test and residual test are conducted between the driving awareness clusters and items of attitude towards distracted driving

Table 4-5 Factor analysis result of driving awareness

Driving awareness item	Factor1	Factor2	Factor3
	Care about other road users	Precautions driving	Stable driving
Priority for pedestrians and cyclists.	0.863	0.192	0.123
There are pedestrians crossing the road, I will certainly stop and wait.	0.834	0.185	0.11
When overtaking pedestrians or cyclists, I will certainly slow down.	0.641	0.26	0.208
As far as possible do not walk pedestrians, cyclists may have auxiliary roads.	0.1	0.853	0.067
I take great care to keep enough distance from the front car.	0.268	0.693	0.204
When the car starts, I will confirm the situation before and after.	0.342	0.671	0.191
I'll make sure I'm not speeding.	0.072	0.062	0.778
I will always confirm the driving speed.	0.121	0.12	0.75
I'll try to drive as steady as I can.	0.285	0.333	0.612
Inherent quality	2.15	1.926	1.696
Contribution ratio	23.89%	21.40%	18.85%
Cumulative contribution	23.89%	45.29%	64.14%

Table 4-6 Average factor score of driving awareness clusters

No.	Care about pedestrians	Precautions driving	Stable driving	n	Name
1	0.45324	0.274221	-1.66752	66	Unstable driving group
2	0.475175	0.413158	0.437758	218	Safe driving group
3	-1.43413	0.669157	0.11905	80	Self-centered driving group
4	-0.17381	-1.49722	0.047232	108	Dangerous driving group

separately, the results are summarized in **Table 4-7**. Except for the item "playing mobile games while driving", the driving awareness groups have shown a significant difference on the attitude towards distracted driving behaviors.

For the drivers who belong to the safe driving group(n=218), they tend to regard every behavior is "dangerous" at 1% level except "playing mobile games". For the drivers of the dangerous driving

Table 4-7 The summary of relationships between driving awareness characteristics and attitude towards distracted driving

Distracted driving behaviors	Unstable driving (n=66)	Self-centered driving (n=80)	Safe driving (n=218)	Dangerous driving (n=108)	P value	
During driving, use a handheld phone.						
Not dangerous	1(1.5%)	1(1.3%)	1(0.5%)	6(5.6%)	P < 0.001	**
Somewhat not dangerous	2(3%)	3(3.8%)	5(2.3%)	4(3.7%)		
Uncertain	4(6.1%)	6(7.5%)	14(6.4%)	5(4.6%)		
Somewhat dangerous	34(51.5%)	39(48.8%)	50(22.9%)	60(55.6%)		
Dangerous	25(37.9%)	31(38.8%)	38(17.4%)	143(132.4%)		
During driving, use a hands-free phone.						
Not dangerous	2(3%)	4(5%)	3(1.4%)	11(10.2%)	0.0104	*
Somewhat not dangerous	20(30.3%)	22(27.5%)	35(16.1%)	48(44.4%)		
Uncertain	17(25.8%)	22(27.5%)	32(14.7%)	33(30.6%)		
Somewhat dangerous	18(27.3%)	27(33.8%)	27(12.4%)	96(88.9%)		
Dangerous	9(13.6%)	5(6.3%)	11(5%)	30(27.8%)		
During driving, send and receive text messages (SMS, WeChat, email, etc).						
Not dangerous, somewhat not dangerous	0%	2(2.5%)	2(0.9%)	9(8.4%)	0.0052	**
Uncertain	2(3%)	2(2.5%)	3(1.4%)	4(3.7%)		
Somewhat dangerous	10(15.2%)	12(15%)	28(12.8%)	17(15.7%)		
Dangerous	54(81.8%)	64(80%)	75(34.4%)	188(174.1%)		
During driving, send and receive voice information (WeChat, etc) .						
Not dangerous	0%	2(2.5%)	0%	5(4.6%)	P < 0.001	**
Somewhat not dangerous	5(7.6%)	3(3.8%)	15(6.9%)	14(13%)		
Uncertain	8(12.1%)	5(6.3%)	13(6%)	7(6.5%)		
Somewhat dangerous	31(47%)	40(50%)	41(18.8%)	79(73.1%)		
Dangerous	22(33.3%)	30(37.5%)	39(17.9%)	113(104.6%)		
During driving, car equipment settings (radio, playing cd, etc) .						
Not dangerous	6(9.1%)	3(3.8%)	5(2.3%)	11(10.2%)	0.0162	*
Somewhat not dangerous	2(3%)	6(7.5%)	12(5.5%)	15(13.9%)		
Uncertain	6(9.1%)	5(6.3%)	16(7.3%)	14(13%)		
Somewhat dangerous	28(42.4%)	44(55%)	46(21.1%)	82(75.9%)		
Dangerous	24(36.4%)	22(27.5%)	29(13.3%)	96(88.9%)		

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Table 4-7 The summary of relationships between driving awareness characteristics and attitude towards distracted driving

Distracted driving behaviors	Unstable driving (n=66)	Self-centered driving (n=80)	Safe driving (n=218)	Dangerous driving (n=108)	P value	
Playing mobile games while driving.						
Not dangerous, somewhat not dangerous, uncertain	1(1.5%)	0(0%)	4(1.8%)	6(5.6%)	0.1421	
Somewhat dangerous	5(7.6%)	4(5%)	11(5%)	8(7.4%)		
Dangerous	60(90.9%)	76(95%)	93(42.7%)	204(188.9%)		
During driving, set the navigation.						
Not dangerous	10(15.2%)	3(3.8%)	13(6%)	22(20.4%)	P < 0.001	**
Somewhat not dangerous	20(30.3%)	40(50%)	28(12.8%)	35(32.4%)		
Uncertain	7(10.6%)	10(12.5%)	25(11.5%)	30(27.8%)		
Somewhat dangerous	20(30.3%)	21(26.3%)	31(14.2%)	77(71.3%)		
Dangerous	9(13.6%)	6(7.5%)	11(5%)	54(50%)		
During driving, eat, drink, smoke, etc.						
Not dangerous	2(3%)	1(1.3%)	3(1.4%)	6(5.6%)	P < 0.001	**
Somewhat not dangerous	6(9.1%)	13(16.3%)	12(5.5%)	17(15.7%)		
Uncertain	8(12.1%)	16(20%)	26(11.9%)	24(22.2%)		
Somewhat dangerous	37(56.1%)	40(50%)	47(21.6%)	86(79.6%)		
Dangerous	13(19.7%)	10(12.5%)	20(9.2%)	85(78.7%)		

Independence analysis   **: significance at 1%,*: significance at 5%

Residual analysis   bold   significance at1%   Blue: high percentage

               significance at 5%   Red: low percentage

(%) Is the basic aggregation result based on the measured frequency

group(n=108), they have a low possibility in regarding basically every behavior is "dangerous" except "playing mobile games while driving", they have shown a high percentage in considering "uncertain" on many behaviors, even regarding "send and receive voice information" is just "somewhat not dangerous". For the drivers of the unstable driving groups(n=66), they have shown a higher percentage in regarding "use a handheld phone", "eat, drink, smoke" are "somewhat dangerous", a low percentage in regarding "use a handheld phone" are "dangerous". For the self-centered driving drivers(n=80), they shared a low percentage in regarding "use a handheld phone" "set the navigation" "eat, drink, smoke" are "dangerous". In summary, driving awareness and attitude towards distracted driving is related.

4.6 QOL scales

According to the World Health Organization (WHO), quality of life is defined as "the individual's perception of their position in life in the context of the culture and value systems in which they live

and in relation to their goals". Unlike the concept of standard of living based primarily on income, QOL includes everything from physical health, family, education, employment, wealth, safety and many other aspects.

The QOL status of drivers is being analyzed to explore whether there is a relation between QOL status and attitude towards distracted driving.

4.6.1 QOL status of participants

For the QOL, there are four domains to summarize including physical health, psychological, social relationships and environment, each do-main is consisting of many questions, the summary of each domain denotes the participants' perception of the quality of life in each particular domain. And the higher the scores equal the higher quality of life. The questions of each domain are listed in **Table 4-8**. Each question has five choices, from 1 to 5 points, and when counting the domain scores, the reverse questions will be adjusted into a positive direction.

Based on the four domains scores to grasp the QOL status of participants. The factor score of each domain has been count, and a cluster analysis was being conducted, the dendrogram of each cluster is shown in **Fig.4-4**. The participants have been divided into three groups. The average do-main scores of each cluster are shown in **Table 4-9**. depending on the domain scores of each group named group 1 is "QOL: low group", group 2 is "QOL: middle group", and group 3 is "QOL: high group". When the normality test was performed on each cluster, the normality was not confirmed. Therefore, the difference in the mean value of the domain scores between the clusters was tested by

the Kruskal-Wallis test. In addition, as a result of multiple comparisons by the Steel-Dwass test, a statistical difference was found at the 1% significance level among all the control groups, indicating the validity of the cluster analysis.

Table 4-8 Items of QOL

Domain	Items
Physical health (Cronbach's α=0.701)	To what extent do you feel that physical pain prevents you from doing what you need to do?
	How much do you need any medical treatment to function in your daily life?
	Do you have enough energy for everyday life?
	How well are you able to get around?
	How satisfied are you with your sleep?
	How satisfied are you with your ability to perform your daily living activities?
	How satisfied are you with your capacity for work?
Psychological (Cronbach's α=0.809)	How much do you enjoy life?
	To what extent do you feel your life to be meaningful?
	How well are you able to concentrate?
	Are you able to accept your bodily appearance?
	How satisfied are you with yourself?
	How often do you have negative feelings such as blue mood, despair, anxiety, depression?
Social relationships (Cronbach's α=0.824)	How satisfied are you with your personal relationships?
	How satisfied are you with your sex life?
	How satisfied are you with the support you get from your friends?
Environment (Cronbach's α=0.813)	How safe do you feel in your daily life?
	How healthy is your physical environment?
	Have you enough money to meet your needs?
	How available to you is the information that you need in your day-to-day life?
	To what extent do you have the opportunity for leisure activities?
	How satisfied are you with the conditions of your living place?
	How satisfied are you with your access to health services?
	How satisfied are you with your transport?

Table 4-9 Average factor score of QOL clusters

No.	Psychological	Physical health	Social relationships	Environment	n	Name
1	19.5643	21.0099	8.64356	24.5446	101	QOL: low
2	23.3096	25.4602	11.159	29.6318	239	QOL: middle
3	26.5076	28.8485	12.6591	34.1515	132	QOL: high

4.6.2 The relationships between QOL and attitude towards distracted driving
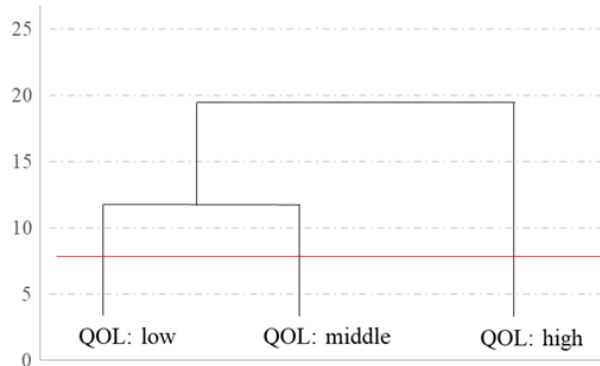
Fig. 4-4 QOL clusters' dendrogram

The independence test and residual test were being conducted to explore the relationship between QOL and driving awareness. The results are shown in **Table 4-10**.

The independence test results show that QOL clusters and attitudes toward distracted driving behaviors are related in some items. The residual test showed that: For drivers in QOL: low group(n=101), they have a larger percentage in regarding "not dangerous" on the items of "use a handheld phone" "set the car equipment (radio, navigation,cd,etc.)" and "playing mobile games while driving." For drivers in QOL: middle group(n=239), they have a larger percentage in regarding "somewhat dangerous" on the item of "send and receive text message (SMS,Wechat, email,etc)", less percentage regarding "not dangerous" on the item of "use a handheld phone" "playing mobile games while driving." For the drivers in QOL: high group(n=132), they shared a larger percentage in regarding "dangerous" on the item of "use a handheld phone" "send and receive voice information (WeChat, etc)." In summary, the higher the quality of life, the more likely they think that distracted driving is more dangerous.

4.6.3 The relationships between QOL status and driving awareness characteristics

In this section, the relationships between QOL status and driving awareness characteristics were analyzed. The results are summarized in **Fig.4-5**.

The independence test has shown a significant relationship between QOL status and driving awareness at a 1% level.

The QOL:low group drivers are more likely to have an unstable driving awareness(significance at 5% level), and less possibility belongs to the safe driving group(significance at 5% level). The drivers of QOL: high group are less possibility belong to the dangerous driving group(significance at 1% level) and more possibility in the safe driving group(significance at 1% level). The results have shown QOL status and driving awareness are positively related.

4.7 The SEM model

Concerning the analysis results up to the previous chapters, we have set the hypothesis that the following stepwise causal relationships exist. We assumed attitude towards distracted driving is influenced by driving awareness, QOL and personal attributes; and the correlation between these

Table 4-10 The summary of relationships between QOL status and attitude towards distracted driving

Distracted driving behaviors	QOL: low(n=101)	QOL: middle(n=239)	QOL: high(n=132)	P value	
During driving, use a handheld phone.				0.0400	*
Not dangerous	5 (5.0%)	1 (0.4%)	3 (2.3%)		
Somewhat not dangerous	6 (5.9%)	6 (2.5%)	2 (1.5%)		
Uncertain	6 (5.9%)	15 (6.3%)	8 (6.1%)		
Somewhat dangerous	39 (38.6%)	101 (42.3%)	43 (32.6%)		
Dangerous	45 (44.6%)	116 (48.5%)	76 (57.6%)		
During driving, use a hands-free phone.				0.1255	
Not dangerous	7 (6.9%)	4 (1.7%)	9 (6.8%)		
Somewhat not dangerous	27 (26.7%)	70 (29.3%)	28 (21.2%)		
Uncertain	23 (22.8%)	57 (23.8%)	24 (18.2%)		
Somewhat dangerous	33 (32.7%)	82 (34.3%)	53 (40.2%)		
Dangerous	11 (10.9%)	26 (10.9%)	18 (13.6%)		
During driving, send and receive text messages (SMS, WeChat, email, etc).				0.0400	*
Not dangerous	2 (2.0%)	1 (0.4%)	4 (3.0%)		
Somewhat not dangerous	2 (2.0%)	1 (0.4%)	3 (2.3%)		
Uncertain	4 (4.0%)	6 (2.5%)	1 (0.8%)		
Somewhat dangerous	11 (10.9%)	44 (18.4%)	12 (9.1%)		
Dangerous	82 (81.2%)	187 (78.2%)	112 (84.8%)		
During driving, send and receive voice information (WeChat, etc).				0.1998	
Not dangerous	3 (3.0%)	1 (0.4%)	3 (2.3%)		
Somewhat not dangerous	9 (8.9%)	19 (7.9%)	9 (6.8%)		
Uncertain	9 (8.9%)	15 (6.3%)	9 (6.8%)		
Somewhat dangerous	41 (40.6%)	107 (44.8%)	43 (32.6%)		
Dangerous	39 (38.6%)	97 (40.6%)	68 (51.5%)		
During driving, set the car equipment (radio, navigation, cd, etc).				0.0478	*
Not dangerous	10 (9.9%)	8 (3.3%)	7 (5.3%)		
Somewhat not dangerous	12 (11.9%)	18 (7.5%)	5 (3.8%)		
Uncertain	5 (5.0%)	24 (10.0%)	12 (9.1%)		
Somewhat dangerous	41 (40.6%)	107 (44.8%)	52 (39.4%)		
Dangerous	33 (32.7%)	82 (34.3%)	56 (42.4%)		
During driving, browsing the web, etc.				0.2262	
Somewhat not dangerous	6 (5.9%)	3 (1.3%)	2 (1.5%)		
Uncertain	1 (1.0%)	4 (1.7%)	1 (0.8%)		
Somewhat dangerous	19 (18.8%)	45 (18.8%)	20 (15.2%)		
Dangerous	75 (74.3%)	187 (78.2%)	109 (82.6%)		

Table 4-10 The summary of relationships between QOL status and attitude towards distracted driving

Distracted driving behaviors	QOL: low(n=101)	QOL: middle(n=239)	QOL: high(n=132)	P value	
Playing mobile games while driving					
Not dangerous, somewhat not dangerous, uncertain	7 (6.9%)	2 (0.8%)	2 (1.5%)	0.0245	*
Somewhat dangerous	4 (4.0%)	19 (7.9%)	5 (3.8%)		
Dangerous	90 (89.1%)	218 (91.2%)	125 (94.7%)		
During driving, set the navigation.					
Not dangerous	14 (13.9%)	18 (7.5%)	16 (12.1%)		
Somewhat not dangerous	26 (25.7%)	66 (27.6%)	31 (23.5%)	0.4681	
Uncertain	15 (14.9%)	42 (17.6%)	15 (11.4%)		
Somewhat dangerous	31 (30.7%)	75 (31.4%)	43 (32.6%)		
Dangerous	15 (14.9%)	38 (15.9%)	27 (20.5%)		
During driving, eat, drink, smoke, etc.					
Not dangerous	3 (3.0%)	3 (1.3%)	6 (4.5%)		
Somewhat not dangerous	14 (13.9%)	17 (7.1%)	17 (12.9%)		
Uncertain	17 (16.8%)	45 (18.8%)	12 (9.1%)	0.0208	*
Somewhat dangerous	35 (34.7%)	109 (45.6%)	66 (50.0%)		
Dangerous	32 (31.7%)	65 (27.2%)	31 (23.5%)		

Independence analysis		**: significance at 1%,*: significance at 5%		
Residual analysis	bold	significance at1%	Blue: high percentage	
		significance at 5%	Red: low percentage	

(%) Is the basic aggregation result based on the measured frequency

factors are also being studied; then, the attitude of distracted driving is directly linked to the accident-related experience.

Then, among these observed variables, delete those variables that are not related to driving awareness and QOL status in chapter 5 and chapter 6. Those whose path reached the significance level of 5% were selected as variables based on the analysis results up to the previous chapters. In addition, for the purpose of the exploratory examination of causal relationships, we decided to add and estimate the paths that reached the significance level of 5% even if the paths were not assumed in the hypothesis. As shown in **Fig.4-6**, the data are standardized for presumption. Some commonly used fit indices, including the good-ness-of-fit index (GFI), adjusted GFI(AGFI), and root mean square error of approximation (RMSEA), are all shown in **Fig.4-6**, which indicates an acceptable fit. The solid line is significant at 1%, the details of variables are shown in **Table 4-11**.

In **Fig.4-6**, the rectangles represent the observed variables. The ellipses represent the unobserved latent variables. The arrows pointing from the observed variables to the latent variables represent the regression paths. In this study, the SEM model consists of 8 latent variables and 22 observed variables, and the measurement error is omitted.

The effect of each variable on the latent variables is studied. In the driving awareness mode, the "accident prevention driving" takes the largest composition with the factor load is 0.89. Driving awareness (factor load=0.25) and QOL (factor load=0.16) have a positive effect on attitude to-wards
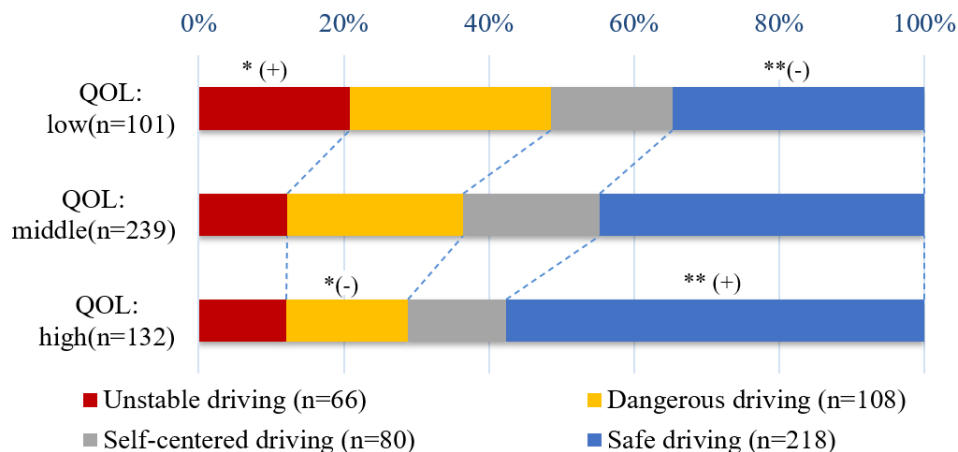
Independence analysis : P value : 0.0000   Significance at 1%
Residual analysis of crosstab:
**1%   *5%   (+) High proportion   (-) Low proportion

Fig. 4-5 The relationship between QOL groups and driving awareness groups

distracted driving; QOL has a positive effect on driving awareness (factor load=0.27); personal attributes also related to attitude towards distracted driving, the drivers with a high education background or driving every day may despise the perceived danger of distracted driving. Female comparing to male is much more cautious about distracted driving. Attitude towards distracted driving is directly linked to accident-related experience, specifically manifested in the traffic accidents, near accidents and violations in last year.

4.8 The summary of this chapter

In this research, through an online questionnaire survey of drivers, we analyzed the relationship between the attitude towards distracted driving and factors including driving awareness, QOL, and personal attributes; and clarified the characteristics of each attitude group. The results are summarized below.

In chapter 4, we analyzed the attitude towards distracted driving. Different from previous studies on distraction attitudes, this time the drivers were asked about their perceptions of the dangers for 9 distraction behaviors, and cluster the drivers by their factor scores on the extracted factors: high demand and low demand distraction. The residual analysis between attitude towards distracted driving group and experience of handheld phone use proved attitude is directly related to behaviors.

In chapter 5, focus on driving awareness, we analyzed the relationship between driving awareness and attitude towards distracted driving through the independence test and residual test. Results showed correct attitude towards distracted driving takes a larger percentage in the safe driving group, a smaller percentage in the self-centered driving group; the incorrect attitude group towards distracted driving takes a larger percentage in the self-centered driving group.

In chapter 6, the QOL status of participants is being analyzed. Relationships between driving awareness and QOL; QOL and attitude towards distracted driving were studied, the independence test showed they are significantly related at 1% level.

Based on the previous chapters' analysis results, in chapter 7, a hypothesis was verified by the SEM model to see the influence degree of each variable on attitude towards distracted driving.

Results show driving awareness and QOL status positively influence attitude to-wards distracted driving; being female, with an education career below than university graduation and not driving every day may have a correct attitude towards distracted driving. The attitude towards distracted driving is strongly related to accident-related experience. The drivers with a correct attitude experienced less accident, less near accident, and fewer violations in the recent year.

As the SEM model shows that it is beneficial to have a correct attitude towards distracted driving. To establish a correct attitude, driving awareness and quality of life are two useful measures. The results show that safe driving tendencies and high QOL status are positively correlated with correct

Table 4-11 Observed variables and latent variables used in the model

Latent variables		Observed variables	Scale / category
Driving awareness	Stable driving	Drive as steady as I can	1. Agree, 0.others
		Confirm the driving speed	
		No speeding	
	Care about other road users driving	Priority for pedestrians and cyclists	
		There are pedestrians crossing the road, I will certainly stop and wait	
		When overtaking pedestrians or cyclists, I will certainly slow down	
	Accident prevention driving	As far as possible do not walk pedestrians, cyclists may have auxiliary roads	
		I take great care to keep enough distance from the front car	
		When the car starts, I will confirm the situation before and after	
QOL		Physical health	3-40 points
		Psychological	
		Social relationships	
		Environment	
Attitude towards to distracted driving		During driving, use a handheld phone	1.Dangerous, 0.others
		During driving, send and receive text messages (SMS, WeChat, email, etc)	
		During driving, set the navigation	
		During driving, eat, drink, smoke, etc	
Personal attributes		Education	1.High school and below, 0. college and above
		Gender	1. Male, 0. female
		Driving frequency	1.Not every day, 0.every day
Accident-related experience		Car accident in recent year	1. Not have, 0.had experienced
		Near-accident in recent year	
		Law violations in recent year	

Fig.4-6 A structural model of attitude towards distracted driving

The present study has certain limitations that must be considered when the results are interpreted. First of all, this research is based on a self-reported questionnaire scale, and the answers suffer from social desirability bias; second, the sample of accident-related experience is quite limited. In further work, the authors are hoped to study the specific drivers who get involved with distracted related accident and to confirm the validity of this model.

[Reference]

1. World Health Organization. Global status report on road safety 2018: Summary. No. WHO/NMH/NVI/18.20. World Health Organization, 2018.

2. Beanland, Vanessa, et al. Driver inattention and driver distraction in serious casualty crashes: Data from the Australian National Crash In-depth Study. Accident Analysis & Prevention Vol.54 pp.99-107, 2013.

3. Honda Masahide. Analysis of accidents caused by the use of mobile phones, etc[C]. Proceedings of the 18th Traffic Accident and Investigation Analysis Research Presentation.Tokyo: Institute for Traffic Accident Research and Data Analysis, 2015.

4. Distracted Driving 2016: DOT HS 812 517[R]. Washington DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 2018.

5. Distracted driving 2014: DOT HS 812 260[R]. Washington DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 2016.

6. Choudhary, Pushpa, and Nagendra R. Velaga. Modelling driver distraction effects due to mobile phone use on reaction time. Transportation Research Part C: Emerging Technologies Vol.77, pp351-365, 2017.

7. Rosenbloom, Tova. Driving performance while using cell phones: An observational study. Journal of Safety Research. Vol.37, No.2, pp207-212, 2006.

8. Strayer, David L., Frank A. Drews, and Dennis J. Crouch. A comparison of the cell phone driver and the drunk driver. Human factors Vol.48, No.2, pp381-391, 2006.

9. Rudin-Brown, Christina M., et al. Driver distraction in an unusual environment: Effects of text-messaging in tunnels. Accident Analysis & Prevention Vol. 50 pp122-129, 2013.

10. Lesch, Mary F., and Peter A. Hancock. Driving performance during concurrent cell-phone use: are drivers aware of their performance decrements?. Accident Analysis & Prevention Vol.36, No.3, pp471-480, 2004.

11. White, Katherine M., et al. Mobile phone use while driving: An investigation of the beliefs influencing drivers' hands-free and hand-held mobile phone use. Transportation Research Part F: Traffic Psychology and Behaviour Vol.13, No.1   pp9-20, 2010.

12. Li, Xiaomeng, et al. A rear-end collision risk assessment model based on drivers' collision avoidance process under influences of cell phone use and gender—A driving simulator based study. Accident Analysis & Prevention Vol. 97, pp1-18, 2016.

13. Areal, A. Texting Distracted Driving Behaviour among European Drivers: Influence of Attitudes, Subjective Norms and Risk Perception. Prevencao Rodoviaria Portuguesa. Paris, France. Accessed 15 March 2017. www.esranet.eu.

14. Carter, Patrick M., et al. Social norms and risk perception: Predictors of distracted driving

behavior among novice adolescent drivers. Journal of Adolescent Health Vol 54, No.5, ppS32-S41, 2014.

15. White, Mathew P., J. Richard Eiser, and Peter R. Harris. Risk perceptions of mobile phone use while driving. Risk Analysis: An International Journal Vol.24, No.2 pp323-334, 2014.

16. Titchener, Kirsteen, and Ides Y. Wong. Driver distractions: characteristics underlying drivers' risk perceptions. Journal of Risk Research Vol.13, No.6 pp771-780, 2010.

17. Huemer, Anja Katharina, and Mark Vollrath. Driver secondary tasks in Germany: Using interviews to estimate prevalence. Accident Analysis & Prevention Vol.43, No.5, pp1703-1712, 2011.

18. Rupp, Michael A., Marc D. Gentzler, and Janan A. Smither. Driving under the influence of distraction: examining dissociations between risk perception and engagement in distracted driving. Accident Analysis & Prevention Vol.97, pp220-230, 2016.

19. Gentzler, Marc D., et al. Examining drivers' perception of internal and external distracter risk and predictors of these perceptions. Proceedings of the Human Factors and Ergonomics Society Annual Meeting. Vol. 57. No. 1. Sage CA: Los Angeles, CA: SAGE Publications, 2013.

20. Wang, Baojin, David A. Hensher, and Tu Ton. Safety in the road environment: a driver behavioural response perspective. Transportation Vol.29.3 (2002): 253-270.

21. Ram, Tika, and Khem Chand. Effect of drivers' risk perception and perception of driving tasks on road safety attitude. Transportation research part F: traffic psychology and behaviour Vol.42, pp162-176, 2016.

22. Rupp, Michael A., Marc D. Gentzler, and Janan A. Smither. "Driving under the influence of distraction: examining dissociations between risk perception and engagement in distracted driving." Accident Analysis & Prevention Vol.97, pp220-230, 2016.

23. Elander, James, Robert West, and Davina French. "Behavioral correlates of individual differences in road-traffic crash risk: An examination of methods and findings." Psychological bulletin Vol. 113, No.2 pp279, 1993.

24. Haruka Uno, Yuyang Zhang, Shigehito Hashimoto. Factor analysis of drivers' driving tendency. Proceedings of the Japan Society of Traffic Engineers Vol.37 pp213-216, 2017.

Chapter 5. Attitude towards distracted driving due to cellphone use of Japanese drivers

Distracted driving by using a mobile phone has a risk of causing a car accident, and in order to eliminate such a risk, it is necessary to study factors that influence the attitude toward the use of a mobile phone while driving. In this study, 338 valid samples collected through Web surveys were used, and structural equation modeling (SEM) was applied as the analysis method. Stable driving style, preventive driving style, and social capital were determined as extrinsic latent variables in the model to assess the impact of mobile phone use on the driver's attitude toward distracted driving. As a result, it was suggested that social capital is an effective factor influencing driving style, and that driving style is also related to the attitude toward involuntary driving using mobile phones.

5.1 Introduction

The so-called "driver distraction" occurs when a driver "is delayed in recognition of information needed to safely accomplish the driving task because some events, activities, objects or persons within or outside the vehicle, compelling or tending to include the driver's attention shifting away from the driving task,"[1] thus forming a major cause of drivers' inattention. In a word, distracted driving is one of the most significant human factors involved in transport safety. In many countries, the number of motor vehicle crashes has declined over years but distracted-driving induced crashes are increasing significantly in morbidity and mortality[2-3]. Among all kinds of distraction reasons, the mobile phone use is taking an increasingly large percentage[4]. Although nearly all countries and nations have illegalized mobile phone use in driving[5-6], many people still do so for many functions, such reading or writing text, dialing or conversing in either handheld or hand-free modes, playing games, navigating, etc. According to an investigation by Oren Musicant et al.[7], phone calls and texting while driving are found to be the most common practice.

Mobile phone usage in driving involves a multitude of cognitive and physical resources, which are consistently linked to inferior driving performance[8-11]. According to a former research[12], the risk of crashes for drivers who use cell phones while driving is four times higher than others not engaged in such actions, and in a research did later, found the risk of mobile phone use are even under-estimated[13]. According to the research of Schattler et al.[14], handheld-device conversations resulted in significantly lowered average speed and poor driving performance, while yielding remarkably improper lateral placements and twofold crashes, compared to control conditions. Stavrinos et al.[15] also found very high fluctuation in speed during handheld-device conversation. In addition, Stavrinos et al.[15] and Beede et al.[16] identified a decreased lane-change frequency during conversations on handheld/handsfree mobile phones. Rudin-Brown[17], Peng[18], Choudhary[19] and Muttart[20] found that the vehicle control would be worsened when drivers use mobile phones. Distracted driving due to mobile phone uses also affect the braking performances by elongating the brake reaction time, the deceleration adjusting time and the maximum deceleration rate[21].

According to the TPB theory proposed by Ajzen and Fishbein[22] in 1985, attitudes are often labeled as the determinants of studied behavior. Studies[23] shown TPB theory is useful to evaluate the motivations and reason behind the behaviors of texting while driving, and risk perception due to mobile phone. Future efforts in mobile phone prevention would benefit from the development of safe attitudes and enhanced risk literacy.

To avoid distracted driving behaviors, it is necessary to conduct research on what factors affect the attitudes.

Social capital can be defined as the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network or networks or less institutionalized relationships of mutual acquaintance and recognition. As a result of social relationships, it consists of expectation of benefits derived from preferential treatments between individuals or groups. Putnam [24] firstly discussed the connection between social capital and transportation in a book he wrote about distracted driving. In the chapter about mobility, he demonstrated long-distance driving harms social capital by reducing public transportation participation. In Japan, many scientists also studied the effect of social capital on transportation. Such as Sakamoto et al.[25], Utsunomiya[26], and Taniguchi et al.[27]'s research showed that social capital is a factor related to individuals' understanding and participation in public transportation. Hamada et al.[28] found the social capital is related to the walkability of residents. Yoshiki et al.[29] found the social capital affects the play on the street in a residential area. As the social capital is composed by "trust," "reciprocity norms," "network"; and the social capital has been connected to many types of mobilities, based on these findings, we are trying to figure out whether social capital, individual' awareness and the driving behavior are related to each other, so, in the following discussion, the relation of social capital and driving behaviors is studied, and an SEM model is built to test each subscale's influence on driving behavior.

Table 5-1 Outline of research

Survey period	2017.4.7-10
Target respondents	20-59 years-old drivers
Distribution method	Web research
Distributed questionnaires	544
Valid sample	338
Main contents	Personal attributes
	Social capital scale
	Driving behaviors scale
	Risk perception of dangerous behavior
	Experience of accident

Table 5.2 Basic information of participants

Gender	Male	59.2%
	Female	40.8%
Age	20~30 years	15.1%
	31~40 years	22.5%
	41~50 years	35.2%
	51~60 years	27.2%
Driving Frequency	Everyday	49.4%
	Not everyday	50.6%
Annual living mileage	<6000km	54.7%
	6000~12000km	33.4%
	>12000km	11.8%

Therefore, a social capital scale is being used to gather social capital information.

Driving style is defined as a set of individual driving habits formed gradually with the accumulation of driving experience. Previous studies have shown that driving styles have significant influences on driving safety. However, few studies have investigated the relationships between driving styles and distracted driving attitudes.

To the authors' knowledge and given the novelty of social capital being used for traffic safety issues, this is the first study to study the relationship between social capital and distracted driving due to mobile phone use. It is hoped that this research can fill the gaps in the literature on distracted driving, reduce traffic accidents caused by mobile phones, and improve road safety.

The purpose of this research is by collect necessary data through online questionnaires to clarify the driver's attitude towards specific behaviors of using mobile phones while driving, then establish a SEM model, and finally evaluate the impact of social capital and driving styles on distracted driving attitudes.

5.2 Research outline

The survey was implemented as an anonymous online questionnaire, which contains demographic factors, social capital scales, driving behavior scales, distracted behaviors, experience of accidents, and so on. After 544 copies of the questionnaire were distributed, collected and checked, 179 questionnaires were deemed disqualified and thus removed from the future use. To ensure the quality of data, this study applied three criteria to remove unusable or careless responses:

a) multiple occurrences of two options were chosen for one item;

b) questionnaires were finished with missing items; and

c) there are no variations across negatively and positively worded items on a personality measure. The outline of the questionnaire survey is shown in **Table 5-2**. Given that mobile phones may not be used very often by older people, this study focuses on drivers under the age of 60.

5.3 Participants' information

As shown in **Table 5-2** for the basic information of the participants, 40.8% were women and 59.2% men. They can be divided into four age groups: 20-30 years old for 15.1%, 31-40 years old for 22.5%, 41-50 years old for 35.2% and 51-60 for 27.2%. 50.59% of them drive every day; 54.7% drive less than 6,000km annually, 33.4% drive less than 12000km but longer than 6000km, 11.8% of participants drive more than 12000km per year.

5.4 Social capital

Regarded as the result of social relationships, social capital consists of the expectation of benefits derived from preferential treatments between individuals or group. The social capital scale includes 9 items, rated on a three-point scale: 1 = "not comply with my situation, uncertain", 2 = "somewhat comply with my situation", and 3 = "comply with my situation". And participants are asked to evaluate which choice best suits them. To understand the social capital feature of participants, the factor analysis of social capital was conducted.

Table5-3　Factor analysis of social capital

Social capital item	Factor 1	Factor 2	Factor 3
	Reciprocity norms	Trust	Network
Live in a place where have friends or relatives	0.1551	0.1375	0.6115
Say hello to neighbors and other people	0.1648	0.2258	0.7866
Interested in the history and culture of the lived city	0.2430	0.5270	0.3624
Support the administrative plan of the lived city	0.2374	0.8002	0.1123
Trust the residents of the lived city	0.3043	0.5759	0.4063
Satisfied with living in this area	0.2256	0.4492	0.4598
Conduct simple cleaning in the neighborhood or building road	0.5937	0.1470	0.2578
Participate in some recreational activities organized by the community	0.8945	0.2538	0.1614
Participate in volunteer activities of community	0.7199	0.2825	0.1349
Inherent quality	1.9810	1.6873	1.6238
Contribution ratio	22.01%	18.75%	18.04%
Cumulative contribution	22.01%	40.76%	58.80%

Table 5-4　Average factor score by groups

Cluster item	n	Factor 1	Factor 2	Factor 3	Item explanation
		Participation	Support	Communication	
High social capital group	58	1.82	0.51	0.3	All three factors are high.
High support group	50	-0.75	1.38	0.46	Factor 2 is higher; the other two factors are generally.
Low social capital group	230	-0.3	-0.43	-0.17	All three factors are generally low.

5.4.1 Factor analysis of social capital

The Cronbach's alpha is 0.8053, indicating that this scale has enough reliability; and the total factor load is 58.8%, meaning that the factor analysis has got reliable results, as shown in **Table 5-3**. Factor 1 is named the "participant" factor because the item of "I will participate in some recreational activities

organized by the community" is highest; Factor 2 is named the "support" factor because the item of "I support the administrative plan of the city where I live" is highest; and Factor 3 is named the "communicate" factor because the item of "I say hello to neighbors and other people" is highest.

Table 5-5 Chi-square analysis of social group cluster and demographics

Demographic item	P value	*：P<0.05 **：P<0.01
Gender	Male(n=200)	0.0037**
	Female(n=138)	
Age	20 ~ 29 years old(n=51)	0.6169
	30 ~ 39years old(n=76)	
	40 ~ 49years old(n=119)	
	50 ~ 59years old(n=92)	
Family composition	Live alone (n=42)	0.0317*
	With family (n=296)	
Driving Distance/year	<6000km (n=185)	0.0755
	6000-12000km (n=113)	
	>12000km (n=40)	

5.4.2 Cluster analysis of social capital

After summarizing the three factors, a cluster analysis was conducted based on the factor scores, with the results shown in **Table 5-4**. According to the percentage of each factor, each cluster is named: The first cluster is called the "high social capital group", because all the three factors are high in this cluster; the second is "high support group", because it is higher in Factor 2; the third is "low social capital group", because the percentage of each factor is the lowest. Then the social capital situation of participants can be understood, and the relations between social capital and other variables are analyzed in the following chapter.

5.4.3 Social capital and demographics

The chi-square analysis is conducted for the relationship between social capital and demographics. Summary result is shown in **Table 5-5**. The results in **Fig.5-1** and **5-2** show that the variables of gender and family composition are significantly related to social capital situations. Specifically, males take a higher percentage in the high social capital group than females; and the participants who live alone have a higher percentage in the low social capital group. These findings are useful for understanding the social capital situations in detail.

5.4.4 Social capital and stable driving styles

The chi-square analysis is also conducted for the relationship between social capital and stable driving styles, with the results shown in **Table 5-6**.
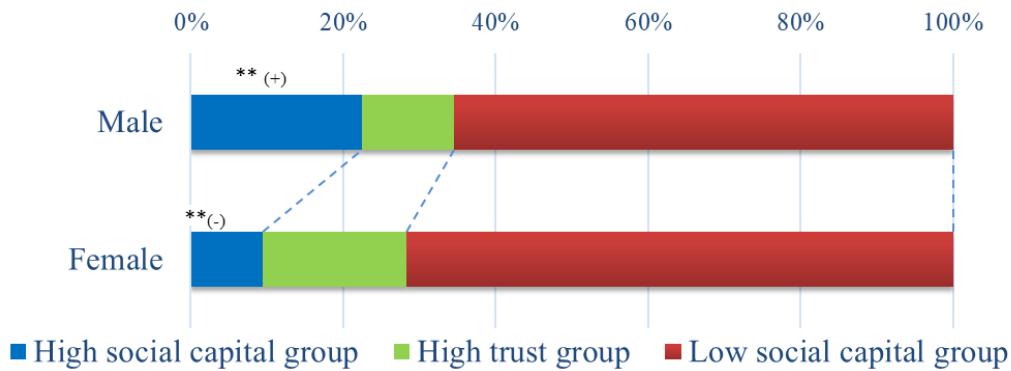
P value : 0.0037
significance at 1%
Residual analysis of crosstab: **1%   *5%   (+) High proportion   (-) Low proportion

Fig. 5-1   The cross analysis between social capital and gender
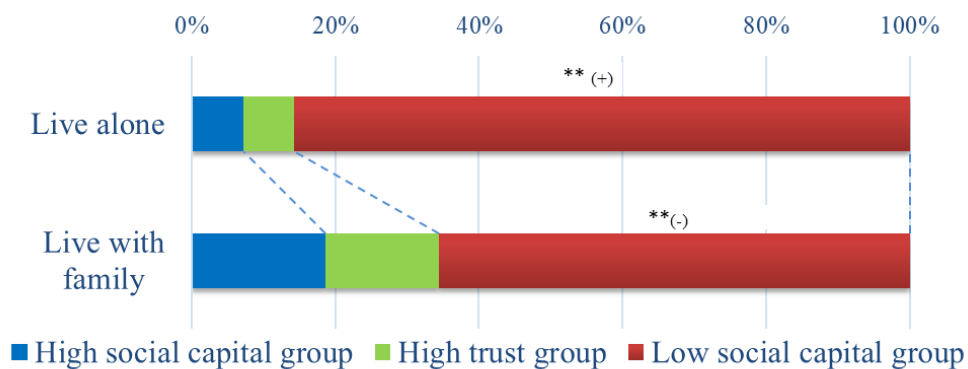
P value : 0.0317
significance at 5%
Residual analysis of crosstab: **1%   *5%   (+) High proportion   (-) Low

Fig. 5-2   The cross analysis between social capital and family composition

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There are obvious relationships between social capital situation and stable driving items, significantly at 5% (p=0.0495, p=0.0168) for the items "No speeding" and "Drive as steady as possible", and significantly at 1% (p=0.0033) at the item "driving while constantly checking the speed meter".

Residual analysis results show that for the speeding, driving while constantly checking speed meter and steady driving, the high support group takes a smaller percentage in "not true, somewhat not true and uncertain" participations and takes a larger percentage in "true" participations. The low social capital group takes a larger percentage in "not true, somewhat not true and uncertain" participations and takes a smaller percentage in "true" participations. The results demonstrate that the low social capital group trends to care less about the driving speeds and steady styles.

Table 5-6   The relation between social capital and stable driving style

	Social capital			p value	
	High social capital group(n=58)	High support group(n=50)	Low social capital group(n=230)		
No speeding					
1.Not true, somewhat not true, uncertain(n=162)	27(46.6%)	16(32%)	119(51.7%)	0.0496	*
2.Somewhat true(n=127)	22(37.9%)	21(42%)	84(36.5%)		
3.True(n=49)	9(15.5%)	13(26.0%)	27(11.7%)		
Drive while constantly checking the speed meter					
1.Not true, somewhat not true, uncertain(n=94)	14(24.1%)	8(16.0%)	72(31.3%)	0.0033	**
2.Somewhat true(n=165)	31(53.4%)	20(40%)	114(49.6%)		
3.True(n=79)	13(22.4%)	**22(44%)**	**44(19.1%)**		
Drive as steady as possible					
1.Not true, somewhat not true, uncertain(n=50)	7(12.1%)	2(4.0%)	**41(17.8%)**	0.0168	*
2.Somewhat true(n=182)	31(53.4%)	24(48.0%)	127(55.2%)		
3.True(n=106)	20(34.5%)	**24(48.0%)**	62 (27.0%)		

Chi-square   **: significance at 1%,*: significance at 5%

Residual analysis   bold   significance at1%   Blue: high percentage

                                        significance at 5%   Red: low percentage

*(%) Is the basic aggregation result based on the measured frequency

5.4.5 Social capital and precaution driving styles

The chi-square analysis is conducted for the relationship between social capital and precaution driving styles, with the results shown in **Table 5-7**.

There is a relation among all groups on the items of precaution driving, significantly at 1% (p=0.0049, p=0.0051, p=0.0043) for the three items. Residual analysis results show that the high support group takes a larger percentage in "true" participation on the items of "When starting off, make sure the situation of front and back," "Do not drive into the roads that pedestrians and cyclists have priority" and "Keep enough distance from the front car"; takes a smaller percentage in "not true, somewhat not true and uncertain"

Table 5-7 The relation between social capital and precaution driving style

	social capital			p value	
	High social tal group(n=58)	High support group(n=50)	Low social ital group(n=230)		
When starting off, make sure the situation of front and back				**0.0049**	**
1.Not true, somewhat not true, uncertain(n=68)	8(13.8%)	6(12.0%)	**54(23.5%)**		
2.Somewhat true(n=150)	26(44.8%)	16(32.0%)	108(47.0%)		
3.True(n=120)	24(41.4%)	28(56%)	68(29.6%)		
Do not drive into the roads that pedestrians, cyclists have priority				**0.0051**	**
1.Not true, somewhat not true, uncertain(n=64)	8(13.8%)	**3(6.0%)**	**53(23.0%)**		
2.Somewhat true(n=159)	27(46.6%)	21(42.0%)	111(48.3%)		
3.True(n=115)	23(39.7%)	**26(52.0%)**	**66(28.7%0**		
Keep enough distance from the front car				**0.0043**	**
1.Not true, somewhat not true, uncertain(n=75)	13(22.4%)	7(14%)	55(23.9%)		
2.Somewhat true(n=142)	25(43.1%)	13(26%)	104(45.2%)		
3.True(n=121)	20(34.5%)	**30(60%)**	**71(30.9%)**		

Chi-square analysis   **: significance at 1%,*: significance at 5%

Residual analysis   bold   significance at1%   Blue: high percentage

     significance at 5%   Red: low percentage

*(%) Is the basic aggregation result based on the measured frequency

participations. The low social capital group takes a larger percentage in "not true, somewhat not true and uncertain" participations; and takes smaller percentage in "true" participations. The results demonstrate that the low social capital group trends to care less about the driving speeds and steady styles.

5.5   Attitudes towards distracted driving due to mobile phone use

In this chapter, the attitudes towards distracted driving due to mobile phone use are analyzed. Four distracted behaviors are integrated into a scale to cluster the attitudes of the participants, with the scale shown in **Fig.5-3**. The Cronbach's alpha of 0.807 means that the scale is reliable. As shown in the table, the participants hold different attitudes towards different distracted driving behaviors. Most participants regard the practice of making/answering a call while driving as "very dangerous", but the dangerous degree would decrease if hands-free devices are used. And setting up a navigation system on mobile phones is regarded as the least dangerous behavior, compared to the other three items. It is necessary to cluster the participants by the choices they have made on this scale.
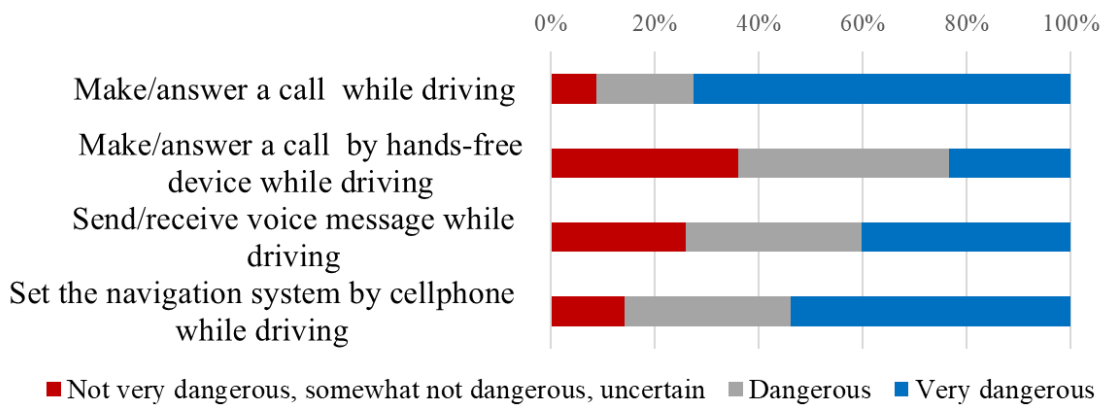

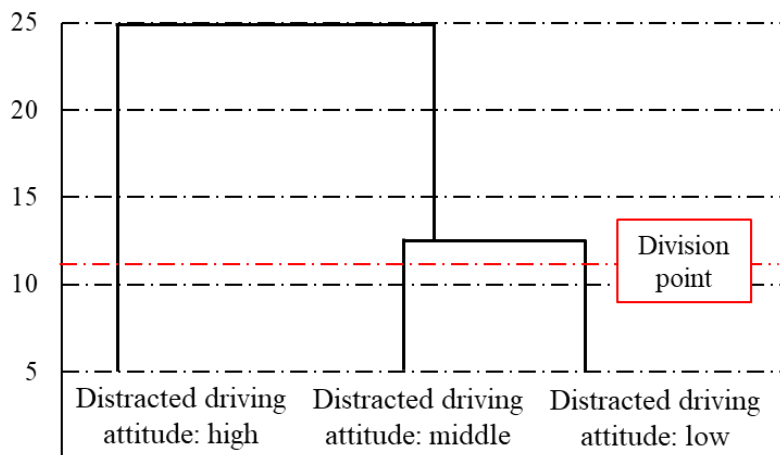**Fig. 5-3** Results of basic tally for attitude towards distracted driving due to cellphone use

Fig. 5-4   Dendrogram of attitude towards distracted driving due to cellphone use cluster

5.5.1 Cluster analysis of attitudes towards distracted driving due to mobile phone use

IBM SPSS 24.0 is used to cluster the participants on the item of attitude towards distracted driving, which the results shown in. **Fig.5-4**. The figure shows the dendrogram of the attitude towards distracted driving cluster. Cluster 1 (n=67) is the participants in the high level of distracted driving attitudes; Cluster 2 (n=206) is the participants in the middle level of distracted driving attitudes; and Cluster 3 (n=65) is the participants in the low level of distracted driving attitudes. Next, the validity of the cluster was examined. Result shown in **Fig.5-5**. Since normality was not recognized when the normality was tested in each cluster, the difference in the average value of the factor scores was tested in each cluster by the Kruskal-Wallis test. As a result, a significant difference was observed at a significance level of 1%, indicating that there is a difference in the average value of each cluster. The Steel-Dwass test performed pairwise comparisons for all combinations of two groups, and as a result, a significant difference was observed at a significance level of 1% between all control groups, indicating the validity of the cluster.

5.5.2 Attitudes towards distracted driving due to mobile phone use and stable driving style

This chapter analyzes the correlation between distracted driving attitudes and driving styles, and the result of chi-square analysis is summarized in **Table 5-8**. The distracted driving attitudes are significantly related to the stable driving styles at 1% (p<0.01). For the drivers in the high risk perception of the distracted driving group, the percentage of "make sure not speeding, constantly checking the speed meter and steady driving" is large; drivers in the middle risk perception group take a high percentage in "somewhat true" on the item of "drive while constantly checking the speed meter" and, meanwhile, take a low percentage in "not true. Somewhat not sure, uncertain". For the drivers at the low risk perception group, they preset a high percentage in "not true, somewhat not true, uncertain" on these three items, and a low percentage in "true" on the three items. In summary, for the drivers who hold a decent attitude towards distracted driving behaviors, the pursuit of "control speed and stability" is also better than other groups. From this perceptive, the safety behaviors are connected to each other, i.e., improving one aspect may help reduce another
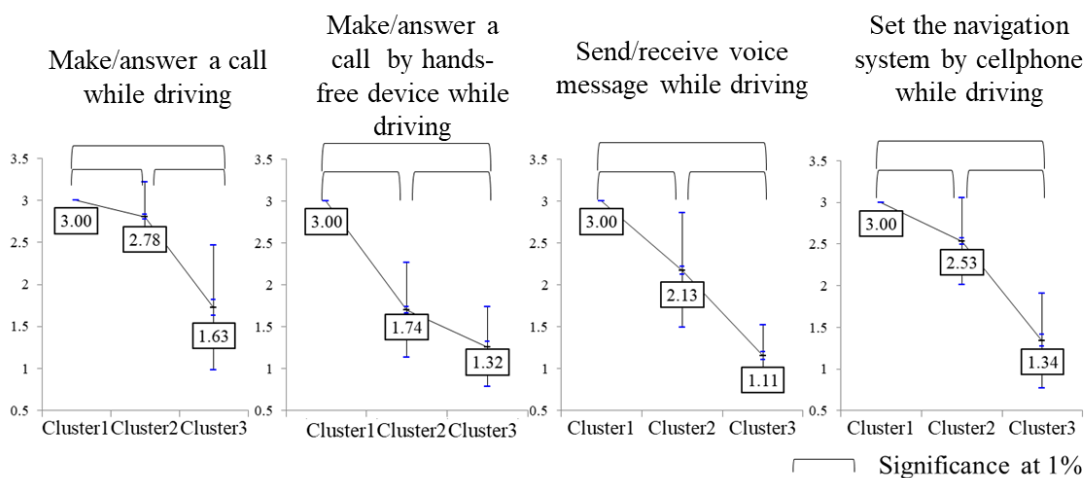

Fig. 5-5 Difference in average score of each cluster on each item of attitude towards distracted driving due to mobile phone use

dangerous behavior.

5.5.3 Attitudes towards distracted driving due to mobile phone use and precaution driving style

The correlation between distracted driving attitudes towards mobile phone use and precaution driving styles are analyzed, with the result of chi-square analysis summarized in **Table 5-9**. Distracted driving attitudes are significantly related to the precaution driving styles at 1% (p<0.01). For the drivers in the high risk perception of the distracted driving group, the percentage of "true" on items of "When starting off, make sure the situation of front and back" and "I keep enough distance from the front car" is larger; meanwhile, the percentage of "not true, somewhat not true, uncertain" on the three items are low. For the drivers at the middle risk perception group, the percentage of "not true, somewhat not true, uncertain" on the items of "Do not drive into the roads that pedestrians, cyclists have priority" and "Keep enough distance from the front car" is low, and the percentage of "somewhat true" on the item "Keep enough distance from the front car" is high. In the low risk perception group, the percentage of "not true, somewhat not true,

Table 5-8   The relation between distracted attitude and stable driving style

	Distracted attitude			P value	
	high(n=67)	middle(n=206)	low(n=65)		
No speeding					
1.Not true, somewhat not true, uncertain(n=162)	26(38.8%)	94(45.6%)	**42**(64.6%)	0.0092	**
2.Somewhat true(n=127)	26(38.8%)	81(39.3%)	20(30.8%)		
3.True(n=49)	15(22.4%)	31(15.0)%	3(4.6%)		
Drive while constantly checking the speed meter					
1.Not true, somewhat not true, uncertain(n=94)	18(26.9%)	**41**(19.9%)	**35**(53.8%)	P < 0.001	**
2.Somewhat true(n=165)	27(40.3%)	112(54.4%)	**26**(40%)		
3.True(n=79)	22(32.9%)	53(25.7%)	4(6.2%)		
Drive as steady as possible					
1.Not true, somewhat not true, uncertain(n=68)	7(10.4%)	**17**(8.3%)	**26**(40%)	P < 0.001	**
2.Somewhat true(n=150)	30(44.8%)	119(57.8%)	33(50.8%)		
3.True(n=120)	**30**(44.8%)	70(34%)	**6**(9.2%)		

Chi-square analysis	**: significance at 1%,*: significance at 5%		
Residual analysis	bold	significance at1%	Blue: high percentage
		significance at 5%	Red: low percentage

*(%) Is the basic aggregation result based on the measured frequency

uncertain" is low, while "true" is high in the three items.

Similar with the stable driving style, for the drivers who hold a decent attitude towards distracted driving behavior, more attention will be paid to accident prevention than other types.

5.5 The relations among variables and distracted driving attitudes

Based on the results of Chapters5.3 and 5.4, this chapter will use an Amos model to evaluate the relations among social capital, driving styles and distracted driving attitudes. Specifically, data of variables are turned into dummy, as shown in **Table 5-10**, by using IBM SPSS 24.0. The variables show a significant relation to the attitudes towards distracted driving. The relations between social capital and driving styles, between driving styles and attitudes towards distracted driving and between attitudes towards distracted driving and distracted driving behaviors are systematically analyzed. As shown in **Fig.5-6**, the data are standardized for presumption. Some commonly used fit indices, including the goodness-of-fit index (GFI), adjusted GFI (AGFI), and root mean square error of approximation (RMSEA), are all shown in **Fig.5-6**, which indicates an acceptable fit. The solid line is significant at 1%.

Table 5-9 The relation between distracted attitude and precaution driving style

	Distracted attitude			P value	
	high(n=67)	middle(n=206)	low(n=65)		
When starting off, make sure the situation of front and back					
1.Not true, somewhat not true, uncertain(n=68)	**4**(6%)	37(18%)	**27**(41.5%)	P < .001	**
2.Somewhat true(n=150)	28(41.8%)	89(43.2%)	33(50.8%)		
3.True(n=120)	**35**(52.2%)	80(38.8%)	**5**(7.7%)		
Drive while constantly checking the speed meter.					
1.Not true, somewhat not true, uncertain(n=64)	9(3.4%)	**28**(13.6%)	**32**(41.5%)	P < .001	**
2.Somewhat true(n=159)	26(38.8%)	103(50%)	75(46.2%)		
3.True(n=115)	**32**(47.8%)	75(36.4%)	**8**(12.3%)		
Keep enough distance from the front car					
1.Not true, somewhat not true, uncertain(n=50)	**6**(9%)	**31**(15%)	**38**(58.5%)	P < .001	**
2.Somewhat true(n=182)	24(35.8%)	**97**(47.1%)	21(32.3%)		
3.True(n=106)	**37**(55.2%)	78(37.9%)	**6**(9.2%)		

Chi-square analysis	**: significance at 1%,*: significance at 5%		
Residual analysis	bold	significance at1%	Blue: high percentage
		significance at 5%	Red: low percentage

*(%) Is the basic aggregation result based on the measured frequency

In **Fig. 5-6**, the rectangles represent the observed variables, the ellipses represent the unobserved latent variables, and the arrows pointing from the observed variables to the latent variables represent the regression paths. In this study, the SEM model consists of 9 latent variables and 25 observed variables, and the measurement error is omitted. According to the results of the SEM model shown in **Fig. 5-6**, the effect of each variable on the latent variables is studied. In the social capital model, the communication variable takes the largest composition (factor load=0.83). Social capital has a positive effect on driving styles,

Table 5-10   Definition of variables used in SEM model

Potential variables		Observation variables	Categories
Stable driving		No speeding	true, 0.other
		Confirm the driving speed	
		Drive as steady as possible	
Precaution driving		When starting off, make sure the situation of frond and back area	true, 0.other
		Do not drive into the roads that pedestrians, cyclists have priority	
		Keep enough distance from the front car	
Social capital	Communication	Live in a place where I have friends or relatives	true, 0.other
		Say hello to neighbors and other people	
		Interested in the history and culture of the city in which I live	
	Support	Support the administrative plan of the city where I live	true, 0.other
		Trust the residents of the city where I live	
		Satisfied with living in this area	
	Participation	Conduct simple cleaning in the neighborhood or building road	true, 0.other
		Participate in some recreational activities organized by the community	
		Participate in the community volunteer activities	
Distracted driving attitude		Make/answer a call while driving	Dangerous, ewhat dangerous; her
		Make/answer a call by hands-free device while driving	
		Send/receive voice message while driving	
		Set the navigation system by cellphone while driving	
Distracted driving behaviors		Use a cellphone while waiting for a signal	not true, somewhat rue hers
		Use a cellphone when running at low speed	
		Use a mobile phone while driving	
Experience of driving		Get warning form passenger in car while driving	have not d
		It is easier to feel tired when using cellphone while driving	true, 0.other
		Get into a wrong way due to distracted driving with cellphone	have not d

including the stable driving style (factor load=0.48) and the precaution driving style (factor load=0.59). Stable driving and precaution driving styles have a positive effect on attitudes towards distracted driving, and the effect of precaution driving is 0.40, stronger than stable driving style (0.20). The attitudes towards distracted driving have effects on distracted driving behaviors, and the distracted driving behaviors affect the experience of driving, including getting warning from the passengers in company. It is easier to feel tired when using mobile phone while driving and to get into a wrong way due to distracted driving with mobile phone use.

5.6 The summary of this chapter

To figure out the factors related to the attitudes towards distracted driving due to mobile phone use is a necessary measure for control over the distracted driving behaviors. In this study, the drivers' attitudes towards specific behaviors with mobile phone use while driving are objective, and the relations between objectives and variables, such as driving style, social capital and specific distracted driving behaviors, are being studied, so as to understand the weight of each factor on the objectives.

In Chapter 5.3, the social capital situation of participants is being analyzed, and the chi-square analysis shows that the social capital is related to family composition and gender. Living alone and being a female are more likely to make the related persons fall into the low social capital group. Social capital has an effect on driving styles, and people with high social capital tend to drive in a safer style. From this perspective, improving the social capital of drivers may help to reduce the occurrence of traffic accidents.

In Chapter5.4, the attitudes towards distracted driving due to mobile phone use are analyzed. The participants are divided into three groups by their risk perceptions about four distracted driving behaviors.
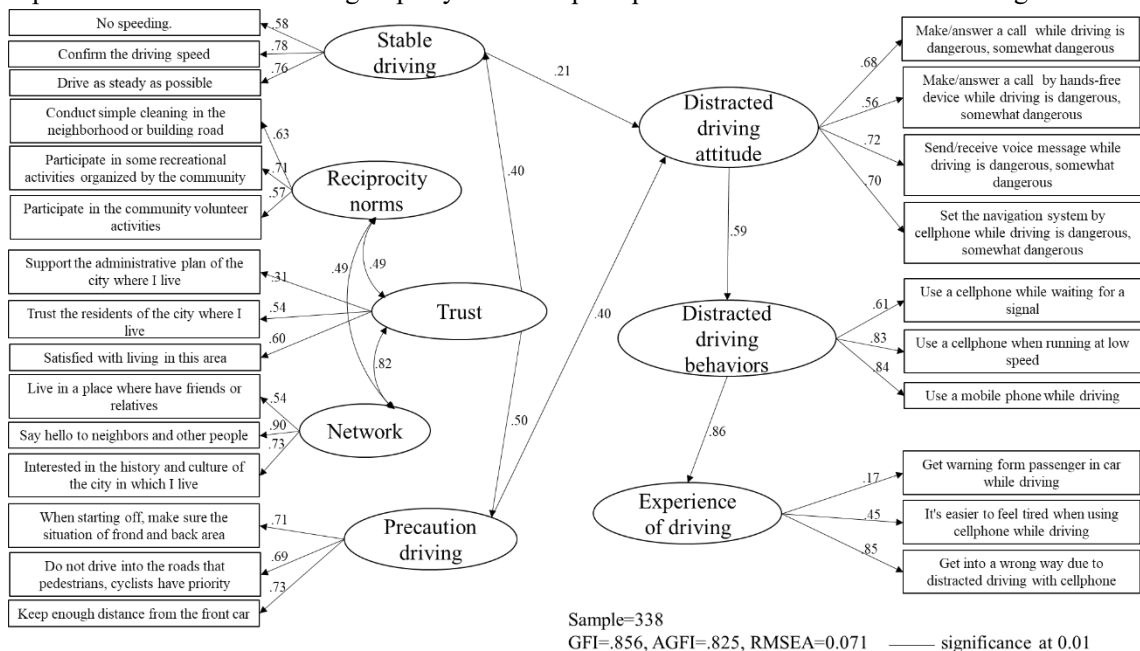

Fig. 5-6 The SEM model of attitude towards distracted driving due to mobile phone use

It can be found from chi-square that the driving styles are related to the distracted driving attitudes. As discussed in the introduction section, the TPB theory shows that specific behaviors are affected by attitudes. In this study, the correlation between attitudes and behaviors is analyzed more systematically, and the results demonstrate that the attitudes and behaviors are affecting each other. Therefore, to avoid distracted driving behaviors, many resources should be deployed to identify many other dangerous behaviors of drivers.

Chapter 5.5 summarizes the results and builds an AMOS model to explain the correlation between each dummy. Based on former chapters, the following recommendations are offered to understand the attitudes towards distracted driving due to mobile phone use.

1) As a significant factor to improve the driving safety, the social capital in this study is composed of three factors: trust, support and social participation. Social capital is positively correlated to safety driving factors, including stable driving and accident precaution driving styles. These findings demonstrate than social capital is an effective forecasting indicator for driving habits.

2) Driving styles deliver a significant effect on attitudes towards distracted driving due to mobile phone use. This finding indicates that improving drivers' safety attitudes is a holistic and effective approach to road safety.

3) Attitudes towards distracted driving due to mobile phone result in such experience as getting warnings from passengers in cars, getting into a wrong way, or feeling exhausted when driving with mobile phone use.

To sum up, in order to build a health attitude towards distracted driving due to mobile phone use, it is necessary for governments and related organizations to boost the social capital ownership and educate on common safety driving habits. As the first research focused on the effect of social capital and driving styles on distracted driving attitudes, this study proves that the TPB theory is effective when reverse applied.

This study has certain limitations that must be considered when its results are interpreted. Because this study adopts self-reported questionnaire data, the usual weaknesses of self-reported questionnaires could not be avoided, and the responses would suffer from social desirability bias. In the future work, experimental survey is necessary to monitor the distracted drivers, and combination of the two resources of data can reduce concerns about potential response bias.

The current study is about the safety attitude and behavior. In future research, the usefulness of education courses will be explored by using the findings, to improve drivers' safety attitudes and reduce the distracted driving behaviors involved mobile phone use.

[Reference]

1. Treat J R. A study of pre-crash factors involved in traffic accidents. HSRI Research Review, No.10-11, 1980, pp. 1-35.
2. Distracted Driving 2016: Washington DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 2018.
3. Honda Masahide. Analysis of accidents caused by the use of mobile phones, etc. Proceedings of the 18th Traffic Accident and Investigation Analysis Research Presentation.Tokyo: Institute for Traffic Accident Research and Data Analysis, 2015.
4. Lipovac K , Deric M , Tesic M , et al. Mobile phone use while driving-literary review[J]. Transportation Research Part F Traffic Psychology and Behaviour, 2017, 47(may):132-142.
5. Rudisill T M, Zhu M. Hand-held cell phone use while driving legislation and observed driver behavior among population sub-groups in the United States. Bmc Public Health, Vol. 17, 2017, pp.437.
6. Sanbonmatsu D M, Strayer D L, Behrends A A, Ward N, & Watson J M. Why drivers use cell phones and support legislation to restrict this practice. Accident Analysis & Prevention, Vol. 92, 2016, pp.22-33.
7. Musicant O, Lotan T, Albert G Do we really need to use our smartphones while driving? Accid Anal Prev Vol.85, 2015, pp.13–21.
8. Oviedo-Trespalacios O, Haque MM, King M, Washington S, editors. Influence of road traffic environment and mobile phone distraction on the speed selection behaviour of young drivers. Driver Distraction and Inattention Conference DDI 2015, 2015, Sydney.
9. Haque MM, Oviedo-Trespalacios O, Debnath A, Washington S. Gap Acceptance Behavior of Mobile Phone—Distracted Drivers at Roundabouts. Transportation Research Record: Journal of the Transportation Research Board. Vol.26, 2016, pp.43–51.
10. Papantoniou, Panagiotis, 'Structural Equation Model Analysis for the Evaluation of Overall Driving Performance: A Driving Simulator Study Focusing on Driver Distraction', Traffic Injury Prevention, Vol.19, 2018, pp.317–25.
11. Shaaban, Khaled, Sherif Gaweesh, and Mohamed M. Ahmed. "Investigating in-vehicle distracting activities and crash risks for young drivers using structural equation modeling." PLoS one 15.7 (2020): e0235325.
12. Redelmeier D A,&Tibshirani R J. AssociationBetween Cellular Telephone Calls and Motor Vehicle Collisions, The New England Journal of Medicine, Vol. 336, No. 7, 1997, pp.453-458.
13. Redelmeier D A , Tibshirani R J. Car phones and car crashes: some popular misconceptions. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne, Vol.164, No. 11, 2001, pp.1581-2.
14. Kerrie l. Schatter, Jiseph Pellerito Jr., Debborah McAvoy, and T. K. D. Assessing Driver Distraction from Cell Phone Use-A Simulator-Based Stydy. Transportation Research Record: Journal of the Transportation Research Board, Vol. 1980, No. 1980, 2006, pp. 87–94.
15. Stavrinos D, J L Jones, A A Garner, R Griffin, C A Franklin, D Ball, S C Welburn, K K Ball, V P Sisiopiku, and P R Fine. Impact of Distracted Driving on Safety and Traffic Flow. Accident Analysis and Prevention, Vol. 61, 2013, pp. 63–70

16. Beede K E, and S J Kass. Engrossed in Conversation: The Impact of Cell Phones on Simulated Driving Performance. Accident Analysis and Prevention, Vol. 38, No. 2, 2006, pp. 415–421.

17. Rudin-Brown C M, K L Young, C Patten, M G Lenné, and R Ceci. Driver Distraction in an Unusual Environment: Effects of Text-Messaging in Tunnels. Accident Analysis and Prevention, Vol. 50, 2013, pp. 122–129

18. Peng Y, L N Boyle, and J D Lee. Reading, Typing, and Driving: How Interactions with in-Vehicle Systems Degrade Driving Performance. Transportation Research Part F: Traffic Psychology and Behaviour, Vol. 27, No. PA, 2014, pp. 182–191.

19. Choudhary P, and N R Velaga. Modelling Driver Distraction Effects Due to Mobile Phone Use on Reaction Time. Transportation Research Part C: Emerging Technologies, Vol. 77, 2017, pp. 351–365.

20. Muttart, Jeffrey W, Fisher, Dinald L. Knoodler, M. Driving Simulator Evaluation of Driver Performance during Hands-Free Cell Phone Operation in a Work Zone: Driving without a Clue. Transportation Research Record: Journal of the Transportation Research Board, 2007, pp. 1–14.

21. Li X, Yan X, Wu J, Radwan E, & Zhang Y. A rear-end collision risk assessment model based on drivers' collision avoidance process under influences of cell phone use and gender—A driving simulator-based study. Accident Analysis & Prevention. Vol.97, 2016, pp. 1–18.

22. Schifter DE, Ajzen I. Intention, perceived control, and weight loss: an application of the theory of planned behavior. J Pers Soc Psychol. Vol. 49, No.3, 1985, pp. 843–51.

23. Benson,Tony, Marian McLaughlin, and Melanie Giles, 'The factors underlying the decision to text while driving', Transportation Research Part F: Traffic Psychology and Behaviour, Vol 35, 2015, pp.85–100.

24. Putnam, Robert D. Bowling alone: The collapse and revival of American community, New York: Cimon & Schuster. 2000.

25. Sakamoto, J., S. Yamaoka, and M. Fujita. A study on residents participate in support activity toward the restoration of local railway: A case study of Tarumi Railway. Journal of the City Planning Institute of Japan Vol..48. No.3 ,2013, pp.183-188.

26. Kiyohito Utsunomiya. Local Transport and Social Capital: An Empirical Analysis Using Panel Data and Survey Research. Transport Policy Studies' Review. Vol.21, 2019, pp.006-014.

27. Mamoru Taniguchi, Ryoji Matsunaka, Aya Shibaike. Does the social capital support "New public" movement?. Infrastructure planning review, Vol. 25, 2008, pp. 311-318.

28. Takayuki Hamada, Kimihiro Hino, Norimitsu Ishii. Associations between physical activity of elderly residents and built environment in a large residential complex. Journal of the City Planning Institute of Japan, Vol.53, No.3, 2018, pp.1523-1528.

29. Syuji Yoshiki, Tastumi Hiroshi, Kayoko Tsutsumi, Syota Itonaga. Local residents' consciousness to play on the street in the residential area. Journal of the City Planning Institute of Japan Vol.54, No.3, 2019, pp.672-679.

30. Carter, Patrick M., et al. Social norms and risk perception: Predictors of distracted driving behavior among novice adolescent drivers. Journal of Adolescent Health Vol.54, No.5, 2014, pp.S32-S41.

31. Li, Wanjun, Konstantina Gkritza, and Chris Albrecht. The culture of distracted driving: Evidence from a public opinion survey in Iowa. Transportation research part F: traffic psychology and

behaviour. Vol. 26,2014, pp.337-347.

Chapter 6. The comparison between Japan and China-the influence of traffic safety culture on distracted driving attitude

In this chapter, the difference between Japanese and Chinese drivers' risk awareness towards distracted driving behaviors was discussed. For road safety, it is necessary to find out what factors affect the driver's attitude towards distracted driving. A questionnaire was designed to collect necessary data including attitudes towards many types of distracted driving behaviors, quality of life (QOL), driving awareness, personal attributes, and accident-related experiences of private car owners. A structural equation model (SEM) was established to estimate the correlation between the attitude towards distracted driving and the observed variables. The results show that driving awareness, QOL, personal attributes are related to the attitude towards distracted driving; QOL and driving awareness are correlated, and the attitude toward distracted driving is related to the accident experience. The result is beneficial for us to understand distracted driving and to improve road safety.

6.1 Introduction

6.1.1 The importance of culture to safety issues

Culture is the rich complex of meanings, beliefs, practices, symbols, norms, and values prevalent among people in a society [1]. It has been a long history since people found that culture influence the traffic behaviors[2-5].

In the organization AAA 2007, the traffic safety culture is "a culture that accepts the loss of life and limb as the price of mobility". In the research did by Edwards et al.[6], traffic safety culture can be defined as the assembly of underlying assumptions, beliefs, values and attitudes shared by members of a community, which interact with the community's structures and systems to influence road safety related behaviors. From this perceptive, it is a useful way to improve road safety and avoid accidents by change the traffic safety culture.

Hence, this chapter aims to investigate the heterogeneity of distracted driving behaviors between and within Japanese and Chinese driver groups. A questionnaire-based survey was designed and conducted. Drivers of japan and china were asked to fulfill a questionnaire including the driving behaviors scales, attitudes of different types of distracted driving behaviors, social capitals, experiences of distracted driving, accident-related experiences, and personal attributes. Heterogeneity between and within participant groups was investigated through statistical analysis of attitude towards distracted driving behaviors. Results shown that Chinese drivers attitude habits

Due to the rapid increase in automobiles and widespread construction, China has a number of safety issues with its traffic infrastructure. The relatively short history of traffic cultures leads to a shortage of design engineers with expertise.

For China, rapid economy growth is together with a dramatic rise in traffic accidents, since 1990, China has ranked first in the world for traffic fatalities [7].

6.1.2 The crash situation

Crash rates can be summarized by crash cases, injuries and fatalities per number of drivers, trends across time can also produce insights into efforts to improve road safety and changes in safety culture within a country. A summary of data for crashes, injuries and fatalities is shown in **Fig. 6-1**.

The figure shows the crashes, injuries and fatalities from 2010-2018. In China, the crashes showed a slight fluctuation, from 2010 to 2015, the crashes decreased year by year but increase in 2016 and 2018, the injuries number is quite consistent with the crashes' tendency. The fatalities have not changed a lot with the time, the year 2015 witnessed the least number of deaths which is 58022, and the year 2010 is the highest in which 65225 people died. According to data from the National Bureau of Statistics of China, the possibility of at least 1 death in an accident is 30%, which is the result of the fatalities dividing the total number of traffic crashes. In Japan, the crashes and injuries are decreasing clearly, from 2010 to 2018, the crashes case decreased by 40%, the injuries decreased by
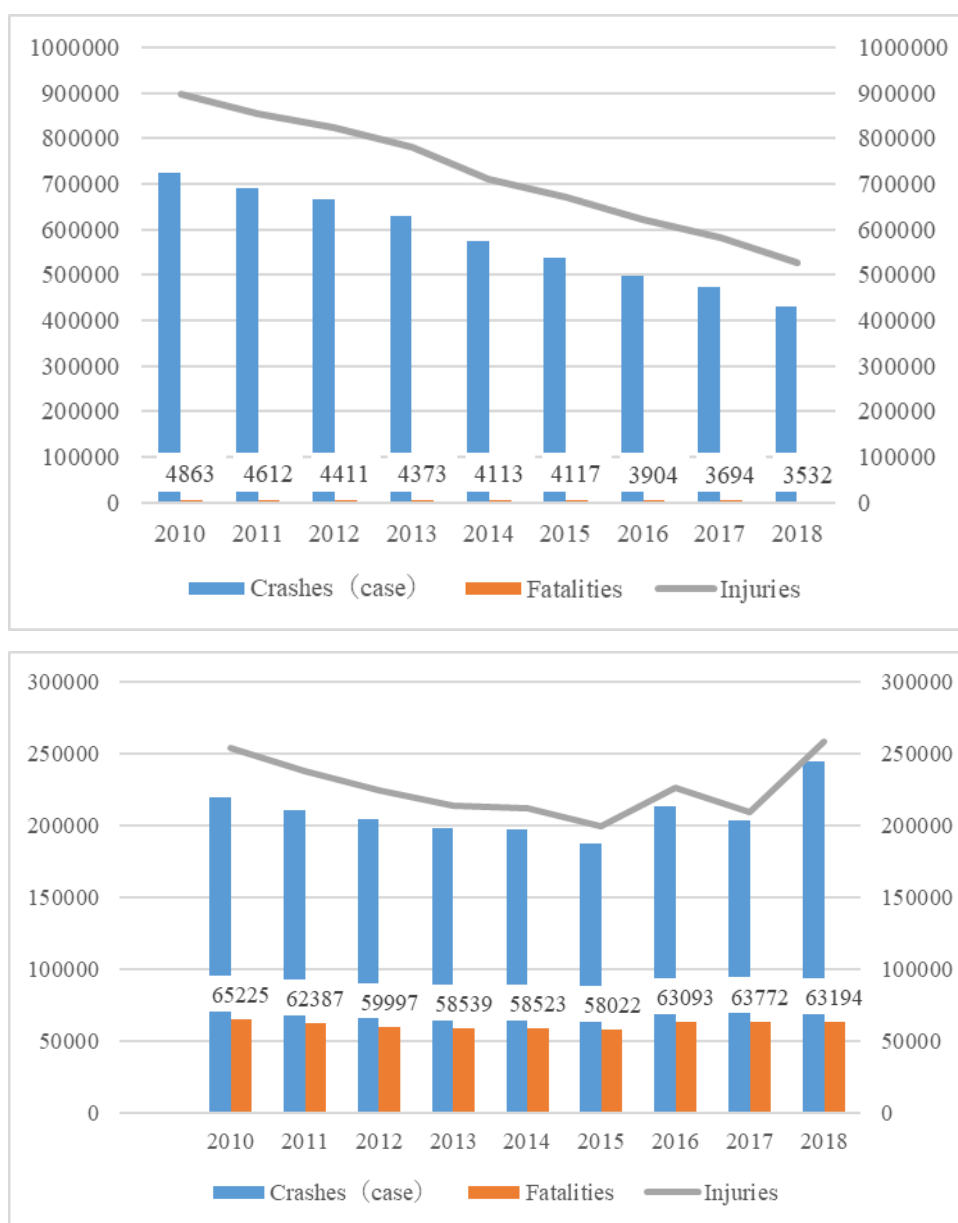

Fig.6-1 The crash, fatalities, injuries of Japan (up) and China (below)

78

41%, fatalities decreased by 27%. Comparing to China, the Japanese car accident mortality rate is extremely low, which is only 0.8%, which means the 1000 crashes may lead to 8 people died, Chinese mortality per crash is 37.5 times of Japanese. The accident of China shown the characteristics of high mortality and high severity.

6.1.3 The laws and regulations

Both Japan and China have enacted laws and regulations to restrict distracted driving, especially those caused by cellphone usage.

In Japan, while driving a car or motorbike, "texting while driving" is prohibited by the Road Traffic Act, and penalties are set for violations, but traffic accidents caused by "texting while driving" are increasing. There is a tendency.

Under these circumstances, the revised Road Traffic Law was promulgated in June of the first year of Reiwa, and from December 1st of the same year, the penalties for "cellphone usage while driving" were strengthened as follows.

■ When you hold a mobile phone and make a call or watch an image (hold)

As for the penalties, a new "imprisonment of 6 months or less" will be set, and the fine will be raised from "50,000 yen or less" to "100,000 yen or less".

If the foul fee is a regular car, it will be tripled (6,000 yen → 18,000 yen);

Violation points have been tripled (1 point → 3 points);

■ When a traffic danger is caused such as an accident caused by using a mobile phone (traffic danger)

Penalties increased from "imprisonment of 3 months or less or fine of 50,000 yen or less" to "imprisonment of 1 year or less or fine of 300,000 yen or less";

Being a non-foul act and subject to criminal penalties (imprisonment or fine);

The number of violation points will be "6 points" and the license will be suspended.

In China, Article 62 of the "Implementation Regulations of the Road Traffic Safety Law of the People's Republic of China" stipulates that driving a motor vehicle must not make calls or answer hand-held phones, watch TV, etc.; violators will be given a warning, or a fine of 20-200 yuan, deduct 2 points.

It is hard to say which of the two countries' laws is stricter on distracted driving caused by mobile phones. But for the drivers in these two countries, the Chinese seem to be more involved in cellphone related distracted driving due to the car sharing system.

6.2 The comparison between Japan and China on risk awareness towards distracted driving behaviors

The risk awareness towards different distracted driving behaviors is summarized in **Fig.6-2**. there are 8 different items. Based on the results of independent t-text, there are significant difference between Japan and China drivers on the items expect "send/receive voice message while driving" "during driving, browse the web".

Comparing to Chinese drivers, the Japanese consider item "make/answer a call while driving" "make/ answer a call by hands-free device while driving" and "during driving, set the car equipment

(radio, navigation, cd, etc)" are more dangerous, while "send/receive text message while driving" "browse the web" "play mobile games" "eat, drink, smoke etc" are less dangerous.
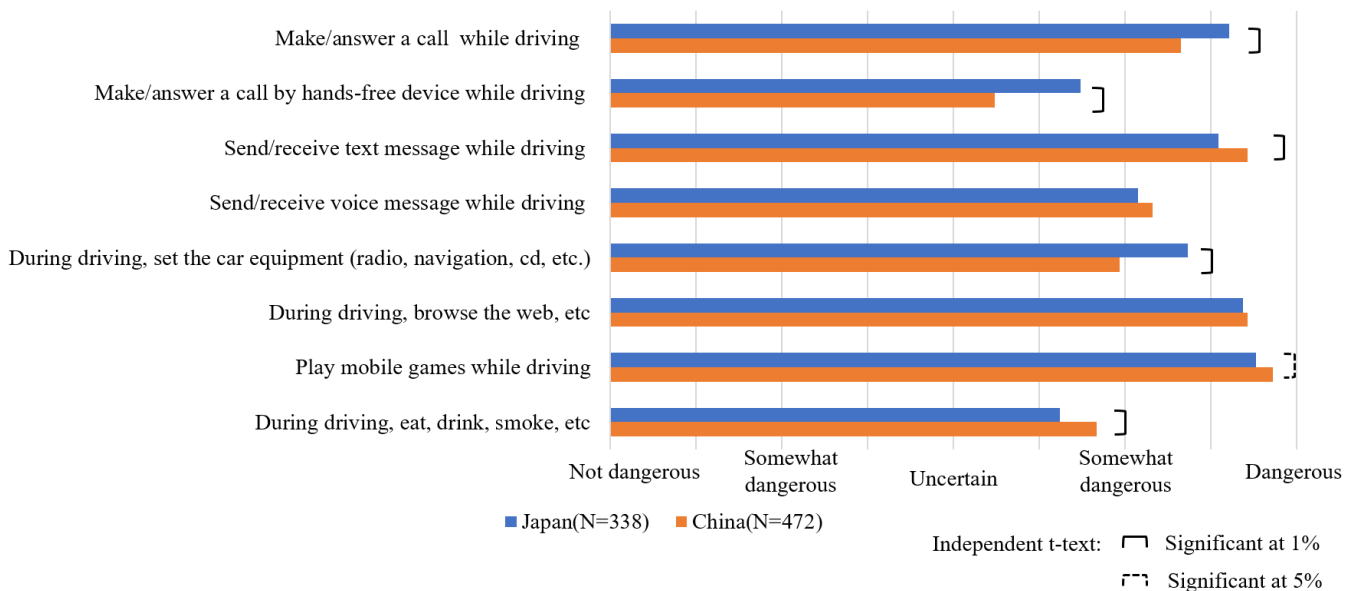

Fig.6-2   The difference between Japan and China on risk awareness towards distracted driving behaviors
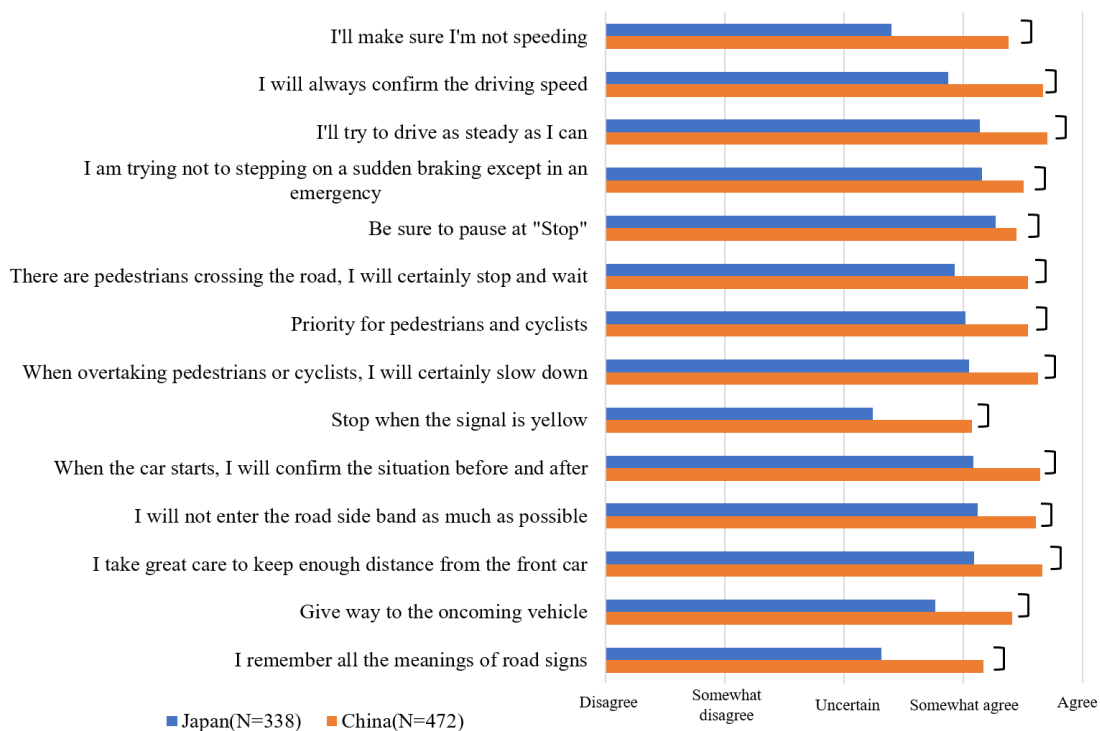

Fig.6-3   The difference between Japan and China on driving behaviors

6.3 The comparison between Japan and China on driving behaviors

After understanding the traffic safety situations of japan and china, then the driving behaviors are being compared. The comparison result is shown in **Fig.6-3**. Firstly, both two scales' the Cronbach's α are more than 0.8, indicating the scales has enough reliability. As the independent t-text shown, there

Table 6-1 Observed variables and latent variables used in SEM

Latent variables		Observed variables	Scale / category
Driving behaviors	Stable driving	Drive as steady as possible	1. Agree, 0.others
		Confirm the driving speed	
		No speeding	
	Care others driving	Priority for pedestrians and cyclists	
		When pedestrians crossing the road, will stop and wait	
		When overtaking pedestrians or cyclists, slow down	
	Accident prevention driving	Do not drive into the roads that pedestrians, cyclists have priority	
		Keep enough distance from the front car	
		When starting off, make sure the situation of frond and back area	
Social capital	Network	Live in a place where have friends or relatives	1. True, 0.others
		Say hello to neighbors and other people	
		Interested in the history and culture of the city in which I live	
	Trust	Support the administrative plan of the city where I live	
		Trust the residents of the city where I live	
		Satisfied with living in this area	
	Reciprocity norms	Conduct simple cleaning in the neighborhood or building road	
		Participate in some recreational activities organized by the community	
		Participate in the community volunteer activities	
Risk awareness toward distracted behaviors		Make/answer a call while driving	1.Dangerous，0.others
		Make/answer a call by hands-free device while driving	
		Send text message while driving	
Personal attributes		Gender	1. Male, 0. female
		Driving frequency	1.Not every day, 0.every day
Accident-related experience		Car accident in recent year	1. Not have, 0. had experienced
		Near-accident in recent year	
		Law violations in recent year	
		warning from passengers in car	

are significant difference on every items of driving behaviors, Chinese shown a higher agreement for every item, which means they have more confidence that they are driving in a safe way comparing to Japanese. As discussed before, the traffic situation in China is much severe than in Japanese, it is by no means that Chinese drivers are drive in a safer way comparing to Japanese, so there is a thinking bias between two nations, the possible reasons are the drivers are influenced by "national character", which Japanese is famous for their cautious and humble, so when they are making a choice, they always choose the most secure, the least error-free, and not too prominent. This conjecture hopes to be verified in future research.

6.4 Factors influencing the risk awareness towards distracted driving-based on the SEM model

The objective of this thesis is attitude toward distracted driving, especially for cellphone related distracted behaviors, in this section, based on the questionnaires of Japanese and Chinese, a similar model was built to describe which factors influence the drivers risk awareness toward distracted driving behaviors.

Data of variables are turned into dummy, as shown in Table. 6-1. The upper model is data of Japanese, the bottom model is data of Chinese, the paths that reached the significance level of 5% were kept, the data are standardized for presumption. Some commonly used fit indices, including the good-ness-of-fit index (GFI), adjusted GFI (AGFI), and root mean square error of approximation (RMSEA), are all shown in **Fig. 6-4**, which indicates an acceptable fit. The solid line is significant at 1%, the dotted line is significant at 5%.

In the model, the rectangles represent the observed variables. The ellipses represent the unobserved latent variables, the arrows point from the observed variables to the latent variables represent the regression paths, the measurement error is omitted. The effect of each variable on the latent variables is studied.

In Japanese model, the risk awareness toward distracted driving behaviors is influenced by driving habits with the factor load is 0.55, which means the more they agree on this good driving habits, the more they thought those distracted driving behaviors are dangerous. Social capital and driving habits are connected to each other with the factor load is 0.37, social capital is not influence risk awareness toward distracted driving behaviors directly. The personal attributes including gender and driving frequency are not significantly relate to the objectives, so is the accident-related experience.

In Chinese model. The risk awareness toward distracted driving behaviors is influenced by driving habits, social capital and personal attributes, driving habits takes the largest influence with the load factor is 0.38, follows by social capital with the load factor is 0.16, not driving everyday and being a female are positively influenced the risk awareness toward distracted driving behaviors. The attitude is strongly related to accident-related experience, the drivers who regard distracted driving behaviors are dangers will experience less accidents, less near-accidents, less violations and less warnings from other passengers in car.
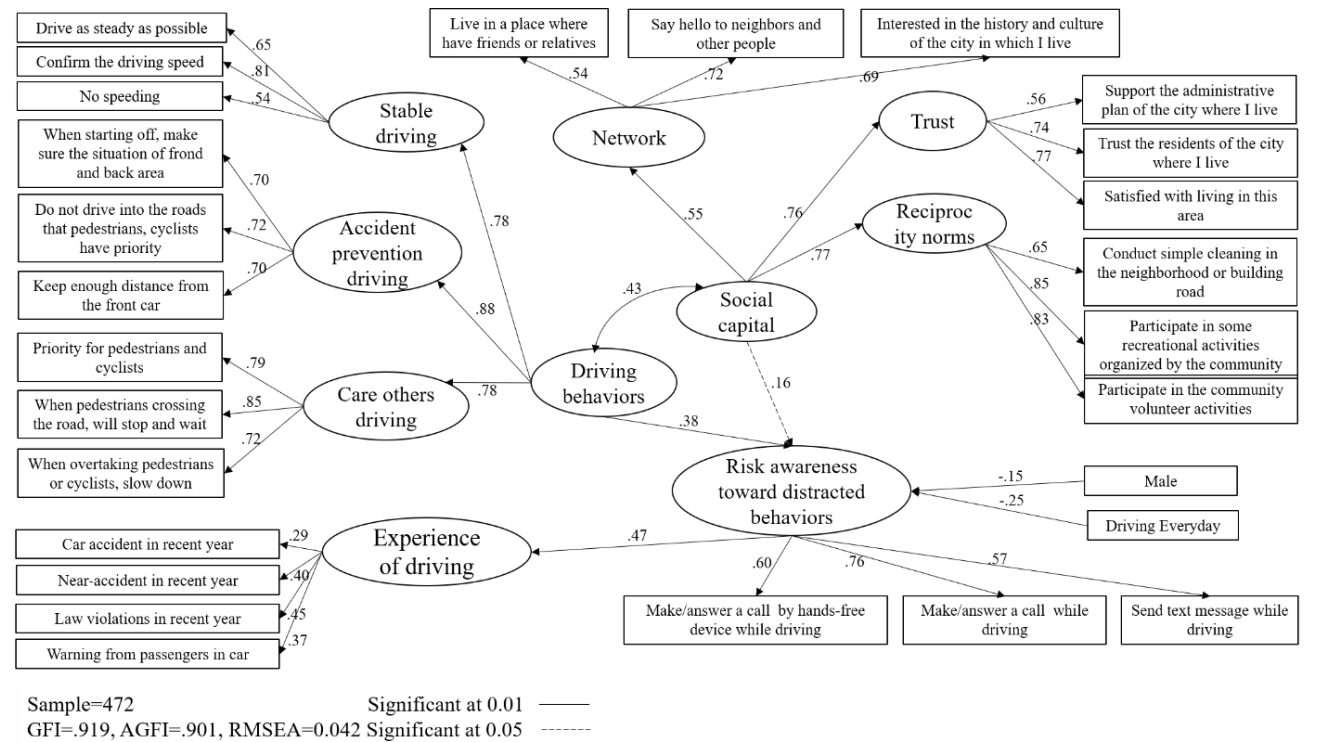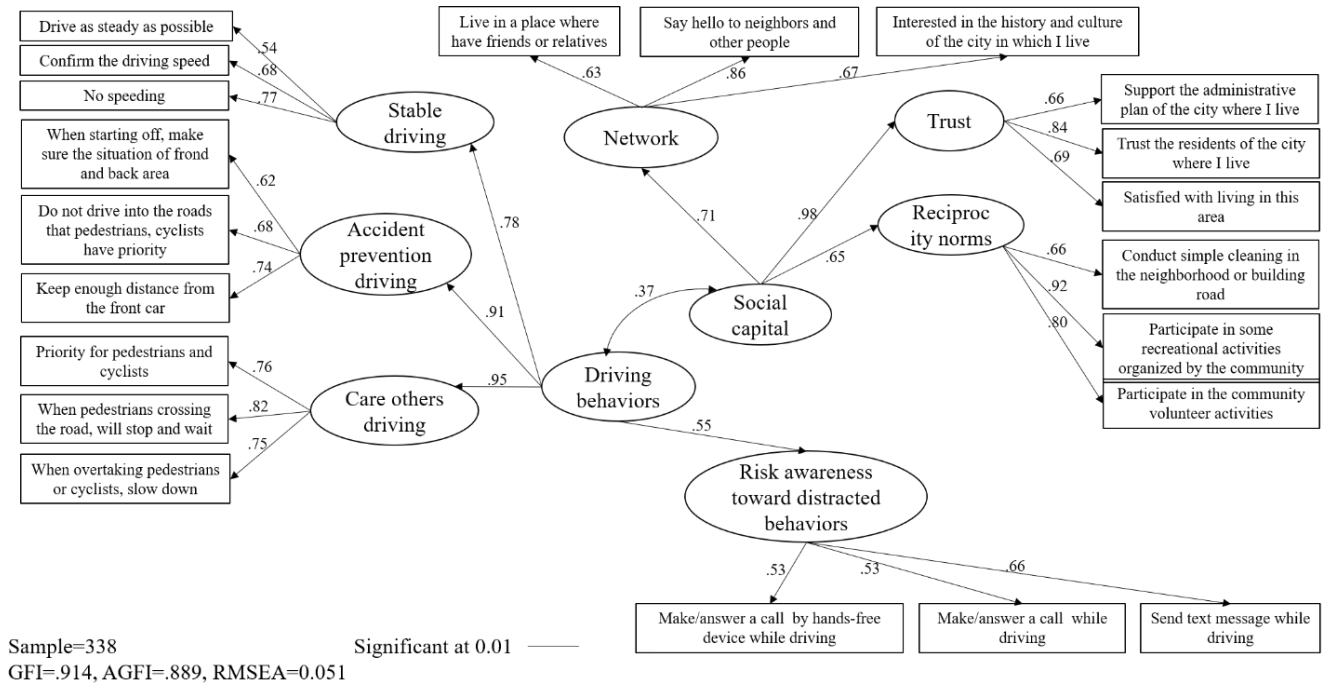
6.5 The summary of this chapter

Upper diagram (Japan):

Drive as steady as possible — .54
Confirm the driving speed — .68
No speeding — .77
→ Stable driving

When starting off, make sure the situation of frond and back area — .62
Do not drive into the roads that pedestrians, cyclists have priority — .68
Keep enough distance from the front car — .74
→ Accident prevention driving

Priority for pedestrians and cyclists — .76
When pedestrians crossing the road, will stop and wait — .82
When overtaking pedestrians or cyclists, slow down — .75
→ Care others driving

Stable driving → Driving behaviors .78
Accident prevention driving → Driving behaviors .91
Care others driving → Driving behaviors .95

Live in a place where have friends or relatives — .63
Say hello to neighbors and other people — .86
Interested in the history and culture of the city in which I live — .67
→ Network

Support the administrative plan of the city where I live — .66
Trust the residents of the city where I live — .84
Satisfied with living in this area — .69
→ Trust

Conduct simple cleaning in the neighborhood or building road — .66
Participate in some recreational activities organized by the community — .92
Participate in the community volunteer activities — .80
→ Reciprocity norms

Network → Social capital .71
Trust → Social capital .98
Reciprocity norms → Social capital .65

Social capital → Driving behaviors .37

Driving behaviors → Risk awareness toward distracted behaviors .55

Make/answer a call by hands-free device while driving — .53
Make/answer a call while driving — .53
Send text message while driving — .66

Sample=338   Significant at 0.01 ———
GFI=.914, AGFI=.889, RMSEA=0.051

Bottom diagram (China):

Drive as steady as possible — .65
Confirm the driving speed — .81
No speeding — .54
→ Stable driving

When starting off, make sure the situation of frond and back area — .70
Do not drive into the roads that pedestrians, cyclists have priority — .72
Keep enough distance from the front car — .70
→ Accident prevention driving

Priority for pedestrians and cyclists — .79
When pedestrians crossing the road, will stop and wait — .85
When overtaking pedestrians or cyclists, slow down — .72
→ Care others driving

Stable driving → Driving behaviors .78
Accident prevention driving → Driving behaviors .88
Care others driving → Driving behaviors .78

Live in a place where have friends or relatives — .54
Say hello to neighbors and other people — .72
Interested in the history and culture of the city in which I live — .69
→ Network

Support the administrative plan of the city where I live — .56
Trust the residents of the city where I live — .74
Satisfied with living in this area — .77
→ Trust

Conduct simple cleaning in the neighborhood or building road — .65
Participate in some recreational activities organized by the community — .85
Participate in the community volunteer activities — .83
→ Reciprocity norms

Network → Social capital .55
Trust → Social capital .76
Reciprocity norms → Social capital .77

Social capital → Driving behaviors .43
Social capital → Risk awareness toward distracted behaviors .16

Driving behaviors → Risk awareness toward distracted behaviors .38

Car accident in recent year — .29
Near-accident in recent year — .40
Law violations in recent year — .45
Warning from passengers in car — .37
→ Experience of driving

Experience of driving → Risk awareness toward distracted behaviors .47

Male — -.15
Driving Everyday — -.25
→ Risk awareness toward distracted behaviors

Make/answer a call by hands-free device while driving — .60
Make/answer a call while driving — .76
Send text message while driving — .57

Sample=472   Significant at 0.01 ———
GFI=.919, AGFI=.901, RMSEA=0.042   Significant at 0.05 -------

Fig.6-4   The difference between Japan and China on driving behaviors(upper: Japan, bottom: China)

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The results shown:

Firstly, the traffic situation between the two nations are different: Chinese drivers experienced more possibility to involve in a fatalities, the possible reasons for this phenomenon are, china lacks a large number of basic statistics on light traffic accidents, which means many accidents without people died are not collected, this is one possible reason, the other is that China experienced a rapid economic development, the construction of transportation infrastructure is proceed very quickly, but the traffic engineering is not get developed with the economic, and the drivers are also not get used to drive in a safe way.

But they do share same problem on distracted driving, especially distracted by cellphone. both two nations enact laws and regulations to control these behaviors, but the accident is increasing year by year, which proves that studying the influencing factors of distracted driving is a very important way to improve traffic safety for both countries.

Then, the risk awareness toward distracted driving behaviors between two nations are being analyzed, results shown Comparing to Chinese drivers, the Japanese consider item "make/answer a call while driving" "make/ answer a call by hands-free device while driving" and "during driving, set the car equipment (radio, navigation, cd, etc)" are more dangerous, while "send/receive text message while driving" "browse the web" "play mobile games" "eat, drink, smoke etc" are less dangerous.

The driving behaviors of two countries also shown significant difference, to sum up, the Chinese drivers shown a high confidence on their behaviors, the impact of national cultural difference implied by this phenomenon.

Finally, a model was built to compare the specific influence degree of each variables on risk awareness on distracted driving.

In conclusion, Japan, China each have unique cultural lessons for traffic safety. Besides the challenge of a large population, China should make effort to reduce the number of casualties in traffic accidents, and education on novice drivers using the results of these chapters may be a good way. The present study investigates the driver's behaviors and risk awareness towards different types of distracted driving behaviors in relation to the safety climate of Japan and China.

[Reference]

1. Schwartz, S. A theory of cultural value orientations: Explication and applications. Comparative sociology, 5(2-3), 137-182, 2006.

2. Zaidel, D. M. A modeling perspective on the culture of driving. Accident Analysis & Prevention, 24(6), 585-597, 1992.

3. Nordfjærn, T., & Şimşekoğlu, Ö. The role of cultural factors and attitudes for pedestrian behaviour in an urban Turkish sample. Transportation Research Part F: Traffic Psychology and Behaviour, 21, 181-193, 2013.

4. Öz, B., Özkan, T., & Lajunen, T. Trip-focused organizational safety climate: Investigating the relationships with errors, violations and positive driver behaviours in professional driving. Transportation research part F: traffic psychology and behaviour, 26, 361-369, 2014.

5. Coogan, M. A., Campbell, M., Adler, T. J., & Forward, S. Examining behavioral and attitudinal differences among groups in their traffic safety culture. Transportation research part F: traffic psychology and behaviour, 26, 303-316, 2014.

6. Edwards, J., Freeman, J., Soole, D., & Watson, B. A framework for conceptualising traffic safety culture. Transportation research part F: traffic psychology and behaviour, 26, 293-302, 2014.

7. Zhao, S.. Road traffic accidents in China. IATSS research, 33(2), 2009.

Chapter 7. Summary

The conclusion summarizes and merges results and discussions of the experiments. Possible implications and recommendations are then derived for governments and organizations to make rules and educate drivers.

7.1 Summary of chapter 3

In this study, the eye movement measures of novice and experienced drivers were being analyzed when conducting n-back experiments. The difference among each level of subtasks were also being compared. It is found that eye movement measures and difficulty of subtask is relevant when trying to differentiate between drivers with different levels of experience. Results are concluded in below.

1) Fixation: firstly, all drivers in both groups (experienced/novice) gazed at the middle area the most. Secondly, when the difficulty of subtask increase, the centralization of novice drivers is much severely than experienced drivers. The fixation distribution on each area were also been quantified. Unlike many studies separated the visual research into two dimensions, horizontal and vertical[1-5], in this study, the comparison is visual area, not only one dimension. Difference between novice drivers and experienced drivers are being found, this finding thrown a light in educate the new drivers, make them get the necessary visual search skills quickly. This finding is also useful for the driver assistance system to distinguish the driver's type, to make better driving assistance.

2) Blink: blink duration of two groups is getting longer with n-back experiment involvement, the time of novice is longer than experience group. Mayhew et al[6]'s result shown that blink duration is related to cognitive distraction degree. The result confirmed that even conducting same subtasks, the effect on cognitive for different drivers is different, the effect to novice drivers is larger than experienced drivers. Since blink has no benefit for information gathering, more blink time cause a decrease of gaze and glance behavior, which result in more exposures to danger.

3) Saccade: saccade peak speed is being studied, research have shown the saccade peak speed could be a useful diagnostic index for the assessment of operators' mental workload and attentional statet[7] as well as fatigue degree[8], As the mental workload increases, the saccade peak speed decreases, in this study, the peak speed of novice is slowly than the experienced, it means when driving at same situation, the driving takes more workload for novice drivers than experienced driver.

4) Pupil size: pupil size of novice group is larger than experienced group, there is no significant difference between each experiment in novice group; the baseline is smaller than 1-back and 2-back experiment in experienced group. Demberg et al. [9]'s results shown, pupil size and distraction degree are related, with distraction degree increase, the pupil size will be getting larger and larger. Similar with blink duration time, the distraction degree of novice drivers is more severely than experienced drivers when conducting same subtasks.

5) Speed performance:

This study provides that comparing to experienced drivers, the novice drivers have a more centralized visual spread area, longer blink duration, faster saccade peak speed and larger pupil size. In a word, when conducting a same task, in same driving situation, the eye movement measures of novice drivers are different comparing to experienced drivers, the difference is not only the driving

skills, but also in the working process of brain. In addition to providing more accurate information on educating novice drivers, it is hoped that these results can be used in the development of distraction monitoring devices and autonomous driving systems, just like Catalbas et al. [10]'s, Di et al. [11]'s and Vicente[12] 's research.

The present study has some methodological limitations should be taken into account. First, the samples of the study were small. Second, the data gathered by eye tracker is not include the head angle when driving, this disadvantage is hoping to be compensated by the simple driving environment, which all drivers do not need to change lanes or turn around, the rotation of head is negligible. Third, not all the eye movement measures are being analyzed, such as saccade average speed and average acceleration. In future, our study will increase the sample size, set up more precise experiment processes, and provide a more com-prehensive analysis of eye movement indictors.

7.2 Summary of chapter 4

In this research, through an online questionnaire survey of drivers, we analyzed the relationship between the attitude towards distracted driving and factors including driving awareness, QOL, and personal attributes; and clarified the characteristics of each attitude group. The results are summarized below.

In chapter 4.4, we analyzed the attitude towards distracted driving. Different from previous studies on distraction attitudes, this time the drivers were asked about their perceptions of the dangers for 9 distraction behaviors, and cluster the drivers by their factor scores on the extracted factors: high demand and low demand distraction. The residual analysis between attitude towards distracted driving group and experience of handheld phone use proved attitude is directly related to behaviors.

In chapter 4.5, focus on driving awareness, we analyzed the relationship between driving awareness and attitude towards distracted driving through the independence test and residual test. Results showed correct attitude towards distracted driving takes a larger percentage in the safe driving group, a smaller percentage in the self-centered driving group; the incorrect attitude group towards distracted driving takes a larger percentage in the self-centered driving group.

In chapter 4.6, the QOL status of participants is being analyzed. Relationships between driving awareness and QOL; QOL and attitude towards distracted driving were studied, the independence test showed they are significantly related at 1% level.

Based on the previous chapters' analysis results, in chapter 4.7, a hypothesis was verified by the SEM model to see the influence degree of each variable on attitude towards distracted driving. Results show driving awareness and QOL status positively influence attitude to-wards distracted driving; being female, with an education career below than university graduation and not driving every day may have a correct attitude towards distracted driving. The attitude towards distracted driving is strongly related to accident-related experience. The drivers with a correct attitude experienced less accident, less near accident, and fewer violations in the recent year.

As the SEM model shows that it is beneficial to have a correct attitude towards distracted driving. To establish a correct attitude, driving awareness and quality of life are two useful measures. The results show that safe driving tendencies and high QOL status are positively correlated with correct distracted driving attitudes, and QOL status is also positively correlated with driving awareness. These

findings help us understand distracted driving behavior and provide a new perspective for avoiding distracted driving by educating driving awareness and improving life quality.

7.3 Summary of chapter 5

To figure out the factors related to the attitudes towards distracted driving due to mobile phone use is a necessary measure for control over the distracted driving behaviors. In this study, the drivers' attitudes towards specific behaviors with mobile phone use while driving are objective, and the relations between objectives and variables, such as driving style, social capital and specific distracted driving behaviors, are being studied, so as to understand the weight of each factor on the objectives.

In Chapter 5.3, the social capital situation of participants is being analyzed, and the chi-square analysis shows that the social capital is related to family composition and gender. Living alone and being a female are more likely to make the related persons fall into the low social capital group. Social capital has an effect on driving styles, and people with high social capital tend to drive in a safer style. From this perspective, improving the social capital of drivers may help to reduce the occurrence of traffic accidents.

The SEM model of attitude towards distracted driving due to mobile phone use

In Chapter5.4, the attitudes towards distracted driving due to mobile phone use are analyzed. The participants are divided into three groups by their risk perceptions about four distracted driving behaviors. It can be found from chi-square that the driving styles are related to the distracted driving attitudes. As discussed in the introduction section, the TPB theory shows that specific behaviors are affected by attitudes. In this study, the correlation between attitudes and behaviors is analyzed more systematically, and the results demonstrate that the attitudes and behaviors are affecting each other. Therefore, to avoid distracted driving behaviors, many resources should be deployed to identify many other dangerous behaviors of drivers.

Chapter 5.5 summarizes the results and builds an AMOS model to explain the correlation between each dummy. Based on former chapters, the following recommendations are offered to understand the attitudes towards distracted driving due to mobile phone use.

1) As a significant factor to improve the driving safety, the social capital in this study is composed of three factors: trust, support and social participation. Social capital is positively correlated to safety driving factors, including stable driving and accident precaution driving styles. These findings demonstrate than social capital is an effective forecasting indicator for driving habits.

2) Driving styles deliver a significant effect on attitudes towards distracted driving due to mobile phone use. This finding indicates that improving drivers' safety attitudes is a holistic and effective approach to road safety.

3) Attitudes towards distracted driving due to mobile phone result in such experience as getting warnings from passengers in cars, getting into a wrong way, or feeling exhausted when driving with mobile phone use.

To sum up, in order to build a health attitude towards distracted driving due to mobile phone use, it is necessary for governments and related organizations to boost the social capital ownership and educate on common safety driving habits. As the first research focused on the effect of social capital and driving styles on distracted driving attitudes, this study proves that the TPB theory is effective

when reverse applied.

7.4 Summary of chapter 6

Firstly, the traffic situation between the two nations are different: Chinese drivers experienced more possibility to involve in a fatalities, the possible reasons for this phenomenon are, china lacks a large number of basic statistics on light traffic accidents, which means many accidents without people died are not collected, this is one possible reason, the other is that China experienced a rapid economic development, the construction of transportation infrastructure is proceed very quickly, but the traffic engineering is not get developed with the economic, and the drivers are also not get used to drive in a safe way.

But they do share same problem on distracted driving, especially distracted by cellphone. both two nations enact laws and regulations to control these behaviors, but the accident is increasing year by year, which proves that studying the influencing factors of distracted driving is a very important way to improve traffic safety for both countries.

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The driving behaviors of two countries also shown significant difference, to sum up, the Chinese drivers shown a high confidence on their behaviors, the impact of national cultural difference implied by this phenomenon.

Finally, a model was built to compare the specific influence degree of each variables on risk awareness on distracted driving.

In conclusion, Japan, China each have unique cultural lessons for traffic safety. Besides the challenge of a large population, China should make effort to reduce the number of casualties in traffic accidents, and education on novice drivers using the results of these chapters may be a good way. The present study investigates the driver's behaviors and risk awareness towards different types of distracted driving behaviors in relation to the safety climate of Japan and China.

7.5 Future plan

Future research will focus on two aspects, one is continuing to dig the relationship between distracted driving and cultural influence. Another is based on the existing conclusions, the drivers will be educated in a targeted manner, and the driving behavior and participation in distracted driving before and after education are compared to verify the results of this research.

[Reference]

1. Mourant, R.R., Rockwell, T.H., 1972. Strategies of visual search by novice and experienced drivers. Hum. Factors 14 (4), 325–335.
2. Bos, A.J., Ruscio, D., Cassavaugh, N.D., Lach, J., Gunaratne, P., Backs, R.W.: Comparison of novice and experienced drivers using the SEEV model to predict attention allocation at intersections during simulated driving. Proceedings of the Eighth International Driving Symposium on Human Factors in Driver Assessment, 2015.
3. Lehtonen, E., Lappi, O., Koirikivi, I., Summala, H.: Effect of driving experience on anticipatory look-ahead fixations in real curve driving. Accident Analysis and Prevention,70, 195–208. 2014.
4. Yeung, J.S., Wong, Y.D.: Effects of driver age and experience in abrupt-onset hazards. Accident Analysis and Prevention, 78, 110–117, 2015.
5. Hills, P.J., Thompson, C., Pake, J.M.: Detrimental effects of carryover of eye movement behaviour on hazard perception accuracy: effects of driver experience, difficulty of task, and hazardousness of road. Transp. Res. Part F Traffic Psychol. Behav. 58, 906–916, 2018.
6. Borowsky, A., Oron-Gilad, T.: Exploring the effects of driving experience on hazard awareness and risk perception via real-time hazard identification, hazard classification, and rating tasks. Accident Analysis and Prevention, 59, 548–565,2013.
7. Mayhew, D. R., Robertson, R. D., Brown, S., and Vanlaar, W. : Driver distraction and hands-free texting while driving, 2013.
8. Di, Stasi.LL, Renner,R., Staehr,P. et al.: Saccadic peak velocity sensitivity to variations in mental workload. Accident Analysis and Prevention,81(4),413-417,2010.
9. Hirvonen, K., Puttonen, S., Gould, K., Korpela, and J. et al. : Improving the saccade peak velocity measurement for detecting fatigue, Journal of Neuroscience Methods, Vol. 187, No. 2, pp. 199–206, 2010.
10. Demberg, V., Sayeed, A., Mahr, A., and Müller, C. : Measuring linguistically-induced cognitive load during driving using the ConTRe task, Proceedings of the 5th international conference on automotive user interfaces and interactive vehicular applications, 2013.
11. Catalbas, M. C., Cegovnik, T., Sodnik, J., and Gulten, A. : Driver fatigue detection based on saccadic eye movements, 2017. 2017 10th International Conference on Electrical and Electronics Engineering (ELECO) : IEEE.
12. Di Stasi, L. L., Marchitto, M., Antolí, A., and Cañas Delgado, J. J. : Testing saccadic peak velocity as an index of operator mental workload: A partial overview, Human Factors and Ergonomics in Manufacturing and Service Industries (submitted for publication),2015.