CHAPTER 1

INTRODUCTION

1.1 Research Background

Road traffic accidents are a major cause of fatality and serious injuries in many countries and extract a high cost on society (Decker et al., 1988; and Kenkel, 1993). According to a World Health Organization (WHO, 2004)/World Bank report "The Global Burden of Disease", deaths from non-communicable diseases are expected to climb from 28.1 million a year in 1990 to 49.7 million by 2020 - an increase in absolute numbers of 77%. Traffic accidents are the main cause of this rise. Road traffic injuries are expected to become the 3rd largest contributor to the global burden of disease by 2020. As accident factor was concerned, NHTSA (2012) reported that in 2010, there were 10,228 fatalities in crashes involving a driver with a BAC of .08 or higher – 31 percent of total traffic fatalities for the year in the United States.

Next, Federal Highway Administration (FHA, 2010) reported that red-light running crashes accounted for 883 fatalities and 165,000 injuries each year. Approximately 35% of all signalized intersection and signalized-intersection-related fatalities involve red-light running. In Taiwan, there were 2117 deaths and 298,647 injuries resulting from road crashes in 2011. According to statistics for 2002-2011 provided by the Taiwan National Police Agency, in terms of irregular driving behaviors, drunk driving, speeding and red light running were ranked the most important three contributing factors to fatal accidents in Taiwan excluding careless and reckless driving. These data indicated that drunk driving, speeding and red light running are severe problems and reducing these illegal driving behaviors is critical for road safety improvement.

Of these three aggressive driving behaviors, instead of performing by police, speeding is mainly hit by using road speed enforcement camera in Taiwan. Thus, this dissertation focuses on drunk driving and red light running enforcements which are chiefly executed by police officers. On average, these two factors accounted for 10,638 and 19,495 injury accidents, and resulted in 495 and 130 fatalities each year, respectively. For example, drunk driving resulted in 437 fatalities, which were involved in about one-fifth of Taiwan traffic fatalities, and 13,584 injuries in 2011. On the part of red light running, 125 people died in traffic crashes, and 19,495 people who injured in this aggressive driving behavior crashes in the same year. That is, on average, someone is killed in alcohol-impaired driving and red light running crash more than one-fourth of traffic fatalities. The easy gains have been made. Public attention and police enforcement have been redirected to other problems. This evidence showed that applying special technique to reduce drunk driving behavior and red light running is needed.

Countermeasures associated with engineering, education and enforcement have been evolved considerably around the world to deal with traffic accidents. However, road safety enforcement has been especially emphasized as a deterrence that acts to improve traffic safety through increasing individual's perceived expected cost and hit rate of engaging drunk driving (Tay, 2005a, 2005b, 2005c, 2005d, 2009; 2010; Tay and de Barros, 2011). Indeed, deterrence, involving specific deterrence and general deterrence, is the main mechanism that acts to improve traffic safety (Tay, 2005b; Tay, 2005c; Tay, 2005d; Tay, 2009 and Tay and de Barros, 2011). The perceived probability of apprehension and avoiding punishment are the two primary impetuses of deterrence in traffic law enforcement (Tay, 2005a; Tay and de Barros, 2011). However, a study which researched the lifecycle of the policy for reducing drunk driving in Taipei by Chang and Yeh (2004) found the number of arrested drunk driving offenders had significant and constant effect on reducing fatal drunk driving accidents over time, but the effect of increasing punishment would significantly decline as time elapsed. It seems to show that increasing the probability of apprehension is more effective than increasing punishment for reducing fatal drunk driving accidents, even though they are the two primary impetuses of deterrence in law enforcement (Tay, 2005a; Tay and de Barros, 2011).

The perceived probability of apprehension depends on two major determinants, level of police presence on the roads and the hit (apprehension) rate. Tay (2005a) argued that the former focuses more on general deterrence whereas the latter focuses more on specific deterrence. Essentially, traffic law enforcements by police officers might be categorized as general deterrence (NHTSA, 2006a). However, this research aimed at measuring police enforcement ability (EA) and then correspondingly designing programs to enhance their ability. Accordingly, given that increasing apprehension rate for certain traffic law enforcement could be achieved through enhancing police enforcement ability, it might be regarded as not only a general deterrence but a specific deterrence in reducing road accidents.

Many enforcement measures have been utilized to deter drivers from driving while intoxicated[1] (DWI), including sobriety checkpoints, saturation patrols and integrated enforcement (NHTSA, 2006a). Nearly all of them were found to be effective in reducing

[1] In this study, DWI is specially related to driving while intoxicated by alcohol.

alcohol-related vehicular accident fatalities and injuries (Elder et al., 2002; Epperlein, 1985; Lacey et al., 1986; Welki and Zlatoper, 2007). Among these measures, sobriety checkpoints and saturation patrols have been prevalently used in many countries such as the United States and New Zealand for more than two decades as a strategy to enforce laws against intoxicated driving. Respecting deterring red light running traffic law enforcement, subject to the high cost of the automated traffic enforcement instrument the typical enforcement for red light running involves police patrols and stand guard at intersection. However, the latter is the major one to execute the traffic law enforcement for Taiwan police.

Conducting sobriety checkpoints, saturation patrols, and red light running enforcement could be defined as demanding duty and their successes are primarily determined by the performance of the police officers involved (Sluiter, 2006). The causal model of job performance proposed by Schmidt et al. (1986) demonstrated that the relationship between ability and performance is stable over time. Campbell (1993) suggested that ability is positively related to performance, which is in line with the findings of Kolz et al. (1998). Collectively, the results of these studies could be applied to support the ability of police officers is an important factor in ensuring enforcement quality when conducting these three enforcements. Thus, we suggest that improving enforcement effectiveness is just the prior choice to reduce the numbers of deaths and injuries resulting from impaired drivers by alcohol and red light runner.

However, the majority of driving behavior studies regarding road safety have focused on improper behavior and perception (Mackintosh, et al., 2006; Fuller, et al., 2009; Peter and William, 2009), traffic risk perceptions (Hatfield and Fernandes, 2009; Nordfjærn and Rundmo, 2009), and driving prohibitions (Li, et al., 2008; Foss, et al., 2009; Robert, et al., 2009). Little research addresses the officers' ability to enforce traffic laws. Accordingly, there is a great need for researchers and authorities to evaluate the ability of the police to conduct their jobs, identify shortcomings, and propose proper actions to remedy the faults (Harris, et al., 1980; Bandura, 1997). In other words, evaluating police officers' ability to enforce traffic laws would assist authorities in designing suitable training programs and further help police officers to improve their ability to cope with abnormal driving behaviors.

1.2 Research Objectives

Improving work ability is an important issue that has been widely discussed in the psychometric and transportation research area (Ilmarinen and Tuomi, 2004; Bugajska and

AAastowiecka, 2005; Chang and Wu, 2008; and Chang and Ju, 2008). The related researchers have paid countless efforts to chase the key for explaining the revealed behavior of an individual.

This study was undertaken to explore the self-perceptions ability of police when conducting sobriety checkpoints in order to prohibit drunk driving and red light running. The successes of conducting sobriety checkpoints, saturation patrols and red light running enforcement are mainly determined by the performance of the police officers involved. Different duty circumstances a worker encountered require different performing abilities (Dijk et al., 1988; Sluiter, 2006; Dijk et al., 1988) to deal with. For example, a police's ability to apprehend DWI driver when conducting sobriety checkpoints basically could include various steps like the ability to detect DWI cues and the ability to detain DWI drivers. Thus, before precisely measuring the police's enforcement ability, developing a conceptual framework of enforcement ability to apprehending drunk drivers is needed.

Since the 1990s, many studies have recognized that some psychological factors, such as attitude, belief, motives, and perception, could play an important role in decision making process (Ben-Akiva et al., 1999). Many psychological factors were thus introduced and discussed as the explanatory variables in the discussion of workers' behavior. Since the psychological constructs have been recognized as significant factors that influence workers' behavior, more and more researchers in transportation have pay their attentions on the relationship between one's latent consideration and his/her revealed behavior. After plenty of related studies were conducted we may question that: did we obtain convincible and comparable measures on the related latent constructs? Such a challenge on the measurement is critical, especially for those unexplored latent constructs which have no normalized scales (the norms) to serve as a reference of measurement. In fact, researchers usually measure such latent constructs by collecting the respondents' opinions, and these opinions are mostly presented by items with ordinal scales (e.g. the Likert scale) in some formed questionnaires. If these ordinal categories in the items were naively assigned with some incremental integers, such integers can only represent the rank among categories in a single item and has limitations in the statistical inference. As a result, demonstrating the approaches how to measure a new-specified latent construct, especially for ensuring the assessment on the trait level could serve as reasonable and effective factors for further statistical inference is another important object. Consequently, the main objectives of this study are listed as follows:

(1) Develop the conceptual frameworks of enforcement ability to apprehending drunk drivers

and red light runner.

(2) Design appropriate approach to collect and measure the self-perceptions ability of police when conducting traffic law enforcement.

(3) Conduct an empirical study to assess the self-perception ability of police on conducting traffic law enforcement.

(4) Conceptualize the contents and measure the enforcement abilities perceived by police.

(5) Provide recommendation to improve polices' ability and solve the problems they encountered.

1.3 Research framework

Based on deterrence theory, recent development of police enforcements for aggressive driving behaviors generally considers the effectiveness of automatic cameras; very little interest has been shown in studying the police conducting abilities on deterring the traffic violator. Therefore, this research tries to realize how the police officers perceived their enforcement abilities and explore their difficulties in dealing with people driving while impaired and red light running, which can be applied to advance the polices' enforcement abilities.

The research structure is divided into three parts: the ability to conduct sobriety checkpoints, saturation patrols and red light running. The component "the ability to conduct sobriety checkpoints" includes abilities on detecting, detaining, and intercepting DWI vehicles (Harris et al, 1980; Scott et al, 2006; NHTSA, 2006a, 2002b). Next, the component "the ability to conduct saturation patrols" includes two police self-perceptive abilities: detecting, detaining abilities. The last component "the ability to conduct red light running" refers to the conceptual framework of traffic law enforcement ability (Tuomi et al., 1998; Markku et al, 2002; Dijk et al, 1988; Chang and Shih, 2007) based on the steps of conducting red light running (Chang and Shih, 2007). The structure and concept for the three components is described in Figure 1.

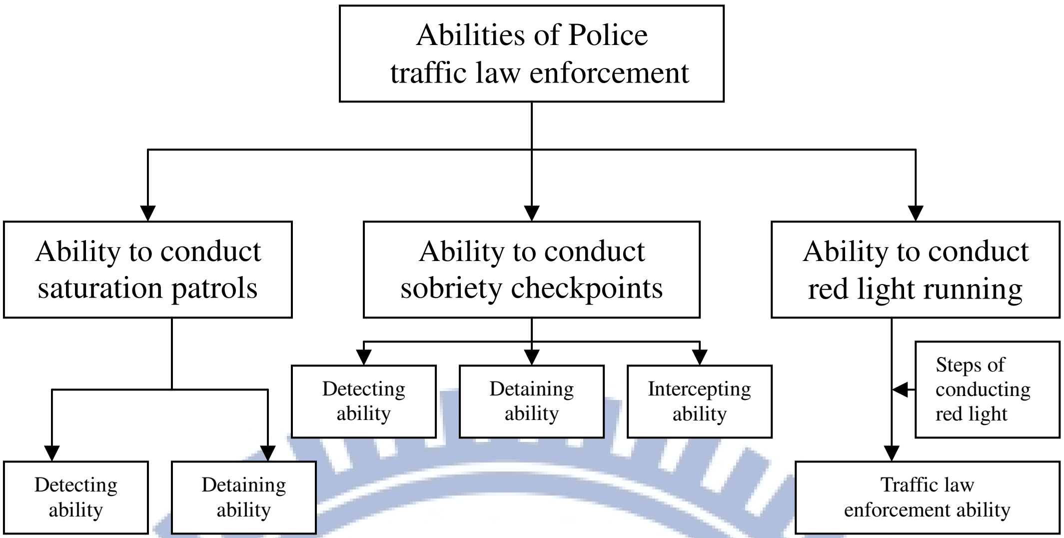


Figure 1 Research structure and concept

1.4 Research Flow Chart

Reviewing the data of road traffic accidents in many countries, we found that deterring drunk driving and red light running could effectively reduce the numbers of fatalities and injuries in crashes. Moreover, improving police enforcement ability is a good policy to prohibit impaired drivers by alcohol and red light runner. Thus, this study was conducted to explore the self-perceptions ability of police and task difficulty when conducting traffic law enforcements. In order to construct the conceptual frameworks of the perceived ability of conducting DWI and red light running enforcement, and measure the enforcement ability for police, this study firstly reviewed literature related to deterrence theory, DWI enforcement strategies, DWI detection guide, red light running violation and work ability. We subsequently identify the driving cues which DWI vehicles usually exhibit, construct the main process of apprehending drunk drivers when conducting sobriety checkpoints and saturation patrols. Next, a pre-test was conducted to explore the most commonly observed driving patterns. Thereafter, two questionnaires, which combined the most important driving patterns observed at checkpoints and when patrolling with the enforcement stages of conducting drunk driving enforcement to generate meaningful items, could be established. Moreover, after constructing the ability model for red light running enforcement, a scale exploring the perceived enforcement ability for red light running was also built.

Three empirical studies were then undertaken to interview Taiwan police officers to collect demographic variables and ability data. The study's results are expected not only to reveal the enforcement ability of police officers, but also provide valuable information for designing proper training programs to improve police conducting ability. Moreover, through analyzing the outcomes of task difficulty, authorities could propose administration or legislation mechanism to resolve problems originated from enforcement process.

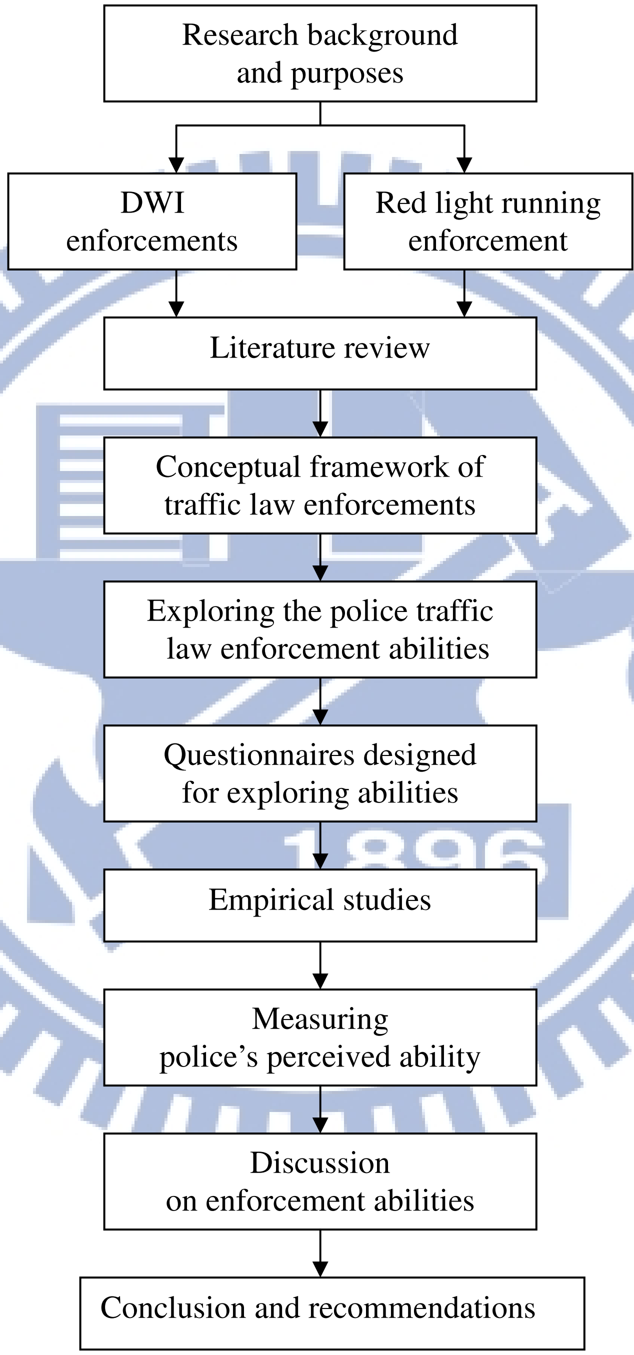


Figure 2 Research flow chart

1.5 Overview of Dissertation

This dissertation contains eleven chapters, which are organized as follows. Chapter 1 introduces our research motivations, objectives, and contributions. According to the research motivations, objectives, chapter 2 presents a brief literature review which concerns to construct a proper scale to measure the police's perceived enforcement ability on (1) deterrence theory, (2) strategies for DWI enforcement, (3) visual detection of DWI, and (4) red light Running Enforcement. Thereafter, the conceptual frameworks of the perceived enforcement abilities could be constructed in Chapter 4-6.

Chapter 3 illustrates our methodology for measuring the perceived enforcement ability. Chapter 4-6, based on the constructed conceptual frameworks of the perceived enforcement abilities, three traffic law enforcement questionnaires were built. Further, they separately demonstrate three on the police enforcement ability for sobriety checkpoints, saturation patrols and red light running enforcements. In these three chapters, we demonstrated our exploration on questionnaire design. Three empirical studies on the police enforcement ability in Taiwan had been conducted to support our conceptual framework. Additionally, a model comparison process which testified the merits of multidimensional approach of Rasch models was also conducted in chapter 4. Moreover, they demonstrated our measurement of the perceived enforcement abilities of police and enforcement difficulties, and also conducted estimations of differential item functioning (DIF) for interpreting the effect of gender on police ability. Further, we derived the findings from both the estimated of person and item parameters. At the end of these chapters, we discussed our findings and results. Finally, some suggestions recommendations on enhancing police's enforcement ability and deterring drunk driving and red light running were proposed in Chapter 7. Flow chart of the research steps is shown in Figure 2.

1.6 Research Contributions

This study, which explored the latent component traits of police enforcement abilities on traffic law enforcements when conducting sobriety checkpoints, saturation patrols and red light running, was explorative analysis. The aim was to realize how the police officers perceived their enforcement abilities and explore their difficulties in dealing with people driving while impaired and red light running, which can be applied to advance the polices' enforcement abilities. Such a self-assessment of police officers on their own enforcement abilities may plays a critical role on designing suitable training courses to improve the polices' enforcement abilities for the police authorities. This issue was seldom discussed on the literatures. Thus in the beginning of this dissertation, we will start with the introduction of this research, including the motivations, objectives, framework and contributions of this study in the following parts. The main contributions of this study could be summarized as follows:

(1) The conceptual frameworks of the perceived DWI enforcement ability when conducting sobriety checkpoints, DWI patrols and red light running can be conceptualized.

(2) The exploration of the most commonly observed driving patterns by police officers when DWI enforcement was running can be constructed.

(3) Our concepts and approaches for assessing the level of a multidimensional component latent trait can serve as a useful example for researchers who have to treat some correlated component latent traits as the influencing variables in their statistical inference.

(4) The realization of the abilities and difficulties in the necessary enforcement actions or motions that a police officer might encounter when conducting DWI checkpoints, patrols and red light running can help to design suitable training programs to improve police ability, and apply administration or legislation mechanism to assist them in resolving problems originated from enforcement process.

CHAPTER 2

LITERATURE REVIEW

Even though many strategies like deterrence, prevention and intervention and alcohol treatment (NHTSA, 2006b; Tay, 2005a) have been applied to reduce drivers from driving while intoxicated (DWI), road safety enforcement efforts have relied primarily to deterrence theory (Tay, 2005a). This study was undertaken to measure the self-perceptions abilities of police and explore their duty difficulties when conducting DWI checkpoints, patrols and red light running enforcement – a deterrence measurement. Thus, this topic firstly should explore the latent component construct of police enforcement ability to conduct traffic law enforcements. Therefore, in order to construct conceptual frameworks of the perceived enforcement abilities, and then develop reasonable questionnaires to measure police's enforcement abilities when conducting traffic law enforcement, the related literature for deterrence theory, strategies for DWI enforcement, visual detection of DWI, red light running problem, and conceptual frameworks of work ability should be firstly reviewed.

2.1 Deterrence Theory

Deterrence is the main mechanism that acts to improve traffic safety in enforcement programs (Tay, 2005b; Tay, 2005c; Tay, 2005d; Tay, 2009 and Tay and de Barros, 2011). Deterrence signifies enacting laws that prohibit drivers from DWI, publicizing and enforcing those laws, and punishing the violators. If drivers believe that drunk driving and red light running are likely to be observed and that those drivers are likely to be arrested, convicted, and punished, many will not drive while intoxicated (NHTSA, 2006a) and run red light.

In criminology and social psychology, the concept of deterrence is used to characterize the prevention of criminal behavior through the use of, or by the threat of, legal sanctions (Meier and Johnson, 1977). Deterrence occurs when a particular sanction functions to prevent the occurrence of an act or is thought to decrease the probability of the act's occurrence (Tay, 2005a). In economics, the main focus of the deterrence theory is on increasing the individual's perceived expected cost of engaging in an illegal activity (Becker, 1968; McCarthy and Oesterle, 1987; Kenkel, 1993 and Tay, 2005a). An increase in the expected cost is posited to decrease the level of illegal activity consumed by the individual or decrease the likelihood of the individual to engage in the illegal activity. This increase in the perceived cost could be a result of an increase in the severity of the sanction, probability of apprehension or the swiftness of punishment. In the road safety area, the main impetus of law enforcement is in increasing the certainty of apprehension and punishment, which is a subjective probability that depends on the individual's information set, and two of the major determinants are the level of police presence on the roads and the hit (apprehension) rate, with different enforcement programs focusing on different aspects of deterrence (Tay, 2005b).

Deterrence strategy involves specific deterrence and general deterrence. General deterrence occurs when a would-be offender refrains from committing a crime because another has been punished for offending. Specific deterrence operates when an individual who has committed a crime and has been sanctioned, refrains from committing additional criminal acts for fear of another punishment. (Piquero and Paternoster, 1998; Stafford and Warr, 1993; Tay, 2005a; Tay, 2005d and Tay, 2010). Stafford and Warr (1993) defined general deterrence as the deterrent effect of indirect experience with punishment and punishment avoidance, and specific deterrence as the deterrent effect of direct experience with punishment and punishment avoidance. In other words, deterrence countermeasures which influence the general driving public through well publicized and highly visible enforcement activities and subsequent punishment refer to general deterrence. This concept is consistent with the general deterrence model containing special enforcement, increased public awareness, increased perceived risk of arrest, and change in drinking and driving behavior proposed by NHTSA (2006b). In contrast, specific deterrence is related to efforts to influence drivers who have been arrested for illegal behavior like drunk driving so that they will not continue to drive while impaired by alcohol (NHTSA, 2006a).

The perceived probability of apprehension is a subjective probability that depends on the individual’s information set. Two of the major determinants of this information set are the level of police presence on the roads and the hit (apprehension) rate. It can be argued that the former like automatic cameras focuses more on general deterrence whereas the latter focuses more on specific deterrence (Tay, 2005a). In the view points of DWI checkpoints, this measure could be operated to deter DWI offence during high alcohol hours on any roadway and on any day of the week (NHTSA, 2006a; Chang and Shih, 2012). Moreover, a harsh punishment should be attracted to offender who has been DWI arrested. Thus, one would refrain from drunk driving for fear being apprehended when passing a nonscheduled sobriety checkpoint whether another has been punished or he/she has been sanctioned for DWI offending. Further, this study aimed at measuring police enforcement and thus designing programs to enhance their hit DWI ability. Accordingly, given increasing apprehension rate can be achieved through enhancing police ability, DWI checkpoints, saturation patrols and red light running enforcement conducted by high police enforcement ability could be regarded as not only a general deterrence but a specific deterrence in reducing DWI accidents.

2.2 Strategies for DWI Enforcement

The arrest rate for drinking and driving is pitifully low, with less than one arrest for every 50 trips by a driver over 0.08 BAC (Hedlund and McCartt, 2002; NHTSA, 2006a). Hedlund and McCartt (2002) further argued that many drinking drivers are "high risk," with one or more of the following characteristics: (1) Half of drinking drivers in crashes or arrests have a BAC of .15 or higher, (2) One-third of drinking drivers in crashes or arrests have a prior DWI conviction, (3) One-quarter of drinking drivers in surveys have some indication of an alcohol problem. On the other hand, alcohol-impaired driving is affected by several external factors, including geography, urbanization, road structure and conditions, and economic activity, as well as by a State's laws and programs. For all of these reasons, both the current level of alcohol-impaired driving and the progress in reducing drunk driving have diverse conditions from district to district (NHTSA, 2004). Thus, how to design and administer effective strategies to reduce and apprehend alcohol-impaired driving is not only an imperative but an essential issue for every country. Reviewing previous literature, five basic strategies are commonly used to reduce alcohol-impaired driving crashes and consequences (NHTSA, 2006a):

(1) Deterrence: enact, publicize, enforce, and adjudicate laws prohibiting alcohol-impaired driving;

(2) Prevention and intervention: reduce drinking, keep drinkers from driving;

(3) Communications and outreach: inform the public of the dangers of impaired driving and establish positive social norms that make driving while impaired unacceptable;

(4) Alcohol treatment: reduce alcohol dependency or addiction among drivers;

(5) Other traffic safety measures: implement strategies that affect alcohol-impaired drivers and other drivers as well.

The first strategy, deterrence, is divided into four parts: (1) laws, (2) enforcement, (3) prosecution and adjudication, and (4) offender treatment, monitoring, and control. Since enforcement countermeasure refers to deterrence strategy and this research discusses the enforcement ability of police to conduct sobriety checkpoints, this section mainly introduces countermeasures of enforcement in this strategy. Enforcement method commonly includes five countermeasures: (1) sobriety checkpoints, (2) saturation patrols, (3) integrated enforcement, (4) preliminary breath test devices, and (5) passive sensors. All of them will be clearly illustrated as following.

2.2.1 Sobriety Checkpoints

This study explores countermeasure of enforcement listed in the first strategy — deterrence. Many other traffic safety countermeasures help reduce alcohol-related crashes and casualties are discussed in this research. Except applying instruments, including preliminary breath test devices and passive sensors, deterrence countermeasures of enforcement include three methods: (1) Sobriety checkpoints, (2) Saturation patrols, and (3) Integrated enforcement. For integrated enforcement, impaired drivers are detected and arrested through regular traffic enforcement and crash investigations as well as through special impaired driving checkpoints and saturation patrols. It contains several enforcement methods but not a unique enforcement. Of those three methods, sobriety checkpoints and saturation patrols have been prevalently applied to prohibit driving while impaired (DWI) in Taiwan and found to be effective in reducing alcohol-related crash fatalities and injuries (Elder et al., 2002; Epperlein, 1985; Lacey et al., 1986; Welki and Zlatoper, 2007).

The checkpoints have been proven effective in reducing alcohol-related accidents (Watson et al, 1994; Epperlein, 1985; Lacey et al., 1986; Voas et al., 1985). Levy et al. (1988, 1990), and Ross (1992) further confirmed that frequent checkpoints could substantially reduce alcohol-related vehicular accidents. In the case of sobriety checkpoints, Watson et al (1994) indicated that operating Reduced Impairment Driving (RID), in which the police are restricted to detaining and testing only drivers whom they suspected had been DWI, could be highly successful in reducing the number of serious crashes. Taiwan has conducted RID checkpoints since 1996 and has been demonstrated its significant effect on reducing fatal drunk driving accidents (Chang and Yeh, 2004).Therefore, how to conduct the enforcement strategies and detect impaired drivers need to make more details and expression in this chapter.

Sobriety checkpoints (also called DWI checkpoints) are roadblocks set up by law enforcement agencies on selected roads and highways to stop and detain individuals suspected of driving while intoxicated. Checkpoints may also be used to check for valid driver licenses, safety belt use, outstanding warrants, stolen vehicles, and other traffic and criminal infractions. Much like a roadblock that is established for traffic violation checks, Police officers use a neutral policy in which to detain vehicles and check the sobriety of the driver. If the driver appears intoxicated (with slurred speech, glassy eyes, etc.) police officers will ask the driver to exit the vehicle and perform field sobriety tests. If the driver is deemed intoxicated, appropriate penalty or detention will follow.

A typical checkpoint requires several hours from each law enforcement officer involved. Officers must either be diverted from other duties or paid overtime. Law enforcement costs can be reduced by operating checkpoints with 3 to 5 officers, instead of the 10 to 12 or more officers used in some jurisdictions in American (NHTSA, 2002a; Stuster and Blowers, 1995). Recently, U. S. police agencies in two rural West Virginia counties were able to sustain a year-long program of weekly low-manpower checkpoints (Lacey et al., 2005). The proportion of nighttime drivers with BACs of 0.05 and higher was 70 percent lower in these counties, compared to drivers in comparison counties that did not operate additional checkpoints.

DWI checkpoints have been used in the United States for more than two decades as a strategy to enforce the law against impaired driving and have demonstrated their effectiveness in reducing alcohol-related crashes (Epperlein, 1985; Lacey et al., 1986; Voas et al., 1985). At a sobriety checkpoint, law enforcement officers detain vehicles at a predetermined location to check whether the driver is impaired. They either detain every vehicle or stop vehicles at some regular interval, such as every third or tenth vehicle. The purpose of checkpoints is to deter driving after drinking by increasing the perceived risk of arrest. To do this, checkpoints should be highly visible, publicized extensively, and conducted regularly. In Taiwan, DWI checkpoints which are frequently administered but unscheduled and set simultaneously at different locations, thus, one would refrain from drunk driving for fear being apprehended when passing a checkpoint. Fell et al. (2004) provide an overview of checkpoint operations, use, effectiveness, and issues. Frequent checkpoint programs substantially reduced alcohol-related crashes (Levy et al., 1988, 1990; Ross, 1992). CDC's (U.S. Centers for Disease Control and Prevention) systematic review of 11 high-quality studies (Elder et al., 2002) found that checkpoints reduced alcohol-related fatal, injury, and property damage crashes each by about 20 percent.

2.2.2 Saturation Patrols

One of the main goals of drunk driving enforcement is to raise the perception of drinking drivers that they will be stopped and investigated for drunk driving (Scott et al., 2006). This aim can be achieved by significantly increasing the frequency and number of alcohol impairment drivers stopped by police, since convincing drivers that they will get caught is perhaps the most important factor in deterring drunk driving (Jones, et al., 1998; Grosvenor, et al., 1999; Michael et al., 2005). Therefore, one might suggest increasing the frequency as well as the number of locations of checkpoints to reduce drunk driving. However, checkpoints are costly (NHTSA, 2006a) and often lack funding and exhaust police resources (James et al., 2003).

Despite evidence that checkpoints are effective in reducing drinking and driving and alcohol-related fatal crashes, many police agencies have been unenthusiastic about using them (Fell, et al., 2003). Lacey et al., (2006) further suggest that although sobriety checkpoints can be effective in reducing alcohol-impaired driving, checkpoints are underused in the United States. States that conducted checkpoints infrequently claimed a lack of funding and police resources prevented more extensive use of checkpoints, and preferred saturation patrols, believing them to be more productive (Fell, et al., 2003).

A saturation patrol (also called a blanket patrol, "wolf pack," or dedicated DWI patrol) consists of a large number of law enforcement officers patrolling a specific area for a set time to detect and arrest impaired drivers (NHTSA, 2006a). The purpose of saturation patrols is to arrest impaired drivers and also to deter driving after drinking by increasing the perceived risk of arrest. To do this, saturation patrols should be publicized extensively and conducted regularly. A less-intensive strategy is the "roving patrol" in which individual patrol officers concentrate on detecting and arresting impaired drivers in an area where impaired driving is common or where alcohol-involved crashes have occurred (Stuster, 2000).

Saturation patrols can be very effective in arresting impaired drivers. For example, in 2001 Minnesota's 96 saturation patrols stopped 13,681 vehicles and arrested 566 impaired drivers (The Century Council, 2003). The effects of saturation patrols on alcohol-related crashes or injuries have not been evaluated. Saturation patrol operations are quite flexible in both the number of officers required and the time that each officer participates in the patrol.

2.2.3 Integrated Enforcement

Impaired drivers are detected and arrested through regular traffic enforcement and crash investigations as well as through special impaired driving checkpoints and saturation patrols. A third opportunity is to integrate impaired driving enforcement into special enforcement activities directed primarily at other offenses such as speeding or safety belt use, especially since impaired drivers often speed or fail to wear safety belts (NHTSA, 2006a).

A study by Jones et al (1995) evaluated a three-site evaluation of integrated impaired driving, speed, and safety belt use enforcement. They found that the sites that combined high publicity with increased enforcement reduced crashes likely to involve alcohol (such as single-vehicle nighttime crashes) by 10 percent to 35 percent (NHTSA, 2006a). They suggested that the outcomes were encouraging but not definitive. This argument is consistent with the findings of Jones and Lacey (2001), and Stuster (2000). In addition, Hingson et al. (1996) researched the Massachusetts Saving Lives comprehensive programs in five communities using integrated enforcement methods and further indicated that the programs reduced fatal accidents involving alcohol by 42 percent, and about half the speeding drivers detected through these enforcement activities had been drinking and about half the impaired drivers were speeding.

Integrated enforcement activities should be publicized extensively to be effective in deterring impaired driving and other traffic offenses whenever this duty to be administered. Noticing media may be necessary to complement news stories, especially in a continuing saturation patrol program. Even though there is no data on how frequently integrated enforcement methods are used in Taiwan, it deserves to be conducted to reduce drivers from DWI.

2.2.4 Alcohol Breath Test Devices (ABTs)

Alcohol breath tester is a small handheld alcohol sensor used to estimate or measure a driver's BAC. Law enforcement officers use ABTs in the field to help establish evidence for a DWI arrest. The driver blows into a mouthpiece and the ABT displays either a numerical BAC level, such as 0.12, or a BAC range, such as a red light for BACs above 0.08 (NHTSA,2006).

Several ABT models are available commercially. They are quite accurate and generally reliable. NHTSA maintains a "Conforming Products List" of alcohol testing and screening instruments, including PBTs that meet accuracy and reliability standards (NHTSA, 2004). The Century Council (2003) proposed that PBTs are used in many States to provide evidence of alcohol use to support a DWI arrest in the untied State. This evidence of alcohol use is admissible in court in approximately half the States, but in most States PBT evidence cannot be used to establish a driver's BAC. California allows officers to use PBT evidence to enforce zero-tolerance laws: Officers at the roadside can issue a citation and seize the driver's license (Ferguson et al., 2000).

According to Taiwan regulations, applying ABT to collect evidence of DWI is the principle method to perform DWI arrest. However, evidence accumulated by Standardized Field Sobriety Test (SFST) is auxiliary status. ABTs are also used at hospital where a driver is injured while he/she is still conscious or at crash scenes where a driver is injured. That is to say, before making an arrest for DWI, a police officer may ask the driver to submit to a preliminary breath test. Moreover, and more importantly, refusing to take the test is not admissible at a DWI trial. Additionally, the police officer must also provide the results of any test to the person taking the test immediately.

2.2.5 Passive/ Informal Alcohol Sensors (PAS)

A passive alcohol sensor is a device to detect alcohol presence in the air. The sensor usually is integrated into a flashlight or clipboard. Officers hold the flashlight or clipboard near the driver's mouth, where it measures alcohol presence in the air where the driver is breathing. The PAS can be used without the driver's knowledge and without any probable cause because the PAS is considered "an extension of the officer's nose" and records information that is "in plain view" (Preusser, 2000; NHTSA, 2006a). The PAS displays its results using lights of different colors to indicate different alcohol concentration levels.

PAS models generally are reliable and effective at detecting alcohol in the surrounding air. PAS units typically are used at the car window after a traffic stop or at a checkpoint. A PAS report of alcohol presence gives the officer evidence to request further examination with SFSTs or a preliminary breath test (PBT) device (also called breath alcohol test device). The PAS is especially effective at checkpoints, where officers must screen drivers quickly with little or no opportunity to observe the drivers on the road. Several evaluations showed that officers using a PAS at checkpoints can detect twice as many drivers at BACs of 0.10 and above than officers not using a PAS (Fell et al., 2004; Century Council, 2003). The PAS can help officers avoid detaining drivers with BACs of 0.04 or below. The PAS also assists officers on routine patrol in detecting alcohol-impaired drivers (Preusser, 2000).

2.3 The Visual Detection of DWI

Referring to the study “visual detection of driving while intoxicated” by Douglas et al (1980), the NHTSA (2005) has produced a pocket-size booklet intended primarily for law enforcement entitled Guide for Detecting Drunk Drivers at Night. The booklet contains a driving under the influence[2] (DUI) Detection Guide, which identifies the twenty-three most common and reliable initial indicators of drunk driving — along with the probability that the

[2] In this study, DUI specifically refers to driving under the influence by alcohol.

driver exhibiting the symptom is, in fact, under the influence. Driving under the influence refers to operating a motor vehicle while affected by alcohol, drugs, or both. Table 1 is a list of the cues and their related indicia of intoxication. Thus, for example, the research indicates that "the percentages are 55 out of 100" that a driver who is straddling a center or lane marker has a blood-alcohol concentration (BAC) of .10 percent or higher.

The report notes that cues are rarely seen in isolation; officers usually see a number of driving symptoms before pulling the suspect over. The NHTSA research indicates that the chances of a driver being intoxicated when multiple cues are observed can also be calculated: "When two or more cues are seen, add 10 to the highest value among the cues observed." For example, if the subject is observed to be weaving (45) and following too closely (60), there are 70 chances out of 100 that he/She has a BAC of .10 percent or more. Similarly, under each condition, probability values for $P(\text{BAC} \geq 0.05)$ were found to be increased by 20 over the value for $P(\text{BAC} \geq 0.10)$.

These twenty-three DWI cues except driving with vehicle defect(s) have been well defined by Douglas et al. (1980) and AHTSA (2005) as following:

(1) Stopping (without cause) in traffic lane: no observable justification for the vehicle to stop in the traffic lane. The stop is not caused by traffic conditions, traffic signals, an emergency situation, or related circumstances.

(2) Following too closely: following another vehicle while not maintaining the legal minimum separation.

(3) Turning with wide radius: During a turn, the radius defined by the distance between the turning vehicle and the center of the turn is greater than normal.

(4) Appearing to be drunk: This cue is actually one or more of a set of indicators related to the personal behavior or appearance of a driver. These indicators include gripping the steering wheel tightly, driving with one's face close to the windshield, slouching in the seat, and staring straight ahead with eyes fixed.

(5) Driving on other than designated roadway: driving on other than the roadway designated for traffic movement. Examples include driving: at the edge of the roadway, on the shoulder, off the roadway entirely and straight through turn-only lanes or areas.

(6) Straddling center or lane marker: moving straight ahead with the center or lane marker between the left and right wheels.

(7) Almost striking a vehicle or other object: driving at slow speed or moving with traffic to pass unusually close to a sign, barrier, building, or other object.

(8) Slow response to traffic signal: exhibiting a longer than normal response to a change in traffic signal.

Table 1 DWI Detecting Guide

Visual DUI cues	Percentages*
1. Stopping (without cause) in Traffic Lane	70
2. Following too closely	60
3. Turning with Wide Radius	60
4. Appearing to be drunk	60
5. Driving on Other Than Designated Roadway	55
6. Straddling Center or Lane Marker	55
7. Almost Striking Object or Vehicle	55
8. Slow response to traffic signal	50
9. Headlights Off	50
10. Signaling Inconsistent with Driving Actions	45
11. Weaving	45
12. Tires on Center or Lane Marker	45
13. Drifting	45
14. Swerving	45
15. Accelerating or Decelerating Rapidly	45
16. Slow Speed	45
17. Fast Speed	35
18. Failing to respond to traffic signals or signs	35
19. Braking Erratically	35
20. Stopping Inappropriately (other than in lane)	35
21. Turning Abruptly or Illegally	30
22. Driving Into Opposing or Crossing Traffic	30
23. Driving with vehicle defect(s)	30

*Percentage of nighttime drivers with BAC equal to or greater than 0.10.

(9) Headlights off: driving with both headlights off during a period of the day when the use of headlights is required.

(10) Signaling inconsistent with driving actions: the driver's signaling to be inconsistent with the associated driving actions.

(11) Weaving: moving alternately toward one side of the lane and then the other side.

(12) Tires on center or lane marker: The left-hand set of tires of the observed vehicle is consistently on the center line, or either set of tires is consistently on the lane marker.

(13) Drifting: moving in a generally straight line, but at a slight angle to the lane.

(14) Swerving: moving in an abrupt turn away from a generally straight course.

(15) Accelerating or decelerating rapidly: accelerating and decelerating rapidly alternately, including any acceleration that is significantly more rapid than that required by the traffic conditions.

(16) Slow speed: driving at a speed that is more than 10 MPH below the speed limit.

(17) Fast speed: driving at a speed that is more than 10 MPH above the speed limit.

(18) Failing to respond to traffic signals or signs (19) Braking erratically: braking unnecessarily frequently, maintaining pressure on the brake pedal ("riding the brakes"), or braking in an uneven or jerky manner.

(20) Stopping inappropriately: stopping at an inappropriate location or under inappropriate conditions, other than in the traffic lane.

(21) Turning abruptly or illegally: executing any turn that is abnormally abrupt or illegal.

(22) Driving into opposing or crossing traffic: heading into opposing or crossing traffic under one or more of the following circumstances: driving in the opposing lane, driving the wrong way on a one-way street, backing into traffic, failing to yield the right-of-way.

2.4 Red Light Running Problems and Enforcement Methods

The problem of restraining motorists from running red lights has been a widely discussed issue. The red light runners cause hundreds of deaths and tens of thousands of injuries each year. According to the statistics of the Taiwan National Police Agency, following drunk driving and speeding, red-light running is ranked as the third major violation factor of fatal accidents in Taiwan. During the period from 2003 to 2011, on average, 132 persons were killed and 11,880 persons were injured in crashes that involved red light running each year. These data showed that red-light running is not only a severe problem but also a critical issue for traffic enforcement.

Red light running is a common traffic violation. Retting and Williams (1996) found that 2 red light runners were observed per hour at an intersection; and further, Porter and England (2000) pointed that there were 10 red light runners noted per hour at an intersection. Retting et al. (1998) argued that 3% of all fatal crashes between 1992 and 1996 involved red light running. Besides, in a study that evaluated location and cause of collisions, Retting et al. (1995) indicated that red light running was involved in 22% of urban crashes. These evidences further showed that the red light running is a significant problem and the reduction in this violation is a critical work for traffic management. Similarly, Porter and England (2000) found that 10 red-light runners were noted per hour. Hill and Lindly (2003) analyzed red light violation data from 19 intersections that without red light cameras, and they found 1,775 violations occurred over 554 hours. These investigations reveal the prevalence of this traffic violation.

To curb this trend, many cities have installed red-light cameras. This automatic device can collect all the evidence authorities need to prosecute light-runners; however, this kind of enforcement has some drawbacks and has been a topic of constant debate in the literature (Erke, 2009). First, a study evaluated red light camera programs in 7 cities found these devices increased rear-end collisions by 15 percent because anxious drivers are more likely to stop abruptly (Council et al, 2005). This finding was correspondent with many studies by Burkey and Obeng (2004), Shin and Washington (2007) and Langland-Orban et al (2008) that using these devices at certain locations might produce some counter-productive outcomes, such as an increase in rear end crashes. Nattaporn (2004) further pointed, at camera sites, the number of killed and seriously injured casualties increased by 15 percent.

Next, the vehicle owner prosecuted may not the real driver running red light. As the automatic device can only identify violated vehicles but not the drivers, the justice of punishment made upon the automatic device is questionable. Third, tickets are typically mailed to owners of violating vehicles, based on review of photographic evidence. Usually, the motorist may not receive a ticket (along with a photograph of the violation) until one or two months after the fact (Agomo v. Fenty, 2007). This trait diminishes the warning effect of enforcement on violators because the automated device can not make an immediately punishment against running red light like the traditional means do. Last, red light camera is costly, so they can not be installed everywhere, especially in the districts with limited budgets.

For above reasons, in Taiwan, excluding patrols, the stand guards at intersection are still in widespread used for deterring red light running. As a result, this enforcement method needs to be systematically researched and aptly used in order to prohibit red light running. However, it is not easy to execute the red light running enforcement because that the drivers believe they can flee away such that red light running can be seen anywhere. For example, Porter and Berry (2001) pointed that drivers perceive less than 2 of 10 violators will be stopped by police. Therefore, evaluating the work ability of police and then enhancing their enforcement ability in order to prevent red light running is a very important issue. The relevant literature for police work ability is rare thus far, such that study for this issue is especially worthy.

2.5 Brief Summary

The conceptual framework underlying traffic enforcement has always been the deterrence theory. Analyzing previous literature, we found that deterring drunk driving and red-light running are critical issue for traffic enforcement. Conducting sobriety checkpoints and DWI patrols are two efficient enforcement countermeasures to prohibit drunk driving and thus reduce DWI accidents. If checkpoints could be conducted regularly, drunk driving could be effectively deterred. However, checkpoints are costly and often exhaust police resources. Comparatively, saturation patrol operations are quite flexible in both the number of officers required and the time that each officer participants. Thus, subject to police resources the two methods are alternately or together conducted to reduce drunk driving in Taiwan.

Enhancing the perception of drinking drivers that they will be stopped and investigated for drunk driving and detain impaired drivers are the main purposes of drunk driving enforcement. Next, twenty-three indicators of drunk driving that can be common detected have been developed; they can be used to explore the enforcement abilities for DWI. It could be said that detecting DWI cues and detaining DWI vehicles are two main missions to conduct sobriety checkpoints and saturation patrols. As for the viewpoints of red light running, in Taiwan, excluding patrols and automatic cameras, stand guards at intersection are widespread used to deterring red light running. Thus, this enforcement method needs to be systematically researched and aptly used in order to prohibit red light running.

CHAPTER 3

MEASURING POLICE'S PERCEIVED ENFORCEMENT ABILITIES

The National Highway Traffic Safety Administration (Blincoe et al, 2000) insists that training is available for law enforcement personnel to improve the enforcement effectiveness. That is to say, the more conducting ability a police officer has, the better he will perform on conducting traffic law enforcememt. In addition, education is an important matter of ability (Ilmarinen et al, 2005) and different audit decision tasks are performed by auditors with differing levels of training (Robert and David, 1990). Further, Hedlund and McCartt (2002) and Robertson and Simpson (2003) have suggested that highlighted training and education for law enforcement is one of the key characteristic of an efficient and effective DWI control system. These arguments have identified the advantages of suitable education and training programs. It indicates that education and training are two key factors to enhance police enforcement ability. Thus, in order to find what kind of ability was insufficient for police, and further provide enforcement authorities guidance in developing programs to improve officers' ability or applying administration or legislation mechanism to assist them in resolving problems originated from enforcement process, the first step of this study aimed at developing an appropriate questionnaire to assess the self-perception ability of police on conducting traffic law enforcement, and providing recommendation to improve their ability and solve the problems they encountered. In other words, evaluating the ability of police to conduct their jobs and identify shortcomings, and then identify proper actions to remedy the faults would be a good strategy for preventing traffic accidents.

In designing a psychometric questionnaire to measure officers' ability to enforce checkpoints, we include items that assess the officers' ability to perform the tasks required for conducting sobriety checkpoints and allow the officers to express their level of confidence or sense of ability with regard to these tasks based on their experience. These officers' responses can then be used to indicate their ability to conduct sobriety checkpoints. However, officers' responses to the designed items will not usually be a simple "yes" or "no." A well-designed questionnaire should provide an opportunity for respondents to express the degree of their feelings or judgments about the items. Therefore, the questions designed to measure the latent trait of enforcement ability should provide several ordinal categories of answer to help the respondent officers express varying levels of perceived ability. However, ordinal data may not be used directly for statistical inference for lacking the property of addition; thus, an appropriate statistical tool should be considered in order to ensure the quality of study results.

3.1 Applying Rasch Models to Measure Police Officers' Perceived Enforcement Abilities

Many typical methods (e.g. structural equation model, factor analysis and cluster analysis) are commonly applied to measure the latent traits. However, these approaches accept raw scores at face value and rely heavily on inferential arguments for validating scales that are calibrated. For example, a response of "Strongly disagree" to an easy item carries the same weight as the same response to a difficult item; both given a score of 1. Nonetheless, those two responses are not equivalent in terms of the ability of the respondents. For the difficult item, a score of 1 means hard things are hard to do. For an easy item, a score of 1 means easy things are hard to do. Besides, items with dramatically different difficulties across groups hint potential item bias. Significantly different item difficulties across groups suggest that the items may have different meanings and/or essentially do not tap the same component latent trait (Holland & Wainer, 1993). However, the Rasch analysis (Rasch, 1960) enables the researcher to estimate the latent variable through assessing the performance of each item as a contributor to the measurement.

Presumably, every police officer n has a unique value associated with his/her perceived enforcement ability θ_n to conduct sobriety checkpoints, which is the personal parameter to be measured. Such a latent trait may be revealed by the police officer's responses to the survey items. That is, officers who have higher enforcement abilities for conducting sobriety checkpoints will respond with higher scores (i.e., they perceive the tasks as being relatively easy to accomplish) on a greater number of items than will those with lower enforcement abilities. In addition, the questionnaire contains items representing various enforcement tasks (e.g., reading drunk-driving cues, detaining DWI drivers, and intercepting escaping vehicles), which are the tasks that the police officers need to perform while staffing the checkpoint. Some tasks reflected in the items might be perceived as simple, but others may be difficult to perform. Thus, we may consider that there is a unique item difficulty value δ_i (the item parameter) for each item i in this study. Items with higher difficulty values are considered to be harder for police officers to perform. Such items (i.e., tasks) may be potential obstacles to effectively conducting sobriety checkpoints and must be overcome. It is apparent that the difference between the person parameter θ_n and the item parameter δ_i will determine the response of police officer n in considering his/her own performance on item i. This observed response may then be formulated as a function of probability and determined by the value of $\theta_n - \delta_i$. Furthermore, to provide a basis for comparison, the person parameters and item parameters must be measured on a consistent interval scale.

The police officers' responses to the questionnaire were collected on an ordinal scale. The Rasch measurement model (Rasch, 1960), which can convert ordinal raw data into the values on an interval scale, has been successfully applied in numerous real-world situations, such as client satisfaction analysis, e-learning, and judged sporting performances (Bond & Fox, 2001). Thus, the Rasch measurement model is considered to be an effective tool to translate the officers' questionnaire responses into their ability to conduct sobriety checkpoints. A brief introduction to the Rasch model is given below.

3.2 The Rasch Model and Its Extended Models

The Rasch model is regarded as a prescriptive rather than a descriptive approach. That is, the data must fit the model, or else the assumptions of the model must be rejected for a particular data set (Bond & Fox, 2001). As a result, some assumptions must be made when applying the Rasch model to measure the ability of police officers to conduct sobriety checkpoints:

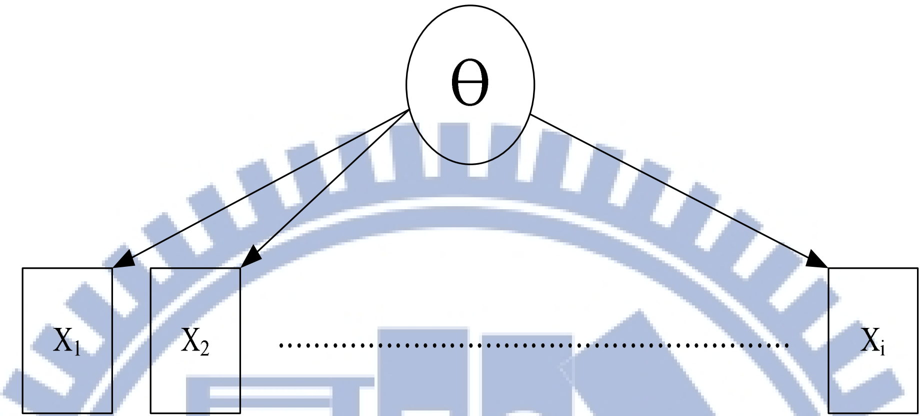
(1) The respondents differ in their abilities to conduct traffic law enforcement;

(2) The respondents' responses to the items depend only on their abilities to conduct traffic law enforcement;

(3) The respondents' responses are probabilistic and conditioned upon their ability to conduct traffic law enforcement;

(4) The odds ratio of achieving an item increases monotonically with the difference between the respondent's ability and item's difficulty.

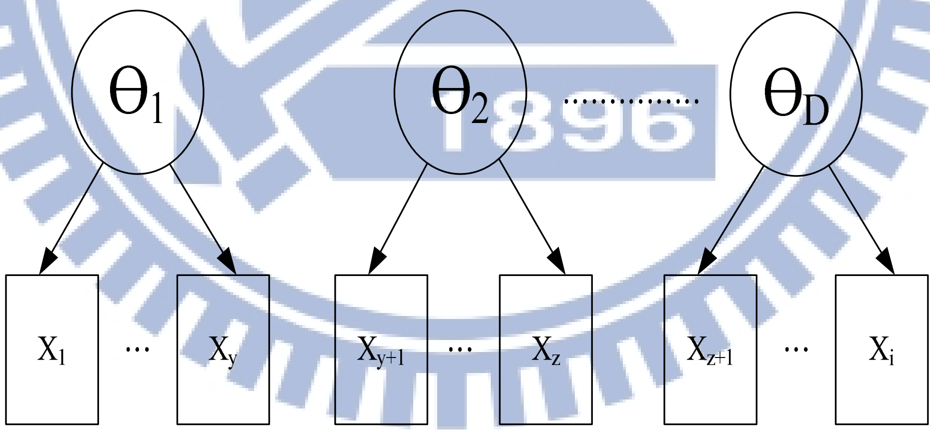
The Rasch model is the simplest model in item response theory (IRT) and requires all of the items to measure the same latent trait. This is the unidimensionality assumption of the Rasch model, shown in Figure 3(a). In some cases, respondents' abilities are composed of several component latent traits. The typical approach to handling such situations is to calibrate the Rasch model for each component latent trait separately with its own items, which is the so-called consecutive approach of Rasch models, shown in Figure 3(b). The consecutive approach of Rasch models, which ignores the possibility that the respondents' performance of items may be interrelated across different component latent traits (Briggs and Wilson, 2003), might yield imprecise results when the models are estimated independently. To take the correlations between component latent traits into account, a multidimensional approach of Rasch models that simultaneously calibrates the component latent traits has been developed to increase measurement precision, as illustrated in Figure 3(c).



X_i = The item *i* within the single latent trait.

θ = Single estimate of the latent trait.

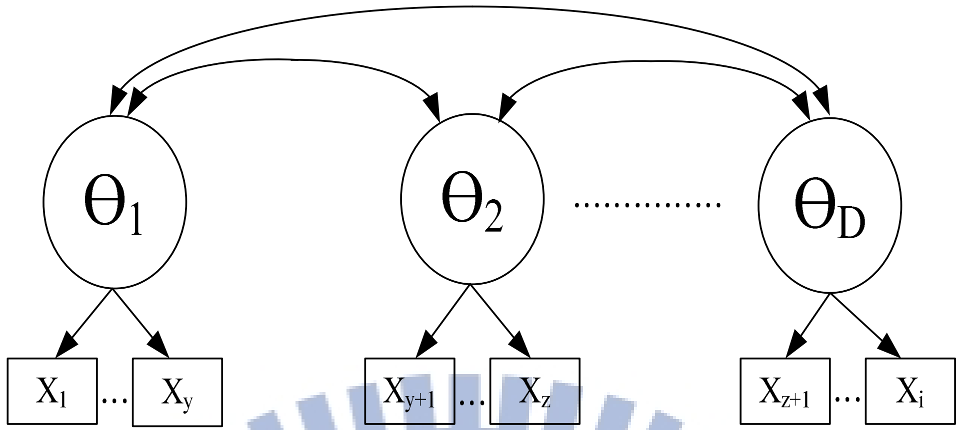
Figure 3(a). Unidimensional approach of Rasch model



X_i = Each item *i* belongs to a specific component latent trait.

θ_d : Latent ability estimate of the independent latent trait *d*, *d* = 1, 2, …, D.

Figure 3(b). Consecutive approach of Rasch models



X_i = Each item i belongs to a specific component latent trait.

θ_d = Estimate of the component latent trait d, d = 1, 2, …, D.

Correlations exist between component latent traits.

Figure 3(c). Multidimensional approach of Rasch models

Figure 3 Illustrations of the unidimensional, consecutive and multidimensional Rasch models

3.2.1 The unidimensional approach and consecutive approach of Rasch models

To simplify our introduction to the Rasch model and its extended models, we shall first consider the dichotomous responses. The items in the questionnaire are first assumed to be of the type "Can you easily perform the following necessary tasks while conducting sobriety checkpoints?" The response is either agreement or disagreement. A score of 1 is assigned to an item to which the police officer responds agreement; otherwise, a score of 0 is assigned. The probability that an officer n will respond with agreement for item i is then expressed as

$$P_{ni}(1|\theta_n, \delta_i) = \frac{\exp(\theta_n - \delta_i)}{1 + \exp(\theta_n - \delta_i)} \tag{1}$$

The probability that an officer n will respond with disagreement for item i is then expressed as

$$P_{ni}(0|\theta_n, \delta_i) = 1 - P_{ni}(1|\theta_n, \delta_i) = \frac{1}{1 + \exp(\theta_n - \delta_i)} \tag{2}$$

Thus, the odds ratio that an officer n can achieve item i is

$$\frac{P_{ni}(1|\theta_n,\delta_i)}{P_{ni}(0|\theta_n,\delta_i)} = \exp(\theta_n - \delta_i) \tag{3}$$

and the logarithm of the odds ratio, known as the "logit," is

$$\ln\frac{P_{ni}(1|\theta_n,\delta_i)}{P_{ni}(0|\theta_n,\delta_i)} = \theta_n - \delta_i \tag{4}$$

which isolates the parameters of interest. The person and item parameters can then be estimated through the response odds ratios in the data set using the formulation of Eq. (4).

In addition to dichotomous responses, the Rasch model can also be modified to be applicable to polytomous rating scale instruments, such as the five-point Likert scale (Andrich, 1978; Masters, 1982). The modified Rasch model decomposes a polytomous response into several dichotomous responses and formulates one rating scale problem into several binary-choice problems. That is, it assigns δ_{ik} as the value of the item parameter for rating category k to item i and assumes that Equation (5) refers to the probability of officer n responding with rating category k rather than k-1 to item i. Thus, we can model the log odds of the probability that an officer responds in category k for item i, compared with category k-1, as a linear function of the person parameter (i.e., the police officer's perceived ability in this study) θ_n and the relative parameter of category k, namely, δ_{ik}, for item i:

$$\ln\left[\frac{P_{nik}}{P_{ni(k-1)}}\right] = \theta_n - \delta_{ik} \tag{5}$$

Per Andrich's (1978) modification of the Rasch model for polytomous responses, two types of formulation are widely applied in assessing the values of item and person parameters: the rating-scale Rasch model and the partial-credit Rasch model. The rating-scale Rasch model is used for instruments in which the definition of the rating scale is identical for all items, whereas the partial-credit Rasch model (PCM) is used when the definition of the rating scale differs from one item to another. The partial-credit Rasch model differs from the rating scale Rasch model in that it possesses its own threshold parameters, F_{ik}, which can vary from one item to the other, for each category k (Wright, 1977). This is achieved by a reparameterization of Equation (6):

$$\delta_{ik} = \delta_i + F_{ik} \tag{6}$$

The partial-credit model can be demonstrated as

$$\ln\left[\frac{P_{nik}}{P_{ni(k-1)}}\right]=\theta_n-\delta_i-F_{ik} \tag{7}$$

The threshold parameters numerically estimate the psychological distances from one rating scale category to another. The PCM doesn't impose thresholds to be the same for all items, whereas they were imposed to be the same by Rating scale model. The partial-credit model (Masters, 1982) is used for items where (1) credits are given for partially correct answers, (2) there is a hierarchy of cognitive demand on the respondents for each item, (3) each item requires a sequence of tasks to be completed, (4) the same response category can have a different attractiveness for each item, or (5) there is a batch of ordered response items with individual thresholds for each item. In assessing the police officer's ability to conduct checkpoints, it is not necessary to assume that the rating scales of the items are the same. Thus, we adopted the partial-credit model for our model formulation. The consecutive Rasch model may be considered to be several unidimensional Rasch models that represent each component latent trait.

3.2.2 Multidimensional Rasch models

The potential usefulness of multidimensional item response models has been recognized for many years in the psychological and educational literature. The statistical problems of multidimensional item response models have been addressed with the development of the multidimensional random coefficients multinomial logit (MRCML) model (Adams, et al., 1997; Wang, et al., 1997). The MRCML model allows sufficient flexibility to present a wide range of Rasch family models, including those that apply to scales having either yes/no or Likert-type responses. The MRCML model is a direct extension of the unidimensional random coefficients multinomial logit (RCML) model, which is built up from a basic conceptual building block (Adams, et al., 1997). It assumes a set of d (d = 1,…,D) component latent traits that determine test performance (i.e., underlie the individuals' responses). The persons responding to a given item are indexed by n (n = 1,…, N). Then the log odds of the probability a person's response in category k of item i (P_{nik}) compared to category $k-1$ $(P_{ni(k-1)})$, as a linear function of latent ability on that dimension (θ_{nd}) and the relative difficulty of category k (δ_{ik}), can be modeled as follows (Briggs and Wilson, 2003):

$$\ln\left[\frac{P_{nik}}{P_{ni(k-1)}}\right]=\theta_{nd}-\delta_{ik} \tag{8}$$

The θ_{nd} in equation (8) represents the person $n's$ latent ability on dimension d to which the item i is only related. The value of δ_{ik}, commonly called a "step difficulty", would indicate whether it is relatively easier or harder for a police officer to be classified as achieving category *k* compared to category *k*-1 for item *i*.

The general MRCML formulation for the probability of a response vector $\mathbf{x}_n$ is

$$\mathrm{P}(\mathbf{x}_n;\boldsymbol{\delta}\mid\boldsymbol{\theta}_n)=\frac{\exp\left[\mathbf{x}'_n(\mathbf{B}\boldsymbol{\theta}_n-\mathbf{A}\boldsymbol{\delta})\right]}{\sum_{\mathbf{z}\in\Omega}\exp\left[\mathbf{z}'(\mathbf{B}\boldsymbol{\theta}_n-\mathbf{A}\boldsymbol{\delta})\right]} \tag{9}$$

where the position of individual *n* in the *D*-dimensional latent space is described by the $D\times 1$ column vector $\boldsymbol{\theta}_n=(\theta_{n\mathbf{1}},\theta_{n\mathbf{2}},...,\theta_{n\mathbf{D}})'$, $\boldsymbol{\delta}$ is the vector of calibrated item parameters, and $\boldsymbol{\Omega}$ is the set of all possible response vectors. We use $\mathbf{z}$ to denote a vector coming from the full set of response vectors, while $\mathbf{x}_n$ denotes the one of interest. The matrices **A** and **B** are known as the scoring and design matrices, respectively. Scoring matrix B allows the description of the score that is assigned to each response category *k* on each of the *D* component latent traits. Design matrix A is used to specify the linear combinations of the *D* ingredient parameters $\boldsymbol{\delta}$ to describe the behavior of the response categories to each item (Cathleen, 2005).

3.3 Evaluating Unidimensionality

The classical Rasch measurement is unidimensional that is a fundamental assumption of most Item response theory models (Wright & Linacre, 1994). The unidimensional Rasch models provide a single latent trait to determine ability underlies test performance. Basically, data must fit the Rasch model expectation, thus the assumed unidimensional latent trait can be quantified successfully. That is to say, the unidimensionality, which identify the single dimension, means that items measure the same unidimensional latent construct, and is the fundamental assumption for a single latent trait. However, the basic assumption of the unidimensionality is usually violated in performance or ability tests (Hambleton, Swaminathan and Rogers, 1991; Ackerman, 1996).

Ackerman (1994) argued that if a test consists of several unidimensional tests, using a unidimensional IRT model to multidimensional latent traits data might guide a suspicion of the validity of person and item parameter estimation and yield an inaccurate model fit. In addition, this approach is likely to yield unnecessarily imprecise measurements, especially when the tests are short (Wang et al, 2004).Thus, a unidimensional model, which ignores the potential intercorrelations between related, is inappropriate and a multidimensional model should be applied (Wang et al., 2006). Nevertheless, the advantages of the multidimensional IRT model cannot be confirmed unless the violation of assumption of typical *unidimensionlity* is tested.

After fitting the Rasch model, the unidimensionality was assessed via a principle components factor analysis and certain Rasch fit statistics. In this study, eigenvalues for the residual factors were first used to assess unidimensionality. Smith & Miao (1994) performed simulation studies and pointed that the first residual factor that explains less than 3.0 units of item residual variance represents a unidimensionality (Linacre, 2004). In addition, the critical value of absolute Outfit statistics (less than 3) is the second method to assess unidimensionality (Wright, 1996).

Now that unidimensionality is an essential factor for IRT models, two methods, removing the bias items to meet unidimensionality(Linacre and Wright, 2004; Kubinger et al, 2006) and applying the multidimensional approach which takes correlation between latent traits into account to improve measurement precision (Kang, 2006; Wang, 2006), are generally manipulated to assess model parameters whenever the assumption is violated. Thus, in this dissertation, both of the two skills will be used to explore different enforcement abilities.

3.4 Model Comparisons

Pearson correlation on the person measures for two latent traits can be indirectly computed when two unidimensional approaches are used. However, using the multidimensional approach, one could directly evaluate the correlation between latent traits. In case of the correlations between latent traits cannot be overlooked, a multidimensional model that utilizes the correlations to increase measurement precision is needed. A study for comparison between unidimensional with multidimensional Rasch model by Yang (2007) indicated that sample size, test length and degree of multidimensionality are three factors influencing the accuracy of parameter estimation. Yang (2007) further pointed out test length had the largest influence on person ability parameter estimation while sample size had the largest effect on item difficulty parameter estimation. In addition, the greater the correlations exist between the latent traits, the greater the measurement precision presents using the estimation of multidimensional approach.

Next, Smith (1996) found that Rasch fit statistics are sensitive to multidimensionality when each latent trait had an approximately equal number of test items and the correlations between the latent traits were not high. Thus, in terms of correlations between the latent traits are considered, the indication by Yang (2007) is principally consistent with the finding by Smith (1996). Further, the longer the tests are, the more accurate measures would be generated by using the unidimensional approach to evaluate each individual latent trait, whereas if the tests are too short for the unidimensional approach to create perfect measures, the utilization of multidimensional approach will provide more precise measures for multiple constructs (Wang et al, 2004). In other words, multidimensional Rasch analysis can be valuable, given that the length of each subscale is short and that the high correlations among them subsist (Skevington et al, 2004; Hsiung et al, 2005). Accordingly, in this study, in order to validate the dimensionality of the three police enforcement ability scales proposed, in addition to the evaluation of unidimensionality assumption, the correlations among the subscales and the length of each subscale should be deliberately contemplated.

Even though Ackerman (1989), De Ayala (1994) and Wang et al (2004) have argued that there are always non-zero correlations between latent traits, meaning that the multidimensional approach is more appropriate than the unidimensional one, Way et al (1988) reported that the ability estimate of the unidimensional IRT model approached the average of the multidimensional ability estimates. In addition, as stated above, the model precision and fitness may be affected by many factors no matter multidimensional or unidimensional Rasch models are used. Thus, it is too premature to define that the multidimensional approach is always better than unidimensional approach. Therefore, given that the unidimensionality assumption is trespassed, some criteria which diagnose model precision and fitness still deserve to be taken into account to compare the contributions of multidimensional Rasch model to precision and fitness with unidimensional Rasch model to precision and fitness.

Among the unidimensional Rasch model (i.e. basic Rasch model), consecutive Rasch model and multidimensional Rasch model, three major measurements are commonly used to diagnose model precision and fitness. They are the reliability index, the change in deviance (G^2) and Akaike's Information Criterion (AIC). The reliability index, which is the percentage of observed response variance that is reproducible (Wright & Masters, 1982), helps us examine whether or not the model is convincing and the material is replicable. The ratio of the adjusted person variability to total person variability (R_p) is used to measure the reliability as:

$$R_p = \frac{SA_p^2}{SD_p^2} \quad (10)$$

The denominator (SD_p^2) represents total person variability; that is, how much people differ on the measure of interest. The numerator (SA_p^2), called the adjusted person variability, represents the reproducible part of this variability (i.e., the amount of variance that can be reproduced by the Rasch model). The adjusted person variability is obtained by subtracting error variance (SE_p^2) from total variance ($SA_p^2 = SD_p^2 - SE_p^2$).

The multidimensional Rasch model is a nested model, and can be evaluated statistically by parameterizing the multidimensional model such that if the variances associated with additional random effects are 0, it reduces to a unidimensional model (Rijmen & Briggs, 2004). In a Rasch analysis, the deviance index (G^2), which equals to –2×ln(*Likelihood*) (Myers, et al., 2006), is often used to measure the fitness. Using a likelihood ratio (LR) test, the relative fitness of unidimensional model to multidimensional model can be assessed by comparing the deviance indices of these two models. The Likelihood ratio statistic is equal to the difference of deviance (G^2) values between undimensional and multidimensional models. It has been shown by Verbeke & Molenberghs (1997) that this LR test-statistic will be an equally weighted mixture of a Chi-Square distribution with the degrees of freedom equal to the difference in the number of parameters estimated by the two models. A lower G^2 indicates a better fit, and a higher one reflects a worse chi-square distribution.

The second way to compare model fit is on the basis of comparison of Akaike's Information Criterion (AIC) (Akaike, 1974). Akaike's information criterion, a method of comparing nested models, is a measure of the goodness of fit of an estimated statistical model. It offers a relative measure of the information lost when a given model is used to describe reality, and can be said to describe the tradeoff between bias and variance in model construction by imposing a penalty for increasing the number of parameters. Given a data set, several competing models may be ranked according to their AIC, with the one having the lowest AIC being the preferred model. The general form for calculating AIC is,

$$AIC = -2\ln(Likelihood) + 2K \quad (11)$$

where ln*(Likelihood)* is the maximized *log-likelihood.* K is the number of parameters in the model, including (a) one variance parameter, (b) the item parameters, (c) the step parameters[3], and (d) the covariance parameters for multidimensional Rasch model.

3.5 Evaluation of Fit to the Rasch Models

The fit of the Rasch model, which can be expressed by either the form of responses observed for each person on all items (person fit) or the form for each item on all persons (item fit), is the degree of match between the form of observed responses and the modeled expectations. Indices of fit statistics estimate the extent to which responses demonstrate adherence to the modeled expectations. Two kinds of fit statistics, termed infit and outfit statistics, can be expressed in two forms, mean squares and standardized t values, and are used to determine how well the data meet the requirements of the model. Infit and outfit statistics are sensitive to violations of assumptions of the Rasch model, such as unexpected variation in response forms (e.g., a person with little ability indicates excellent ability) or unequal slopes (e.g., item discrimination) across item response functions (Bond & Fox, 2001). Infit statistics, which are more sensitive to irregular inner forms, place more of an emphasis on unexpected responses near a person's or item's measure; outfit statistics, which tend to be influenced by off-target observations, place more emphasis on unexpected responses far from a person's or item's measure. Compared with the outfit statistics, which are more sensitive to the influence of outlying scores, the infit t statistics give more weight to on-target performances.

As the estimation of fit is concerned, the calculation of a response residual (Y_{ni}) for each item i of person n is encountered. In other words, how far does the actual response (X_{ni}) deviate from Rasch model expectation (E_{ni}) (Wright and Master, 1982)?

$$Y_{ni} = X_{ni} - E_{ni}\text{, and} \tag{12}$$

$$E_{ni} = \sum_{k=0}^{K-1} k(P_{nik}) \tag{13}$$

where K is the number of available response categories for observations and P_{nik} is the probability of person n being observed in category k on item i.

The outfit statistic is an unweighted average of the standardized residual (Z_{ni}) variance across both person and item, as in the following equation:

[3] The number of step parameters that has been estimated for each item is one less than the number of thresholds for the item (Wu, et al., 2007).

$$\text{Outfit Mean-square} = (\sum_{n=1}^{N} Z_{ni}^2) / N \quad (14)$$

where Z_{ni} is obtained by standardizing the residual that is the deviation of the actual response from the modeled expectation, and N is the number of items/persons. The standardized residual, Z_{ni}, is calculated

$$Z_{ni} = Y_{ni} / (W_{ni})^{1/2}, \quad (15)$$

where $W_{ni} = \sum_{k=o}^{K-1} (k - E_{ni})^2 P_{nik}$ is the variance of X_{ni}. These standard residuals are squared and summed to form a chi-squared statistic:

$$\chi^2 = \sum_{n=1}^{N} Z_{ni}^2 \quad (16)$$

However, infit statistics are generally preferred, as they are weighted locally and are thus less susceptible to outlier influences (Bond & Fox, 2001). Residuals are weighted by their individual variance (W_{ni}) to diminish the impact of off-target improbable responses:

$$\text{Infit Mean-square} = \sum_{n=1}^{N} W_{ni} Z_{ni}^2 / \sum_{n=1}^{N} W_{ni} \quad (17)$$

Both infit and outfit statistics can be expressed in the form of a mean square with an expected value of unity and reported by the standardized form as a t statistic as well. Items for which the fit mean square statistic (MNSQ) is smaller than 0.8 or larger than 1.2 (Linacre and Wright, 1994; Wang et al., 2004), and for which the fit t statistic is smaller than -2.0 or larger than 2.0 (Smith, 1992), are considered to be of poor fit.

3.6 Scale Stability across Samples

The ability perception measures estimated by the Rasch model provide the opportunity to compare the differences among respondent groups. This comparison ensures that different group characteristics do not affect the interpretation of the total measures of ability, and thus, equal comparisons can be made. The estimation of differential item functioning (DIF) involves comparing analyses conducted separately within each group (Holland & Wainer, 1993). When developing new tests, items displaying DIF have long been recognized as a potential source of bias in person measurement.

Latent regression methods (Adams, et. al, 1977) are applied to estimate the difference in the mean achievement of two groups. The chi-squared test is addressed first to discriminate the existence of DIF.[4] Once DIF is found to exist, whether the effect of DIF is of substantive importance for an individual item is further analyzed. In addition, Wu et al. (2007) proposed that the between-group difference in item difficulties larger than 0.2 logit suggests evidence of DIF. However, Cohen (1977) showed that the criterion for explaining significant differences between groups was 0.5 logit, at least in the difference of item difficulty estimates. This argument was consistent with Wright and Douglas' (1975) suggestion that differences in item parameters less than 0.5 logit had little effect on the accuracy of tests. Moreover, Smith (2004) and Wang et al. (2006) pointed that those differences smaller than 0.5 logit are difficult to discriminate. Thus, 0.5 logit is commonly used as an acceptable criterion of removing individual items for significant DIF.

[4] See Millsap and Everson (1993) and Wiberg (2007) for details of measurement and detection of DIF.

CHAPTER 4

MEASURING POLICE'S PERCEIVED ABILITY TO CONDUCT RED LIGHT RUNNING ENFORCEMENT

This chapter aims at designing suitable questionnaires which can precisely measure the police enforcement abilities to conduct red light running and then applying Rasch models to analysis respondents' data. According to the tasks required for conducting red light running tasks, an enforcement ability scale which could effectively measure the police abilities was explored. After collecting the participants' response data, the WINSTEPS was used to check unidimensionality assumption and measure the mission abilities.

4.1 Constructing Conceptual Frameworks of the Perceived Ability for Red Light Running Enforcement

In order to develop a questionnaire in which major tasks of executing red-light running enforcement are completely contained, the process of red-light running enforcement should be decomposed, and then it could be used to design items based on the stated latent traits. The relation between these decompositions is illustrated as Figure 4 (Chang and Shih, 2007).

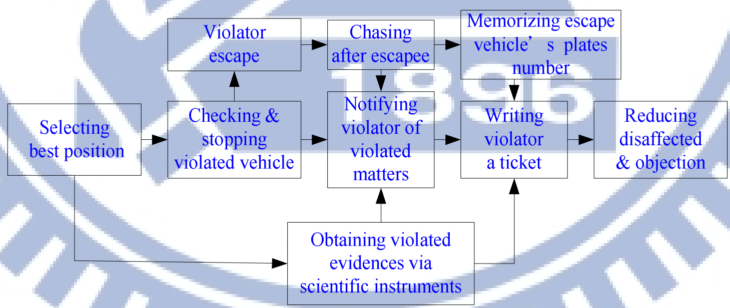


Figure 4 Decomposition of conducting red light running enforcement

This procedure enables us to investigate every individual task that comprises a whole job, and by which an insightful survey could be provided. As depicted in Figure 4, when executing a red-light running enforcement, the first step is to obtain the best position in order to detect a violation. When violation behavior happens, police officers stop and check the violator, notify him/her about violation facts, and then write a ticket. If violator escapes, police officers ought to chase the escaped vehicle with the help of patrol cars for conducting subsequent enforcement procedures. In addition to finishing enforcement procedures at the scene, a scientific instrument can be used to collect violation evidence and, subsequently, a ticket is issued to the driver at a later time. When conducting their duties, police officers need to assure the safety of related individuals including themselves, violators, and other road users, and avoid any complaint resulted from their enforcement. Accordingly, the major tasks of executing red-light running enforcement contain several processes which should be performed by police when conducting traffic law enforcement. These processes should combine with the framework of perceived enforcement ability to design a suitable scale for measuring police enforcement abilities.

4.2 Empirical Study for Red Light Running Enforcement

Because there are no available scales to measure police officer's red light running enforcement ability, to explore our own questionnaire for assessing their conducting ability is needed. Even though the process of red-light running enforcement had been proposed in chapter 3, in order to design items based on specific ability latent traits, constructing the conception of police's perceived ability to conduct red light running is integral (Chang and Shih, 2012).

4.2.1 The conceptual framework of traffic law enforcement ability

Self-perceived ability can be defined as self-efficacy — the belief of an individual associated with his or her ability to perform and complete tasks successfully (Bandura, 1997). It can be said that perceived ability mimics the expectations of ability, taking into account the determinants of ability. A previous research to measure the self-perceived ability in humor, grammar, and logic by Kruger and Dunning (1999) indicated that perceptions of ability could be positively related to actual ability. Accordingly, self-perceived ability measured by a suitable standard might be considered a reasonable proxy of their actual ability.

Work ability cannot be measured objectively by a single instrument; it always requires an assessment based on the data obtained from several different sources. In previous studies, such as Tuomi et al. (1991), Seitsamo and Ilmarinen (1997), Liira et al. (2000), Ilmarinen and Tuomi (2004), and Bugajska and Łastowiecka (2005), the work ability index is broadly applied to assess the ability to work. The most important indices in work ability index (Tuomi et al., 1998) include subjective estimations of work ability in relation to physical demands, mental job demands, and psychological resources. Markku et al. (2002) postulated that work ability is a complex of interactions involving major factors including the physical, psychological, environment, and others.

According to the Dutch Medical Examination Act in 1998, specific job demands are defined as job demands that cannot be eliminated by current state-of-the-art (ergonomic) measures and that may exceed exposure safety levels or average human capacities. Sluiter (2006) defined high-demand jobs as those involve potential public health implications because of the health risks that workers may impose upon others (e.g. colleagues and public) during the course of their work. The traffic police work is physically demanding. In general, despite of any horrible weather conditions, the traffic police are owed to execute the traffic control and enforce the traffic violation by standing in front of heavy traffic main roads. Frequently, they have to chase the escaping violator and write him a ticket. These duties are highly related to the public safety for police himself, violators, and other public road users. Thus, the work of traffic law enforcement is a high-demand job. Following to Dijk et al. (1988), the specific job demands that characterizing high-demand jobs are classified according to physical, mental and psychosocial job characteristics. Physical demands include two elements: energetic (aerobic or anaerobic) and biomechanical (static and dynamic demands on the musculoskeletal system). Mental demands refer to concentration, memory, decision-making and attention. Psychosocial demands are affiliate with emotional demands, interpersonal relations, time-pressure and safety.

Moreover, the weather condition plays an important role for traffic law enforcement performance because that traffic is an activity of outdoor (Chang and Shih, 2007). Shinar (1998) argued that traffic law enforcement and perceived congestion (measured by having observers to rate how congested they believed each light cycle to be) were significantly related. Besides, it is a consensus that work performance might be influenced by the number of performing workers. As red light running enforcements are generally conducted by single police or two officers, to access the influence of the number of conducting officers on enforcement performance is needed. Thus, traffic condition, weather condition and the number of conducting officers are considered as the major environment factors in traffic law enforcement. Following previous studies, the characteristic model for police's perceived traffic enforcement ability consists of four key factors: the perceptions of one's ability of mental demands, physical demands, psychological demands and environment factors, as shown in Figure 5.

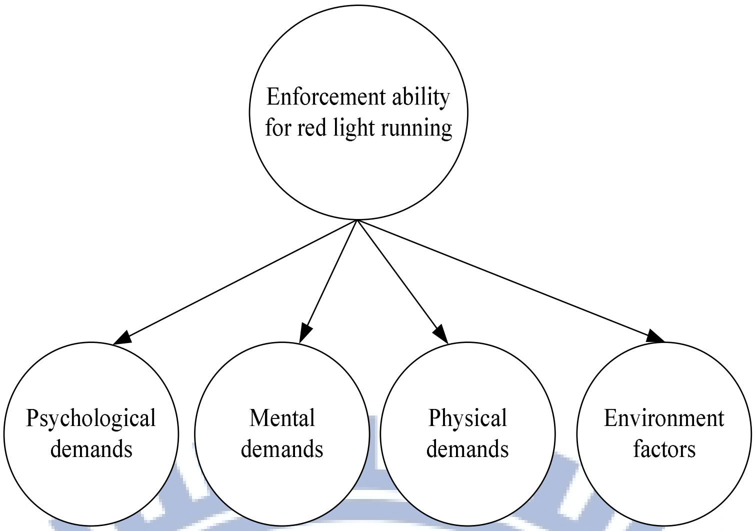


Figure 5 The conceptual model of police's perceived ability to conduct red light running

4.2.2 Questionnaire design for Red Light Running Enforcement

A questionnaire (Traffic Police Enforcement Ability Questionnaire, TPEAQ) to explore the perceived enforcement ability for traffic policeman was designed according to the decomposition shown in Figure 4. Based on the prior discussion on the required traffic law enforcement ability for participating in the enforcement environment, 20 items were designed to determine the perceived enforcement ability of traffic policemen as shown in Table 3, and the 7-point Likert scale is used to measure the response of respondent.

There are five items (items 01 to 05) designed to determine traffic policemen perception in their ability of mental demand. These items are selected to explore how the traffic policemen consider their mental demand ability in their concentration, memory, decision-making or attention. Eight items, item 6 to13, are designed to determine how traffic policemen consider their performance in psychological demand like feeling of safety, emotional demands, interpersonal relations, time-pressure etc. Items14 to 16 are designed to determine to what degree the traffic policemen consider themselves having a good state of physical demand. Five items, Items 17 to 20, are selected to measure how the traffic policemen judge their ability in different environment and traffic condition. Three personal characteristics, age, rank, and gender are included into this questionnaire. They serve as comparative indicators for the detailed discussion.

Table 3 Contents of designed questionnaire items for TPEAQ

Variable/Question	Attribute
Ability of Mental demands	
Item01: I can find the best position to stand guard red light running vehicles.	Decision-making
Item02: I can attentively detect red light running vehicles.	Attention
Item03: I can concentrate my attention to detect the escaping intention of red light runner.	Concentration
Item04: I can easily record the escaped red light running vehicle's license number.	Memory
Item05: I can successfully detain the escaping red light running vehicle whenever I intend to do.	Decision-making
Ability of psychological demands	
Item06: I can safely direct the red light running vehicle to stop.	Safety
Item07: I can react rapidly to detain the vehicle.	Time pressure
Item08: I can get on the patrol rapidly to intercept the escaped vehicle.	Time pressure
Item09: I can chase escaped red light running vehicle and detain it safely.	Safety
Item10: I have a good emotion management so that seldom be enraged by the red light runner.	Emotional demand
Item11: When traffic violator disagree my disposal at the scene, I can deal with it politely and prevent his further objection.	Emotional demand
Item12: Scarcely did the red light runner argue against my disposal at the scene.	Interpersonal relation
Item13: Rarely does the red-light runner lodge a complaint after I write him/ her a ticket.	Interpersonal relation
Ability of physical demands	
Item14: I don't have leg-ache or backache after two hours red light running duty.	Biomechanical demand
Item15: I don't have leg-ache or backache after four hours red light running duty.	Biomechanical demand
Item16: I am not tired after two hours duty on red light running.	Energetic demand
Ability in different environment factor	
Item17: I can enforce the duty on red light running without other police's help.	Number of officers
Item18: I can enforce the duty on red light running effectively even in the rainy day.	Weather condition
Item19: I can enforce the duty on red light running effectively even in the extreme cold weather.	Weather condition
Item20: I can enforce the duty on red light running effectively even in the traffic peak hour.	Traffic condition

Note: The scale of this questionnaire is the 7-point Likert scale.

4.2.3 Data collection and descriptions

As illustrated and administered in chapter 4, multistage sampling was adopted in this study. A sample consisting of 358 investigated policemen was drawn randomly (125 from north Taiwan, 120 from the middle of Taiwan, 113 from south Taiwan). Policemen ranged in age from 22 to 55; the average age was 37.45 ± 9.81 (under the age of 50s contained 308 peoples). The sample consisted of 220 (61.4%) police officers, 87 (24.3%) sergeants and 51 (14.3%) heads. The missions of Taiwan traffic execution was divided into Traffic Polices and Precinct Administrative Polices respectively taking corresponding legitimate duties. Fifty-five percent of the subjects were traffic polices, and forty-five percent were administrative polices in this sampling samples. In terms of gender, 90.2% were male, and 9.8% were female. Personal characteristics and enforcement ability perception of these police were collected by completing the questionnaire under the supervision of well-trained officer's investigators.

4.3 Measuring Results for Red Light Running Enforcement

We examined the fit of the 20-item TPEAQ scale to the Rasch model, as shown in Table 4. Values for each person's level of traffic policemen enforcement ability were estimated from two runs of the Rasch model for all 358 participants. The estimate results were illustrated as follows.

4.3.1 Model fit estimation and unidimensionality evaluation

In the first run, infit and outfit mean square values for individual items all fell within the expected range of 1 ± 0.2 (Table 4). The Z-standardized fit statistic (Zstd) values for individual items about 85% fell within the range of ± 2 except three items (items 15, 17, 18).

These three items were excluded from further analysis; and then in the second run, the Zstd values are all fell within ± 2. The first residual factor explained 2.8 units (i.e. eigenvalue) of the 17 units of residual variance, indicating that the remaining 17 items were functioning reliably according to Rasch model assumptions. The absolute values of all outfit statistics were less than 2.0, below the critical value of 2. Thus, the scale appears to assess a single, interval scale that fits the assumptions for Rasch models.

Table 4 Estimates of item measures and fit statistics

Item	Raw Score	δ_i	Infit MNSQ	Infit Zstd	Outfit MNSQ	Outfit Zstd
18	1165	0.28	1.09	3.3	1.27	3.4
15	1112	0.38	1.23	3.0	1.25	3.1
03	1750	0.18	1.13	1.7	1.15	1.9
01	1865	-0.35	1.07	1.0	1.02	0.2
02	1952	-0.85	1.07	0.9	1.01	0.1
09	1429	0.59	1.06	0.9	1.05	0.7
08	1477	0.38	1.06	0.8	1.04	0.6
20	1449	0.42	0.99	-0.1	1.04	0.5
14	1475	0.45	1.03	0.5	0.99	-0.1
12	1761	-0.49	0.99	-0.2	1.01	0.2
11	1724	-0.46	1.01	-0.2	1.00	0.0
13	1772	-0.6	1.01	0.1	0.98	-0.2
16	1492	0.31	0.99	-0.1	0.98	-0.2
07	1527	-0.84	0.96	-0.6	0.97	-0.4
05	1440	0.33	0.92	-1.1	0.94	-0.9
04	1758	0.17	0.94	-0.9	0.88	-1.5
19	1452	0.54	0.90	-1.5	0.91	-1.3
10	1805	0.05	0.90	-1.4	0.84	-1.9
06	1766	-0.08	0.89	-1.4	0.87	-1.6
17	1516	-0.39	0.84	-2.3	0.85	-1.9

4.3.2 DIF Analysis

Table 5 showed descriptive and statistical results for DIF analyses based on police rank and work experience. Panel A demonstrated that police officers were more likely to endorse item 19 " I can enforce the duty on red light running effectively even in the extreme weather." compared to Heads. The item difficulty estimates for item 19 were significantly different among the three police groups, and it showed that DIF didn't follow the pattern expected based on previous expectancies. As for item 11 "When traffic violator disagree my disposal at the scene, I can deal **with** it politely and prevent his further objection." police officers' ability was significantly lower than heads', but it showed DIF followed the pattern expected. The differences among groups of these two items were all less than 0.5 logits, so that these two items were both preserved. As for work experience, group 3 were more likely to endorse item 11 "When traffic violator disagree my disposal at the scene, I can deal with it politely and prevent his further objection." compared to group 2. This result indicated that experienced officiers presented **better** emotional performance than others, which was consistent with the general sense. Besides, the differences among groups of item 11 were all less than 0.5 logits, so item 11 can be retained.

Table 5 The result of DIF analyses (Item difficulty measure)

item	t-tests			parameter estimate		
Panel A: police rank						
	1 vs. 2	1 vs. 3	2 vs.3	group 1	group 2	group 3
11	0.85	2.11*	1.23	-0.35	-0.47	-0.71
19	0.61	-2.32*	-2.49**	0.56	0.50	0.87

Degree of freedom for 1 vs. 2 tests=307, for 1 vs. 3 tests=271, for 2 vs. 3 tests=138.

group 1: police officer, groups 2: sergeant, group 3: captain (second-lieutenant included)

item	Panel B: work experience					
	1 vs. 2	1 vs. 3	2 vs.3	group 1	group 2	group 3
11	-1.38	0.63	2.00*	-0.23	-0.05	-0.31

Degree of freedom for 1 vs. 2 tests=241, for 1 vs. 3 tests=233, for 2 vs. 3 tests=236.

group 1: 0-10 years, groups 2: 11-20 years, group 3: larger than 20years

*p-value < 0.05, **p-value < 0.01

Further, item difficulty estimates for the remaining 17 items were derived for each gender separately. One item was found to show significantly bias between genders. Result indicated that females has significantly higher item difficulty estimates (-0.1 logits) compared to males' (-0.52 logits) on item 11 ("prevent further objection") with a mean difference of 0.51 logits (t-statistic=2.10, p-value < 0.025). Gender is the most important factor for developing an unbiased scale, while police rank and work experience have not been identified as an essential element for exploring a precise one. Thus, only Item 11 should be dropped from the scale. The remaining 16 items did not show significant bias between different age groups (less than 49 years vs. bigger than 50 years), and differences in item parameters were all less than 0.5 logits.

After dropping the four items that showed significant differences or bias based on unidimensionality and DIF process, a shortened 16-item TPEAQ (Rasch TPEAQ) measure was assessed through a final Rasch model. Before we start detailed discussions and interpretations of the estimated item and person parameters, however, the reliability and validity of this Rasch model must be discussed first.

4.3.3 Final Estimate of item fit and scale reliability

Table 6 Model estimation and fit statistics of the Rasch analysis

Persons	358Input	358 Measured	Number of observations:16.0				
Persons	Raw Score	Measure	Standard Error	Infit		Outfit	
				MNSQ	ZSTD	MNSQ	ZSTD
Mean	73.2	0.14	0.29	1.01	-0.1	0.99	-0.2
Person Reliability: 0.89			Item Reliability: 0.99				
Items	Raw Score	Measure	Standard Error	Infit		Outfit	
				MNSQ	ZSTD	MNSQ	ZSTD
Mean	1637	0.00	0.05	1.00	0.00	0.99	-0.1

The person and item reliability coefficients can be interpreted similarly to a Cronbach alpha reliability coefficient for the internal consistency of responses to items (Wright, 1996). Overall scale reliability was 0.89 (person reliability index), which was equal to the scale reliability of 20-item TPEAQ scale, and the item reliability index was 0.99, and infit and outfit Zstd for all items were within the acceptable range $\pm 2\sigma$ criteria (See table 6), indicating that the shortened 16-item TPEAQ here are consistent with the assumptions of the Rasch model from the viewpoints of both items and persons.

4.4 Findings for Measuring Police's Perceived Ability to Conduct Red Light Running Enforcement

The Rasch assessment fixed the average measure of all item parameters at zero logit to be a comparative basis of the relative interval scale; the average value of the enforcement ability of all the traffic police was 0.14 logit (Table 6). The results of final estimates of item parameters (δ_is) and fit statistics are illustrated in Table 7. The item parameters (δ_is) for each task are displayed in column 4 and the outfit and infit Zstd are listed in columns 5 – 6, respectively.

4.4.1 Findings from the estimated item parameters

According to the definition of item difficulty, the lower the item difficulty, the easier the task will be accomplished. As demonstrated in Table 7, Chasing and detaining escaped vehicle (Item 9 with 0.62 logits) was the most difficult mission to be conducted, which was followed by enforcing in extreme cold weather (Item 19 with 0.54 logits) and leg-ache or backache after two hours duty (Item 14 with 0.45 logits). This result might indicate that it is dangerous to intercept escaped violator in extreme cold weather. It is possible that police usually have to expose themselves to frigid winds that slow their actions and thereby decrease enforcement efficiency. In addition, after two hours duty, police officers often have sore leg and waist and painful back. Therefore, strengthen the physical loading on leg, waist and back was the key content of physical training such as sit-up and split jump.

Table 7 Estimates of item measures and fit statistics

Item	Variables/ Questions	Characteristic	δ_i	Infit ZSTD	Outfit ZSTD
09	Chase and detain escaped vehicle successfully.	Psychological	0.62	1.2	1.1
19	Enforce the duty in extreme cold weather.	Environment	0.54	0.5	0.3
14	Feel leg-ache or backache after two hours duty.	Physical	0.45	1.4	0.8
20	Enforce the duty in the traffic peak hour.	Environment	0.42	0.5	0.8
08	Get on patrol rapidly and intercept the escaped vehicle.	Psychological	0.39	0.4	0.3
05	Detain escaping vehicle whenever he/she intends to do.	Mental	0.35	-0.9	-0.6
16	Not tired after two hours duty.	Physical	0.30	1.5	1.2
03	Concentrate their attention to detect escaping intention.	Mental	0.17	1.2	1.7
04	Record escaped vehicle's license number.	Mental	0.16	-1.1	-1.8
10	Seldom be enraged by the red light runner.	Psychological	0.03	-1.6	-1.9
06	Direct vehicle to stop safely.	Psychological	-0.1	-2.0	-1.7
01	Find the best enforcing position.	Mental	-0.38	0.1	-0.7
12	Scarcely be argued at the scene.	Psychological	-0.52	0.1	0.6
13	Scarcely be complained.	Psychological	-0.64	0.2	-0.3
07	React rapidly to detain violator intending to escape.	Psychological	-0.90	0.1	-0.8
02	Attentively detect red light running vehicles.	Mental	-0.90	-1.2	-0.5

Among the items considering the mental abilities, successfully detaining escaping vehicle whenever he/she intends to do (Item 5 with 0.35 logits) and concentrating their attention to detect escaping intention (Item 3 with 0.17 logits) were relatively difficult to perform than the other mental tasks (see Table 7). It could be considered that training and increasing the ability of decision-making on detaining escaping vehicle is needed. Moreover, police should be cultivated to pay more attention to detect the violator's escaping intention. Regarding to the psychological abilities, Item 9 was the most difficult task to execute, followed by Item 8 (get on patrol rapidly and run after the escaped vehicle), while Items 7 was the easiest item. This result exhibited that polices' abilities to detain escaping vehicle was worrisome. Moreover, these situations might because that the escaping driving patterns, such as weaving (Harris, et al.,1980; Sarkar, et al., 2000), fast speed or other aggressive behaviors, may not only increase police officer's psychological loading (Chang and Shih, 2007), but also endanger police officers and other road users. Thus, how to deter violator escaping and to increase the police abilities to intercept escaped vehicle are urgent issues.

In terms of the physical abilities and abilities in different environment, the most serious problems were Items 14 and 19, respectively. On the other hand, the easiest items for them were Items 16 and 20, respectively. However, even though Item 20 is easier than Item 19, it was ranked the fourth difficult task to be performed in this study. It may be that police officers ought to control traffic to avoid traffic jam in traffic peak hours, so that officers have not spare energy to enforce red-light running. This result could demonstrate that polices' abilities were deeply influenced by weather and traffic condition. In addition, the item parameters of Items 14 and 16 were positive, which might indicate that polices' physical abilities were deficient.

4.4.2 Analyzing the estimated person parameters

In the applying of the Rasch model estimate, another important result that we interest was the person parameter in this experimental exploration. The Rasch model helps us to estimate the self-rated enforcement ability in traffic law enforcement of the 358. As shown in Table 8, there were 23.45% of the surveyed policemen had fit statistics outside the ±2 Zstd tolerance box. The response patterns of those responses to the 16 items were inconsistent with the expectations of the model. The abilities from the policemen numbered 158, 157 and 120 are the top three misfit responses with Zstd more than +2, called over-dispersed responds, can be concluded as "specific ability missing", and those from the policemen numbered 236, 23 and 20 are the top three misfit response with Zstd less than –2, called under-dispersion responds, regarded as "too determined"(Smith, 1992).

Figure 6 illustrates the distributions of infit and outfit Zstd statistics for estimates of θ. Each data point represents the infit and outfit Zstd values for an individual respondent. The raw score of each person has been transformed into a measure of enforcement ability on a logit scale from -2.5 to 3.8, and 76.55% of the surveyed policemen had fit statistics inside the ± 2 Zstd tolerance box.

Table 8 Summarized estimates of person measures and fit order statistics

Person number	Raw scale	θ_n	Infit Zstd	Outfit Zstd
158	97	2.62	3.3	3.8
157	88	1.06	2.8	2.1
120	93	1.72	2.7	2.1
------Infit or outfit ＞ 2------ ；Number of observations：32 (8.94%)				
216	68	-0.25	1.8	2.1
289	68	-0.25	1.8	2.1
------Better Fitting Omitted------ ； Number of observations：274 (76.54%)				
132	64	0.09	-2.0	-2.1
209	64	-0.25	-2.0	-2.1
------Infit or outfit ＜-2------ ；Number of observations：52 (14.53%)				
20	96	0.50	-2.5	-2.4
23	96	0.50	-2.5	-2.4
236	96	0.50	-2.5	-2.4

After dropping the 84 misfit persons, measure was assessed through the Rasch model again. There were 18.98% of the remaining 274 surveyed policemen had fit statistics outside the ±2 Zstd tolerance box, and the average value of the enforcement ability of all the traffic police was 0.13 logits, which was closed to the 0.14 logits of original sample sets. This result showed that the person parameter differences between these two samples were not significant.

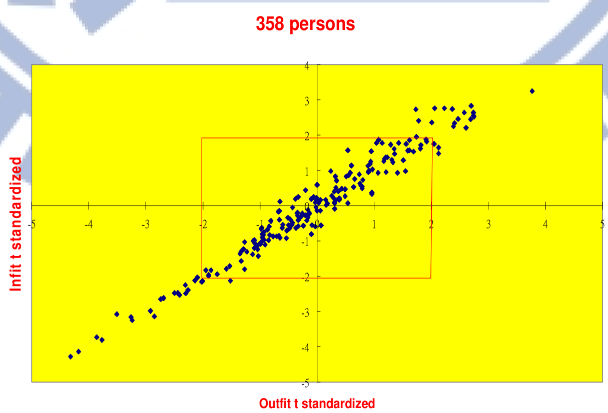


Figure 6 Scatter plot of infit and outfit statistics for estimates of person measures.

Despite perceived enforcement abilities were not largely significantly different between the female and male respondents except item 11 (“prevent further objection”), some findings are interesting and worth to discuss as below. The mean person measure parameter was 0.38 for females and 0.12 for males. The perceived enforcement ability of female polices is slightly, but insignificant, higher than male polices'. Furthermore, men weigh item 2 (When going on duty, I can detect red light running vehicles very easily) and item 7 (I can react rapidly to stop the vehicle when the red light running driver intends to escape) as the easiest tasks to achieve. While women ranked item 6 (I can direct the red light running vehicle to stop, without endangering myself) and item 2 (I can detect red light running vehicles easily) as the easiest tasks. On the contrary, female polices considered items 10 (I have a good emotion management so that seldom be enraged by the red light runner), item 5 (I can stop a escaping red light running vehicle whenever I want to do so), and item 3 (It is very easy for me to nose out the escaping intention of red light runner) as the most difficult tasks to achieve, but male polices weighed items 9 (I can get on the patrol rapidly and chase escaped red light running vehicle closely and stop it successfully), 19 (I can enforce the duty on red light running effectively even in the extreme weather) and 14 (I don't have leg-ache or backache after two hours duty on red light running.) as the most difficult ones. Higher percentage of female polices disagree to item 11 than male polices did, which suggested that males can deal with the violator's complain well to prevent his/ her objection.

The evidences indicate that the prior abilities needed to enhance for females are mental and psychosocial demands. As for males police, the physical demands is the priority since they tend to feel incapable of physical demands. As their enforcement abilities were also drastically affected by extreme weather condition, the future training for men's physical ability should take the weather condition into account.

4.5 Discussion

Four of twenty items were removed without meaningfully decreasing reliability with measures of work ability, in applying the Rasch model. Although the last form of the scale is brief, it estimates the true relations among underlying constructs and lends support to establishing invariance of the measure across groups. Confirming the interval level of measurement also can assure researchers that the scale can answer to assumptions for parametric statistics. The items formed an interval scale, but one showed biases related to rank level. The content of the biased item deserves comment. While omitting the biased items shortened the scale, meaningful links to measures of ability for enforcement were not sacrificed with preserving main framework of enforcement ability and skeleton of enforcement course process. This Rasch analysis of the TEPAQ showed that a 20% decrease in the length of the original scale appears could be made without sacrificing the strong correlations with enforcement ability variables found in enforcement ability framework. One can expect that if Rasch modeling could help decrease the length of scales, researches could shorten the questionnaires and potentially advance scale utility, save time, and decrease participant burden. Furthermore, in the analysis of person parameter, the result showed that the person parameter differences between those two samples (with 358 samples vs. with 274 samples) were not significant, but the percentage (81.02%) of the surveyed policemen of later sample set fit statistics inside the ± 2 Zstd tolerance box is larger than that of original sample set. We can use the later shortened sample set for further analysis.

The results on DIF indicated that police officers and sergeants had higher agreement on item 19 than heads had. Note that this outcome may confound the general consensus that heads, as a leader, were expected to have higher ability than police officers and sergeants. The dissonance might result from that heads weigh safety in extreme weather than others did. In contrast, higher percentage of police officers disagree to item 11 than heads did, which suggested that heads can deal with the violator's complain well to prevent his/ her objection. This finding is consistent with the general sense that heads always be a mediator between police officer and violator.

CHAPTER 5

MEASURING POLICE'S PERCEIVED ABILITY TO CONDUCT DWI PATROLS

This study aims at designing suitable questionnaires which can precisely measure the police enforcement abilities and then applying Rasch models to analysis respondents' data. Firstly, according to the tasks required for conducting DWI patrols' missions, an enforcement ability scale which could effectively measure the police abilities was explored. After collecting the participants' response data, the WINSTEPS was used to check unidimensionality assumption and measure the mission abilities.

5.1 Conceptual Framework of the Perceived Abilities for Conducting DWI Patrols

Referring to the conceptual frameworks for the required ability to conduct DWI checkpoints, the main processes of apprehending drunk driver when conducting DWI patrols basically should include two major stages (see Figure 7): the first is discriminating possible drunk driver by observing DWI cues, and the second is detaining the suspicious DWI motorist. Hence, in addition to the discriminating ability, the detaining ability to apprehend DWI violators is worthy of our attention as well. Considering the detection cues for DWI are derived from abnormal driving patterns, there is a need to further discuss this intriguing issue from the aspect of most common DWI driving patterns.

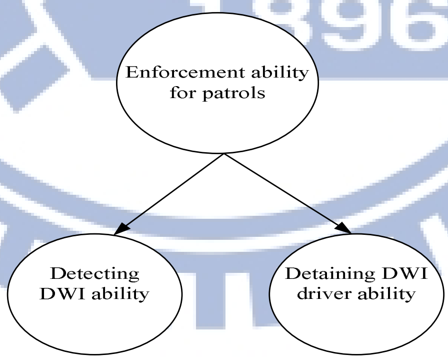


Figure 7 A conceptual frameworks for the required ability to conduct DWI patrols

DWI patrols is an efficient enforcement countermeasure to prohibit drunk driving and thus reduce DWI accidents. Generally, one or two officers are assigned to conduct DWI patrols. The commander, whose position is in the passenger seat, is responsible for detecting signs of intoxicated driving. The driver is responsible for not only driving but also detecting DWI cues and detaining DWI vehicle. Because police are required to make turn to be on duty for a commander or a driver, each one has the experience for detecting and detaining missions. However, this study focused on exploring the enforcement abilities of driving police.

Analyzing previous literature, we found detecting possible drunk drivers by observing DWI cues and detaining suspected DWI motorists are two main processes to apprehend drunk drivers. Thus, in order to reduce the numbers of deaths and injuries resulting from drunk driving, how to conceive police enforcement ability on detecting and detaining DWI vehicle and further propose method to enhance their ability are important issues. Consequently, for performing different enforcement process, various level of enforcement ability should be possessed by police. Moreover, different drunk driving patterns that an officer might encounter hold diverse enforcement latent risk. Hence, in order to assess police officers' perceived abilities when conducting DWI patrols, the usually observed driving patterns should join the two main conducting processes then to design a proper scale.

5.2 Empirical Study for Conducting DWI Patrols

The enforcement ability of a police officer is a latent trait that could not be observed and measured directly. Typically, latent traits are explored by means of questionnaires that include appropriate items to which the respondents can respond based on their experience. Because there are no available scales to measure police officers' enforcement ability, to design our own questionnaire for this study is needed.

5.2.1 The common DWI driving patterns observed when conducting DWI patrols

Taiwan has conducted DWI patrols for more than two decades. This operation is individually arranged and executed by each police precinct. Police officers detain and check motorists according to reasonable and objective criteria, including signs of intoxication, traffic violations, or other aberrant behavior of the oncoming vehicle, or they conduct the checks arbitrarily based on the principle of proportionality.

There are various DWI patterns that provide different cues for detecting whether a driver is intoxicated, and each brings different demands and risks to enforcing DWI patrols. Thus, enforcement ability for specific drunk driving patterns is considered for analysis. The questionnaire used in this study was built by following steps. First, we discovered the most common drunk driving patterns in Taiwan, and then in the second step, the questionnaire is constructed according to these patterns.

Table 9 DWI driving pattern frequencies

Driving patterns	Percentages*	Mean
Straddling Center or Lane Marker	55	4.07
Weaving	45	3.95
Drifting	45	3.76
Swerving	45	3.43
Fast Speed**	35	3.27
Turning with Wide Radius	60	3.21
Almost Striking Object or Vehicle	55	3.10
Slow Response or Failing to Response to Traffic Signals	50	3.08
Signaling Inconsistent with Driving Action	45	3.05
Following too Closely	60	3.01
Tires on Center or Lane Marker	45	2.84
Accelerating or Decelerating Rapidly	45	2.83
Slow Speed	45	2.58
Driving on other Than Designed Roadway	55	2.50
Braking Erratically	35	2.48
Stopping Inappropriately	35	2.45
Failing to Response to Traffic Signals	35	2.39
Driving into Opposing or Crossing Traffic	30	2.35
Turning Abruptly or Illegally	30	2.30

Note: 1=Rarely, 2=Seldom, 3=Neutral, 4=Often, 5=Frequently. *Percentage of nighttime drivers with BAC equal to or greater than 0.10. ** driving at a speed that is more than 10 MPH above the speed limit.

The National Highway Traffic Safety Administration (NHTSA) has developed a list of 23 cues to detect drunk driver in 2005, which is used prevalently by police to detect DWI[5]. The cues presented in these categories predict that a driver is DWI at least 30 percent of the time, as shown in the second column of Table 9. Thus, for example, the research indicates that "the percentages are 55 out of 100" that a driver who is straddling a center or lane marker has a blood-alcohol concentration (BAC) of 0.10 percent or higher. However, four of these visual cues are not driving patterns[6]; therefore, we excluded them from the survey that was for

[5] The DWI cues have been well defined by Douglas (1980) and NHTSA (2005).
[6] They are stopping in traffic lane, appearing to be drunk, headlight off, and driving with vehicle defect.

extracting the most common drunk driving patterns in Taiwan.

5.2.2 Questionnaire design for DWI patrols

Table 10 Designed items of DWIPEAS

Item/Question		Type
	Detecting ability (DeteA)	
01	I can promptly detect vehicles drifting.	5-point scale
02	I can promptly detect vehicles almost striking object or vehicle.	5-point scale
03	I can promptly detect vehicles swerving.	5-point scale
04	I can promptly detect vehicles turning with wide radius.	5-point scale
05	I can promptly detect vehicles straddling center of lane marker	5-point scale
06	I can promptly detect vehicles weaving.	5-point scale
07	I can promptly detect vehicles signaling inconsistent with driving action.	5-point scale
08	I can promptly detect vehicles following too closely.	5-point scale
09	I can promptly detect vehicles with fast speed.	5-point scale
10	I can promptly detect vehicles slow response to traffic signals.	5-point scale
	Detaining ability (DetaA)	
11	I can safely detain a vehicle drifting.	5-point scale
12	I can safely detain a vehicle almost striking object or vehicle.	5-point scale
13	I can safely detain a vehicle swerving.	5-point scale
14	I can safely detain a vehicle turning with wide radius.	5-point scale
15	I can safely detain a vehicle straddling center of lane marker.	5-point scale
16	I can safely detain a vehicle weaving.	5-point scale
17	I can safely detain a vehicle signaling inconsistent with driving action.	5-point scale
18	I can safely detain a vehicle with following too closely.	5-point scale
19	I can safely detain a vehicle with fast speed.	5-point scale
20	I can safely detain a vehicle slow response to traffic signals.	5-point scale

Afterward 101 experienced police officers were asked to fill out a 5-point Likert scale to express their opinion on the frequencies of nineteen DWI driving patterns during patrol duty. As illustrated in the Table 10, we identified 10 driving patterns, whose percentage of nighttime drivers with DWI are not less than 45 except fast speed pattern, with mean value about or more than 3 points, which could be considered as the most common DWI abnormal driving patterns in Taiwan and then were considered into the following analysis.

According to the tasks required for conducting saturation patrols, the police officers should have sufficient ability to detect and detain DWI drivers to achieve their mission. Thus, both of the conducting steps combined with the ten most common abnormal driving patterns were used to generate 20 meaningful items for the Traffic Police DWI Patrols Enforcement Ability Scale (DWIPEAS), as shown in Table 10. Ten items (Items 01 to 10) are designed to determine the ability of detecting (DeteA) DWI. The remaining items (Items 11 to 20) measure the ability on Detaining (DetaA) DWI motorist. The 5-point Likert scale (1 is assigned as Strongly Disagree, and 5 refers to Strongly Agree) was used to measure the officer's perception of their DWI enforcement ability when they are going on patrol.

To summarize, the DWI patterns researched in this study related to problems in maintaining proper lane position include weaving, straddling a lane line, drifting, swerving, almost striking a vehicle or other object and turning with a wide radius. Next, the DWI pattern of fast speed is related to speed problem. In addition, following too closely refers to judgment problem. Finally, The DWI patterns referring to vigilance problems include signaling inconsistent with driving actions and "slow or failing to respond to officer's traffic signals" (NHTSA,2005).

5.2.3 Data collection and descriptions

There were twenty one police bureaus in Taiwan in 2010. Multistage sampling was adopted in this study. Police bureau distribution in three main areas in Taiwan (northern, central, and southern areas) and distribution in city (Taipei and Kaohsiung) or county (Taichung and Chunghwa) location were the two principles adopted in sampling. 521 traffic police officers were randomly selected from the four police bureaus to fill out the enforcement questionnaire. Having deduced 19 invalid questionnaires with incomplete answers, the final effective sample size was 502.

As shown in Table 11, a sample consisting of 502 policemen was randomly selected (166 from north Taiwan, 171 from the middle of Taiwan, 165 from south Taiwan); 94.22% (n = 473) of them were male and 5.78% (n = 29) were female. The age of the officers ranged from 22 to 55 years, with an average of 36.97 years. The ages were further categorized into three groups in this study, including 188 young participants (age < 36), 194 middle-age participants ($36 \le$ age < 46), and 120 senior participants ($46 \le$ age ≤ 55). The sample consisted of 474 (94.42%) police officers (sergeants included) and 28 (5.58 %) captains (branch captains included). In terms of age, gender, and rank, the characteristics of participants were not found to significantly deviate from those of population at $\alpha = 0.05$.

Table 11 Statistics of the demographic variables surveyed

Respondent's personal characteristics								
Gender			Age			Rank		
	Frequency	%		Frequency	%		Frequency	%
Male	473	94.22	< 36	188	37.45	Captain	28	5.58
Female	29	5.78	36 ≤ age < 46	194	38.65	Police officer	474	94.42
Total	502	100.0	46 ≤ age ≤ 55	120	23.90	Total	502	100.0
			Total	502	100.0			

5.3 Measuring Results for Police's Perceived Ability to Conduct DWI Patrols

The WINSTEPS developed by Linacre & Wright provides powerful diagnosis of Rasch model. Thus, it is utilized in this study to assess the extent to which responses show adherence to the modeled expectations.

5.3.1 Model fit estimation and unidimensionality evaluation

We examined the fit of the 20-item DWIPEAS to the Rasch model, as shown in Table 12. Values for each person's level of EA were estimated by Rasch model for all 502 participants. In the first run, infit and outfit mean square values for individual items all fell within the expected range of 1 ± 0.2 (Table 12). The Zstd values for individual items 90% fell within the expected range of ±2, except Items 4 and 14, which are designed to measure abilities of detecting and detaining drunk driving cue of turning with wide radius, respectively.

These two items were removed from further analysis; and then the Zstd values are all fell within ±2. The first residual factor explained 2.9 units (i.e. eigenvalue) of the 18 units of residual variance, indicating that the remaining 18 items were functioning reliably according to the Rasch model assumptions. The absolute values of all outfit statistics were less than 2.0, below the critical value of 3. Consequently, the scale appears to assess a single, interval scale that fits the unidimensional assumptions for Rasch models.

Table 12 Estimates of item measures and fit statistics from the Rasch analysis

Item	Raw Score	δ_i	Infit MNSQ	Infit Zstd	Outfit MNSQ	Outfit Zstd
01	1785	-0.04	1.06	0.9	1.03	0.4
02	1850	-0.41	0.93	-1.1	0.97	-0.4
03	2017	-0.77	1.12	1.8	1.09	0.9
04	1892	-0.45	0.82	-2.9	0.79	-3.1
05	1914	-0.54	0.96	-0.6	0.9	-1.2
06	1964	-0.81	1.02	0.4	1.14	1.6
07	1849	-0.27	0.94	-1.0	1.11	1.4
08	1843	-0.24	1.00	0.0	0.98	-0.2
09	1819	-0.28	0.99	-0.2	1.09	1.2
10	1923	-0.55	0.98	-0.3	1.08	1.0
11	1574	0.68	1.03	0.5	1.05	0.8
12	1640	0.37	1.00	0.1	0.98	-0.3
13	1721	0.09	0.96	-0.6	0.95	-0.7
14	1609	0.57	0.84	-2.7	0.81	-3.2
15	1588	0.6	1.08	1.2	1.05	0.7
16	1519	0.96	1.06	1.0	1.07	1.0
17	1655	0.33	1.09	1.4	1.09	1.4
18	1769	-0.01	1.1	1.6	1.15	2.0
19	1585	0.64	1.01	0.2	0.98	-0.2
20	1751	0.14	0.91	-1.5	0.88	-1.9

Table 13 Model estimation and fit statistics of the Rasch analysis

Persons	502 Input	502 Measured	Number of observations:18.0				
Persons	Raw Score	Measure	Standard Error	Infit		Outfit	
				IMNSQ	ZSTD	IMNSQ	ZSTD
Mean	64.1	0.86	0.36	1.00	-0.2	1.01	-0.2
			Person Reliability: 0.89	Item Reliability: 0.99			
Items	Raw Score	Measure	Standard Error	Infit		Outfit	
				IMNSQ	ZSTD	IMNSQ	ZSTD
Mean	1763	0.00	0.06	1.00	0.00	1.01	-0.1

After dropping two items, a shortened 18-item DWIPEAS measure was assessed through a final Rasch model. Before we start detailed discussions and interpretations of the estimated item and person parameters, however, the reliability and validity of this Rasch model must be discussed first. Reliability in latent trait measurement is commonly defined as the consistency of the responses to a set of items, or the consistency of scores from the same instrument. It is also defined as the degree to which scores are free from measurement errors. The person and item reliability coefficients can be interpreted similarly to a Cronbach's alpha reliability coefficient for the internal consistency of responses to items (Wright, 1996). The results showed that overall scale reliability was 0.89 (person reliability index), the item reliability index was 0.99. Next, infit and outfit Zstd for all items were all fall inside the acceptable range of 0.8 – 1.2, as shown in Table 13, indicating that the final scale here is consistent with the assumptions of the Rasch model from the viewpoints of both items and persons.

5.3.2 DIF analysis

Further, since gender has long been recognized as the most important factor for developing an unbiased scale (David, et al., 2005, Mackintosh, 2006), DIF analyses were applied to examine whether difference in item difficulty exists between male and female police officers. For the two groups, eighteen items showed evidence of DIF but the difference estimates are no larger than 0.5 logits, which suggested insignificant bias between male police and female police, and insisted that the final DWIPEAS is a qualified scale.

5.4 Findings for Measuring Police's Perceived Ability to Conduct DWI Patrols

Table 14 Estimates of item measures and fit statistics from Easier to Harder

Variables/ Questions	δ_i	Percentage of persons with sufficient ability	Infit		Outfit	
			MNSQ	**Zstd**	**MNSQ**	**Zstd**
06 (Detecting – weaving)	-0.81	93.62	1.01	0.2	1.09	1.1
01 (Detecting – drifting)	-0.76	93.62	1.1	1.5	1.07	0.8
09 (Detecting – fast speed)	-0.55	90.83	0.96	-0.6	1.04	0.5
07 (Detecting – signaling inconsistent with driving action)	-0.54	90.63	0.95	-0.7	0.9	-1.3
08 (Detecting – following too closely)	-0.41	88.64	0.91	-1.5	0.93	-1.0
10 (Detecting – slow response to traffic signals)	-0.29	86.06	0.99	-0.2	1.06	0.9
05 (Detecting – straddling center of lane marker)	-0.28	86.06	0.92	-1.3	1.06	0.8
03 (Detecting – swerving)	-0.24	86.06	0.99	-0.1	0.98	-0.3
02 (Detecting – almost striking objection or vehicle)	-0.05	78.28	1.05	0.9	1.02	0.2
18 (Detaining – following too closely)	-0.02	74.82	1.04	0.6	1.01	0.2
20 (Detaining – slow response to traffic signals)	0.08	76.09	1.03	0.5	1.03	0.4
13 (Detaining – swerving)	0.13	74.51	0.98	-0.3	0.95	-0.8
17 (Detaining – signaling inconsistent with driving action)	0.36	64.94	0.91	-1.4	0.89	-1.8
12 (Detaining – almost striking objection or vehicle)	0.56	55.78	0.94	-1.0	0.93	-1.2
15 (Detaining – straddling center of lane marker)	0.58	55.78	0.98	-0.4	0.95	-0.7
19 (Detaining – fast speed)	0.63	52.39	1.09	1.5	1.12	1.9
11 (Detaining – drifting)	0.66	52.39	1.01	0.2	1.02	0.4
16 (Detaining – weaving)	0.94	42.82	1.07	1.1	1.06	1.0
Mean	0.00	74.82	NA	NA	NA	NA

The results of final estimates of item parameters (δ_is), persons' average abilities and fit statistics are illustrated in Table 13and Table 14. The third column of Table 14 presents the percentage of police officers with enough abilities to complete each item/task. The item parameters (δ_is) for each task are displayed in Column 3, and the outfit and infit statistics for mean square (MNSQ) and standardized Z are listed in columns 5 – 8, respectively.

5.4.1 Findings from the estimated item parameters

The Rasch model suggests that the answer to an item can be explained by two parameters: the difficulty of the item and the ability of the person. As item parameters are concerned, according to the definition of item difficulty, the lower the item difficulty, the easier the task will be accomplished. Thus, among the items considering the detecting abilities, *weaving* (Item 6 with −0.81 logits), *drifting* (Item 1 with −0.76 logits) and fast speed (Item 9 with −0.55 logits) were relatively easier to detect than the other patterns of drunk driving behaviors (see Table 14). It may be the case that the lateral movement of both weaving and drifting patterns can be fairly regular so that they were easier to be detected (Douglas et al., 1980; NHTSA, 2005). On the other hand, the cues of *almost striking object or vehicle* (Item 2 with −0.05 logits) and swerving (Item 3 with −0.24 logits; i.e., making an abrupt turn away from a generally straight course) often appear transiently, thus they were less likely to be caught by police officers. Hence, police officers should pay more attention and concentrate to detect DWI vehicles characterized by *swerving* and *almost striking an object or vehicle*.

Regarding to the detaining abilities, weaving (Item 16 with 0.94 logits) was the most difficult pattern to detain, followed by drifting (Item 11 with 0.66 logits) and DWI speeding (Item 19 with 0.63 logits), while following too closely (Item 18 with −0.02 logits) and slow response to traffic signals (Item 20 with 0.08 logits) were the two easiest DUI driving patterns to detain. Interestingly, the most three difficult driving patterns to detain are just the easiest three to be detected. The lateral movements of a weaving pattern are fairly regular as one steering correction is closely followed by another[7] (Douglas et al., 1980). This visual cue also has a pattern of frequently cutting off other drivers in traffic. If a motorist is weaving in traffic, there is a 60% chance of drunk driving (Harris et al., 1980). Detaining a weaving vehicle is dangerous when conducting saturation patrols. According to the results of the Rasch analysis, weaving was the most difficult drunk driving pattern to detain. This finding was consistent with the argument of Harris et al. (1980) and Sarkar et al. (2000) that *weaving* is the most aggressive driving pattern. According to NHTSA (Douglas et al., 1980), drifting was defined as "when a vehicle is moving in a generally straight line, but at a slight angle to the lane." The driver might correct his/her course continually or fail to correct in time to avoid a collision, so this driving pattern was quite dangerous. Thus, this pattern was not easy to detain. DWI speeding is the driving combination of DWI and driving at a speed that is more than 10 MPH

[7] The DWI cues have been well defined by Douglas et al. (1980) and NHTSA (2006).

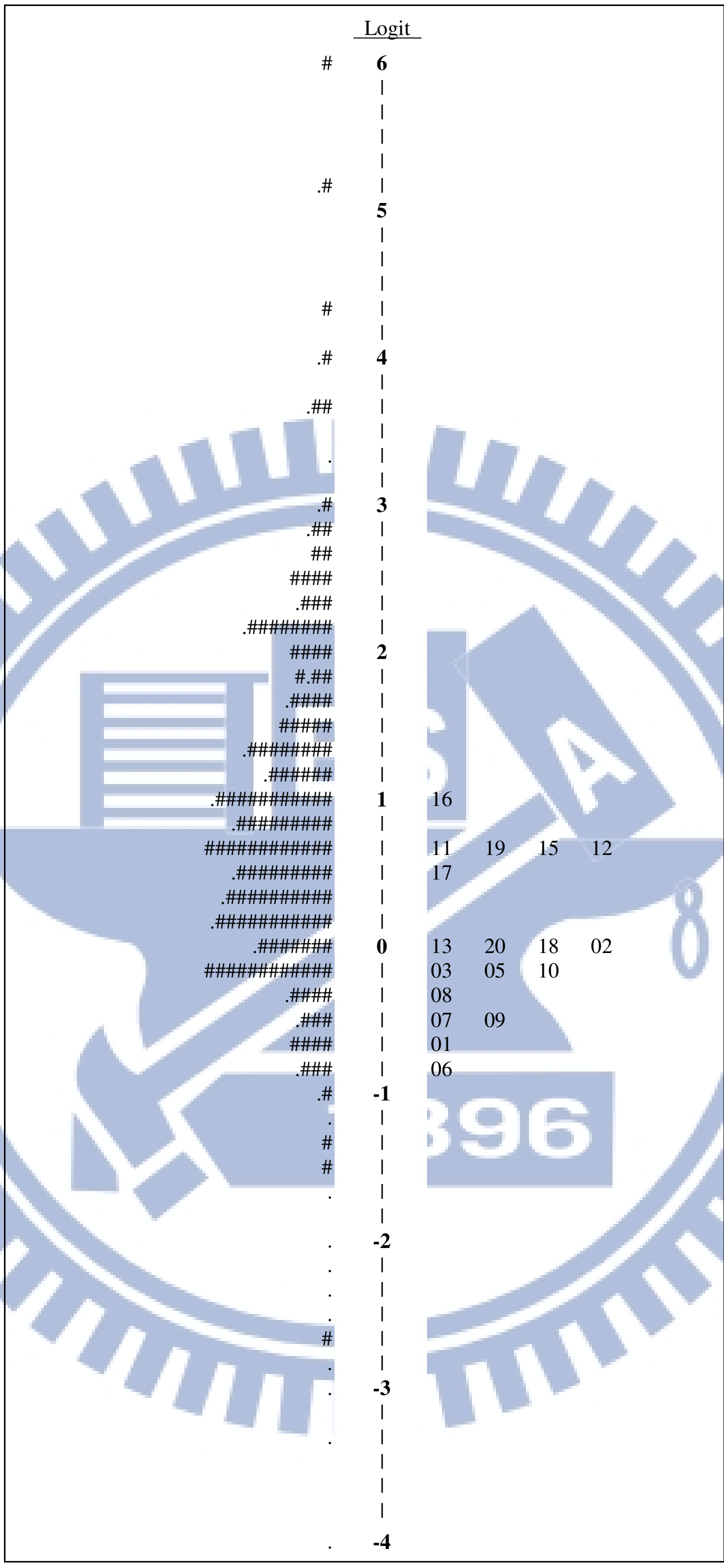
above the speed limit. Hence, this driving pattern can be detected easily; and it is a danger driving pattern.

As for *straddling center of lane marker*, the set of tires of the observed motor is consistently on the center line or lane marker. As the driver may drive into opposing lane and result in severe traffic crash, this kind of driving behavior was not easy to detain (Item 15 with 0.58 logits). Concerning the cue of signaling inconsistent with driving action, the difficulties to detect (Item 7) and to detain (Item 17) this kind of driving pattern were moderate so it was with moderate danger. Swerving driving (Item 13) usually occurs with an abrupt turn to correct course or return the vehicle to the traffic lane. Usually, swerving driving is not an impetuous or intentionally maneuver; and its lateral movements are discontinuous. This kind of driving behavior possesses low dangerous to detain according to the results. Similar to a swerving driving pattern, an *almost striking object or vehicle* driving pattern (Item 12) is also transient and can also be detained easily. For the cues of following too closely (Item 18) and slow response to traffic signals (Item 20), these kinds of driving cues were not difficult to detect and easy to detain, so they were with less danger.

5.4.2 Findings from the estimated person parameters

In view of person parameters, the average value of the EA, which is calculated by averaging the person parameter estimates (θ_n) across all respondents, of all the participant officers is 0.86 logits, as shown in the third column of Table 13. Because the mean value of all item difficulties (δ_is) is anchored at 0 logit in Rasch analysis, the positive mean ability value confirmed that the traffic police officers perceived that generally they were confident on conducting saturation patrols.

Figure 8 plots the positions of item difficulties and person abilities for DWI patrols, which are measured by logit scale. The logit scale is an interval scale in which the unit intervals on the person-item map have a consistent value or meaning. (Bond and Fox, 2001) The numbers on the right side of map are item numbers whose locations are assigned according to their item parameters which is the proxy of item difficulty for Rasch model. The higher the item parameter estimate, the more difficult the item be performed, and the locations of item number are higher in the person-item map as well. Similarly, ranked by the person parameter estimates, the distribution of officer's ability is displayed on the left side of the map. The officer located at a higher position represents (s)he has higher ability to conduct DWI patrols.



Note: A dot represents a person, and each “#” represents 4 persons.

Figure 8 Item-person map for DWI patrol

This map provides a visual illustration of the relative positions between persons’ abilities and item difficulties. When a police officer is located on the same level as a specific item, (s)he has a probability of 50% to accomplish this item successfully. The probability of whose successful enforcement on a specific item increases (decreases) 25% when whose person parameter is 1 logit higher (lower) than the item parameter for that item (Bond & Fox, 2001). The drawing shows that a lot of police officer located far below item numbers, which means those officers lack available abilities to perform that item. Therefore, from the item-person maps in Figure 8, we can calculate the percentage of participant police officers with enough ability to complete each item/task, which is displayed on the forth column of Table 14. On average, about 74.82% of police officers are capable of performing saturation patrols tasks well.

Table 15 Distribution of police officers abilities

Item	Fail		Fair		Good		Excellent	
	number	%	number	%	number	%	number	%
01	32	6.37	130	25.90	175	34.86	165	32.87
02	109	21.71	194	38.65	94	18.73	105	20.92
03	82	16.33	176	35.06	132	26.29	112	22.31
05	70	13.94	188	37.45	132	26.29	112	22.31
06	31	6.18	113	22.51	186	37.05	172	34.26
07	46	9.16	147	29.28	169	33.67	140	27.89
08	57	11.35	165	32.87	155	30.88	125	24.90
09	46	9.16	147	29.28	169	33.67	140	27.89
10	70	13.94	188	37.45	132	26.29	112	22.31
11	239	47.61	146	29.08	68	13.55	49	9.76
12	222	44.22	155	30.88	76	15.14	49	9.76
13	143	28.49	187	37.25	88	17.53	84	16.73
15	222	44.22	155	30.88	76	15.14	49	9.76
16	303	60.36	94	18.73	69	13.75	36	7.17
17	176	35.06	170	33.86	95	18.92	61	12.15
18	120	23.9	183	36.45	102	20.32	97	19.32
19	239	47.61	146	29.08	68	13.55	49	9.76
20	128	25.5	190	37.85	88	17.53	96	19.12

Note: Item 01~09 are related to detecting tasks; the remainders are related to detaining tasks.

In order to provide quantitative evidences, accordingly, we compute the differences between whose person parameter and each item parameter for every police officer. If the difference is more than 2 logits, the officer could be classed into ‘Excellent’ on that item because (s)he can fulfill the task absolutely. If the difference is more than 1 logit and less than 2 logits, the probability of whose success on that item is more than 75%, thus (s)he is classed into ‘Good’. The officer is classified into ‘Fair’ as whose success probability is merely more than 50% when the difference is between 0 logit and 1 logit. The officer is classed into 'Fail' if the difference is negative that implies a success probability of less than 50%. The distributions of police officers abilities are summarized as Table 15.

The results show that expect for Item 16 (detaining a weaving vehicle), more than half of sample police officers have enough ability (a probability of more than 50% to achieve this item) to cope with various DWI driving patterns. Most officers have fair or even better ability to carry out their duty. Comparing to the last nine detaining related items, police officers have more confidence to conduct the first nine items which are about detecting DWI. More than 20% police officers are excellent in detecting tasks, yet for detaining tasks this kind of police officers only share 7.17% up to 19.32%. This evidence demonstrates that the police officers have better abilities on *detection* tasks than *detaining* tasks.

However, a more in-depth investigation of the item-person maps showed that all item difficulties were relatively concentrated as compared with their corresponding distributions of person abilities. It seems to indicate that all the jobs required to detect and to detain DWI motorists have quite similar difficulties, which constitutes an ability threshold to determine whether a police officer is qualified to conduct the mission of detecting DWI vehicles. Accordingly, the threshold of the required EA construct could be assumed to be the highest value of item difficulty among all DeteA items, which was -0.05 logits when detecting drunk driving vehicles *almost striking an object or vehicle* (Item 2). Among all 502 participant police officers, there were 393 persons (78.3%) passing the required DeteA threshold (i.e., who can achieve all the tasks of detecting DWI vehicles well). As the other 109 participants (21.7%) were classified as unqualified officers for conducting the mission, they should be forced to take further training and education to enhance their DeteA and DetaA before they are allowed to conduct saturation patrols.

5.5 Discussion

The interval scale measurements of EA obtained from Rasch analysis provide a convenient opportunity to explore whether police officers with different characteristics have different EA to conduct saturation patrols. Thus, a multiple regression model was applied to investigate the effect of gender, rank, and age of police officers on EA. The study results shown in Table 16 indicated there was no significant difference between the two gender groups and the two rank groups. Officers aged 36-45 had significantly higher EA than those aged 46-55, moreover, aged 36-55 had significantly lower EA than those aged under 36 was found. This finding indicated that younger police was better for conducting saturation patrols.

Table 16 The estimated results of regression models for EA

Model/Construct	EA	
Variable	coefficient	t-value
Constant	1.854	7.233
Gender (male=1, female=0)	-0.094	-0.393
Rank (captain=1, others=0)	0.278	1.142
Aged 36-45 (under 36=0)	-0.978	-7.629*
Aged 46-55 (under 36=0)	-2.036	-13.946*
Number of observations	502	
R^2	0.314	
Adjusted R^2	0.301	

*significant at $\alpha = 0.05$

Detecting DWI vehicles requires police officers to have good vision, sufficient attention, and excellent concentration to perform it well (Dijk et al., 1988). However, detaining DWI vehicles are demanding and dangerous tasks that require police officers to have the energy, physical and psychological ability to fight aggressive DWI drivers (Sluiter, 2006; Dijk et al., 1988). Thus, according to the study results, the difficulty parameters of detaining tasks were all positive except Item 18, yet the difficulty parameters of detecting tasks were all negative. It suggested that to detain DWI drivers was more difficult than to detect DWI vehicles. Therefore, promoting the skill of detaining a drinking driver was training priority. Age was found to be the most important influential factor to determine police officers' EA to conduct this mission. Among the police officers qualified for conducting this mission, only 14.2% of them were over 45; however, 58.7% of those unqualified to conduct this mission were over 45. The results further indicated that young police officers were more appropriate than older police officers to conduct saturation patrols.

CHAPTER 6

MEASURING POLICE'S PERCEIVED ABILITY TO CONDUCT SOBRIETY CHECKPOINTS

The enforcement ability of a police officer is a latent trait that could not be directly observed and measured. Typically, latent traits are explored by means of questionnaires that include appropriate items to which the respondents can respond based on their experience. Because there are no available scales to measure police officers' enforcement ability, we thus needed to design our own questionnaire for this study.

This study, being a follow-up study of saturation patrols, aims at designing suitable questionnaires which can precisely measure the police enforcement abilities and then applying Rasch models to analysis respondents' data. Firstly, according to the tasks required for conducting DWI checkpoints' missions, an enforcement ability scale which could effectively measure the police abilities was developed. After collecting the participants' response data, the unidimensionality assumption for Rasch model was tested, and then Rasch models were applied to measure the mission abilities. If the data is fit for multidimensional Rasch models, factor analysis was conducted to extract underlying latent factors influencing enforcement ability before administering multidimensional Rasch analysis. The WINSTEPS (Linacre and Wright, 1998) which provides not only person ability, item difficult and fit statistics but also the residual variance of the first residual factor was applied to check unidimensionality assumption in this study. The Acer ConQuest (Wu, 2007) was used for multidimensional responses' data.

6.1 Conceptual Framework of the Perceived Abilities for Conducting DWI Checkpoints

The conception of police's perceived enforcement abilities are rarely discussed by previous research. In order to explore reasonable and readable enforcement ability questionnaires, firstly, the major tasks of conducting DWI Checkpoints must be constructed. Thus, the conceptual frameworks of the perceived abilities for this enforcement were illustrated as follows.

6.1.1 Sobriety checkpoints conducted in Taiwan

Watson et al (1994) indicated that operating Reduced Impairment Driving (RID), in which the police are restricted to detaining and testing only drivers whom they suspected had been DWI, could be highly successful in reducing the number of serious crashes. In Taiwan, police officers detain and check motorists at checkpoints according to reasonable and objective criteria, including signs of intoxication, traffic violations, or other aberrant behavior of the oncoming vehicle, or they conduct the checks arbitrarily based on the principle of proportionality. Thus, it could be considered as an operation of RID.

Taiwan has conducted RID checkpoints since 1996 and each police precinct is required to conduct checkpoints 10 times per month. Police officers detain and check motorists according to reasonable and objective judgments on signs of intoxication, traffic violation, or other aberrant behavior of the oncoming vehicle, or do it arbitrarily based on the principle of proportionality. According to current Taiwan regulations, if the driver does not pass the formal breath alcohol test, he/she will receive a ticket ($0.25 \leq$ BrAC < 0.5mg/L) or a DWI arrest (BrAC $\geq$ 0.55 mg/L). This operating should be conducted for 3 hours whenever it is performed. Usually, checkpoints are randomly set at predetermined points on straight roadways. Two DWI checkpoints are set simultaneously at different locations within a police precinct district whenever the program is running. Therefore, this law enforcement could be operated to deter DWI offence during high alcohol hours on any roadway and on any day of the week.

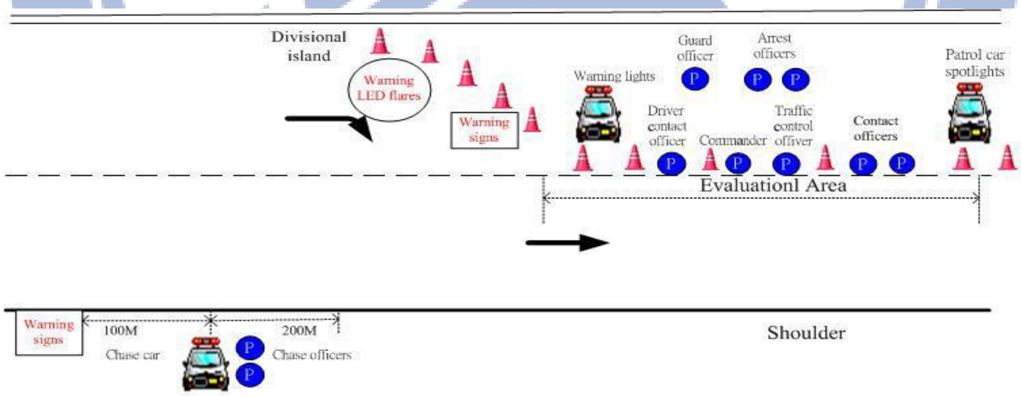


Figure 9 The Operation Diagram of Conducting Checkpoints on a Two-way Four-lane Highway

Figure 9 depicts a typical operation diagram of sobriety checkpoints on a two-way four-lane undivided highway. The workforce includes 5–10 officers. The commander and traffic control officer are located behind the driver-contact officer and are followed by one or two contact/alcohol breath-testing officers. To protect these officers from oncoming traffic, two patrol cars are parked ahead of and behind those officers. Frequently, on the shoulder ahead of the evaluation zone, two officers with a chase car are located to intercept escaping vehicles that cannot be detained at the sobriety checkpoint. The driver-contact officers look for signs of intoxicated driving before their initial contact and stop potential DWI vehicles. The commander is responsible for conducting the initial alcohol breath test using an alcohol breath screen tester. The traffic control officer directs the intoxicated driver to an evaluation area. Contact officers are then responsible for conducting chemical examinations with portable digital breath-test instruments on drivers who are directed into the evaluation area. Arrest officers stand aside and are responsible for carrying out duties such as completing paperwork required by their agency, writing tickets, or making DWI arrests. Chase officers with a chase car stand ahead of the operation area and are responsible for intercepting escaping vehicles.

6.1.2 Constructing conceptual frameworks of the perceived ability for drunk driving enforcement

The important factors of successful DWI enforcement have been studied by several authors (Grosvenor et al., 1999; Jones et al.,). A study investigating the impact of officers' ability to detect drunk-driving cues on DWI arrest rates by Harris et al. (1980) found that the DWI arrest rate of an experimental group that was trained to note DWI cues was significantly higher than that of the control group. In addition, NHTSA (2002a) suggests that sobriety checkpoints can be implemented if officers are trained in detecting impaired drivers in the United States. In addition, detecting alcohol-impaired drivers is a complex action and officers must observe some traffic violation or other aberrant behavior before they can stop a motorist (NHTSA, 2006a). These findings confirmed that the detecting abilities of police officers play an important role in successful DWI enforcement. Scott et al. (2006) further argued that detaining DWI vehicles is one of the main goals of DWI enforcement. Moreover, according to the aforementioned, chase car, which is responsible for intercepting escaping vehicle, is required for this work force (NHTSA, 2002b).

Detecting DWI vehicles requires police officers to have enough mental abilities, including good vision, sufficient attention, and excellent concentration to perform it well (Dijk et al., 1988). However, detaining and intercepting DWI vehicles are highly demanding and dangerous tasks that require police officers to have the energy, physical ability and psychological ability to resist aggressive DWI drivers (Sluiter, 2006; Dijk et al., 1988). It implies that different duty circumstances a police encountered require different enforcement abilities (Chang and Shih, 2012). Accordingly, as shown in Figure 10, the main process of apprehending drunk drivers when conducting sobriety checkpoints should include three steps: detecting possible drunk drivers by observing DWI cues, detaining suspected DWI motorists, and intercepting escaping motorists. However, previous research addressing officers' self-perceived abilities to enforce DWI laws is limited. For different DWI driving patterns, the difficulties and risks of enforcement are diverse (Harris et al., 1980; Sarkar et al., 2000), and thus the outcomes of law enforcement would be dissimilar. In all, three major steps (i.e. detecting, detaining, and intercepting) are required to detain DWI drivers successfully.

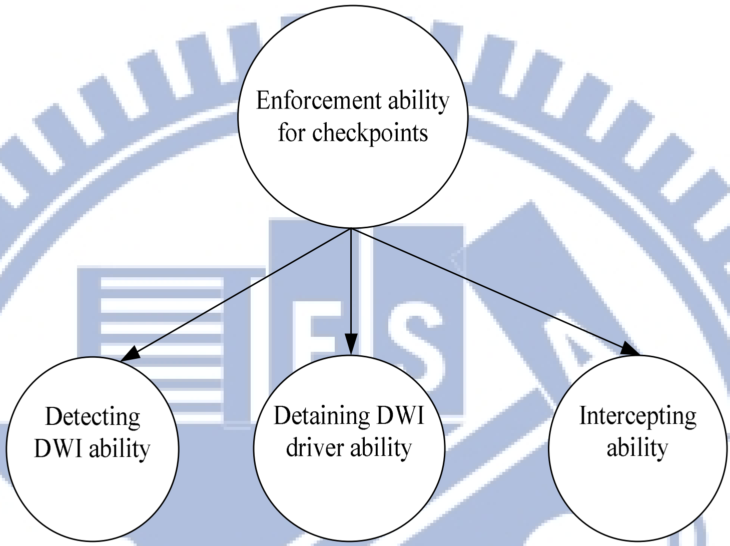


Figure 10 A conceptual frameworks for the required ability to conduct DWI checkpoints

Further, to deeply depict the correlation between enforcement ability characteristics and the steps to apprehend drunk drivers, detecting DWI vehicles requires police officers to have enough mental abilities, including good vision, sufficient attention, and excellent concentration to perform it well (Dijk et al., 1988). However, detaining and intercepting DWI vehicles are highly demanding and dangerous tasks that require police officers to have the energy, physical ability and psychological ability to resist aggressive DWI drivers (Sluiter, 2006; Dijk et al., 1988). It implies that different duty circumstances a police encountered require different enforcement abilities.

The conceptual framework underlying traffic enforcement has always been the deterrence theory. Conducting sobriety checkpoints is an efficient enforcement countermeasure to prohibit drunk driving and thus reduce DWI accidents. In Taiwan, DWI checkpoints which are frequently administered but unscheduled and set simultaneously at different locations, thus, one would refrain from drunk driving for fear being apprehended when passing a checkpoint.

Analyzing previous literature, we found detecting possible drunk drivers by observing DWI cues, detaining suspected DWI motorists, and intercepting escaping motorists are three main processes to apprehend drunk drivers when conducting sobriety checkpoints. Additionally, the enforcement ability of police officers is one of the key elements to gain success on conducting sobriety checkpoints. Thus, in order to reduce the numbers of deaths and injuries resulting from drunk driving, how to conceive police enforcement ability on detecting, detaining and intercepting DWI vehicle and further propose method to enhance their ability are important issues.

Twenty-three driving cues which are general and reliable initial indicators are typically used to distinguish drunk driving from normal driving. Moreover, different drunk driving patterns that an officer might encounter hold diverse enforcement latent risk. Hence, in order to assess police officers' perceived abilities when conducting DWI checkpoints, the commonly observed driving patterns should join the three main conducting processes then to design a proper scale.

6.2 Empirical Study for Conducting DWI Checkpoints

According to the tasks required for conducting sobriety checkpoints, the police officers should have sufficient ability to detect and detain DWI drivers and to intercept escaping vehicles to achieve their mission. However, there are various DWI patterns that provide different cues for detecting whether a driver is intoxicated, and each brings different demands and risks to enforcing sobriety checkpoints. Nunnally (1978) indicated that one should ensure the method's validity according to its plan and procedures for construction but not test the validity of measures after they have been constructed. Careful selection of initial items will help to ensure the "content validity" for scales (Davis, 1989). Thus, the questionnaire was carefully developed in two stages. We first identified the most common and important drunk-driving behaviors and then developed the questionnaire based on the cues seen at sobriety checkpoints, along with the necessary actions to detain the DWI drivers or intercept the escaping vehicles.

6.2.1 Questionnaire design for Sobriety Checkpoints

In 2006, the National Highway Traffic Safety Administration developed a list of 23 cues (Harris et al., 1980) to detect drunk drivers, which police officers commonly use to detect

DWI. Four of these visual cues are not driving patterns[8]; therefore, we excluded them from the survey, which included the most commonly observed drunk-driving patterns at sobriety checkpoints.

Because sobriety checkpoints are established on straight road sections (other than intersections) in Taiwan, certain cues for drunk driving are invisible (e.g., turning with a wide radius). To identify the most commonly observed driving patterns at sobriety checkpoints, 108 experienced police officers, who were was randomly selected from three main area of Taiwan (northern, central, and southern areas) and have served more than ten years in traffic police unit, were asked to fill out a 5-point Likert scale to express their opinions regarding the frequency of observed patterns involving DWI for these 19 indicators. If the response is "5" or "4," that indicator may be regarded as one of the most common observed ones.

Table 17 Supported percentage of the observed driving patterns involving DWI for sobriety checkpoints

Detecting patterns	Percentage (%)
Swerving	94
Weaving	90
Straddling Center or Lane Marker	89
Drifting	86
Accelerating or Decelerating Rapidly	83
Almost Striking Object or Vehicle	82
Braking Erratically	39
Driving into Opposing or Crossing Traffic	38
Tires on Center or Lane Marker	35
Fast Speed	31
Slow Speed	25
Signaling Inconsistent with Driving Action	20
Stopping Inappropriately	17
Driving on other Than Designed Roadway	10
Others	6
Stopping (without cause) in Traffic Lane	3
Turning Abruptly or Illegally	3
Turning with a Wide Radius	3
Following too closely	2
Slow Response to Traffic Signals	0

[8] These four visual cues which are not driving patterns are appearing to be drunk, headlights off, falling to respond to traffic signals or signs, and driving with vehicle defect(s).

Table 17 shows the responses of the 108 participants regarding the patterns of DWI suspects at checkpoints. The results indicated that six cues were supported (i.e., with a response of “5” or “4”) by more than 80% of the interviewees: swerving (94%), weaving (90%), straddling center or lane marker (89%), drifting (86%), accelerating or decelerating rapidly (83%) and nearly striking object or vehicle (82%). Hence, the items related to detecting, detaining and intercepting missions in this study focused on these six frequent patterns.

Table 18 Designed items of TPSCEAS

Item/question	Type
Detecting Ability (DetcA)	
Item 01: I can promptly detect vehicles accelerating or decelerating rapidly.	5-point scale
Item 02: I can promptly detect vehicles nearly striking an object or vehicle.	5-point scale
Item 03: I can promptly detect vehicles swerving.	5-point scale
Item 04: I can promptly detect vehicles weaving.	5-point scale
Item 05: I can promptly detect vehicles straddling the center of lane marker.	5-point scale
Item 06: I can promptly detect vehicles drifting.	5-point scale
Detaining Ability (DetaA)	5-point scale
Item 07: I can safely detain an accelerating or decelerating vehicle.	5-point scale
Item 08: I can safely detain a vehicle almost striking an object or vehicle.	5-point scale
Item 09: I can safely detain a swerving vehicle.	5-point scale
Item 10: I can safely detain a weaving vehicle.	5-point scale
Item 11: I can safely detain a vehicle straddling the center of lane marker.	5-point scale
Item 12: I can detain safely a rapidly drifting vehicle.	5-point scale
Intercepting Ability (IA)	
Item 13: I can successfully drive a patrol car to intercept an escaping vehicle rapidly accelerating or decelerating.	5-point scale
Item 14: I can successfully drive a patrol car to intercept an escaping vehicle almost striking an object or other vehicle.	5-point scale
Item 15: I can successfully drive a patrol car to intercept a swerving escaping vehicle.	5-point scale
Item 16: I can successfully drive a patrol car to intercept a weaving escaping vehicle.	5-point scale
Item 17: I can successfully drive a patrol car to intercept an escaping vehicle straddling center of lane marker.	5-point scale
Item 18: I can successfully drive a patrol car to intercept a drifting escaping vehicle.	5-point scale

These six most important patterns observed at checkpoints were then combined with the three stages of conducting the checkpoint to generate 18 meaningful items for the Traffic

Police Sobriety Checkpoints Enforcement Ability Scale (TPSCEAS), as shown in Table 18, which was used to measure police officers' perceived abilities in detecting, detaining and intercepting DWI vehicles. The 5-point Likert-type scale (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree) was used to reflect interviewees' responses to the items.

6.2.2 Data collection and descriptions

The participants of this empirical study were the same as the study of sobriety checkpoints. Multistage sampling was adopted as illustrated and administered in chapter 5. A sample consisting of 502 investigated policemen was drawn randomly in Taiwan. Of them, 94.23% (n = 473) were male and 5.77% (n = 29) were female. The age of the officers ranged from 22 to 55 years, with an average of 36.97 years. The ages were further categorized into three groups in this study, including 188 young participants (age < 36), 194 middle-age participants (36 $\leq$ age < 46), and 120 senior participants (46 $\leq$ age $\leq$ 55). The sample consisted of 474 (94.42%) police officers (sergeants included) and 28 (5.58 %) branch captains. In terms of age, gender, and rank, the characteristics of participants were not found to significantly deviate from those of population at $\alpha=0.05$.

6.2.3 Factor analysis

Firstly, we examined the unidimensionality assumption. The residual variance of the first residual factor explained 3.2 units (i.e. eigenvalue) of the 18 units, indicating that the 18 TPSCEAS items were not reliably according to the Rasch model assumptions. Consequently, the scale appears violation of the unidimensionality assumption on parameter estimation and to present a non-unidimensional one.

According to previous studies, the three main processes that the police use to apprehend drunk drivers are detecting possible drunk drivers, detaining the suspected DWI motorists and intercepting escaping motorists. However, the way in which these three component latent traits correlate with apprehending ability has not been analyzed. Therefore, to develop a new scale, the correlation between latent traits and enforcement ability, must be confirmed before measuring perceived ability.

Factor analysis (Field 2005) can be used to reduce the data set into a set of factors by explaining the maximum amount of common variance in a correlation matrix using the smallest number of explanatory concepts. To extract underlying latent factors influencing enforcement ability, factor analysis (FA), which examines the pattern of correlation between observed measures and cumulative variance, was utilized.

The Cronbach α of the measurement is 0.948, which exceeds the recommended value of 0.7 (Nunnally, 1978); this value indicates that the measurement is reliable and has adequate internal consistency. Significant Bartlett's test of sphericity (at 0.01 level) and Kaiser's measure (KMO) of 0.953 confirm that the data are appropriate for conducting common factor analysis. Therefore, factor analysis was employed to explore the latent component traits of the questionnaire.

Table 19 Final items of TPSCEAS

Item/question	Type
<u>Detecting Ability (DA)</u>	
Item 01: I can promptly detect vehicles accelerating or decelerating rapidly.	5-point scale
Item 02: I can promptly detect vehicles nearly striking an object or vehicle.	5-point scale
Item 03: I can promptly detect vehicles swerving.	5-point scale
Item 04: I can promptly detect vehicles weaving.	5-point scale
Item 05: I can promptly detect vehicles straddling the center of lane marker.	5-point scale
Item 06: I can promptly detect vehicles drifting.	5-point scale
<u>Detaining and Intercepting Ability (DIA)</u>	5-point scale
Item 07: I can safely detain an accelerating or decelerating vehicle.	5-point scale
Item 08: I can safely detain a vehicle almost striking an object or vehicle.	5-point scale
Item 09: I can safely detain a swerving vehicle.	5-point scale
Item 10: I can safely detain a weaving vehicle.	5-point scale
Item 11: I can safely detain a vehicle straddling the center of lane marker.	5-point scale
Item 12: I can detain safely a rapidly drifting vehicle.	5-point scale
Item 13: I can successfully drive a patrol car to intercept an escaping vehicle rapidly accelerating or decelerating.	5-point scale
Item 14: I can successfully drive a patrol car to intercept an escaping vehicle almost striking an object or other vehicle.	5-point scale
Item 15: I can successfully drive a patrol car to intercept a swerving escaping vehicle.	5-point scale
Item 16: I can successfully drive a patrol car to intercept a weaving escaping vehicle.	5-point scale
Item 17: I can successfully drive a patrol car to intercept an escaping vehicle straddling center of lane marker.	5-point scale
Item 18: I can successfully drive a patrol car to intercept a drifting escaping vehicle.	5-point scale

Several methods such as principal component analysis (PCA), the maximum likelihood method and Kaiser's alpha factoring can be applied to unearth factors in the data. The method choice depends on the analysis purpose. Principal Component Analysis is a technique that attempts to reduce complex data sets consisting of many different variables to a simple and smaller set of new variables that still manage to describe much of the variation in the original data. These new variables, called principal components, are chosen to be independent and to maximize the variance found in the original data set. Thus, PCA was used in this study.

The interpretability of factors can be improved through rotation. Rotation maximizes the loading of each variable on one of the extracted factors which minimize the loading of the other variables. Therefore, this process makes it much clearer which variables are related to which factors. In order to decide which rotation method is more appropriate to our data, we tried to run both methods: the orthogonal rotation (varimax) and the oblique rotation. The late one produced a correlation matrix between the factors. If the components were independent then we would expect the oblique rotation to provide an identical solution to the orthogonal rotation and the component correlation matrix should be an identity one. The fact that the correlation (r = 0.64) existed told us that we could not assume independence and therefore the results of the orthogonal rotation should not be trusted and the obliquely rotated solution is more meaningful.

As shown in Figure 11, two factors with eigenvalues exceeding 1 were extracted from the original TPSCEAS by SPSS, which explained 64.7% of the cumulative variance. These two factors separately explained 53.65% and 11.05% of variance. The result demonstrated that the ability of an officer to detain a DWI motorist and intercept a DWI motorist may be integrated into a single component latent trait, whereas the ability to detect DWI patterns was a single component latent trait. This finding demonstrated that enforcement ability could be divided into two component latent traits: detecting ability (DA) for DWI vehicles and detaining and intercepting ability (DIA) for DWI vehicles (shown in Table 19), which together account for all 18 items.

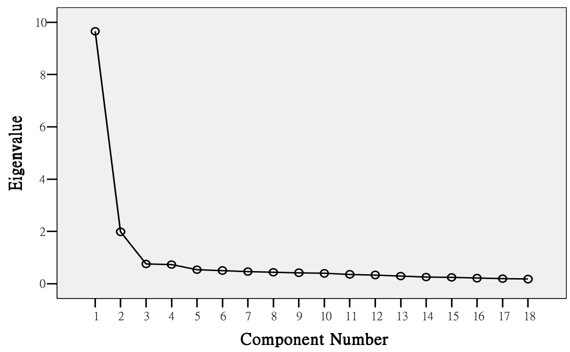


Figure 11 The screen plot for factor analysis

6.2.4 Model comparison and selection

Based on the results of the factor analysis, we confirmed that there were two latent factors of police abilities for conducting sobriety checkpoints. Thus, the single Rasch model was excluded and two partial-credit Rasch models (i.e., consecutive approach of Rasch models and multidimensional approach of Rasch models) are then applied to measure police officers' abilities on conducting sobriety checkpoints by using the marginal maximum likelihood estimation method proposed by Bock and Aitkin (1981). We found that the multidimensional approach of Rasch models was apparently superior to the consecutive approach of Rasch models due to its higher reliabilities for both the DIA and DA component latent traits, as shown in Table 20.

Table 20 Test reliabilities for different approaches of Rasch Models

Dimension	Single Rasch model	Consecutive Rasch Model	Multidimensional Rasch Model
DIA	NA	0.934	0.948
DA	NA	0.871	0.887
Whole scale	0.941	NA	NA

Note: Though the single Rasch model violates the assumption of unidimensionality, we still reserve its results in Table 20 for comparison purposes.

As to the fitness of estimated models, the statistics for the deviance index (G^2), Akaike's Information Criterion (AIC), and correlation coefficient (γ) between DIA and DA for these three approaches to Rasch modeling are provided in Table 21. The likelihood ratio statistics indicated the multidimensional approach Rasch model was significantly better than both single Rasch model ($\chi^2 = 714$, *df* = 2) and consecutive approach Rasch model ($\chi^2 = 136$, *df* =1) at $\alpha = 0.01$. Furthermore, the multidimensional approach had the lowest value of AIC among the three models, which indicated the multidimensional approach fitted the data much better than the other two Rasch models. Finally, the highly correlation ($\gamma = 0.595$) between DIA and DA was found in the consecutive Rasch model, which suggests that two component latent traits would be bias estimated when applying this approach to measure police officers' abilities on conducting sobriety checkpoints.

In sum, the multidimensional Rasch model allows to separate the ability of conducting sobriety checkpoints into two component latent traits of DIA and DA, which is superior to the unidimensionality assumption of single Rasch model. Furthermore, the multidimensional Rasch model possesses the advantages of better reliability, allowance of item correlation across different latent traits, and better model fit compared to consecutive model. Thus the multidimensional Rasch model was finally chosen as the best model to measure police officers' perceived abilities on conducting sobriety checkpoints in this study.

Table 21 Comparing model fit of three analyses of the self-determination data

Approach	No. of parameters*	G^2	AIC	r^{**}
Single Rasch	73	21548	21694	
Consecutive Rasch	74	20960	21108	0.595
Multidimensional Rasch	75	20834	20984	0.722

* In the unidimensional approach, 73 parameters would be estimated (the mean and one variance estimate plus 17 item parameters and 54 parameters for estimated steps (18 items × 3 steps)). The mean of item difficulty parameters has been made zero, so that a total of 17 parameters is required to describe the difficulties of the 18 items. In addition, the model exhibits 4 threshold parameters for each item; instead, the number of free threshold parameters for each item is one less than threshold parameters due to the sum of threshold parameters is anchored at zero. For consecutive approach, the number of variance estimates is two, so that there are 74 parameters in total. For multidimensional approach, an extra covariance estimate is needed in addition to those parameters of consecutive approach, which results in 75 parameters in total.

** The correlation coefficient between DIA and DA.

6.3 Measuring Results for Police's Perceived Ability to Conduct DWI Checkpoints

Based on the results of factor analysis, we confirmed that there were two latent factors in officers' ability to conduct sobriety checkpoints. Thus, a partial-credit Rasch model was applied to measure police officers' abilities to conduct sobriety checkpoints by using the marginal maximum likelihood estimation method proposed by Bock and Aitkin (1981). To process the collected data, the Acer ConQuest was used in this study.

6.3.1 Model fit estimation and differences in item functioning (DIF)

According to the estimation results of the multidimensional approach, the statistics of infit mean square (MNSQ) for all individual items fell within the expected range of 1 ± 0.2 except for Item 7. Thus, Item 7 was removed from further analyses.

Furthermore, because gender has long been recognized as the most important factor for developing an unbiased scale (David, et al., 2005, Mackintosh, et al., 2006), DIF analyses were applied to examine whether any difference in item difficulty exists between male and female police officers. Further investigation indicated that only Item 17 was found to have 0.558 logit of item difficulty difference between female and male police officers, which is higher than the criterion of 0.5 logit for removing DIF items from the scale. The differences between male and female police officers for all other items are less than 0.5 logit, which implies the effects of DIF for the other items are not substantively important and may be retained.

6.3.2 Estimate of person and item reliability

After removing two items due to model fitness and DIF, a shortened 16-item TPSCEAS was then used for a final multidimensional approach with item reliability of 0.998. The person reliabilities for DA and DIA are 0.89 and 0.94, respectively, and their correlation is 0.720. After removing Items 7 and 17, the average person reliabilities increased from 0.908 to 0.915. This evidence confirmed that the reliabilities of latent traits were not harmed by item elimination. Moreover, correlation between DA and DIA latent traits was marginally smaller than that for the original scale (from 0.722 to 0.720). These evidences confirmed that the reliabilities of latent traits and the correlation between DA and DIA were not harmed by item elimination.

6.4 Findings for Measuring Police's Perceived Ability to Conduct DWI Checkpoints

Details of the model estimation results are shown in Table 22. The second column depicts the average person ability of all participant police officers for DA and DIA; the third column presents the percentage of police officers with sufficient ability to complete each item/task. The item parameters (δ_i's) for each task are displayed in Column 4. The outfit and infit statistics for the mean square (MNSQ) and standardized Z are listed in column 5－8, respectively.

6.4.1 Findings from the estimated item parameters

The items for each component latent trait are arranged from top to bottom according to their item difficulties from low to high. Thus, for the latent trait of DA, the most difficult item is Item 2, followed by Item 3, while Items 4 and 5 are the two easiest. As to the latent trait of DIA, Item 16 is the most difficult, while Items 8 and 9 are the two easiest. As indicated in Table 22, the weighted (infit) and unweighted (outfit) MNSQ and Z statistics for all items are within the acceptable range, which indicates the shortened 16-item TPEAQ is consistent with the assumptions of the Rasch model in terms of both items and persons.

Table 22 Estimates of item measures and fit statistics for each component latent trait

Latent trait/ Item	Average ability of θ *	Percentage of persons with sufficient ability	Item difficulty δ_i	Outfit		Intfit	
				MNSQ	Z	MNSQ	Z
DA	1.525	**82.17****					
04 (Detecting - Weaving)		88.45	-0.253	0.89	-1.8	0.89	-1.8
05 (Detecting - Straddling)		87.65	-0.219	0.94	-0.9	0.98	-0.3
01 (Detecting - Accelerating or Decelerating)		81.87	0.006	1.10	1.5	1.08	1.3
06 (Detecting - Drifting)		79.48	0.015	1.05	0.9	1.06	1.0
03 (Detecting - Swerving)		78.69	0.160	0.98	-0.4	0.93	-1.1
02 (Detecting - Striking an Object)		76.89	0.292	1.02	0.4	1.02	0.3
DIA	-0.0184	**52.46** (44.88 for IA, 60.03 for DTA, respectively) *****					
08 (detaining - Striking an Object)		66.33	-0.750	0.88	-1.9	0.89	-1.8
09 (detaining - Swerving)		64.14	-0.620	1.03	0.5	1.01	0.2
14 (Intercepting - Striking an Object)		58.96	-0.471	1.05	0.9	1.05	0.8
15 (Intercepting - Swerving)		57.67	-0.429	0.89	-1.8	0.89	-1.8
11 (detaining - Straddling)		57.17	-0.421	0.94	-1.0	0.94	-0.9
12 (detaining - Drifting)		56.57	-0.344	1.11	1.7	1.12	1.9
10 (detaining - Weaving)		55.98	-0.310	0.90	-1.7	0.93	-1.1
13 (Intercepting - Accelerating or Decelerating)		52.99	-0.177	1.11	1.7	1.11	1.7
18 (Intercepting - Drifting)		50.60	-0.119	1.06	0.9	1.07	1.1
16 (Intercepting - Weaving)		4.18	3.642	1.12	1.9	1.11	1.7

* This statistic is the average enforcement ability of all participant police for latent traits.

** The average percentage across items in the same trait.

*** The average percentage across items for IA and DTA.

According to the definition of item difficulty, the lower the item difficulty is, the more easily the task will be accomplished. Thus, among the items for the DA latent trait, *weaving* (Item 4 with -0.253 logit) and *straddling the center of lane marker* (Item 5 with -0.219 logit) were easier to detect than the other indicators of drunk driving (see Table 22). It may be the case that these two driving behavior patterns last longer than the others, so they are more easily noted. However, the cues of *nearly striking an object or vehicle* (Item 2 with 0.292 logit) and *swerving* (i.e., making an abrupt turn away from a generally straight course, Item 3 with 0.160 logit) often appear transiently; thus, they are less likely to be observed by police officers. Hence, police officers must pay more attention and concentrate on detecting DWI vehicles characterized by *swerving* and *nearly striking an object or vehicle*.

As demonstrated in Table 23, DIA includes two categories of ability to accomplish the mission of sobriety checkpoint. They are "detaining ability (DTA)" and "intercepting ability (IA)." The estimated results summarized in Table 23 further indicated that intercepting an escaping vehicle was consistently more difficult than detaining a vehicle with the same drunk-driving pattern. For DTA in the latent trait of DIA, *weaving* (Item 10 with -0.310 logit) was the most difficult pattern to detain among the five drunk-driving patterns, followed by *drifting* (Item 12 with -0.344 logit) and *straddling center of lane markers* (Item 11 with -0.421 logit), while *almost striking an object or vehicle* (Item 8 with -0.750 logit) and *swerving* (Item 9 with -0.620 logit) were the two easiest drunk-driving patterns to detain.

For IA in the latent trait of DIA, *weaving* (Item 16 with 3.642 logit) was also the most difficult escaping drunk-driving pattern to be intercepted, followed by *drifting* (Item 18 with -0.119 logit) and *rapidly accelerating or decelerating* (Item 13 with -0.177 logit). *Nearly striking an object or vehicle* (Item 14 with -0.471 logit) and *swerving* (Item 15 with -0.429 logit) were the two easiest escaping drunk-driving patterns to be intercepted.

The lateral movements of a weaving pattern are fairly regular, as one steering correction is closely followed by another. Drivers who are weaving frequently cut off other drivers in traffic. If a motorist is weaving in traffic, there is a 60% chance of drunk driving (Harris et al., 1980). Detaining and intercepting a weaving vehicle are dangerous when conducting checkpoints. According to the results of Rasch analysis, weaving was the most difficult drunk-driving patterns to detain or intercept. This finding is consistent with the argument of Harris et al. (1980) and Sarkar et al. (2000) that *weaving* is the most aggressive driving pattern.

A drunk driver with a drifting driving pattern might correct his/her course continually or fail to correct it in time to avoid a collision (Harris et al., 1980). According to the study results, the difficulty of detecting a drifting driving pattern was moderate. However, because a drifting car might move across lanes and even across the center line, it may be difficult to intercept safely. Detaining and intercepting a drifting vehicle were relatively difficult as indicated by the results of Rasch analysis (as shown in Table 23). This driving pattern threatens police officers' safety when conducting checkpoints and can be regarded as the second most aggressive driving behavior in this study.

Table 23 The item difficulties for DA and DIA latent traits **(Unit: logit)**

Pattern of drunk-driving behavior	DA	DIA	
	To detect	To detain (DTA)	To intercept (IA)
Rapidly accelerating or decelerating	0.006	--	- 0.177
Almost striking an object or vehicle	0.292	- 0.750	- 0.471
Swerving	0.160	- 0.620	- 0.429
Weaving	- 0.253	- 0.310	3.642
Straddling center of lane markers	- 0.219	- 0.421	--
Drifting	0.015	- 0.344	- 0.119

The pattern of *straddling center of lane markers* lasts longer; thus, it is easy to detect. However, this type of DWI driver may drive toward the checkpoint station and strike the safety equipment or drive into oncoming traffic, resulting in a severe traffic accident. According to the study results, detaining a drunk driver *straddling the center of lane markers* was a moderately difficult task when conducting checkpoints. As for intercepting a driver who was *rapidly accelerating or decelerating*, it was a task of moderate difficulty due to its threat to police officers' safety.

Swerving is a transient pattern, as it usually occurs with an abrupt turn to correct course or return the vehicle to the traffic lane. Typically, swerving seems not to be a severe impetuous maneuver, so the driver could be easily detained at DWI checkpoints and might tend to acquiesce when the police chase him/her. This kind of driving behavior is less dangerous for intercepting. Similar to a *swerving* driving pattern, the *almost striking an object or vehicle* driving pattern is also transient and can also be detained and intercepted easily. Therefore, drunk driving with *swerving* or *almost striking an object or vehicle* can be classified into a less dangerous driving behavior when conducting checkpoints.

6.4.2 Findings from the estimated person parameters

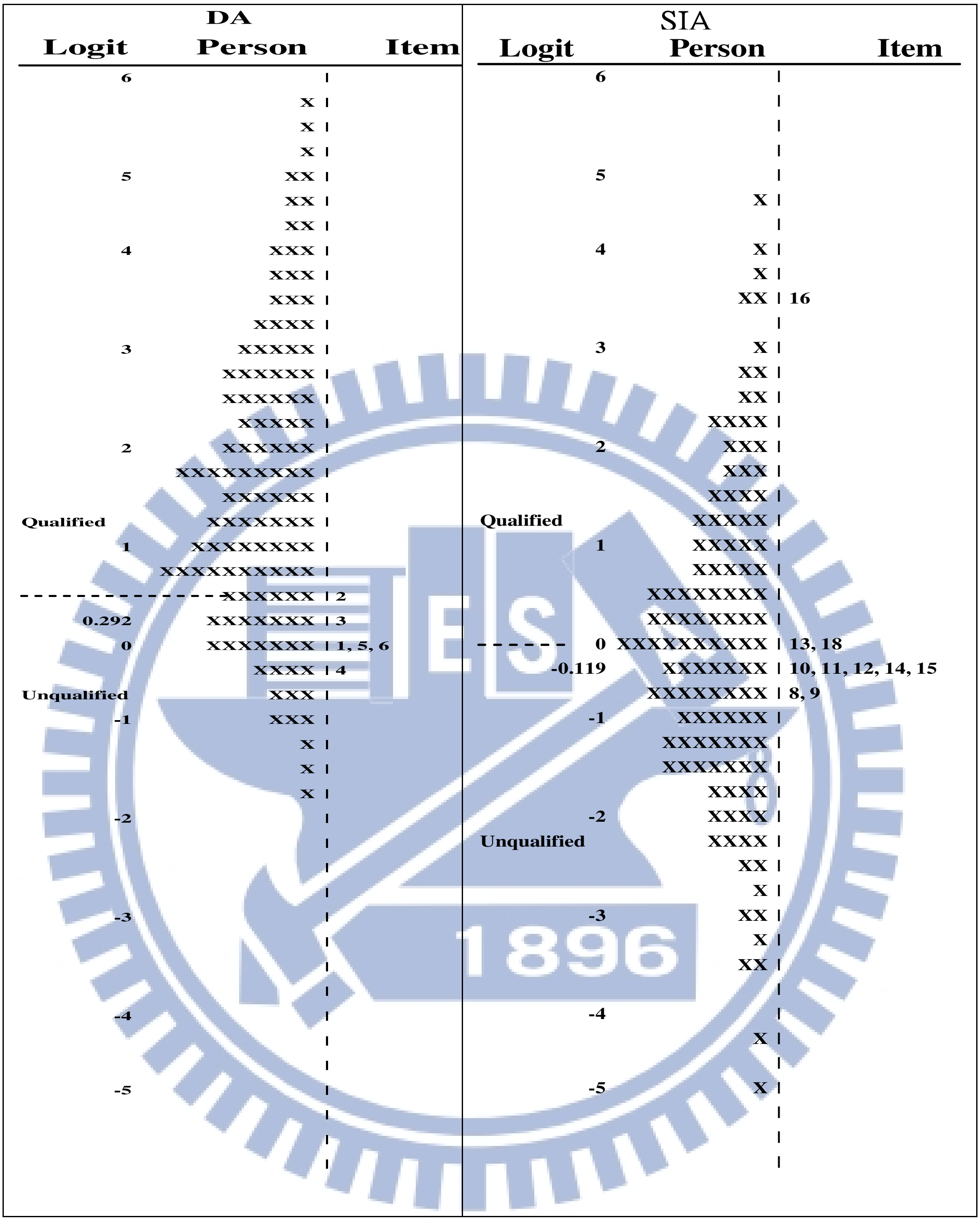
Rasch analysis converts the original ordinal raw scores into the measurements on an interval scale and provides the opportunity to compare officers' abilities on conducting checkpoints with item difficulties on a consistently meaningful basis. The mean value of all item difficulties for each component latent trait is anchored at 0 logit; thus, the positive mean value (1.525 logit) of DA for all participant officers indicates that they were confident of detecting DWI vehicles when conducting sobriety checkpoints (see Table 22). On the contrary, the negative mean value (-0.084 logit) of DIA implies that traffic police officers did not have confidence in their abilities to detain and intercept DWI vehicles. This result also indicates that detaining and intercepting drunk drivers are more difficult than detecting drunk drivers.

Figure 12 further plots the distributions of item difficulties and person abilities on a map for both the DA and DIA component latent traits. It provides a visual representation of the relative positions between persons' abilities and items' difficulties. The vertical dashed line represents a scale with the logit unit, and the numbers on the right side of the logit scale are the corresponding items arranged according to their item difficulties. Similarly, the distributions of persons' abilities are displayed on the left side of the logit scale according to their abilities. A higher position on the list represents greater DA/DIA ability.

When a police officer is located on the same level as a certain item/task, he/she has a probability of 50% of accomplishing the task well; when a police officer lies higher than a certain item/task, he/she has a probability of greater than 50% to handle the task well. Therefore, from the item-person maps for both the DA and DIA latent traits in Figure 12, we can calculate the percentage of participant police officers with enough ability to complete each item/task, as depicted in the third column of Table 22. On average, 82.17% of the participants were capable of performing the detecting tasks; however, only 52.46% of the participants could perform the tasks of detaining and intercepting DWI vehicles well

Figure 12 Item-person maps for police officers to conduct sobriety checkpoints

A more in-depth investigation on the item-person maps finds that all items' difficulties were relatively concentrated as compared with their corresponding distributions of person abilities for both DA and DIA latent traits, except for the outlier of Item 16. This finding seems to indicate that all of the tasks required to detect DWI vehicles have a similar level of difficulty, which constituted an ability threshold for detecting whether a police officer is qualified to detect DWI vehicles. Accordingly, the threshold of the required DA latent trait was assumed to have the highest value for item difficulty among all the DA items, which was 0.292 logit for detecting DWI vehicles *nearly striking an object or vehicle* (Item 2). Among the 502 participating police officers, there were 386 (76.89%) passed the required DA threshold (i.e., those who can perform all of the tasks necessary to detect DWI vehicles). The other 116 participants were classified as officers who are unqualified to detect DWI vehicles (i.e., those who need more education and training if they are assigned to conduct sobriety checkpoints).



Note: (1) Each 'X' represents 4.0 cases: (2) Participants above the horizontal dash-line are classified as the police officers with a qualified ability.

Figure 12 Item-person map for DWI checkpoints

Because intercepting a weaving and escaping vehicle was extremely difficult (3.642 logit) and only 4.18% of all participant police officers had sufficient ability to accomplish it well, *intercepting a weaving escaping vehicle safely* (Item 16) may be considered a specialty task. Thus, the second-highest item difficulty (-0.119 logit) for DIA was suggested as the minimum DIA required for conducting the mission of detaining DWI vehicles and intercepting escaping

DWI vehicles. Among the 502 participating police officers, 254 (50.6%) were qualified for detaining DWI vehicles and intercepting escaping DWI vehicles, and the other 248 participants were classified as unqualified, requiring further education and training before participating in such a dangerous task.

6.5 Discussion

Police officers' ability to conduct sobriety checkpoints was measured according to their ability to accomplish specific tasks within checkpoints. After a factor analysis, the officers' ability to conduct sobriety checkpoints was found to be comprised of two component latent traits, DA and DIA. Two of the original 18 items were removed due to different item functioning and model fit issues without meaningfully decreasing the correlation between DA and DIA. Applying the multidimensional Rasch model approach to examine the issues of interest in this study is justified. The evidence of less error and higher reliability confirm that the multidimensional approach provides a useful tool for this study.

Based on the estimated results shown in the third column of Table 22, we find that the average percentage of officers with sufficient IA was the lowest (44.88%), followed by DTA (60.03%) and DA (82.17%). The task of intercepting DWI vehicles is the most difficult, while the simplest is that of detecting DWI vehicles. Figure 13 further displays the scatter plots of both the DA and DIA measurements for all participant police officers and divides them into four groups according to whether they pass the required ability thresholds of DA and DIA. It is apparent that a positive correlation exists between DA and DIA. According to the study results, approximately three-fourths of participant police officers were confident in their abilities to detect DWI vehicles, while only half felt they have the ability to detain and intercept escaping DWI vehicles.

Accurate identification of DWI vehicles will help police officers to take the necessary actions to quickly detain and intercept the DWI vehicles. In this study, DIA was found to be highly correlated with DA. As indicated in Figure 13, the police officers qualified in DIA were also nearly qualified in DA, which implies that DIA would be the critical factor to determine whether a police officer is well-suited to conduct sobriety checkpoints. Thus, only the 49.4% (N = 248) of participant police officers, who had sufficient DA (person ability larger than 0.292 logit) and DIA (person ability larger than -0.119 logit), should be considered to conduct sobriety checkpoints. The 22.1% (N = 111) who failed to pass the minimum required DA and DIA should be compelled to accept specific training before they are permitted to conduct sobriety checkpoints. The 28.5% (N = 143) of participant police officers, who passed the required DA/or DIA but failed to pass the required DIA/or DA, should be required to take further training to enhance their DIA/or DA.

Table 24 The estimated results of regression models for DA and DIA.

Model/Latent trait	DA		DIA	
Variable	coefficient	t-value	coefficient	t-value
Constant	2.275	8.43*	-0.212	-0.68
Gender (male=1, female=0)	-0.346	-1.30	0.306	1.29
Rank (captain=1, others=0)	0.703	2.60*	0.336	1.07
Aged 36-45	0.010	0.07	-0.081	-0.50
Aged 46-55	-1.957	-12.07*	-1.921	-10.24*
Number of observations	502		502	
R^2	0.384		0.336	
Adjusted R^2	0.379		0.320	

*significant at α = 0.05

The interval scale measurements of the two latent traits obtained from Rasch analysis provide a convenient opportunity to explore whether police officers with different demographic characteristics have different abilities to conduct sobriety checkpoints. Before conducting further statistical analyses, the associations among gender, age, and rank of police officers were tested and no significant correlation among them was found. Furthermore, the residuals of regression approximately follow the normal distribution by visual inspection and no significant deviation from the assumption of homogeneity was found. Thus, two multiple-regression models were applied to investigate the effect of gender, rank, and age of police officers on DA and DIA respectively. The study results shown in Table 24 indicated that there was no significant difference of DA and DIA between the two genders. Branch captains had significantly higher DA than their colleagues, but no significant difference in DIA was found between these two ranks. Officers aged 46-55 had significantly lower DA and DIA than those aged under 46, but no significant difference between officers aged 36-45 and those under 36 was found for either DA or DIA.

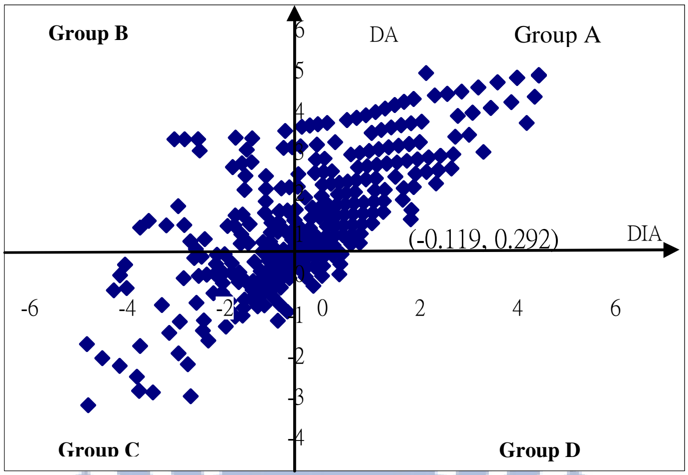


Figure 13 Scatter plots of participant officers' DA and DIA

CHAPTER 7

CONCLUSION

This dissertation used the multidimensional Rasch model approach to assess police officers' perceived enforcement ability on conducting sobriety checkpoints, and unidimensional Rasch approach was applied to measure the abilities on DWI patrols and red light running enforcement. This special technique can transfer ordinal responses onto an interval scale to provide a comparative basis for further interpretations and discussions. Further, this analysis not only estimates the perceived ability of each individual respondent but also provides the difficulty level of each task with regard to conducting traffic law enforcement with a consistent scale, which enables us to explore some valuable information behind the measurement. Moreover, not only unidimensional approach, which was used when scale presented unidimensionality, but the multidimensional approach of Rasch models, which takes the correlations between component latent traits into account in order to increase measurement precision, was also applied to measure latent component ability constructs of the respondents. Therefore, in this study, the Rasch model was used to validate the designed items of questionnaire and measure the enforcement ability of police officers. However, given the limited relevant literature, it is too premature to conclude that the multidimensional approach is better than the other approaches. Thus, in this study, compared with unidimensional and consecutive Rasch model, the merits of multidimensional approach of Rasch models were further testified.

Rasch analysis provides item parameters to explore the relative difficulties of tasks to be accomplished within the same construct and guide the direction for drawing the strategies to improve police officers' ability to conduct saturation patrols. This study developed two scales to measure police officers' ability to conduct sobriety checkpoints and saturation patrols, and explored the difficulties of tasks required to confront those challenging enforcement missions. The study results derived from 502 police officers' responses really provided the valuable information and guidance to improve the effectiveness of conducting sobriety checkpoints. However, limited by available resource, this dissertation still left much room to be extended in the future. First, this study only included the tasks required for conducting sobriety checkpoints in questionnaire. Some additional items (such as workforce, working hours, weather condition, etc.) are suggested to enhance the discriminating power of the scale and explore the difficulties of conducting sobriety checkpoint under different circumstances. In addition, this study concentrated its effort on developing well-validated questionnaires and applying appropriate models to measure police officers' ability on the two traffic enforcements, and only few characteristics of participant police officers were collected. Thus, it limited the opportunity to apply the study findings to assist enforcement authorities to design suitable program or policy to enhance police officers' enforcement ability. There is a need for future research to investigate more respondent's characteristics with an enriched questionnaire.

As red light running enforcement was concerned, this study applied the Rasch model to develop an Enforcement Ability Questionnaire (TPEAQ), and then used it to assess the perceived enforcement ability of red light running. The results offer helpful references for further investigations of work ability for different tasks in traffic law enforcement, and guide a precise direction for future trainings of police enforcement skill and knowledge. The average value of the enforcement ability of all the traffic police was 0.14 logit, commenting that there were greater than half (56.25%) of the major tasks of executing red light running enforcement would be perceived difficulty for the traffic polices. Police considered Items 9, 19 and 14 as the most difficult tasks. Hence, in order to increase its performance of red light running enforcement, we have to focus on safety driving discipline to enhance the abilities of chasing escaped vehicles, and strengthen physical loading. Moreover, to increase the ability to accommodate extreme weathers is also the prior objection in police training projects.

Furthermore, five main results were obtained. First, chasing and detaining escaped vehicle was the most difficult mission to be conducted. Second, to intercept escaped violator in extreme cold weather may be the most dangerous mission. Third, strengthening the physical loading was an imperative issue to enhance enforcement ability. Forth, the prior abilities needed to enhance for females are mental and psychosocial demands. As for males police, the physical demands is the priority. Finally, in order to enhance the traffic police enforcement ability of red light running, the future training for traffic police should focus on safety driving discipline, strengthen physical loading and ability to accommodate extreme weathers.

In fact, the duty of a traffic police is multi-tasks. He/She has to treat any kind of violations, not only red light running, but also drunk driving, speeding, driving against traffic, etc. Besides, it can be that a policeman with high ability on red light running enforcement has less ability on speeding and/or drunk driving enforcement, etc. Therefore, a further research that integrated in larger context in which the police would have abilities to carry out any required enforcement is truly needed.

According to the study results for DWI patrols, the duration of cue appearance seems to be the determinant for the difficulties of items within detecting abilities. That is, the shorter the cue duration, the more difficult the DetcA item will be. Thus, the DWI patterns of almost striking an object or vehicle and swerving, which often appear transiently, should be targeted as the pressing topics for training and education programs. As for the difficulties of detaining ability items, the difficulties of DetaA items were dominantly determined by the threat brought by DWI motorists to the safety of both police officers and the other road users. Therefore, DWIs that weave was the most aggressive driving pattern, which was extremely difficult to detain and needed the specialty of some police officers with excellent ability to do it. On the contrary, “almost striking an object or vehicle” was the easiest pattern to detain, for it is not an impetuous or reckless behavior.

Next, the study results found that traffic police in Taiwan were able to perform well in detecting DWI vehicles, but they were weak in detaining DWI vehicles. This result implied that the mental abilities such as vision, attention and concentration for police might be superior to their physical and psychological abilities. According to the study results, even though only 21.74% of traffic officers possessed insufficient DeteA and DetaA to conduct saturation patrols in Taiwan, police officers’ abilities to detain some aggressive DWI driving patterns such as weaving, drifting, speeding are deficient. This finding implied that the effectiveness of this traffic law enforcement could be significantly improved by administering education and training programs for such adverse DWI driving patterns to unqualified officers. In addition, the difficulties of detaining tasks are mainly determined by the safety concern both for police officers and the other drivers. When detaining aggressive driving patterns like weaving, drifting or DWI speeding, the irritated DWI driver may drive more aggressive and result in more severe traffic disaster. That makes police officers have scruples in detaining the DWI motorist. Thus, these programs should focus on improving the critical weakness in police officers’ ability in detaining vehicles. Moreover, Police officers should be educated and trained not only on how to detain vehicles but also on how to protect themselves and other road users when facing aggressive DWI vehicles.

Additionally, enhancing punishment could impel the effectiveness on deterring DWI vehicles from roads (Tay, 2005). According to our survey, detaining DWI vehicle with weaving, drifting and speeding behavior was extremely difficult. Only a few police officers with excellent abilities had enough confidence to do them well. This evidence showed that lacking the ability to detain DWI vehicles with these behaviors is a severe enforcement problem. Given the danger and difficulty of conducting practical training for detaining DWI motorist, in addition to training and education, raising the fine through legislation to deter aggressive drunk driving could be considered. Further, Young police officers were found to be better suited to conducting DWI patrols in this study. Thus, incentives should be constructed to encourage young officers to devote themselves to traffic enforcement.

Among the police officers qualified for conducting sobriety checkpoints, only 8.5% were aged over 45; however, 60% of those unqualified to conduct sobriety checkpoints were aged over 45. This finding indicated that young police officers were more qualified than older police officers to conduct sobriety checkpoints. Next, branch captains were found to have higher DA than their colleagues. Thus, it is more efficient to assign the branch captains to detecting DWI vehicles when conducting sobriety checkpoints. In addition, for the difficulties of DIA items, intercepting an escaping DWI vehicle was consistently more difficult than detaining it for the same pattern of DWI driving behavior. The difficulty of the DIA items was primarily determined by the threat DWI vehicles posed to the safety of both police officers and other drivers. Weaving, which is the most aggressive DWI driving pattern and is difficult to intercept, requires special abilities on the part of the police officers. On the contrary, nearly striking an object or vehicle is the easiest pattern to detain and intercept, given that it is not an impetuous act or reckless behavior.

The study results found that traffic police in Taiwan were able to perform well in detecting DWI vehicles, but they were weak in detaining DWI vehicles and intercepting escaping DWI vehicles when conducting DWI checkpoints. This result implied that the mental abilities such as vision, attention and concentration for police might be superior to their physical and psychological abilities. Enhancing traffic police's enforcement ability is needed to conduct the sobriety checkpoints more effectively and some strategies and programs are suggested as follows.

(1) Continuing programs to improve police officers' enforcement abilities:

According to the study results, only 49.4% of traffic officers had sufficient DA and DIA to be qualified to conduct sobriety checkpoints in Taiwan. This finding implies that the effectiveness of sobriety checkpoints would not be significantly improved unless continuing education and training programs could be implemented to enhance police officers' DA and DIA. These programs should focus on improving the critical weakness in police officers' ability in detaining and intercepting escaping DWI vehicles. Police officers should be educated and trained not only on how to detain, pursue, and intercept DWI vehicles but also on how to protect themselves and other road users when facing aggressive DWI vehicles (such as weaving, drifting, and rapidly accelerating or decelerating drivers) at checkpoints.

(2) Raising the fine to deter escapism

Enhancing punishment is one of primary impetuses of deterrence in law enforcement (Tay, 2005). According to our survey, weaving was the second most frequent drunk-driving behavior in Taiwan, and intercepting an escaping DWI vehicle with weaving behavior was extremely difficult. Only a few police officers with excellent abilities had enough confidence to do it well. This evidence showed that lacking the ability to intercept DWI vehicles with weaving behavior is a severe enforcement problem. Given the danger and difficulty of conducting practical training for intercepting DWI motorist, raising the fine for fugitive vehicles through legislation to deter escapism could be considered, in addition to training and education, especially for weaving DWI behaviors.

(3) Efficient use of human resources

Young police officers were found to be better suited to conducting sobriety checkpoints in this study. Thus, incentives should be established to encourage young officers to devote themselves to traffic enforcement. Furthermore, branch captains perform better on detecting tasks than other police officers and could be dispatched to a position to take charge of detecting tasks. Finally, unqualified officers should be educated and trained to do the job well and protect themselves if they are allowed to conduct sobriety checkpoints.

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Appendix A: Questionnaire for DWI Patrols

No.: ☐☐☐☐

Dear police,

We are interested in knowing the enforcement ability of police to conduct DWI checkpoints. Your cooperation will help us a great deal. The results of this questionnaire will be anonymous and will not be used for any other purposes. Thanks your cooperation and attention.

PART ONE：PERSONAL INFORMATION

Please fill in your personal information, thank you very much.

1. Gender	☐Male ☐Female
2. Rank	☐Captain (branch captain concluded) ☐police officer
3. Age	☐Under 36 ☐36-45 ☐46-55

PART TWO：THE “CONDUCTING ABILITY” FOR DWI PATROLS

What extent the following 20 ability items you feel to conduct DWI patrols? Please answer the following statements by checking (√) the most appropriate response (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree).		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	Enforcement Ability Item					
01	I can promptly detect vehicles drifting.	☐	☐	☐	☐	☐
02	I can promptly detect vehicles almost striking object or vehicle.	☐	☐	☐	☐	☐
03	I can promptly detect vehicles swerving.	☐	☐	☐	☐	☐
04	I can promptly detect vehicles turning with wide radius.	☐	☐	☐	☐	☐
05	I can promptly detect vehicles straddling center of lane marker	☐	☐	☐	☐	☐
06	I can promptly detect vehicles weaving.	☐	☐	☐	☐	☐
07	I can promptly detect vehicles signaling inconsistent with driving action.	☐	☐	☐	☐	☐
08	I can promptly detect vehicles following too closely.	☐	☐	☐	☐	☐
09	I can promptly detect vehicles with fast speed.	☐	☐	☐	☐	☐
10	I can promptly detect vehicles slow response to traffic signals.	☐	☐	☐	☐	☐
11	I can safely detain a vehicle drifting.	☐	☐	☐	☐	☐
12	I can safely detain a vehicle almost striking object or vehicle.	☐	☐	☐	☐	☐
13	I can safely detain a vehicle swerving.	☐	☐	☐	☐	☐
14	I can safely detain a vehicle turning with wide radius.	☐	☐	☐	☐	☐
15	I can safely detain a vehicle straddling center of lane marker.	☐	☐	☐	☐	☐
16	I can safely detain a vehicle weaving.	☐	☐	☐	☐	☐
17	I can safely detain a vehicle signaling inconsistent with driving action.	☐	☐	☐	☐	☐
18	I can safely detain a vehicle with following too closely.	☐	☐	☐	☐	☐
19	I can safely detain a vehicle with fast speed.	☐	☐	☐	☐	☐
20	I can safely detain a vehicle slow response to traffic signals.	☐	☐	☐	☐	☐

THANKS FOR YOUR COOPERATION AND HAVE A NICE DAY！

Appendix B: Questionnaire for DWI Checkpoints

No.: ☐☐☐☐

Dear police, *We are interested in knowing the enforcement ability of police to conduct DWI checkpoints. Your cooperation will help us a great deal. The results of this questionnaire will be anonymous and will not be used for any other purposes. Thanks your cooperation and attention.*

PART ONE：PERSONAL INFORMATION

Please fill in your personal information, thank you very much.

1. Gender	☐Male ☐Female
2. Rank	☐Captain (branch captain concluded) ☐police officer
3. Age	☐Under 36 ☐36-45 ☐46-55

PART TWO：THE “CONDUCTING ABILITY” FOR DWI CHECKPOINTS

What extent the following 18 ability items you feel to conduct DWI checkpoints? Please answer the following statements by checking (√) the most appropriate response (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree).		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	Enforcement Ability Item					
01	I can promptly detect vehicles accelerating or decelerating rapidly.	□	□	□	□	□
02	I can promptly detect vehicles nearly striking an object or vehicle.	□	□	□	□	□
03	I can promptly detect vehicles swerving.	□	□	□	□	□
04	I can promptly detect vehicles weaving.	□	□	□	□	□
05	I can promptly detect vehicles straddling the center of lane marker.	□	□	□	□	□
06	I can promptly detect vehicles drifting.	□	□	□	□	□
07	I can safely detain an accelerating or decelerating vehicle.	□	□	□	□	□
08	I can safely detain a vehicle almost striking an object or vehicle.	□	□	□	□	□
09	I can safely detain a swerving vehicle.	□	□	□	□	□
10	I can safely detain a weaving vehicle.	□	□	□	□	□
11	I can safely detain a vehicle straddling the center of lane marker.	□	□	□	□	□
12	I can detain safely a rapidly drifting vehicle.	□	□	□	□	□
13	I can successfully drive a patrol car to intercept an escaping vehicle rapidly accelerating or decelerating.	□	□	□	□	□
14	I can successfully drive a patrol car to intercept an escaping vehicle almost striking an object or other vehicle.	□	□	□	□	□
15	I can successfully drive a patrol car to intercept a swerving escaping vehicle.	□	□	□	□	□
16	I can successfully drive a patrol car to intercept a weaving escaping vehicle.	□	□	□	□	□
17	I can successfully drive a patrol car to intercept an escaping vehicle straddling center of lane marker.	□	□	□	□	□
18	I can successfully drive a patrol car to intercept a drifting escaping vehicle.	□	□	□	□	□

THANKS FOR YOUR COOPERATION AND HAVE A NICE DAY！

Appendix C: Questionnaire for Executing Red Light Running Enforcement

No.: □□□□

Dear police, *We are interested in knowing the enforcement ability of police to conduct red light running enforcement. Your cooperation will help us a great deal. The results of this questionnaire will be anonymous and will not be used for any other purposes. Thanks your cooperation and attention.*

PART ONE：PERSONAL INFORMATION

Please fill in your personal information, thank you very much.

1.Location of the base	□North Taiwan □middle of Taiwan □south Taiwan
2. Gender	□Male □Female
3. Rank	□Captain (branch captain concluded) □sergeant □police officer
4. Age	Please fill in your actual age ( )

PART TWO：THE "CONDUCTING ABILITY" FOR RED LIGHT RUNNING ENFORCEMENT

What extent the following 20 ability items you feel to conduct rde light running enforcement? Please answer the following statements by checking (√) the most appropriate response (Strongly Agree, Agree, Somewhat Agree, Neutral, Somewhat Disagree, Disagree, Strongly Disagree). Enforcement Ability Item		Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
Ability of Mental demands								
01	I can find the best position to stand guard red light running vehicles.	☐	☐	☐	☐	☐	☐	☐
02	I can attentively detect red light running vehicles.	☐	☐	☐	☐	☐	☐	☐
03	I can concentrate my attention to detect the escaping intention of red light runner.	☐	☐	☐	☐	☐	☐	☐
04	I can easily record the escaped red light running vehicle's license number.	☐	☐	☐	☐	☐	☐	☐
05	I can successfully detain the escaping red light running vehicle whenever I intend to do.	☐	☐	☐	☐	☐	☐	☐
Ability of psychological demands								
06	I can safely direct the red light running vehicle to stop.	☐	☐	☐	☐	☐	☐	☐
07	I can react rapidly to detain the vehicle.	☐	☐	☐	☐	☐	☐	☐
08	I can get on the patrol rapidly to intercept the escaped vehicle.	☐	☐	☐	☐	☐	☐	☐
09	I can chase escaped red light running vehicle and detain it safely.	☐	☐	☐	☐	☐	☐	☐
10	I have a good emotion management so that seldom be enraged by the red light runner.	☐	☐	☐	☐	☐	☐	☐
11	When traffic violator disagree my disposal at the scene, I can deal with it politely and prevent his further objection.	☐	☐	☐	☐	☐	☐	☐
12	Scarcely did the red light runner argue against my disposal at the scene.	☐	☐	☐	☐	☐	☐	☐
13	Rarely does the red-light runner lodge a complaint after I write him/ her a ticket.	☐	☐	☐	☐	☐	☐	☐
Ability of physical demands								
14	I don't have leg-ache or backache after two hours duty on red light running.	☐	☐	☐	☐	☐	☐	☐
15	I don't have leg-ache or backache after four hours duty on red light running duty.	☐	☐	☐	☐	☐	☐	☐

16	I am not tired after two hours duty on red light running.	☐	☐	☐	☐	☐	☐	☐
Ability in different traffic factor								
17	I can enforce the duty on red light running without other police's help.	☐	☐	☐	☐	☐	☐	☐
18	I can enforce the duty on red light running effectively even in the rainy day.	☐	☐	☐	☐	☐	☐	☐
19	I can enforce the duty on red light running effectively even in the extreme cold weather.	☐	☐	☐	☐	☐	☐	☐
20	I can enforce the duty on red light running effectively even in the traffic peak hour.	☐	☐	☐	☐	☐	☐	☐

THANKS FOR YOUR COOPERATION AND HAVE A NICE DAY！