ABSTRACT

Title of Dissertation: PREVENTING DROWSY DRIVING IN YOUNG ADULTS THROUGH MESSAGING STRATEGIES THAT INFLUENCE PERCEPTIONS OF CONTROL AND RISK

Clark Johnson Lee, Doctor of Philosophy, 2024

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Drowsy driving is a serious health and safety problem in the United States: thousands of car crashes on U.S. roadways each year are attributed to this risky driving behavior. Although young drivers under the age of 26 years are especially at risk for being involved in drowsy driving car crashes, few anti-drowsy driving interventions targeting such drivers have been developed. Furthermore, most existing educational materials and interventions against drowsy driving have focused primarily on providing factual information about the dangers of drowsy driving and countermeasures against these dangers rather than on influencing beliefs and motivations underlying drowsy driving behavior, which may explain their apparent ineffectiveness at preventing drowsy driving behavior and resultant car crashes.

Recent research indicates that messages targeting perceptions of control may be effective intervention strategies against drowsy driving behavior for young adult drivers by influencing

their drowsy driving-related perceptions of risk, intentions, and willingness. This dissertation continues this line of research by pursuing two lines of inquiry.

In Study #1, the efficacy of anti-drowsy driving messaging strategies designed to influence perceptions of control and risk related to drowsy driving behavior in reducing drowsy driving intentions, willingness, and behavior in a sample of young adult U.S. drivers between 18 and 25 years of age was evaluated through a randomized controlled trial. Study #1 sought to test the following hypotheses:

> *Hypothesis 1:* Participants exposed to interventional messaging strategies primarily aimed at lowering perceptions of control *or* heightening perceptions of risk related to drowsy driving report significantly less perceived control, greater perceived risk, less intentions, less willingness, and less behavior related to drowsy driving at 30-day post-intervention follow-up compared to participants exposed to messaging strategies providing only factual information about the dangers of drowsy driving; and
>
> *Hypothesis 2:* Participants exposed to interventional messaging strategies aimed at *both* lowering perceptions of control *and* heightening perceptions of risk related to drowsy driving report significantly less perceived control, greater perceived risk, less intentions, less willingness, and less behavior related to drowsy driving at 30-day post-intervention follow-up compared to participants exposed to messaging strategies providing only factual information about the dangers of drowsy driving, messaging strategies primarily aimed at lowering perceptions of control related to drowsy driving, *or* messaging strategies primarily aimed at heightening perceptions of risk related to drowsy driving.

In Study #2, the relationships between perceived behavioral control, risk perception, intentions, willingness, and drowsy driving behavior in a sample of young adult U.S. drivers between 18 and 25 years of age were examined. Study #2 sought to test the following hypotheses:

> *Hypothesis 3:* The impact of interventional messaging strategies targeting drowsy driving perception of control on drowsy driving intentions, willingness, and behavior is mediated by drowsy driving risk perception such that messages lowering drowsy driving perceptions of control also heighten drowsy driving risk perception, which in turn decreases drowsy driving intentions, willingness, and behavior;
>
> *Hypothesis 4:* Interventional messaging strategies targeting drowsy driving-related perceptions of control or risk have a greater impact on drowsy driving willingness than on drowsy driving intentions; and
>
> *Hypothesis 5:* Drowsy driving willingness is a stronger predictor of drowsy driving behavior than is drowsy driving intentions.

Study #1 provided supporting evidence of short-term cognitive effects but not short-term behavioral effects after exposure to messaging interventions designed to influence perceptions of control and risk related to drowsy driving behavior. Perceptions of risk were especially influenced by the messaging strategies examined, including those that provided only factual, knowledge-based information about drowsy driving. Study #2 provided supporting evidence that perceived behavioral control influenced drowsy driving intentions and drowsy driving willingness indirectly through perceptions of risk. Furthermore, willingness to drive drowsy was a stronger predictor of actual drowsy driving behavior than intentions to drive drowsy. The

findings from these two studies should inform future research aimed at developing more effective messaging strategies against drowsy driving behavior in young adults.

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PREVENTING DROWSY DRIVING IN YOUNG ADULTS THROUGH MESSAGING STRATEGIES THAT INFLUENCE PERCEPTIONS OF CONTROL AND RISK

by

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Dedication

To

My wife MEREDITH,

My sons LIAM JOHNSON and LOUIS OLIVER,

and

THE TAXPAYERS OF THE STATE OF MARYLAND,

without whom (and for very different reasons) this work would not have been possible.

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Chapter 1: Introduction

1.1 Problem Statement: Improving Drowsy Driving Prevention and Education Efforts

Drowsy driving is a significant cause of car crashes on public roadways in the United States. The AAA Foundation for Traffic Safety has estimated that drowsy drivers are involved in an average of 328,000 police-reported automobile crashes each year in the U.S., including 109,000 crashes resulting in injuries and 6,400 fatal crashes (Tefft, 2014). Researchers studying driver performance and behavior in the moments leading up to a car crash have found that 22 percent of all crashes and 16 percent of near-crashes could be attributed to drowsy driving (Dingus et al., 2006). In various survey studies of U.S. drivers from the last three decades, about half of the drivers reported driving while drowsy and about a third reported falling asleep behind the wheel at least once in their lifetime (McCartt et al., 1996; National Sleep Foundation, 2005a; Tefft, 2010a). More recently, Higgins et al. (2017) cite estimates from a variety of studies indicating that as much as 4% of the driving population report falling asleep at the wheel within the past month. The U.S. Government has taken notice of these findings and has made the reduction of drowsy driving crashes on U.S. roadways one of its *Healthy People 2020* objectives (U.S. Department of Health and Human Services [HHS], 2010) and has engaged with stakeholders to develop a multi-disciplinary approach to addressing drowsy driving on U.S. roadways (Higgins et al., 2017; National Highway Traffic Safety Administration [NHTSA], 2017).

Young drivers under the age of 26 years are particularly at-risk for becoming involved in drowsy driving crashes (AAA Foundation for Traffic Safety, 2011, 2012; Lindsay et al., 1999; Pack et al., 1995; Taylor & Bramoweth, 2010) and self-reported drowsy driving experiences (AAA Foundation for Traffic Safety, 2011, 2012; Hershner & Chervin, 2014; Lindsay et al.,

1999; McCartt et al., 1996; Taylor & Bramoweth, 2010; Taylor et al., 2008; Watling et al., 2014; Wheaton et al., 2013; Wheaton et al., 2014). These high prevalence rates have been observed despite the efforts of governments and other organizations in developing educational materials and other interventions aimed at preventing drowsy driving crashes (American Academy of Sleep Medicine, 2012, 2015; De Dobbeleer et al., 2009a; Driver Reviver, 2008; Lee et al., 2016; National Healthy Sleep Awareness Project, 2014, October 21; National Sleep Foundation, 2013), suggesting that existing drowsy driving interventions have been ineffective in influencing drowsy driving behavior among young drivers.

Traffic safety experts have long advocated for drowsy driving interventions grounded in behavioral change theories (Commonwealth of Massachusetts, 2009; Foss, 2007; National Center on Sleep Disorders Research [NCSDR], 2011; National Center on Sleep Disorders Research/National Highway Traffic Safety Administration [NCSDR/NHTSA] Expert Panel on Driver Fatigue and Sleepiness, 1998; National Sleep Foundation, 2007b; Thiffault, 2011a). Such theories have been used to design successful interventions against other risky driving behaviors (Elliott & Armitage, 2009; Stead et al., 2005; Steinmetz et al., 2016). However, most existing messages and interventions against drowsy driving have focused primarily on providing factual information about the dangers of drowsy driving and countermeasures against these dangers rather than on influencing the cognitive and motivational factors underlying drowsy driving behavior (Lee et al., 2016). This shortcoming in existing drowsy driving messaging and interventions may explain their apparent ineffectiveness at preventing drowsy driving behavior and resultant car crashes. Thus, there is a critical need for research to develop and evaluate the efficacy and effectiveness of drowsy driving messaging strategies and interventions grounded in behavioral change theories.

1.2 Research Questions and Hypotheses

The primary aim of this dissertation was to evaluate the efficacy of anti-drowsy driving messaging strategies designed to influence perceptions of control and risk related to drowsy driving behavior in reducing drowsy driving intentions, willingness, and behavior in a sample of young adult U.S. drivers between 18 and 25 years of age. Specifically, the following hypotheses were investigated through a randomized controlled trial (Study #1):

> *Hypothesis 1:* Participants exposed to interventional messaging strategies primarily aimed at lowering perceptions of control *or* heightening perceptions of risk related to drowsy driving report significantly less perceived control, greater perceived risk, less intentions, less willingness, and less behavior related to drowsy driving at 30-day post-intervention follow-up compared to participants exposed to messaging strategies providing only factual information about the dangers of drowsy driving;
>
> *Hypothesis 2:* Participants exposed to interventional messaging strategies aimed at *both* lowering perceptions of control *and* heightening perceptions of risk related to drowsy driving report significantly less perceived control, greater perceived risk, less intentions, less willingness, and less behavior related to drowsy driving at 30-day post-intervention follow-up compared to participants exposed to messaging strategies providing only factual information about the dangers of drowsy driving, messaging strategies primarily aimed at lowering perceptions of control related to drowsy driving, *or* messaging strategies primarily aimed at heightening perceptions of risk related to drowsy driving;

As a secondary aim, this dissertation examined the relationships between perceived behavioral control, risk perception, intentions, willingness, and drowsy driving behavior in a sample of young adult U.S. drivers between 18 and 25 years of age (Study #2). Specifically, the following hypotheses were investigated using data collected in the aforementioned randomized controlled trial:

> *Hypothesis 3:* The impact of interventional messaging strategies targeting drowsy driving perception of control on drowsy driving intentions, willingness, and behavior is mediated by drowsy driving risk perception such that messages lowering drowsy driving perceptions of control also heighten drowsy driving risk perception, which in turn decreases drowsy driving intentions, willingness, and behavior;
>
> *Hypothesis 4:* Interventional messaging strategies targeting drowsy driving-related perceptions of control or risk have a greater impact on drowsy driving willingness than on drowsy driving intentions; and
>
> *Hypothesis 5:* Drowsy driving willingness is a stronger predictor of drowsy driving behavior than is drowsy driving intentions.

1.3 Justification for the Current Studies

This dissertation builds on previous work by Lee and Beck at the University of Maryland Department of Behavioral and Community Health investigating the utility of the Theory of Planned Behavior (TPB) and the Prototype Willingness Model (PWM) in influencing drowsy driving behavior and its cognitive antecedents (Beck et al., 2018; Lee, 2014; Lee & Beck, 2019; Lee et al., 2016). This work suggests that the TPB and PWM are compelling theoretical frameworks for designing more effective anti-drowsy driving messages and interventions for

young adult drivers. To date, there has been scant effort to develop anti-drowsy driving messages or interventions that are grounded in behavioral change theories such as the TPB and PWM. Consequently, by developing and evaluating the efficacy of anti-drowsy driving messaging strategies grounded in the TPB and PWM that are targeted at young adult drivers, this dissertation offers a novel approach to developing new messaging strategies and interventions to prevent drowsy driving incidents.

The findings from this dissertation represent a crucial step towards developing more effective messaging strategies against drowsy driving for young adult U.S. drivers that are grounded in behavioral change theories, which eventually could be used in interventions to prevent drowsy driving behavior and resultant car crashes in this population. This study also represents the next steps in an ongoing process for developing more effective interventions against drowsy driving for young drivers, thereby contributing significantly to addressing a major public health and safety problem that the U.S. Government has committed to combating as part of its *Healthy People 2020* agenda (HHS, 2010).

1.4 Public Health Significance

Each year, hundreds of thousands of car crashes in the United States are attributed to drowsy driving. Although young drivers under the age of 26 years are especially at risk for being involved in drowsy driving car crashes, this group of drivers largely perceive drowsy driving to be less dangerous than other risky driving behaviors. To date, few messaging strategies or interventions targeting young drivers have been developed that are designed to address their beliefs and motivations concerning drowsy driving. This dissertation aims to address this issue by evaluating the impact of messaging strategies designed to influence perceptions of control and risk related to drowsy driving among young adult U.S. drivers in

reducing drowsy driving intentions, willingness, and behavior in this group of drivers. In so doing, this dissertation research helps address the mismatch between perceptions of risk and the actual dangers associated with drowsy driving in young adult drivers.

1.5 Theoretical Framework

Recent studies indicate that certain behavioral change theories are useful for predicting self-reported drowsy driving intentions, willingness, and behavior and that perceived behavioral control is a particularly prominent psychosocial antecedent to drowsy driving behavior. Lee and colleagues (2016) recently examined the predictive utility of the Theory of Planned Behavior (Ajzen, 1991) and constructs from the Prototype Willingness Model (Gerrard et al., 2008; Gerrard et al., 2005) in the context of drowsy driving among young adult university students in the U.S. Students who reported more favorable attitudes and greater perceived control in relation to drowsy driving were more likely to report stronger intentions and willingness to engage in this behavior (Lee et al., 2016). It was also found that perceived behavioral control was consistently the strongest predictor of both drowsy driving intentions and willingness, while another research team recently reported that perceived behavioral control was the second strongest predictor of drowsy driving behavior after behavioral intentions among Chinese drivers (Jiang et al., 2017). Furthermore, recent qualitative research of college (*i.e.*, undergraduate university) students in the U.S. indicated that many members of this population are willing to drive drowsy in part because insufficient sleep is a common facet of their lives over which they feel they have little control (Beck et al., 2018). Together, these findings suggest that incorporating messages designed to influence perceptions of control over drowsy driving behavior into drowsy driving prevention education campaigns and interventions for young adult drivers may enhance the efficacy and effectiveness of these campaigns and interventions.

Perceived behavioral control may influence drowsy driving intentions, willingness, and behavior indirectly through risk perceptions. Researchers from several fields have found that perceptions of control are closely related to perceptions of risk (2010; Klein & Helweg-Larsen, 2002; Krueger & Dickson, 1994; Nordgren et al., 2007), which in turn influences behavioral intentions, willingness, and actual risk behaviors (Brewer et al., 2007; Brewer et al., 2004; Deery, 1999; Hatfield & Fernandes, 2009; Machin & Sankey, 2008). In their study of U.S. university students, Lee and Beck found that elevated perceived behavioral control concerning drowsy driving may negate or attenuate either a person's perceived risk regarding drowsy driving or the impact of perceived risk on intention to drive drowsy (Lee et al., 2016). In fact, Lee and Beck have found that risk perception partially mediates the relationship between perceived behavioral control and intentions and willingness to engage in drowsy driving behavior: *greater* perceived control over drowsy driving behavior *decreases* perceived risk concerning drowsy driving, which in turn *increases* intentions and especially willingness to engage in drowsy driving behavior (Lee & Beck, 2019). These mediational findings are consistent with recent qualitative findings that many U.S. college students are willing to drive drowsy in part because they perceived the consequences of failing to meet various personal obligations (*e.g.*, getting to school or work on time) to be more tangible, immediate, and probable compared to the consequences of a car crash or legal sanctions resulting from driving drowsy (Beck et al., 2018).

Constructs from the Theory of Planned Behavior (TPB, see Appendix 2, Figure 1.1) and Prototype Willingness Model (PWM, see Appendix 2, Figure 1.2) and their relationship with risk perception provided the theoretical basis for the conceptual framework for this study (see Appendix 2, Figure 1.3). It was expected that exposing young adult drivers to anti-drowsy

driving messages that specifically target the construct of perceived behavioral regarding drowsy driving behavior would heighten their perceptions of risk regarding drowsy driving, which in turn would reduce their intentions and willingness to drive drowsy in the future and ultimately their actual future drowsy driving behavior.

1.6 Definition of Terms

The following definitions apply to the entirety of this dissertation.

"*Drowsy driving*" means the act of operating a motor vehicle while drowsy, sleepy, asleep, or fatigued (National Highway Traffic Safety Administration [NHTSA], 2011).[1]

"*Drowsiness*" (adjective: "*drowsy*") means a fluctuating intermediate state between alert wakefulness and sleep which is most often experienced when a person struggles to maintain wakefulness at a time appropriate for sleep, either because of pathologic conditions or sleep deficiency (National Center on Sleep Disorders Research [NCSDR], 2011).

"*Fatigue*" means a state of increased discomfort and decreased efficiency resulting from prolonged or excessive exertion. Fatigue is often the consequence of physical labor or a prolonged experience and is characterized by a loss of power or capacity to respond to stimulation, or a disinclination to continue a task at hand (*Dorland's Illustrated Medical Dictionary*, 2003; NCSDR/NHTSA, 1998, p. 3).

"*Sleep*" (adjective: "*asleep*") means a period of rest for the body and mind, during which volition and consciousness are in partial or complete abeyance and the bodily functions are

[1] The terms drowsiness, sleepiness, and fatigue often are used interchangeably in the drowsy driving literature National Center on Sleep Disorders Research/National Highway Traffic Safety Administration [NCSDR/NHTSA] Expert Panel on Driver Fatigue and Sleepiness. (1998). Drowsy Driving and Automobile Crashes: Report and Recommendations. In. Washington, DC: National Highway Traffic Safety Administration (DOT HS 808 707).. In the field of sleep research, however, each of these terms has definitions of their own. Some of these definitions are provided in this section.

partially suspended. Sleep is a behavioral state characterized in humans by periods of reduced activity, a particular immobile posture (*e.g.*, lying down with eyes closed), and diminished but readily reversible sensitivity to external stimuli. The ready reversibility of sleep distinguishes it from other states of reduced consciousness such as hibernation and coma (*Dorland's Illustrated Medical Dictionary*, 2003; Harvard Medical School Division of Sleep Medicine & WGBH Educational Foundation, 2008; Lockley, 2010).

"*Sleep deficiency*" means a deficit in the quantity or quality of sleep obtained relative to the quantity or quality of sleep needed for optimal health, performance, and well-being. Sleep deficiency may result from prolonged wakefulness leading to sleep deprivation, insufficient sleep duration, and sleep fragmentation or sleep disorders that disrupts sleep and thereby renders sleep non-restorative (Lee et al., 2013; National Center on Sleep Disorders Research [NCSDR], 2011).

"*Sleepiness*" (adjective: "*sleepy*") means the subjective sensation of the desire or need to sleep. Factors that may increase sleepiness include sleep deficiency, misalignment of circadian phase, sleep inertia, some illnesses (including sleep disorders), hypnotic agents, central nervous system depressants (*e.g.*, alcohol), and other pharmacologic agents that induce sleepiness. Factors that may reduce sleepiness include sleep, some illnesses (*e.g.*, hypomania), wake-promoting therapeutics (*e.g.*, caffeine), central nervous system stimulants (*e.g.*, amphetamines), advancing age, and emotional and sympathetic nervous system activation (NCSDR, 2011, p. 26; NCSDR/NHTSA, 1998, p. 3).

"*Wakefulness*" (adjective: "*awake*") means a condition of alertness or watchfulness. It is also a state marked by indisposition to sleep (*Dorland's Illustrated Medical Dictionary*, 2003).

Chapter 2: Literature Review

2.1 Drowsy Driving in the United States

2.1.1 Drowsy Driving as a Public Health and Safety Problem

In recent years, researchers from advocacy organizations, government, and academia have built a substantial evidence base indicating that drowsy driving is a significant public safety and health concern in the United States. In its first *State of the States Report on Drowsy Driving* report published in November 2007, the National Sleep Foundation (NSF) cited statistics by the National Highway Traffic Safety Administration indicating that 100,000 police-reported crashes are the direct result of driver fatigue each year in the United States, resulting in an estimated 1,550 deaths, 71,000 injuries, and $12.5 billion in monetary losses (National Sleep Foundation, 2007a). Polling data collected by NSF annually from 1998 through 2005 reveal that the percentage of U.S. adults who reported driving a vehicle while feeling drowsy in the past year ranged from 51 to 62 (National Sleep Foundation, 2005b, p. 42). NSF polling data from 2005 and 2009 also reveal that about one-third of U.S. adult drivers reported actually having fallen asleep while driving a vehicle at some point, and that between 1 and 4 percent admitted getting into an accident or near accident in the past year because they dozed off or were too tired to drive (National Sleep Foundation, 2005b, pp. 42-43; 2009, p. 42).

These findings are consistent with more recent analyses of data collected by the AAA Foundation for Traffic Safety, which reveal that 41 percent of U.S. drivers surveyed in 2010 reported falling asleep or nodding off while driving at least once in their lifetime, with 11 percent reporting that they did so within the past year and 4 percent reporting that they did so in the past month (Tefft, 2010b); and 32 percent of U.S. drivers surveyed in 2011 admitted that they had driven while they were “so sleepy that [they] had a hard time keeping [their] eyes open” within

the past month (AAA Foundation for Traffic Safety, 2011). Moreover, an analysis of actual U.S. crash data from 1999 to 2008 in which at least one passenger vehicle was towed from the scene of the crash revealed that a drowsy driver was involved in 16.5 percent of fatal crashes, 13.1 percent of crashes resulting in hospitalization, and 7 percent of all crashes (Tefft, 2010b). The AAA Foundation also found that among drivers surveyed in 2010 who reported falling asleep while driving in the past year, over half did so while driving on a high-speed divided highway or after driving for less than an hour, and more than a quarter did so between the day-time hours of noon and 5:00 p.m. (Tefft, 2010b). Most recently, in analyzing data from a large-scale (N = 3,593) naturalistic driving study conducted between 2010 and 2013 that used a validated objective measure of drowsiness (PERCLOS, the percentage of time that the driver's eyes were closed in the 3 minutes preceding each of 589 crashes and for 1 minute preceding each of 701 crashes), the AAA Foundation found that drowsy driving was involved in 8.8 to 9.5 percent of all crashes examined and 10.6 to 10.8 percent of crashes that resulted in significant property damage, airbag deployment, or injury (Owens et al., 2018).

Researchers from academia and government have provided additional information illustrating the magnitude of drowsy driving as a societal problem. In a study that continuously observed drivers of 100 video-instrumented cars for more than 42,000 miles in naturalistic driving conditions, researchers at Virginia Tech investigating driver performance and behavior in the moments leading up to a motor vehicle crash found that 22 percent of all motor vehicle crashes and 16 percent of near-crashes could be attributed to drowsy driving (Dingus et al., 2006). Furthermore, data maintained by the National Highway Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation reveal that drowsy driving was reportedly involved in 2.2 to 2.6 percent of total fatal crashes and in 2.0 to 2.3 percent of total non-fatal

injury crashes annually nationwide between 2005 to 2009 (National Highway Traffic Safety Administration [NHTSA], 2011). During this 5-year period, the number of fatalities in crashes on U.S. roadways decreased slightly, while the proportion of such fatalities reported to involve drowsy driving remained relatively consistent at between 2.3 and 2.7 percent (NHTSA, 2011, p. 1, Table 1). NHTSA estimates that in 2009, 2.0 percent of all crashes with non-fatal injuries (approximately 30,000 out of 1.5 million total non-fatal injury crashes) and 1.3 percent of all police-report crashes (72,000 out of 5.5 million total fatal, non-fatal injury, and property-damage-only crashes) on U.S. roadways involved drowsy driving (NHTSA, 2011, p. 2, Table 2).

Brian Tefft from the AAA Foundation recently quantified the dose-response relationship between drowsy driving and motor vehicle crash risk (Tefft, 2018). Using crash study data previously collected by the U.S. Department of Transportation (N = 6,845) in a modified case-control study design, Tefft found significantly increased crash risks for all drivers who reported sleeping less than 7 hours in the 24 hours before crashing compared to drivers who reported sleeping 7 to 9 hours in the 24 hours before crashing (*sleeping 6 hours:* OR = 1.3, 95% CI = 1.04, 1.7; *sleeping 5 hours:* OR = 1.9, 95% CI = 1.1, 3.2; *sleeping 4 hours:* OR = 2.9, 95% CI = 1.4, 6.2; and *sleeping < 4 hours:* OR = 15.1, 95% CI = 4.2, 54.4). In addition, drivers who reported sleeping for less than 4 hours in the 24 hours before crashing had a crash risk comparable to that reported in other studies for drivers with blood alcohol concentration approximately 1.5 times the legal limit effective in all U.S. states.

2.1.2 Populations Vulnerable to Drowsy Driving

Since the 1990s, analyses of governmental and non-governmental traffic safety data consistently indicate that young and inexperienced drivers (and especially young and inexperienced males under the age of 25 years) are particularly at high risk of experiencing

drowsy driving crashes (Commonwealth of Massachusetts, 2009, pp. 14-16; Di Milia et al., 2011; McCartt et al., 1996, pp. 514-515; NCSDR/NHTSA, 1998, pp. 16-18; Pack et al., 1995; Tefft, 2010b, p. 3). In a 1994 survey of 1000 randomly selected New York State licensed drivers, 26.2 percent of respondents in the 25 to 34 years age group (compared to 13.3% in the 16 to 24 age group and < 19% in the 35+ age group) reportedly drove drowsy "sometimes or often" during the past year (McCartt et al., 1996, p. 515, Table 7). More recently, CDC researchers (Wheaton et al., 2013) analyzing 2009-2010 data from the Behavioral Risk Factor Surveillance System (BRFSS) found that younger adults reported higher rates of falling asleep while driving in the past 30 days than older adults (>4.9% among adults aged 18 to 44 years versus 1.7% among adults aged ≥65 years). Interestingly, drowsy driving prevalence in the BRFSS study sample was lower among adults ages 18 to 24 years than among adults ages 25 to 34 years (4.9% versus 6.3%). This difference in prevalence rates may be attributed to differences in driving frequency between the two groups of young adult drivers, with the higher drowsy driving rates in the older group arising from the fact that members of this group drive more often and thus have more opportunities to fall asleep while driving. The investigators of the 1994 New York study reached a similar conclusion in finding that "[h]igher levels of education were associated with increased frequency of drowsy driving" and "[g]reater frequency of drowsy driving was associated with greater reported numbers of hours worked per week, working more than one job, working rotating shifts, and driving as part of work responsibilities" (McCartt et al., 1996, p. 514).

In 2012, the AAA Foundation reported that among licensed drivers ages 16 to 24 years that it surveyed that year, 31 percent reported that they had driven while they were "so sleepy that they had a hard time keeping their eyes open" in the past 30 days, 18 percent reported

having done so more than once in this time and 5.7 percent reported having done so fairly often or regularly. Furthermore, one in seven (14.8%) of these young licensed drivers reported having fallen asleep or nodded off while driving within the past year, and 33 percent reported having done so at least once in their lifetime (AAA Foundation for Traffic Safety, 2012). Data from an earlier AAA Foundation survey revealed that drivers ages 16-24 years were nearly twice as likely to be involved in a drowsy driving crash as drivers ages 40-59 years (AAA Foundation for Traffic Safety, 2011, 2012). In analyzing data from a large-scale naturalistic driving study conducted between 2010 and 2013 that included PERCLOS as an objective measure of drowsiness, AAA Foundation found that drowsy driving was involved in between 8 and 11 percent of the analyzed crashes where the driver was ages 16-24 years (Owens et al., 2018).

Similarly, high drowsy driving prevalence rates have also been well-documented in populations of university students. For example, 32 percent of respondents in a stratified random sample of 300 undergraduate and graduate students at a large religiously-affiliated private university in Utah who reported experiencing a "dozing and driving" incident since the beginning of their college career (Lindsay et al., 1999). Among these students, 48 percent also reported experiencing a less severe dozing incident earlier in the same driving trip and 68 percent reported that they continued driving after experiencing the dozing and driving incident. The investigators for this study also estimated the annual incidence rate for fatalities attributable to driver fatigue or dozing and driving in university students to be 1.37 per 10,000, based on their analysis of 86 traffic fatalities involving students at the Utah university that occurred between 1981 and 1996. More recently, 16 percent of respondents in a sample of 1,039 undergraduate students (72% female, average age = 20.39 years) at a public university in Texas who reported falling asleep while driving (Taylor & Bramoweth, 2010). In their surveyed sample of 642

undergraduate and graduate students (71% female, average age = 23.5 years) at the University of Maryland, College Park (UMCP), Lee and Beck found that over 70% of the students reported any drowsy driving experience in their lifetime, with 40% reporting a drowsy driving experience in the last year and over 30% reporting a drowsy driving experience at least once in the past month (Lee et al., 2016). Furthermore, over 10% admitted to "falling asleep or nodding off while driving a motor vehicle, even for just a second or two" at least once in the past month.

Drowsy driving in young people outside of the U.S. also has been investigated extensively. In a study of Norwegian drivers, Sagberg (1999, Table 4) found that the strongest predictors of the probability of falling asleep while driving were annual driving distance (OR = 1.14, $p < .0001$) and being a male driver (OR = 3.49, $p < .0001$), and that age reduced the odds of having fallen asleep while driving by about 2 percent per year (OR = 0.98, $p < .0001$). Furthermore, Sagberg (1999, Table 1) found that years with driver's license appeared to have a protective effect on the odds of sleep involvement as a contributing factor in car crashes (OR = 0.98, $p = .01$). Although age and gender were not found to impact the odds of sleep involvement in car crashes, years with driver's license arguably may be considered a proxy for age of the driver. In their prospective study of subjective and predicted sleepiness while driving in 47 young Australian drivers (ages between 18 and 25 years) over a 4-week period, Smith and colleagues (2005) concluded from their data analysis that young drivers frequently drove at times of day of predicted sleepiness (>7% of the 2518 driving episodes analyzed) and at times they felt sleepy (>23% of episodes).

2.1.3 Risk Perceptions About Drowsy Driving

Despite the high prevalence of drowsy driving reported among U.S. drivers, there appears to be great awareness among U.S. drivers overall of the dangers of drowsy driving. In the 1994

New York State drowsy driving survey, 54.7 percent of respondents reported that being drowsy (*i.e.*, "so tired you could easily fall asleep") greatly affected their ability to drive safely, and that being drowsy had a greater effect on their ability to drive safely than either adverse weather or having two drinks of wine, beer, or liquor (McCartt et al., 1996; New York State Task Force on the Impact of Fatigue on Driving, 1994). Nonetheless, 54.6 percent of the survey respondents reportedly experienced driving while drowsy in the last year, with 2.5 percent reportedly driving drowsy "very often" in the last year. Moreover, 24.7 percent of the respondents reportedly fell asleep at the wheel at some point in their driving career, with 2.8 percent reportedly falling asleep at the wheel and crashing in their driving career; and 26.1 percent of the respondents reportedly knew someone who had a crash due to falling asleep at the wheel or drowsiness (McCartt et al., 1996, pp. 513-514, Tables 3 & 5).

Similar findings have been reported among drivers outside of the U.S. In analyzing data from an internet survey of 1513 Norwegian drivers (55% male, 45% female, average age = 39.6 years) in 2003 to increase understanding of drivers' actions when feeling sleepy, Nordbakke and Sagberg (2007) found that although drivers generally had a good knowledge of the various risk factors for falling asleep while driving and that most drivers were aware of the most effective countermeasures to prevent falling asleep while driving, 73 percent of the drivers surveyed reported that they continue driving even they felt too tired to do so. Similarly, Obst and colleagues (2011) reported that although there appeared to be good awareness of the substantial risks associated with driving while sleepy in a survey sample of 305 Australian drivers (114 males, 191 females, average age = 44.67 years, age range 17 to 78 years), 77 percent of these drivers reported having driven while sleepy, 20 percent reported driving while sleepy relatively

frequently, and 30 percent reported having experienced a "close call" on the road due to being sleepy.

Significant social disapproval of drowsy driving behavior also exists within U.S. society. The AAA Foundation found that among U.S. drivers surveyed in 2011, 96 percent viewed it as unacceptable to drive drowsy, 82 percent viewed it as unacceptable for someone to drive when they have trouble keeping their eyes open, and 56 percent rated drowsy drivers as "a very serious safety threat" (AAA Foundation for Traffic Safety, 2011). Furthermore, data from NHTSA's 2002 National Survey of Distracted and Drowsy Driving reveal that "[v]irtually all drivers believe that other drivers who drive while sleepy or drowsy are a threat to their own personal safety and that of their family[,]" with 95 percent perceiving this behavior by others to be a "major threat" and 5 percent perceiving it as a "minor threat" (NHTSA, 2002, pp. 52-53, Figure 18-A). The NHTSA survey did not detect significant differences between gender and age groups in perceived threat from other drowsy drivers: over 90 percent of the males, females, young drivers, and old drivers surveyed all perceived drowsy driving by others to be a major threat to their personal and family's safety. Males were slightly more likely to perceive drowsy driving by others to be a minor (6%), rather than a major (93%), threat to their personal and family's safety compared to female drivers (3% and 96%, respectively); and drivers in their 20s were more likely than other driver age groups to perceive drowsy driving by others as a minor (8%) rather than a major threat (91%) to their personal and family's safety (NHTSA, 2002, pp. 52-53, Figures 18-B & -C).

NHTSA's finding that younger drivers perceive less risk and express less disapproval of drowsy driving compared to older drivers is consistent with research on drowsy driving-related risk and hazard perceptions in young and inexperienced drivers from around the world. For

example, Smith and colleagues studied the impact of sleepiness on driving-related hazard perceptions in a sample of 32 "novice" (age range from 17 to 24 years, with a mean driving experience of 1.65 years) and 30 "experienced" (age range from 28 to 36 years, with a mean driving experience of 14.41 years) drivers drawn from the student body at an Australian university and found that the hazard perception skills of novice drivers were significantly slowed by mild increases in sleepiness, whereas the hazard perception skills of the more experienced drivers were relatively unaffected by mild increases in sleepiness (2009). The additional 0.38 seconds in hazard response time observed in novice drivers with high sleepiness levels compared to those with low sleepiness levels was equivalent to 6.33 meters (~21 feet) of travel when driving at a speed of 60 kilometers per hour (~37 miles per hour).

In a survey study of 305 drivers in Queensland, Obst and colleagues (2011) found that male drivers and younger drivers reported the lowest perceived personal risk in regards to driving while sleepy. Risk perceptions related to driving when sleepy were significantly different between age groups, with drivers in the 17- to 24-years age group perceiving driving when sleepy to be significantly less risky than drivers in the 45- to 64- years age group. Risk perceptions related to driving at 4:00 a.m. (*i.e.*, corresponding approximately to the circadian nadir in humans, which is associated with low alertness) were significantly higher in females compared to males.

In a study of 695 young (average age of 20.85 years) and relatively inexperienced (*i.e.*, between 6 and 24 months) drivers in Italy who were asked to rate on a 10-point scale (1 = "very low"; 10 = "very high") their likelihood (*i.e.*, perceived risk) of having a night-time car crash due to sleepiness and their level of concern (*i.e.*, worry) about the possibility of having such a crash, Lucidi and colleagues (2006) found that a driver's experience with drowsy driving and frequency

of night-time driving in the past 6 months significantly influenced the driver's risk perception and worries related to night-time car crashes due to sleepiness. Subjects with no experience of night-time driving in the previous 6 months reported significantly higher perceived risk than in subjects who reportedly engaged in night-time driving "once a month" and "more than once a month," and significantly higher worry than in subjects who reportedly engaged in night-time driving "once a month" and "more than once a month." Interestingly, Lucidi and colleagues observed without explanation that subjects with drowsy driving experience reported significantly higher perceived risk but significantly lower worry than subjects with no drowsy driving experience.

In their qualitative study of college-aged U.S. drivers, Lee and Beck found that compared with other forms of impaired driving (*e.g.*, drunk driving), college students viewed drowsy driving as less risky from a legal perspective (*e.g.*, less likely to result in a traffic citation), although not necessarily from an overall risk perspective (Beck et al., 2018). Furthermore, the students reported that although they were familiar with public safety messages that one should not drink or text while driving, most had not been exposed to anti–drowsy driving messages. As one student observed:

> I feel like everyone has … driven while they've been a little bit tired, but they might not realize that it's just as dangerous as any other like bad driving behavior.…Like we haven't…stigmatized it yet, but … people have done a good job of being like, texting is bad, driving drunk is bad, but there's not like tired driving is bad. (Beck et al., 2018, p. 119).

These findings are consistent with data from a 2006 public opinion poll of 750 Canadian (*viz.*, Ontarian) drivers ranging in age from 16 to 93 years ($M = 48$; Males = 44% of polling sample) revealing that drivers were less concerned about fatigued or drowsy driving than about other traffic safety issues, with 59.6 percent of the drivers surveyed reporting that they thought

fatigued or drowsy driving was a “serious” or “extremely serious” problem, compared with ~65 percent for driving while using cell phones and other forms of distracted driving, 69.2 percent for speeding, 71.9 percent for illicit drug-impaired driving, and 82.2 percent for alcohol-impaired driving (Vanlaar et al., 2008, p. 307, Fig. 2).

2.1.4 Motivations to Drive Drowsy

Various individual-level motivational factors have been put forward to explain the high prevalence of drowsy driving reported around the world. About a quarter of the respondents to the 1994 New York State drowsy driving survey reportedly drove drowsy during the past year while on a long trip (29.5%), at night (27.7%), due to lack of sleep (26.6%), or during the day (22.9%), whereas fewer than one in 20 of the respondents reportedly drove drowsy during the past year due to an illness or medical condition (4.6%), taking medications (3.5%), or drinking alcohol (1.8%) (McCartt et al., 1996, p. 513, Table 4). Nordbakke and Sagberg (2007, p. 8, Fig. 4) found that among Norwegian drivers who reported sometimes driving while tired (n = 1098), the most frequently reported reasons for continuing to drive while fatigued or sleepy were short trips (60%), appointments that had to be kept (39%), short distance remaining to destination (34%), and desire to arrive home from a road trip at a reasonable hour (32%) or from work quickly (23%).

Among college students in the U.S., Lee and Beck found that drowsiness appears to be a common feature reported by these young adult drivers (Beck et al., 2018). Many of the student participants in this study stated that they were prone to experiencing insufficient sleep due to their various professional, academic, and social demands. However, even if they recognized how sleep-deprived they were and the dangers of driving drowsy, many of the students admitted to driving drowsy in the past and expressed a willingness to do so in the future. One of the

primary reasons these students provided for their past drowsy driving behavior was the difficulty of avoiding situations in which they had to drive while drowsy. The students explained that they and other young adults face numerous competing demands in their lives such that they rarely get enough sleep to be fully rested. Consequently, many feel compelled to drive when less than fully awake and alert to get to class, work, or some other appointment on time. These individuals value getting to a destination at which they feel professionally, socially, or personally obliged to be over avoiding the dangers of drowsy driving. This may be especially true if the consequences of failing to meet these obligations are perceived to be more immediate and tangible than the consequences of drowsy driving. Thus, for these students, the very real and immediate consequences of failing to get to school or work on time outweigh the relatively remote and improbable consequences of a car crash or legal sanctions resulting from driving drowsy. Many of the students in this study indicated that it was unlikely they would alter their drowsy driving behavior given their current circumstances.

2.1.5 Messaging Strategies and Interventions to Prevent Drowsy Driving: Existing Efforts and Recommendations for Improvement

Policy-makers have been advised to develop and implement interventions targeting young people and other identified high-risk groups (Commonwealth of Massachusetts, 2009, pp. 22-24, 28-29; NCSDR/NHTSA, 1998, pp. 22-25; National Sleep Foundation, 2007a, p. 4; Thiffault, 2011b). Some organizations have developed materials and resources to educate young people and members of the general public on the dangers of drowsy driving (American Academy of Sleep Medicine, 2012; De Dobbeleer et al., 2009b; Driver Reviver, 2008; National Sleep Foundation, 2013).

In their previous focus group work with U.S. college students, Lee and Beck explored the types of messages and message delivery strategies that these students might find effective to reduce drowsy driving among themselves and their young adult peers (Beck et al., 2018). From these focus group discussions, several recommendations emerged relating to substantive messaging strategies for preventing drowsy driving in young adults (see Sections 2.1.5.1 to 2.1.5.3) and to approaches for effectively delivering these substantive messaging strategies to young adult drivers (see Section 2.1.5.4).

2.1.5.1 Messaging to Increase Perceptions of Legal Risk of Drowsy Driving

Although Lee and Beck found that perceptions of the legal risks of drowsy driving were very low among the students they studied, some of these students also admitted that they were generally more afraid of getting a ticket than dying in an automobile crash because a traffic ticket was a more realistic and immediate possibility, whereas dying was a remote abstraction. Consequently, Lee and Beck concluded that messaging aimed at heightening the perceived legal risks of drowsy driving could be an effective messaging strategy for preventing drowsy driving behavior in young adult drivers, especially by increasing the perceived threat of interaction with law enforcement authorities. Possible approaches for executing this strategy that were endorsed by the students Lee and Beck studied included messaging campaigns featuring actual car crash incidents attributed to drowsy driving and the resulting legal (*e.g.*, citations, criminal charges) and financial (*e.g.*, traffic fines, lawsuit payouts) consequences to the at-fault drowsy driver.

2.1.5.2 Messaging to Increase Perceptions of the Dangers of Drowsy Driving

Similar to Vanlaar et al.'s survey of Canadian drivers (Vanlaar et al., 2008), Lee and Beck found that the students in their U.S. study viewed drowsy driving as less of a concern than driving while alcohol-impaired or texting. Noting that many of their student focus group

participants were well-aware of the dangers of alcohol-impaired driving and expressed high levels of personal and social disapproval concerning this driving behavior, Lee and Beck concluded that messaging strategies designed to equate the dangers of drowsy driving with those of alcohol-impaired driving might be an effective messaging strategy for preventing drowsy driving behavior in young adult drivers. In fact, the students Lee and Beck studied explicitly endorsed the development of messages highlighting the empirically-observed similarities between the impairing effects of sleep deprivation and blood alcohol level (Dawson & Reid, 1997). Such messages would promote the idea that drowsy driving is as dangerous as alcohol-impaired driving and that law enforcement officers would stop and arrest impaired drivers regardless of the cause (*i.e.*, whether by alcohol, drugs, or drowsiness). This messaging approach would effectively combine messages that heighten perceptions of danger with messages that heighten perceptions of legal risk to increase overall risk perceptions of drowsy driving.

2.1.5.3 Messaging to Influence Perceptions of Control Concerning Driving Drowsy

As mentioned previously, the students Lee and Beck studied viewed drowsy driving as a form of impaired driving over which they had little control and which they perceived as relatively common and non-risky from a personal liability and safety standpoint (see Sections 2.1.3 and 2.1.4). Unsurprisingly, these students indicated that they were more willing to engage in drowsy driving compared to other forms of impaired driving. In addition, these students largely rejected messages built on the theme that one is not as good a driver when drowsy, arguing that such messages would be viewed by some drivers as a challenge to overcome and would engender an "I'll show you" attitude in these individuals. Thus, although Lee and Beck found from their quantitative questionnaire-based research that feelings of self-efficacy and

behavioral control influence intentions and willingness to drive drowsy among college-aged adults (Lee et al., 2016), their qualitative focus group-based research suggested that changing perceptions of control may not be the best messaging strategy for drowsy driving prevention in this population.

2.1.5.4 Approaches for Delivering Drowsy Driving Prevention Messages

Several recommendations for message delivery strategies emerged from the student focus groups conducted by Lee and Beck. First, the students believed that messages depicting the graphic consequences of drowsy driving would be effective for college students and their young adult peers. Noting the impact that recent vivid and realistic anti-drunk driving and anti-distracted driving messaging campaigns depicting the gruesome aftermath of a car crash had on their traffic safety attitudes and behavior, many students in the focus groups opined that a similarly graphic approach for anti-drowsy driving messaging campaigns would get their attention, increase their awareness of drowsy driving, and motivate them to take preventive actions. In addition, the students advised that such campaigns should include strong emotional appeals, and that messages arousing feelings of guilt, horror, or even heartbreak could be especially effective. An example of such a message would be one in which someone driving drowsy inadvertently kills a friend or relative.

The student focus groups also recommended that visual channels, such as television or social media, would be the most effective means of delivering drowsy driving prevention messages to young adults. In-vehicle alert systems and print or electronic billboards near roadways were mentioned repeatedly as visual means of delivering short but substantive messages directly to drivers on roadways that provide timely and relevant cues to action such as information about the nearest rest stop or restaurant serving caffeinated beverages. The students

advised that such visual messages should not be too complicated and distracting for drivers, and that they should contain memorable short slogans such as *DDD - "Don't Drive Drowsy"* or *Drowsy Driving = Drunk Driving*.

2.2 Theoretical Framework: Psychosocial Antecedents of Drowsy Driving Behavior

Behavioral change theories have been useful for designing effective interventions and messaging strategies against risky driving behaviors by suggesting relevant cognitive and motivational targets for intervention. Thus, theory-based messaging strategies and interventions may more effectively prevent drowsy driving behavior compared to knowledge-based messaging strategies by altering relevant psychosocial antecedents of drowsy driving behavior (Commonwealth of Massachusetts, 2009; Foss, 2007; Higgins et al., 2017; NCSDR, 2011; NCSDR/NHTSA, 1998; National Sleep Foundation, 2007b; Thiffault, 2011a).

Several traffic safety advocates have argued that principles derived from the behavioral change theory research should guide the development and implementation of more effective interventions against drowsy driving in the future, and that additional research on sleep and drowsy driving as a health behavior phenomenon is needed (NCSDR, 2011; Thiffault, 2011b). This approach is consistent with that advocated by Robert Foss from the University of North Carolina to incorporate human behavior theory into traffic safety interventions and practice:

> As the fundamental principle of a traffic-safety culture, every program, policy, and law whose goal is to reduce motor vehicle-related injuries and deaths should be derived from, or be demonstrably consistent with, well-documented fundamental principles of human behavior. To implement this principle, we should consciously and conscientiously use existing, well-supported theories in several of the social/behavioral sciences as guides in developing program and policy ideas. In cases where a strategy has been developed in the absence of theoretical guidance, it should be carefully vetted against sound theory before being implemented. (2007, p. 156)

2.2.1 Drowsy Driving Intention and Willingness

Behavioral intention (*i.e.*, one's intention to engage in the behavior) and behavioral willingness (*i.e.*, one's openness to engaging in a particular risk behavior in circumstances that are conducive to that behavior even if the individual had not previously intended or contemplated engaging in the behavior) are among the most studied theoretical psychosocial antecedents to risky driving behavior in the traffic safety literature (Ajzen, 1991; Elliott & Armitage, 2009; Elliott et al., 2003, 2007; Gerrard et al., 2008; Gerrard et al., 2005; Gibbons, Gerrard, Blanton, et al., 1998; Lambert & Laird, 2016; Rivis et al., 2011; Rivis et al., 2006; Todd et al., 2014). Whereas "intentions are plans that have been formulated in order to achieve a particular goal state through certain, instrumental actions" and "involve contemplation of the behavior and, usually, of its consequences," willingness "does not involve goal states, plans, or instrumental actions" and "involves relatively little forethought, which means less consideration of outcomes or consequences" (Gibbons, Gerrard, Ouelette, et al., 1998, p. 321). Thus, behavioral intention and behavioral willingness are distinguishable primarily by the deliberative nature of the former and the reactive nature of the latter (Gibbons, Gerrard, Blanton, et al., 1998; Gibbons, Gerrard, Ouelette, et al., 1998). However, theorists have postulated that behavioral intention and behavioral willingness are both affected by attitudinal factors, social influences, salient beliefs, and past behavior through theoretical frameworks such as the Theory of Planned Behavior (TPB) and the Prototype Willingness Model (PWM).

2.2.1.1 Theory of Planned Behavior

The TPB (Appendix 2, Figure 1.1) has been one of the most extensively utilized and studied behavioral change theories in risky driving prevention and traffic safety promotion contexts (Chan et al., 2010; Conner et al., 2007; Elliott & Armitage, 2009; Elliott et al., 2003;

Nemme & White, 2010; Parker et al., 1992; Rivis et al., 2011; Stead et al., 2005; Warner & Åberg, 2006; Zhou et al., 2009). Originally developed as an intra-personal theory to explain behaviors that are not completely volitional (Ajzen, 1991), the TPB asserts that *behavioral intention* is the strongest predictor of future behavior. Intentions are influenced by three cognitive antecedents and their underlying salient beliefs: (1) *attitudes toward the behavior* (*"attitudes"*), which reflect a person's beliefs about the outcomes of engaging in a particular behavior (*behavioral beliefs*) weighted by the person's evaluation of these outcomes *(outcome evaluation)*; (2) *subjective norms,* which reflect one's belief as to how important referents (*e.g.,* a parent or peer) to a person would view the person's engagement in a particular behavior (*normative beliefs*) weighted by the person's motivation to comply with these referents; and (3) *perceived behavioral control*, which reflects a person's perceptions of the presence or absence of facilitators and barriers to perform a particular behavior (*control beliefs*) weighted by the person's perception of the power of these facilitators or barriers to influence performance of the behavior. In general, people with more favorable attitudes and subjective norm and greater perceived control regarding a behavior should have stronger intentions to perform the behavior (Ajzen, 2006).

Since its proposal, the TPB has been applied to numerous health behaviors (Godin & Kok, 1996). Armitage and Conner (2001) found from their meta-analysis of 185 studies published through the end of 1997 that attitude toward the behavior, subjective norm, and perceived behavioral control together accounted for 39 percent of the variance in behavioral intention and 27 percent of the variance in explaining behavior. Furthermore, the TPB could account for 31 percent of the variance in prospective measures of self-reported behavior and 20 percent of the variance in prospective measures of observed behavior (Armitage & Conner,

2001, p. 482). From their analysis of 56 reported studies of 58 health-related behavioral applications of the TPB, Godin and Kok (1996) found that the TPB performed very well for explaining behavioral intention (averaged R^2 = .41), with attitude toward the behavior and perceived behavioral control most often the significant variables responsible for this explained variation in intention; and for predicting behavior (averaged R^2 = .34), with intention being the most important predictor but perceived behavioral control significantly adding to the prediction in half of the studies analyzed.

Over the past three decades, researchers have applied the TPB successfully to predict intentions to engage in various risky driving behaviors in a number of populations around the world. One of the earliest of these studies was conducted by Parker and colleagues (1992), who found from a sample of 881 English drivers that attitude toward the behavior, subjective norm, and perceived behavioral control together explained significant proportions of the variance in intentions to commit four specific driving violations (42.3% with respect to drinking and driving, 47.2% with respect to speeding, 23.4% with respect to close following, and 31.7% with respect to dangerous overtaking). Subsequent studies have examined the utility of the TPB in predicting intentions to engage in and subsequent performance (both self-reported and observed) of numerous driving behaviors that may be described as dangerous (Conner et al., 2007; Warner & Åberg, 2006), impaired (Chan et al., 2010; Rivis et al., 2011), or distracted (Nemme & White, 2010; Zhou et al., 2009).

2.2.1.2 Prototype Willingness Model

An underlying assumption of the TPB is that an individual's behavior is the result of deliberative and rational decision-making. However, risk behavior is often not the result of deliberative and rational decision-making, especially among adolescents (Chan et al., 2010;

Gibbons, Gerrard, Blanton, et al., 1998; Gibbons, Gerrard, Ouelette, et al., 1998). In recognition of this phenomenon, theoretical frameworks such as the Prototype Willingness Model of Adolescent Health Risk Behavior (PWM) have been conceptualized as extensions of the TPB to better predict impulsive and unplanned behaviors (Gerrard et al., 2008; Gerrard et al., 2005). In explaining the development of the PWM, Gibbons and colleagues argued that "[a]lthough many adolescents do not intend to engage in risky behaviors, they do frequently find themselves in situations in which the opportunity to perform these actions is presented to them (*e.g.*, a party where cigarettes are available, an enthusiastic boyfriend or girlfriend who wants to have sex)[,]" so that "[i]n these settings, the issue is more appropriately framed as 'What are you willing to do?', which is not the same as 'What do you plan to do?'" (Gibbons, Gerrard, Blanton, et al., 1998).

The PWM (Appendix 2, Figure 1.2) is predicated on the idea that two types of decision-making pathways contribute to adolescent risk behavior (Lambert & Laird, 2016). The *reasoned path* reflects the principles of the TPB and involves analytic processing of attitudinal factors and social influences to account for intentional or planned risk behaviors. By contrast, the *social reaction path* involves heuristic processing to account for unintended or unplanned behavior which originates with perceptions of *risk prototypes* (*i.e.*, a person's images of the type of individuals who engage in particular risk behaviors) and proceeds through *behavioral willingness* to behavior (Gerrard et al., 2008; Gerrard et al., 2005; Gibbons, Gerrard, Blanton, et al., 1998). The PWM predicts that "the more strongly a person identifies with a particular prototype [*prototype similarity*], and the more favourably the image is viewed [*prototype favorability*], the more willing the person is to engage in the behaviour defined by the prototype" (Gibbons & Gerrard, 1995; Rivis et al., 2011, p. 447).

Gibbons and colleagues have distinguished behavioral willingness from behavioral intention primarily by the reactive nature of the former and the deliberative nature of the latter, with behavioral willingness characterized by a relative lack of planning or premeditation and self-focus compared to behavioral intention (Gibbons, Gerrard, Blanton, et al., 1998; Gibbons, Gerrard, Ouelette, et al., 1998). Whereas "intentions are plans that have been formulated in order to achieve a particular goal state through certain, instrumental actions" and "involve contemplation of the behavior and, usually, of its consequences[,]" willingness "does not involve goal states, plans, or instrumental actions" and "involves relatively little forethought, which means less consideration of outcomes or consequences" compared to behavioral intentions (Gibbons, Gerrard, Ouelette, et al., 1998, p. 321). Using the example of excessive drinking on college campuses to illustrate this distinction, Gibbons and colleagues explain:

> The student who states that he intends to get drunk this coming Friday night has made some commitment to the behavior and has spent some time considering its requirements and sequelae; the same would be true for the student who says he intends *not* to get drunk. Some students fall into a middle-ground category, however, [and] would be willing to drink, even to excess, *if* the opportunity is afforded, but getting drunk is not a goal for them. They have not given much thought to the prospect and have not specific plans as to how they might get drunk. Unlike the intending (or "willful") student, who creates risk opportunities, the willing student responds to them. (Gibbons, Gerrard, Ouelette, et al., 1998, pp. 321-322)

Furthermore, Gibbons and colleagues (1998) have hypothesized that compared to individuals who express a commitment (*i.e.*, intention) to engage in a particular risky behavior, individuals who express a willingness to engage in such a behavior are less likely to acknowledge and more likely to deny their personal vulnerability to those risks (*i.e.*, perceived risk, or likelihood that the individual will experience the negative consequences associated with the risky behavior).

To test these theories and hypothesis, Gibbons and colleagues conducted a series of studies to demonstrate that willingness and intention are related but independent constructs, each

of which can be cognitive antecedents to health risk behavior (Gibbons, Gerrard, Blanton, et al., 1998; Gibbons, Gerrard, Ouelette, et al., 1998). Using behavioral expectation (*i.e.*, an individual's assessment of the likelihood that he or she will actually engage in a particular behavior, which includes acknowledgment of relevant past behavior and estimations of opportunity) as a proxy for behavioral intention in these studies (*viz.*, of smoking behavior in adolescents and drunk driving in college students), Gibbons and colleagues found that behavioral expectations and behavioral willingness independently predicted subsequent involvement in risk behavior; and that behavioral expectations were independently associated with personal vulnerability, whereas no such independent association was observed between behavioral willingness and personal vulnerability (Gibbons, Gerrard, Ouelette, et al., 1998). Based on these and other findings, Gibbons and colleagues concluded that behavioral willingness and behavioral expectation (and by extension, behavioral intention) are related constructs that involve different cognitive processes; that individuals who intend to engage in a particular risky behavior acknowledge their personal risk (vulnerability); and that individuals who are only willing to engage in a particular risky behavior do not acknowledge their personal vulnerability and are "more likely to deny the relation between the risk behavior and its personal consequences" (Gibbons, Gerrard, Ouelette, et al., 1998, p. 336).

2.2.1.3 Augmenting the TPB with PWM Constructs

Empirical support for augmenting the TPB with constructs from the PWM to explain young drivers' intentions and willingness to engage in risky driving behavior (Rivis et al., 2011) and various other risk behaviors (Lambert & Laird, 2016; Rivis et al., 2006; Todd et al., 2014) have been reported. In a study of 200 male licensed drivers in a mid-sized English city, half of which were in the 17- to 29-year age group (M = 23.34, SD = 3.19) and the other half in the 30-

to 60-year age group (M = 46.3, SD = 8.98), Rivis and colleagues (2011) found that the TPB and PWM variables explained 62 percent of the variance in the willingness of young male drivers to drive after drinking and 47 percent of the variance in the willingness of older male drivers to drive after drinking. Moreover, the interaction between prototype favorability and similarity contributed 7 percent to the variance explained in the willingness of older males to drive after drinking. Rivis and colleagues further assert that their analyses of the study data indicate that: (1) "young male drivers are more willing to drive while intoxicated when they perceive little pressure from significant others to not drink and drive, have a favourable overall evaluation towards driving while intoxicated, believe they are similar to the drink-driver prototype, and find it difficult to never drive when there is any risk that they might be over the [blood alcohol concentration] limit"; and (2) older male drivers are more willing to drink and drive when they perceive little pressure from significant others to not drink and drive, find it difficult to never drive when there is any risk they might be over the limit, and when they have a favourable impression of, and identify with, the type of person who drives after consuming [alcohol]" (2011, pp. 450-451).

Lee and Beck have found empirical support for the utility of the TPB and PWM in predicting self-reported drowsy driving intention, willingness and behavior: in a study of young adult university students in the U.S., students who reported more favorable attitudes and greater perceived control in relation to drowsy driving were more likely to report stronger intentions and willingness to engage in this behavior (Lee et al., 2016). Attitudes, subjective norms, and perceived control significantly explained an additional 37 to 47 percent of the variance in drowsy driving intention and an additional 23 to 37 percent of the variance in drowsy driving willingness after controlling for personal characteristics and past driving behavior (*i.e.*, gender, age,

ethnicity, race, annual driving exposure, employment status, sense of invulnerability to danger, past drowsy driving experience, and past asleep driving experience). Empirical support for the utility of the TPB in predicting self-reported drowsy driving behavior also was reported in a recent study (Jiang et al., 2017) of 214 Chinese drivers (52.8% female) primarily 20 to 39 years of age (n = 197). In this Chinese study, the primary TPB constructs (attitudes, subjective norms, perceived control, and intentions) significantly explained an additional 30 percent of the variance in drowsy driving behavior after controlling for various personal characteristics and past behaviors (*i.e.*, gender, age, driving experience, sleep quality, and fatigue history).

The TPB and PWM are suitable theoretical frameworks for addressing the health problem of drowsy driving in young adult drivers for a variety of reasons. Although interpersonal and environmental-level factors contribute to drowsy driving behavior (Beck et al., 2018), the decisions to get behind the wheel while drowsy or to continue driving while drowsy are ultimately individual-level choices largely based on cognitive processes related to both rational deliberation and social reaction. Moreover, the individual-level biological underpinnings of chronic sleep deprivation and sleepiness in young adults mean that drowsy driving episodes are not completely voluntary actions: one cannot consciously control at will when one will fall asleep or start feeling sleepy (Dijk & Czeisler, 1995; Luyster et al., 2012). Given that the TPB is designed to explain behaviors that are not completely volitional and that are based on rational decision-making, it is an appropriate theoretical framework for developing prevention messages and interventions to address drowsy driving in young adults.

Furthermore, young adults frequently engage in risk-taking behaviors (*e.g.*, excessive drinking, unprotected sex, drowsy driving) as a result of reacting to social situations in which the opportunity to engage in the risk behavior arises spontaneously rather than from rational

decision-making or planning (Gibbons, Gerrard, Blanton, et al., 1998; Gibbons, Gerrard, Ouelette, et al., 1998). Thus, the PWM is also an appropriate theoretical framework for developing prevention messages and interventions to address drowsy driving in young adults. In addition, the TPB's subjective norm construct indirectly recognizes the influence of social (inter-personal) influences behavior. This factor makes the TPB suitable for designing prevention messages and interventions related to individual behaviors with social dimensions such as drowsy driving, despite the TPB being an intra-personal behavioral theory.

2.2.2 Perceived Behavioral Control and Drowsy Driving

The concept of perceived behavioral control is closely associated with the concept of *self-efficacy* (Ajzen, 1991, 2002; Bandura, 1977, 1991). Perceived behavioral control relates to an individual's perception of the ease or difficulty with which he or she can perform a behavior and reflects both past experience and anticipated impediments and obstacles (Ajzen, 1991). Self-efficacy relates to an individual's belief in his or her capacity to perform behaviors that bring about specific desired outcomes and to influence events affecting his or her life (Bandura, 1977, 2004; McAlister et al., 2008; Strecher et al., 1986); it reflects confidence in one's ability to exert control over his or her own motivation, behavior, and social environment (Bandura, 1977, 1991, 2004). As mentioned previously, perceived behavioral control reflects a person's perceptions of the presence or absence of facilitators and barriers to perform a particular behavior (*control beliefs*) weighted by the person's perception of the power of these facilitators or barriers to influence performance of the behavior. Furthermore, according to the TPB, perceived behavioral control may be a direct predictor of behaviors for which perceived control can serve as a proxy for actual control over performance of the behavior (Ajzen, 2006).

Conner and Armitage have argued that although past behavior does not cause subsequent behavior, "frequent performance of a behaviour may bring subsequent behaviour under the control of habitual processes and make subsequent performance more likely" (1998, p. 1436). Elliott and colleagues (2003) reported empirical support for this argument from their study of 598 licensed drivers in the United Kingdom, in which they found that past behavior moderated the perceived behavioral control–behavioral intention and perceived behavioral control–future behavior relationships, with both relationships decreasing in strength with increasing frequency of past behavior. According to Elliott and colleagues, these findings were consistent with the theory that future behavior is based less on conscious processes (*e.g.*, perceived behavioral control) and more on automatic processes (*e.g.*, by habit) when the behavior is performed frequently in the past.

Perceptions of control emerged as a particularly prominent construct from the recent studies of the TPB and PWM in drowsy driving contexts. Lee and Beck (Lee et al., 2016) found that perceived behavioral control was the strongest predictor of both drowsy driving intentions ($\beta > 0.33$, $p < .001$) and willingness ($\beta > 0.37$, $p < .001$) in U.S. university students, while Jiang et al. (2017) found that perceived behavioral control ($\beta > 0.225$, $p < .01$) was the second strongest predictor of drowsy driving behavior after intentions ($\beta > 0.326$, $p < .001$) in Chinese drivers. More recently, Lee and Beck reported qualitative research indicating that many U.S. college students are willing to drive drowsy in part because insufficient sleep is a common facet of their lives over which they feel they have little control (Beck et al., 2018). These students viewed drowsy driving as a form of impaired driving over which they had little control and which they perceived as relatively common and non-risky from a personal liability and safety standpoint. Furthermore, these students appeared to be more willing to engage in drowsy driving compared

with other forms of impaired driving, especially if they felt that they could effectively cope with driving while drowsy. This may explain why these students were skeptical about the effectiveness of drowsy driving prevention messages built on the theme that one is not as good a driver when drowsy. These findings suggest that targeting perceptions of behavioral control alone may not be the best messaging strategy for drowsy driving prevention in young adults.

2.2.3 Drowsy Driving Risk Perception

In addition to the TPB and PWM constructs, an individual's perception of risk has been recognized as a cognitive influence on drowsy driving intention and behavior. Risk perception concerning driving behavior refers to "the subjective experience of risk in potential traffic hazards" (Deery, 1999, p. 226). Perceived risk has been found to mediate the relationship between gender and drowsy driving intention (Fernandes et al., 2010) and age differences in self-reports of continuing to drive while sleepy (Watling et al., 2014). U.S. college students also have reported being willing to drive drowsy in part because they perceived the consequences of failing to meet various personal obligations (*e.g.*, getting to school or work on time) to be more tangible, immediate, and probable compared to the consequences of a car crash or legal sanctions resulting from driving drowsy (Beck et al., 2018).

Risk perception has long been recognized as a predictor of various risk behaviors (Brewer et al., 2007; Brewer et al., 2004), including those related to driving (Deery, 1999; Hatfield & Fernandes, 2009; Machin & Sankey, 2008; Trivedi & Beck, 2018) and has been incorporated into a number of behavior theories (Glanz et al., 2008; Noar & Zimmerman, 2005). Most of these theories have conceptualized risk perception as having at least two primary dimensions: *perceived likelihood* or *probability*, which is the probability that one will be harmed by a hazard; and *perceived severity*, which is the extent of harm a hazard would cause (Brewer et

al., 2007). The PWM captures these dimensions in its outcome-focused conceptualization of attitudinal factors such that "the less danger or the less likelihood of negative outcome an individual associates with a particular risk behavior, the more willing he or she is to engage in that behavior" (Gibbons, Gerrard, Blanton, et al., 1998, p. 1165; Gibbons, Gerrard, Ouelette, et al., 1998).

2.2.4 Mediational Role of Drowsy Driving Risk Perception

Researchers from several fields have found that perceptions of control and self-efficacy are closely related to perceptions of risk concerning various risk behaviors. For example, Krueger and Dickson (1994) found that in the field of business management and administration, an increase in perceived self-efficacy decreases perceived risk, which in turn increases risk-taking behavior. Similarly, researchers of optimistic bias [*i.e.*, the tendency of individuals to believe that their risk of adverse events happening to them is less than that of their peers (Weinstein, 1980)] have found that the greater control people perceive over the outcome of a future event, the greater their optimistic bias for that event (Klein & Helweg-Larsen, 2002). In a more recent study of various risk behaviors in college students in the Netherlands, Nordgren and colleagues (2007) distinguished between two types of perceived control over risk behavior: *volition*, or command over exposure to a risk, which reflects whether the risk is one that people can willingly avoid; and *control*, or command over the outcome of a risk, which reflects people's ability to prevent negative outcomes once the risk behavior has been initiated. These European researchers found that perceived control decreased perceived risk while volition increased perceived risk through the mediating role of anticipated regret (Nordgren et al., 2007).

In the context of risky driving behavior in young people, Chan and colleagues (2010) have reported empirical support for their theory that a young driver's *sense of invulnerability to*

danger (*i.e.*, a person's over-optimistic perception that he or she is less vulnerable than others to danger) undermines the driver's *sense of perceived risk* and expectations of negative consequences of a risky driving behavior, thereby resulting in less negative attitudes toward the behavior, overestimation of perceived behavioral control, and greater intention to perform the behavior in question. Based on this research, Lee and Beck hypothesized in their previous study of U.S. university students that drowsy driving intention and willingness would be positively associated with perceived behavioral control and negatively associated with risk perception (Lee et al., 2016). Although Lee and Beck observed most of these hypothesized associations in their study, they also unexpectedly observed positive associations between intentions and risk perception. Furthermore, Lee and Beck observed negative but non-significant correlations between willingness and risk perception, and small but significant negative correlations between perceived behavioral control and risk perception. From these empirical findings, Lee and Beck surmised that elevated perceived behavioral control negates or attenuates either: (1) a person's perceived risk regarding drowsy driving behavior; or (2) the impact of perceived risk on intention to engage in drowsy driving behavior. Lee and Beck found additional support for these suppositions in their qualitative findings that young adult university students minimize the personal and legal risks of drowsy driving, fail to recognize when they are in a state of drowsiness and cannot drive safely, and overestimate their ability to drive safely even when they know they are drowsy (Beck et al., 2018).

To better understand the relationships involving perceived behavioral control, risk perception, intentions, and willingness in the context of drowsy driving behavior, Lee and Beck analyzed questionnaire data collected from 497 UMCP students to assess the hypotheses that perceived risk concerning drowsy driving behavior (*i.e.*, "Drowsy Driving Risk Perception")

mediates both: (1) the relationship between perceived behavioral control and intentions concerning drowsy driving behavior; and (2) the relationship between perceived behavioral control and willingness concerning drowsy driving behavior (Lee & Beck, 2019). This study found moderate to strong negative correlations between perceived risk and perceived behavioral control, intention, and willingness related to drowsy driving behavior ($|r| > 0.4$, $p < .05$ for all bivariate correlations). Furthermore, this study provided substantial evidence that drowsy driving risk perception partially mediates the relationship between perceived control and drowsy driving willingness (Sobel test: $4.08 \leq z\text{-score} \leq 5.38$, $p < .001$ for all three drowsy driving situations examined), as well as some evidence that drowsy driving risk perception partially mediates the relationship between perceived control and drowsy driving intention (Sobel test: z-score = 2.41, $p = .016$ for one drowsy driving situation examined). Based on the stronger findings relating to behavioral willingness compared to behavioral intention in this study, Lee and Beck concluded that willingness is a more relevant psychosocial antecedent (compared to intentions) of drowsy driving behavior among young adult university students. This conclusion is consistent with previous research demonstrating that younger people have a higher propensity to engage in non-deliberate, unplanned decision-making related to risky driving behavior compared to older people (Hatfield & Fernandes, 2009; Rivis et al., 2011).

2.3 Conceptual Framework: Reducing Drowsy Driving Intentions, Willingness, and Behavior through Messaging Strategies Targeting Drowsy Driving-Related Perceptions of Control and Risk

Constructs from the Theory of Planned Behavior (TPB) and Prototype Willingness Model (PWM) and their relationship with risk perception provided the theoretical basis for the conceptual framework for this dissertation (Appendix 2, Figure 1.3). According to this framework, young adult drivers exposed to anti-drowsy driving messages specifically designed

to lower perceptions of behavioral control regarding drowsy driving behavior would perceive heightened risk regarding drowsy driving, which in turn would reduce their intentions and willingness to drive drowsy in the future and ultimately their actual future drowsy driving behavior.

Based on the aforementioned conceptual framework, this dissertation pursued two lines of inquiry to explore the research aims and hypotheses set forth in Section 1.2.

Chapter 3: Methods

3.1 Study Design

The efficacy of interventional anti-drowsy driving messaging strategies designed to influence perceptions of control and risk related to drowsy driving behavior was assessed using a four-arm randomized controlled trial (RCT) as summarized in Appendix 3, Figure 3.1 (Study #1). Study participants were randomized either into a *Factual Messaging Group* (*i.e.*, exposed to an interventional messaging strategy that emphasizes messages that *only* provide factual, knowledge-based information about drowsy driving and its dangers and about drowsy driving countermeasures) or one of three *Intervention Messaging Groups* (*i.e.*, a *Perceived Behavioral Control ("PBC") Messaging Group* targeting *only* perceptions of control related to drowsy driving, a *Perceived Risk ("Risk") Messaging Group* targeting *only* perceptions of risk related to drowsy driving, *or* a *Perceived Behavioral Control + Risk ("PBC+Risk") Messaging Group* exposed to an interventional messaging strategy that emphasizes messages targeting *both* perceptions of control and risk related to drowsy driving). All messages and questionnaires (see Appendices 1a and 1b) were administered to participants using an internet-based platform developed with Qualtrics® (Provo, UT, 2019). Randomization was achieved using the *Randomizer* function in Qualtrics.

Background information and baseline measurements were collected from all participants before receiving their respective messaging intervention. After receiving their messaging intervention, participants were asked to summarize the key points in the PSAs and to share their reactions and impressions as to the quality of the content and delivery of the messaging intervention they received. Post-intervention measurements also were collected at this time ("*immediate post-intervention follow-up"*). Before ending the initial study day intervention

session, participants were invited to provide their personal feedback and opinions about the content of the intervention messages they viewed, and to provide their contact information if they would like to participate in an additional round of post-intervention measurements approximately 30 days later ("*30-day post-intervention follow-up*").

3.2 Population to be Studied and Sampling Procedure

Young adult drivers between the ages of 18 and 25 years in the U.S. were the focus population for this study. Consequently, study participants were recruited from the undergraduate and graduate student bodies at the University of Maryland, College Park (UMCP) and were individuals between the ages of 18 and 25 years, inclusive, who drove at least once a month. Ineligibility criteria included visual or hearing disabilities and inability to read, understand, or communicate in English. Recruitment efforts consisted of announcements disseminated through UMCP-affiliated websites and social media sites (primarily websites and social media channels associated with UMCP schools, departments, or programs), with permission of these UMCP units; campus e-mail lists administered by individual UMCP schools, departments, or programs (with permission of these UMCP units), as well as targeted e-mail groups created by the UMCP Office of the Registrar at the request of the Student Investigator; flyers posted around the UMCP campus; and large UMCP lecture classes and their affiliated Canvas sites.

Per calculations using G*Power 3.1 (Faul et al., 2007), a difference of 0.2 standard deviation units in measurements of drowsy driving-related perceptions of control and risk, intentions, willingness, and behavior between the control and messaging groups using factorial repeated measures ANOVA (assuming a .35 correlation among repeated measures) could be detected with 80 percent power and a probability level of .05 if a total of 188 participants (47 per

group) were recruited for the RCT. By contrast, assuming a .35 correlation among repeated measures, an effect size of 0.5 could be detected with 80 percent power and a probability level of .05 if a total of 36 participants (9 per group) could be recruited for this study. Assuming a .50 correlation among repeated measures, 212 subjects would have to be recruited to detect an effect size of .2 with 80 percent power and a probability level of .05. Assuming the desired effect size to be detected in this study was 0.2 and in anticipation of a .35 correlation among repeated measures, a manipulation check failure rate of ~25 percent, and an attrition rate of ~15 percent, a *minimum of* 300 participants (75 per group) were recruited for this study (see also Appendix 3, Figure 3.1). This target sample size was consistent with other reported studies that have applied the TPB and PWM to impaired or distracted driving behaviors in young drivers (Chan et al., 2010; Nemme & White, 2010; Rivis et al., 2011; Zhou et al., 2009).

As an incentive to participate in this study, participants who completed the initial study day intervention session (including the baseline and immediate post-intervention follow-up questionnaires) had the opportunity to enter into a random (raffle) drawing to receive one of fifteen $10 electronic gift cards from a small selection of retailers (*e.g.*, Amazon, Starbucks Coffee, Apple). Assuming that the minimum target sample size of 300 participants was achieved, the odds of a participant winning a gift card after the initial study day session would be approximately 1 in 20. Furthermore, participants who completed the 30-day post-intervention follow-up questionnaire had the opportunity to make additional entries into the raffle to triple their chances of winning a gift card.

3.3 Study Protocol

3.3.1 Data Collection

Study participants were directed to a Qualtrics-developed website through which the messaging intervention was delivered and relevant study data were collected. After reading a disclosure statement on the website landing page and providing implied informed consent by continuing the study, participants were asked to complete an initial questionnaire designed to collect background information about participant demographics and driving habits, as well *baseline* measurements of their drowsy driving-related perceived behavioral control, risk perception, and behavior in the past 30 days and in their lifetime (see Appendix 1a). After receiving their messaging intervention (see Section 3.3.2), participants were asked to complete an *immediate post-intervention follow-up* questionnaire designed to measure their drowsy driving-related perceptions of control and risk, intentions, and willingness. The immediate post-intervention follow-up questionnaire also asked participants to summarize the key points of the messaging interventions they viewed as a way to verify and evaluate the extent to which the participant successfully received their assigned messaging intervention. At *30-day post-intervention follow-up*, interested participants were asked once again to complete an internet-based questionnaire designed to measure their drowsy driving-related perceptions of control and risk, intentions, willingness, and behavior in the past 30 days (see Appendix 1b). All administered questionnaires were designed to take participants 20 to 25 minutes to complete and used previously validated scale-based measures of the constructs of interest for this study (see Section 3.4).

3.3.2 Messaging Interventions

Messaging interventions consisted of two components: (1) a 90-second online English language educational video presenting factual, knowledge-based information about drowsy driving, its dangers, and effective countermeasures against it; and (2) a 2- to 2.5-minute video-recorded slide presentation with audio in English designed to influence the participant's perceptions of control, risk, or both control and risk related to drowsy driving behavior. The face and content validity of these messaging interventions were reviewed by a number of experts knowledgeable in the fields of traffic safety, health risk communication, strategic communications, and drowsy driving (see Appendix 4). This approach aimed at ensuring that the content of the messaging interventions reflected current concepts, understanding, and recommendations regarding drowsy driving behavior and its psychosocial antecedents that are relevant to young adult drivers.

Before the RCT was launched, each messaging intervention was pilot-tested with at least 7 individuals primarily under the age of 30 years who drove at least once a month (for a total pilot-testing sample of $N = 33$). These pilot-testing individuals viewed one of the messaging interventions and completed the questionnaire items described in Section 3.4**.** Individuals who participated in the pilot-testing were not excluded from participating in the RCT if they met the RCT's eligibility requirements. The pilot-testing data were not combined with the RCT data or otherwise included in the final dataset used for analysis in this dissertation.

All messaging interventions were delivered to study participants using Qualtrics. Each participant was randomly assigned to a single messaging group using the *Randomizer* function in Qualtrics. All participants viewed the same 90-second knowledge-based drowsy driving education video before receiving the video-recorded slide presentation designed for their

assigned messaging group. *Factual Messaging Group* participants received a video presentation that provided additional factual, knowledge-based information about drowsy driving, its dangers, and effective countermeasures against it. *PBC Messaging Group* participants received a video presentation designed to lower perceptions of control related to drowsy driving. *Risk Messaging Group* participants received a video presentation designed to heighten perceptions of risk related to drowsy driving. *PBC+Risk Messaging Group* participants received a narrated slide presentation designed to lower perceptions of control *and* to heighten perceptions of risk related to drowsy driving. Hyperlinks to the Qualtrics pages and the messaging videos described in this section are provided in Appendix 5.

3.4 Measurement

Internet-based questionnaires were the primary instrument for collecting participant background data and quantitative measurements of the various cognitive constructs of interest in this study (see Appendices 1a and 1b).

3.4.1 Demographic Information and Driving Habits

Background information collected from study participants at baseline included age, gender, race and ethnicity, driving exposure (*i.e.*, years of driving experience, driving frequency, and annual miles driven), and past history of drowsy driving behavior (*i.e.*, in the past 30 days and in their lifetime). For details, see Appendix 1a, Part 1a**.**

3.4.2 Participant Feedback Regarding Messaging Interventions

To assess intervention dosage, participants were asked to summarize the key points in the messaging interventions they received in their respective messaging interventions. Participants were also asked to share their reactions and impressions as to the quality of the content and

delivery of the messaging intervention they received through a series of open-ended questions designed to elicit content-rich qualitative responses. For details, see Appendix 1a, Part 2.

3.4.3 Perceived Behavioral Control

Perceived behavioral control (PBC) was measured by calculating the mean score of three items, each rated on a 7-point unipolar scale ranging from 1 to 7, with higher mean scores indicating greater perceived control. The three items were:

> [Q12(a)] How much do you agree with the statement: "In general, I believe that I have the ability to drive while feeling drowsy or sleepy"? (*strongly disagree* to *strongly agree*).
>
> [Q12(b)] For me, driving while feeling drowsy or sleepy is ____. (*extremely difficult* to *extremely easy*).
>
> [Q12(c)] How much do you agree with the statement: "Whether or not I drive while feeling drowsy or sleepy is completely up to me"? (*strongly disagree* to *strongly agree*).

These items incorporated Ajzen's recommendations (1991, 2006, n.d.) and were modeled after questionnaire items used previously to assess the applicability of the TPB to a number of risky driving behaviors (Chan et al., 2010; Elliott et al., 2003; Nemme & White, 2010; Zhou et al., 2009). Variations of the first two PBC items were strongly correlated ($r > .65$, $p < .01$) in earlier studies of drowsy driving in university students (Lee & Beck, 2019; Lee et al., 2016). The third PBC item was added in this dissertation based on the rationale that a three-item scale would be an improvement from the two-item scale Lee and Beck used in their previous drowsy driving research. In the present RCT, the three PBC items demonstrated modest internal consistency at all three measurement timepoints (Cronbach's alpha ranging from .548 to .608).

3.4.4 Drowsy Driving Risk Perception

Drowsy driving risk perception was measured by calculating the mean score of three items, each rated on a 7-point unipolar scale ranging from 1 to 7 (*extremely unlikely* to *extremely likely*), with higher mean scores indicating greater perceptions of risk. The three items were:

> [Q13(a)] If you were driving drowsy, how likely is it that you will crash your car into something?
>
> [Q13(b)] If you were driving drowsy, how likely is it that you will drive in an unsafe manner?
>
> [Q13(c)] If you were driving drowsy, how likely is it that you will injure yourself or others?

These items were adapted from those used by researchers who have investigated young peoples' risk perceptions of numerous risky driving behaviors (Lee et al., 2016; Lucidi et al., 2006; Zhou et al., 2009), as well as other risk behaviors (Nordgren et al., 2007), and are phrased in a way that elicits subjective global evaluations of the probability of outcomes and the perceived severity of these outcomes. Variations of these three drowsy driving risk perception items demonstrated excellent internal consistency in earlier studies of drowsy driving in university students (Cronbach's alphas >.900). In the present RCT, the three Risk items also demonstrated excellent internal consistency at all three measurement timepoints (Cronbach's alpha > .900).

3.4.5 Drowsy Driving Intention

Drowsy driving intention was assessed by calculating the mean score of three items, each rated on a 7-point unipolar scale ranging from 1 to 7, with higher mean scores indicating greater intentions. The three items were:

[Q14(a)] In the next 30 days, how likely is it that you will drive while feeling drowsy or sleepy? (*extremely unlikely* to *extremely likely*).

[Q14(b)] In the next 30 days, do you intend to drive while feeling drowsy or sleepy? (*definitely not* to *definitely yes*).

[Q14(c)] In the next 30 days, how much will you try to avoid driving while feeling drowsy or sleepy? (*extremely little* to *extremely great*).

The third item was reverse scored before computing the mean item score. These items incorporated Ajzen's recommendations (1991, 2006, n.d.) and were modeled after questionnaire items used previously to assess the applicability of the TPB to a number of risky driving behaviors (Chan et al., 2010; Elliott et al., 2003; Nemme & White, 2010; Zhou et al., 2009). Variations of these three intention items demonstrated suitable internal consistency (Cronbach's alphas > .88) in earlier studies of drowsy driving in university students (Lee & Beck, 2019; Lee et al., 2016). In the present RCT, the three Intention items also demonstrated suitable internal consistency at all three measurement timepoints (Cronbach's alpha ≈ .700).

3.4.6 Drowsy Driving Willingness

Drowsy driving willingness was measured by presenting participants with a hypothetical scenario conducive to drowsy driving behavior[2] and then asking them to rate on a 7-point unipolar scale ranging from 1 (*extremely unwilling*) to 7 (*extremely willing*) their willingness to do the following if they were the driver in the situation presented: stop driving immediately to get some rest; drive a little further before stopping to get some rest; or continue driving until

[2] *Example:* "Suppose you are driving home at the end of the school year after getting very little sleep over the past 2 weeks due to final exams, term papers, packing your belongings, *etc.* As you drive, you find yourself having a hard time keeping your eyes open."

reaching their destination (Q15). The first item was reverse scored before computing a mean item score, with higher mean scores indicating greater willingness. This approach was adapted from that developed by Gibbons and colleagues to measure behavioral willingness in adolescents (Gerrard et al., 2008; Gerrard et al., 2005; Gibbons, Gerrard, Blanton, et al., 1998). Variations of these three willingness items demonstrated unacceptable internal consistency (Cronbach's alphas < .300) in earlier studies of drowsy driving in university students (Lee & Beck, 2019; Lee et al., 2016), although the Cronbach's alpha rose to acceptable levels (> .700) when the second willingness item was discarded (possibly because the "drive a little further" language of this item was more vague and non-specific compared to the language of the other two willingness items). In the present RCT, the three Willingness items demonstrated relatively poor internal consistency at all three measurement timepoints (Cronbach's alpha ranging from .369 to .671).

3.4.7 Drowsy Driving Behavior

Self-reported drowsy driving behavior was measured by asking participants to identify the number of times (episodes) they had engaged in the following three drowsy driving behaviors in the past 30 days:

> [Q16(a)] Driven a motor vehicle while being so drowsy or sleepy that [the participant] had a hard time keeping his or her eyes open.
>
> [Q16(b)] Fallen asleep or nodded off while driving a motor vehicle, even just for a second or two.
>
> [Q16(c)] Been involved in a motor vehicle crash that resulted from [the participant] driving while drowsy or asleep.

Participants were given four categorical response options for each drowsy driving behavior: *Never*, *1 Time*, *2 to 4 Times*, and *5 Times or More*. To allow for rank ordering, each of these

response categories were assigned a numerical score (0 = *Never*, 3 = *5 Times or More*). The scores for the three drowsy driving behaviors were added together to produce a composite score for self-reported drowsy driving behavior ranging from 3 to 12, with higher scores indicating greater experience with drowsy driving behavior. Alternatively, to allow for analysis using skewed data, the composite score for self-reported drowsy driving behavior was also regrouped into the following ordinal categories: *Never* (for composite cores of 3), *Rarely* (for composite scores ranging from 4 to 6), *Sometimes* (for composite scores ranging from 7 to 9), and *Frequent* (for composite scores ranging from 10 to 12).

3.5 Analysis Plan

Statistical analyses for both Studies #1 and #2 were performed using Version 29.0.2.0 of the IBM® SPSS® Statistics software for students and the .05 level to define statistical significance. Specific analysis plans for the two studies are presented in Chapters 4 and 5.

3.6 Ethical Issues

The complete protocol for this study was initially reviewed and approved by the Institutional Review Board (IRB) for the University of Maryland, College Park on August 2, 2023 (IRB Protocol #2074553-1). After finalization of the messaging interventions for the RCT, an amendment was submitted and approved by the IRB on April 9, 2024 (IRB Protocol #2074553-3). Images of both IRB approval letters are provided in Appendix 6.

All recruiting materials developed for this study informed the prospective participant of the purpose of the study, the procedures involved, steps taken to protect the participant's confidentiality, potential risks and benefits of participating in the study, eligibility information for the gift card drawing, the contact information of the Student Investigator, and the

participant's absolute right to withdraw from the study at any time for any reason without any detrimental consequences. Participants gave their online consent to participate in the study by completing the online questionnaire. A waiver of documented consent was granted by the IRB.

Chapter 4: Study #1 – Randomized Controlled Trial to Assess Efficacy of Anti-Drowsy Driving Messaging Strategies

4.1 Analysis Plan for Study #1

4.1.1 Assessing Between-Group Baseline Differences and Manipulation Checks

Baseline differences in drowsy driving-related perceptions of control and risk, intentions, willingness, and past behavior (all operationalized as continuous variables) across the four messaging groups were assessed using one-way analysis of variance (ANOVA) for normally distributed data and the Kruskal-Wallis H Test for non-normally distributed data. These baseline assessments were conducted to ensure that participants in all groups were similar with regard to the cognitive variables of interest prior to receiving the messaging intervention. Assuming no significant differences in these variables of interest existed between the groups at baseline, any differences observed between groups at the post-intervention follow-up points could be attributed to messaging (*i.e.*, intervention) effects.

Furthermore, in order to characterize the study sample more fully, between-group baseline differences were assessed with regard to demographic characteristics and driving habits. One-way ANOVA or the Kruskal-Wallis H Test was used to assess baseline differences in the characteristics and habits operationalized as continuous variables. Pearson's chi-square test was used to assess baseline differences in the characteristics and habits operationalized as categorical variables.

To ensure that messaging manipulations of perceptions of control and risk related to drowsy driving were successful, one-tailed paired sample *t*-tests (for normally distributed data) or the Wilcoxon Signed-Rank Test (for non-normally distributed data) was used to assess changes in drowsy driving-related perceptions of control and risk between baseline and

immediate post-intervention follow-up among participants in all four messaging groups. In the event that messaging manipulations were not universally successful between individual participants within a group, subsequent analyses were limited to the participants who successfully responded to the messaging manipulations.

4.1.2 Hypotheses 1 and 2: Changes at 30-Day Post-Intervention Follow-Up

Differences in drowsy driving-related perceptions of perceived behavioral control, risk perception, behavioral intentions, and behavioral willingness (all operationalized as continuous variables) across all four messaging groups at baseline, immediate post-intervention follow-up, and 30-day post-intervention follow-up were assessed using mixed repeated measures ANOVA and appropriate post-hoc tests for normally distributed data and the Kruskal-Wallis H Test for non-normally distributed data. Pearson's chi-square test was used to assess differences in drowsy driving-related behavior (when operationalized as an ordinal categorical variable) across all four messaging groups at 30-day post intervention follow-up.

4.2 Study #1 Results

4.2.1 Analysis of the Full Study Sample

Data collection for the RCT began on April 10, 2024 and continued until August 26, 2024. In total, 275 participants completed a messaging intervention and the initial study day questionnaire (63 in the Factual Messaging Group, 70 in the PBC Messaging Group, 74 in the Risk Messaging Group, 68 in the PBC+Risk Messaging Group). Demographic characteristics and descriptive statistics for the composite scores calculated from the scale-based measures of neurocognitive variables for the Study Sample are presented in Tables 4.1, 4.2a and 4.2b. No significant differences were observed across all four groups at baseline.

Table 4.1

Demographic and Driving Behavior Characteristics of the Study Sample

Characteristic	Study Sample ($N = 275$)	Factual Messaging Group ($n = 63$)	PBC Messaging Group ($n = 70$)	Risk Messaging Group ($n = 74$)	PBC+Risk Messaging Group ($n = 68$)	Baseline Comparisons
Age [*M* (SD)]	21.4 (1.89)	21.3 (1.77)	21.2 (1.82)	21.8 (1.94)	21.4 (1.97)	Kruskal-Wallis $H(3, N = 275) = 3.71$, $p = .294$
Gender [*n* (%)]						
Male	108 (39.3)	27 (42.9)	24 (34.3)	29 (39.2)	28 (41.2)	χ^2 (9, $N = 275$) = 7.51, $p = .584$
Female	163 (59.3)	35 (55.6)	45 (64.3)	43 (58.1)	40 (58.8)	
Transgender	3 (1.1)	1 (1.6)	0 (0.0)	2 (2.7)	0 (0.0)	
Different Term	1 (0.4)	0 (0.0)	1 (1.4)	0 (0.0)	0 (0.0)	
Race/Ethnicity [*n* (%)]						
American Indian or Alaska Native	4 (1.5)	0 (0.0)	2 (2.9)	0 (0.0)	2 (2.9)	χ^2 (18, $N = 275$) = 21.0, $p = .277$
Asian or Pacific Islander	92 (33.5)	20 (31.7)	17 (24.3)	24 (32.4)	31 (45.6)	
Black or African-American	33 (12.0)	10 (15.9)	7 (10.0)	11 (14.9)	5 (7.4)	
Hispanic or Latino	12 (4.4)	5 (7.9)	4 (5.7)	2 (2.7)	1 (1.5)	
White or Caucasian	103 (37.5)	21 (33.3)	32 (45.7)	27 (36.5)	23 (33.8)	
Two or More	24 (8.7)	4 (6.3)	6 (8.6)	8 (10.8)	6 (8.8)	
Other or Unknown	7 (2.5)	3 (4.8)	2 (2.9)	2 (2.7)	0 (0.0)	
Driving Experience, Years [*M* (SD)]	4.23 (1.96)[a]	4.10 (1.91)[b]	4.19 (2.06)[c]	4.49 (1.97)[b]	4.10 (1.88)[b]	Kruskal-Wallis $H(3, N = 269) = 1.62$, $p = .654$
Driving Frequency [*n* (%)]						
At least one a month	146 (53.1)	38 (60.3)	31 (44.3)	40 (54.1)	37 (54.4)	χ^2 (3, $N = 275$) = 3.56, $p = .311$
Every Day	129 (46.9)	25 (39.7)	39 (55.7)	34 (45.9)	31 (45.6)	

Characteristic	Study Sample (N = 275)	Factual Messaging Group (n = 63)	PBC Messaging Group (n = 70)	Risk Messaging Group (n = 74)	PBC+Risk Messaging Group (n = 68)	Baseline Comparisons
Annual Miles Driven [*n* (%)]						
Less than 5,000 miles	70 (25.5)	19 (30.2)	17 (24.3)	19 (25.7)	15 (22.1)	χ^2 (12, N = 272) = 7.50, p = .823
5,000 to 10,000 miles	112 (40.7)	20 (31.7)	31 (44.3)	29 (39.2)	32 (47.1)	
10,000 to 15,000 miles	55 (20.0)	12 (19.0)	15 (21.4)	14 (18.9)	14 (20.6)	
15,000 to 20,000 miles	25 (9.1)	6 (9.5)	5 (7.1)	8 (10.8)	6 (8.8)	
More than 20,000 miles	10 (3.6)	4 (6.3)	1 (1.4)	4 (5.4)	1 (1.5)	
Unknown/Missing	3 (1.1)	2 (3.2)	1 (1.4)	0 (0.0)	0 (0.0)	
Drowsy Driving Experience, Lifetime [*n* (%)]						
Never	48 (17.5)	12 (19.0)	7 (10.0)	16 (21.6)	13 (19.1)	χ^2 (9, N = 274) = 7.74, p = .560
Rarely	131 (47.6)	26 (41.3)	39 (55.7)	34 (45.9)	32 (47.1)	
Sometimes	83 (30.2)	23 (36.5)	19 (27.1)	21 (28.4)	20 (29.4)	
Frequent	12 (4.4)	2 (3.2)	5 (7.1)	2 (2.8)	3 (4.4)	
Unknown/Missing	1 (0.4)	0 (0.0)	0 (0.0)	1 (1.4)	0 (0.0)	

Note. Percentages may not add up to 100% because of rounding errors. n = Responses included in calculations of descriptive statistics; M = Mean; PBC = Perceived Behavioral Control; SD = Standard Deviation.

[a] Calculated with 6 missing cases. [b] Calculated with 1 missing case. [c] Calculated with 3 missing cases.

Table 4.2a

Descriptive Statistics for Neurocognitive Measures in the Study Sample

Variable	*n*	*M* (*SD*)	Median	Mode	Range (Min., Max.)	IQR (Q1, Q3)
Perceived Behavioral Control						
Baseline	275	3.60 (1.25)	3.6	4.00	5.33 (1, 6.33)	2.00 (2.67, 4.67)
Post-Intervention	273	3.42 (1.28)	3.33	3.33	5.67 (1, 6.67)	1.67 (2.67, 4.33)
30-Day Follow-Up	116	3.24 (1.25)	3.33	3.00	6 (1, 7)	1.33 (2.67, 4.00)
Risk Perception						
Baseline	275	4.09 (1.74)	4.33	5.00	6 (1, 7)	3 (2.67, 5.67)
Post-Intervention	273	4.67 (1.81)	5.00	7.00	6 (1, 7)	3.00 (3.00, 6.00)
30-Day Follow-Up	116	4.92 (1.58)	5.00	7.00	5.67 (1.33, 7)	2.33 (3.67, 6.00)
Behavioral Intention						
Baseline	275	2.35 (1.35)	2.00	1.00	5.67 (1, 6.67)	1.67 (1.33, 3.00)
Post-Intervention	273	2.12 (1.22)	1.67	1.00	6 (1, 7)	2.00 (1.00, 3.00)
30-Day Follow-Up	116	2.25 (1.14)	2.25	2.00	5.33 (1, 6.33)	1.67 (1.33, 3.00)
Behavioral Willingness						
Baseline	275	4.20 (1.25)	4.67	5	5.67 (1, 6.67)	1.67 (3.33, 5.00)
Post-Intervention	272	3.67 (1.32)	3.67	4.67	6 (1, 7)	2.00 (2.67, 4.67)
30-Day Follow-Up	116	3.82 (1.42)	4.00	4.33	5.33 (1, 6.33)	1.6 (3.08, 4.67)

Note. *n* = Responses included in calculations of descriptive statistics; *M* = Mean; *SD* = Standard Deviation; Max. = Maximum Value; Min. = Minimum Value; *IQR* = Interquartile Range; Q1 = 25th Percentile; Q3 = 75th Percentile.

Table 4.2b

Descriptive Statistics for Neurocognitive Measures in the Study Sample, by Messaging Group

Variable	Factual Messaging Group (n = 63)		PBC Messaging Group (n = 70)		Risk Messaging Group (n = 74)		PBC+Risk Messaging Group (n = 68)		Between-Group Comparisons (Kruskal-Wallis Test)
	n	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	
Perceived Behavioral Control									
Baseline	63	3.70 (1.26)	70	3.70 (1.25)	74	3.58 (1.29)	68	3.41 (1.20)	H = 2.47, p = .481
Post-Intervention	62	3.51 (1.25)	70	3.55 (1.21)	74	3.21 (1.37)	67	3.41 (1.25)	H = 2.31, p = .510
30-Day Follow-Up	23	2.99 (1.43)	30	3.14 (1.03)	30	3.33 (1.16)	33	3.45 (1.38)	H = 1.65, p = .648
Risk Perception									
Baseline	63	3.86 (1.80)	70	4.14 (1.65)	74	4.11 (1.85)	68	4.23 (1.65)	H = 1.33, p = .722
Post-Intervention	62	4.33 (1.97)	70	4.65 (1.68)	74	4.99 (1.73)	67	4.64 (1.85)	H = 4.37, p = .224
30-Day Follow-Up	23	4.77 (1.84)	30	5.07 (1.32)	30	5.07 (1.67)	33	4.75 (1.56)	H = 1.01, p = .799
Behavioral Intention									
Baseline	63	2.56 (1.46)	70	2.37 (1.28)	74	2.23 (1.36)	68	2.27 (1.32)	H = 2.66, p = .448
Post-Intervention	62	2.51 (1.57)	70	2.04 (1.01)	74	1.97 (1.12)	67	2.01 (1.11)	H = 3.96, p = .266
30-Day Follow-Up	23	2.49 (1.52)	30	2.24 (.844)	30	2.11 (1.13)	33	2.22 (1.13)	H = 1.15, p = .766
Behavioral Willingness									
Baseline	63	4.19 (1.18)	70	4.23 (1.17)	74	3.91 (1.46)	68	4.48 (1.12)	H = 4.78, p = .189
Post-Intervention	62	3.64 (1.39)	69	3.82 (1.35)	74	3.35 (1.36)	67	3.84 (1.13)	H = 5.60, p = .133
30-Day Follow-Up	23	3.57 (1.46)	30	3.80 (1.27)	30	3.86 (1.63)	33	3.98 (1.34)	H = 1.16, p = .762

Note. n = Responses included in calculations of descriptive statistics; M = Mean; PBC = Perceived Behavioral Control; SD = Standard Deviation.

Changes in PBC, risk, intentions, and willingness over the course of the efficacy trial for all four messaging groups are presented in Figures 4.1a through 4.1d. PBC, intentions, and willingness generally decreased and perceptions of risk generally increased between baseline and immediate post-intervention follow-up and between baseline and 30-day follow-up in all four groups. Perceptions of risk increased significantly from baseline to immediate post-intervention follow-up in all four groups (Wilcoxon Signed-Rank Test, $z = -2.82$, $p = .005$ for the Factual Messaging Group, $z = -3.01$, $p = .003$ for the PBC Messaging Group, $z = -5.04$, $p < .001$ for the Risk Messaging Group, and $z = -2.93$, $p = .003$ for the PBC+Risk Messaging Group). The increase in risk perceptions from baseline to immediate post-intervention follow-up in the Risk Messaging Group was significantly greater than the increase in the Factual Messaging Group (Mann-Whitney U Test comparing Risk change scores, $U = 1742.0$, $z = -2.44$, $p = .015$). By contrast, PBC only decreased significantly from baseline to immediate post-intervention follow-up in the Risk Messaging group (Wilcoxon Signed-Rank Test, $z = -3.37$, $p < .001$), indicating that the messages targeting PBC did not have a significant impact on PBC in all participants.

Figure 4.1a

Perceived Behavioral Control (PBC) measures at Baseline (Time 1), Immediate Post-Intervention Follow-Up (Time 2), and 30-Day Post-Intervention Follow-Up (Time 3) by Messaging Group

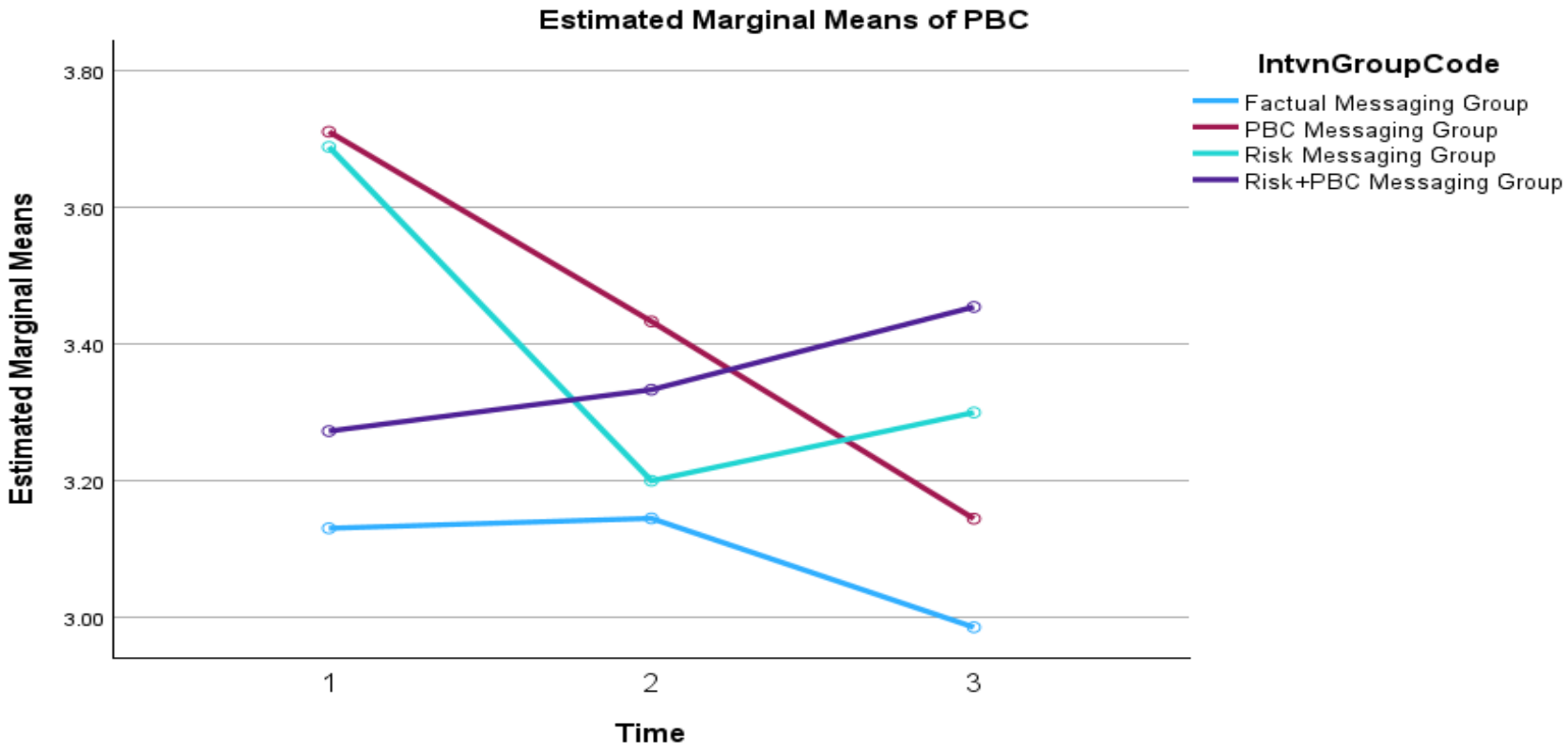


Figure 4.1b

Risk perception measures at Baseline (Time 1), Immediate Post-Intervention Follow-Up (Time 2), and 30-Day Post-Intervention Follow-Up (Time 3) by Messaging Group

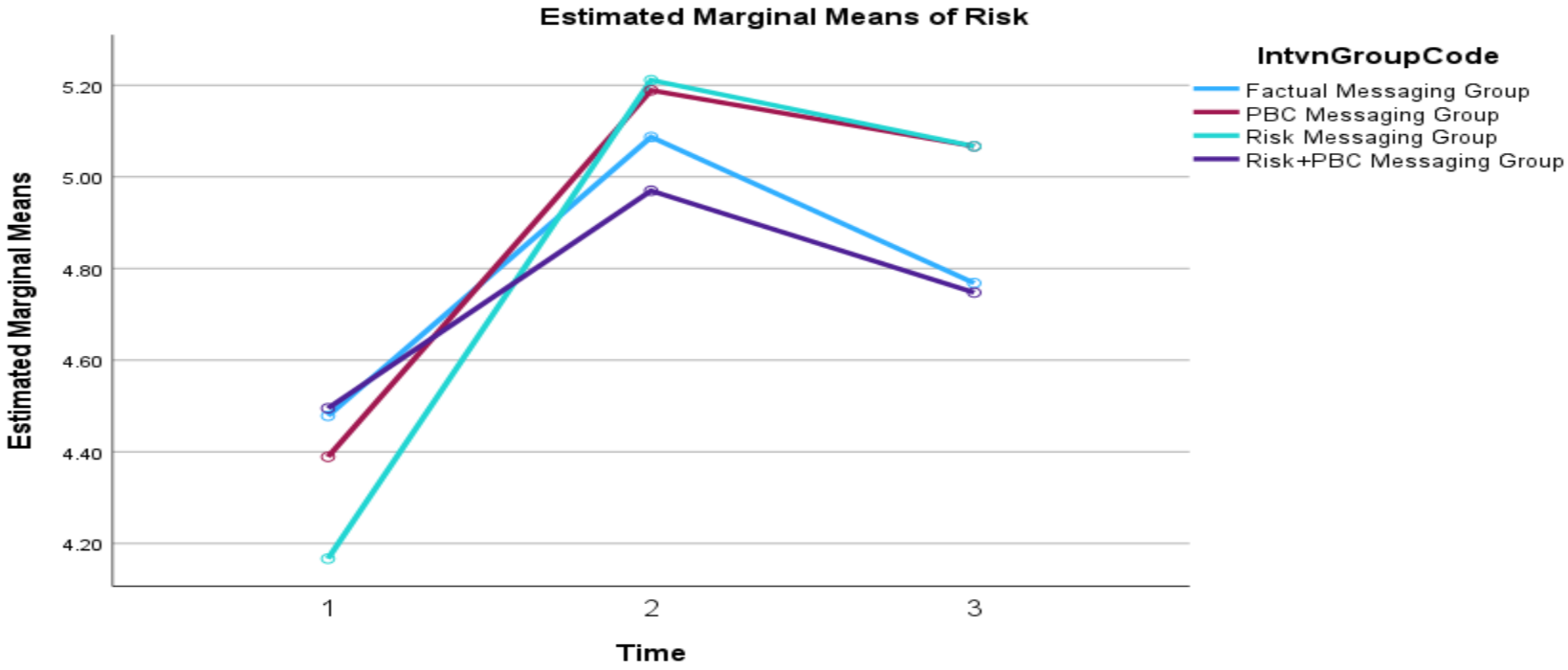


Figure 4.1c

Behavioral Intention measures at Baseline (Time 1), Immediate Post-Intervention Follow-Up (Time 2), and 30-Day Post-Intervention Follow-Up (Time 3) by Messaging Group

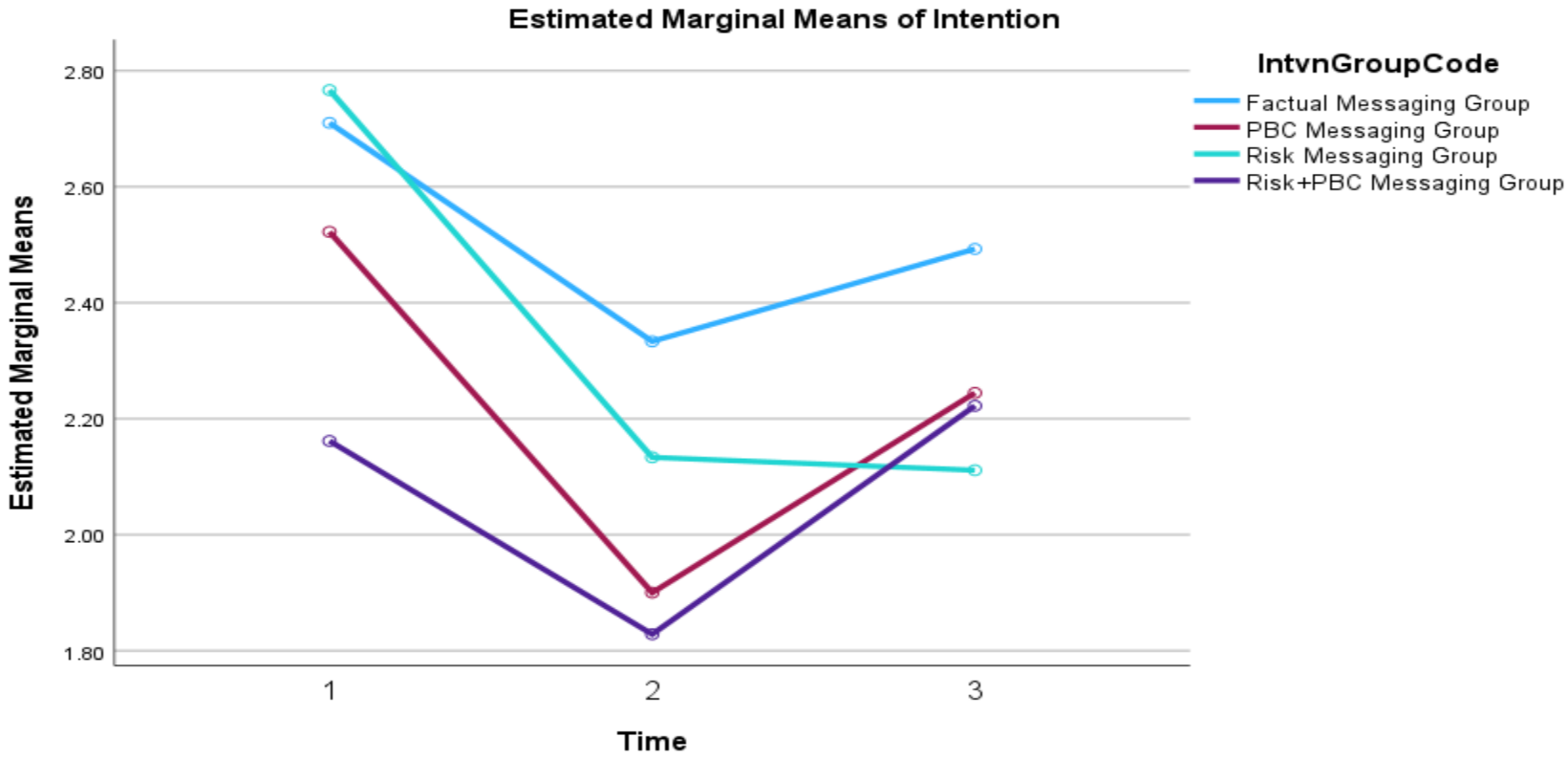
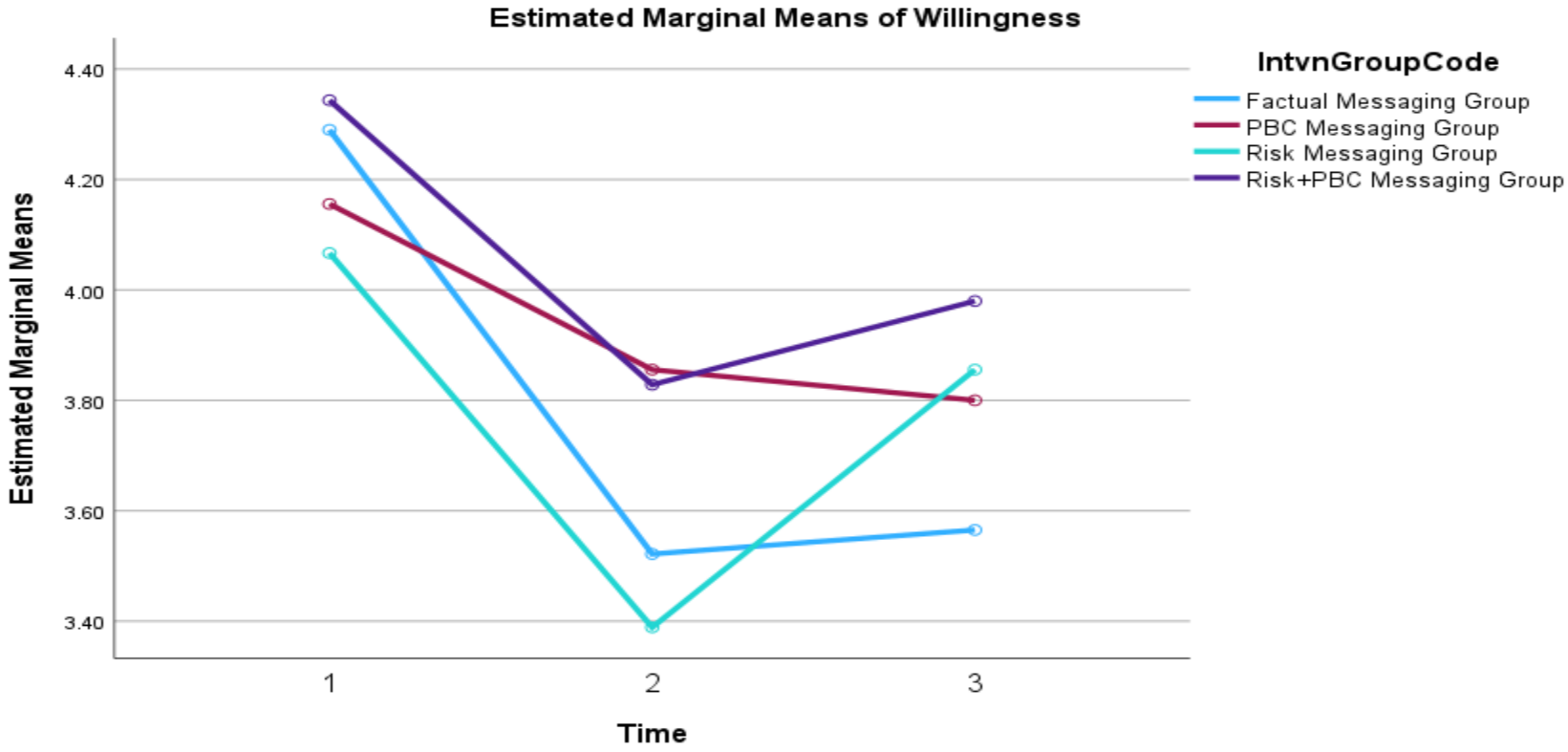


Figure 4.1d

Behavioral Willingness measures at Baseline (Time 1), Immediate Post-Intervention Follow-Up (Time 2), and 30-Day Post-Intervention Follow-Up (Time 3) by Messaging Group



4.2.2 Analysis of the Subsample of Successfully Manipulated Cases

Because messaging manipulations were not universally successful between individual participants within the PBC, Risk and PBC+Risk Messaging Groups, subsequent analyses were limited to the participants who successfully responded to the messaging manipulations. Members of the PBC Messaging Group were considered successfully manipulated if they their raw PBC scores decreased from baseline immediately after receiving the intervention (*i.e.*, from Time 1 to Time 2 in Figure 4.1a), while members of the Risk Messaging Group were considered successfully manipulated if their raw Risk scores increased from baseline immediately after receiving the intervention (*i.e.*, from Time 1 to Time 2 in Figure 4.1b). Members of the PBC+Risk Messaging Group were considered successfully manipulated if their raw PBC scores decreased and their raw Risk scores increased from baseline immediately after receiving the intervention.

Based on these criteria, a total of 88 participants across the PBC (n = 29), Risk (n = 47), and PBC+Risk Messaging Groups (n = 12) were considered successfully manipulated. Together with the 63 participants in the Factual Messaging Group, a total of 151 participants remained in the RCT dataset. Due to loss of follow-up 30 days after the initial study day, a total of 66 subjects (23 in the Factual Messaging Group, 14 in the PBC Messaging Group, 22 in the Risk Messaging Group, 7 in the PBC+Risk Messaging Group) were included in the final analysis for the efficacy trial. Demographic characteristics and descriptive statistics for the composite scores calculated from the scale-based measures of neurocognitive variables for the subsample of successfully manipulated cases are presented in Tables 4.3 and 4.4. No significant differences were observed across all four groups at baseline among the successfully manipulated cases, with

the exception of perceived risk at immediate post-intervention follow-up (Kruskal-Wallis H(3, N = 150) = 10.1, $p < .05$).

Table 4.3

Demographic and Driving Behavior Characteristics of the Subsample of Successfully Manipulated Cases

Characteristic	Manipulated Cases Subsample (N = 151)	Factual Messaging Group (n = 63)	PBC Messaging Group (n = 29)	Risk Messaging Group (n = 47)	PBC+Risk Messaging Group (n = 12)	Between Group Comparisons
Age [*M* (SD)]	21.6 (1.82)	21.3 (1.77)	21.4 (1.94)	21.9 (1.71)	22.6 (1.93)	Kruskal-Wallis H(3, N = 151) = 6.29, p = .098
Gender [*n* (%)]						
Male	64 (42.4)	27 (42.9)	14 (48.3)	18 (38.3)	5 (41.7)	χ^2 (6, N = 151) = 2.63, p = .853
Female	84 (55.6)	35 (55.6)	15 (51.7)	27 (57.4)	7 (58.3)	
Transgender	3 (2.0)	1 (1.6)			0 (0.0)	
Different Term	0 (0.0)	0 (0.0)			0 (0.0)	
Race/Ethnicity [*n* (%)]						
American Indian or Alaska Native	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	χ^2 (15, N = 155) = 12.6, p = .635
Asian or Pacific Islander	49 (32.5)	20 (31.7)	10 (34.5)	13 (27.7)	6 (50.0)	
Black or African-American	23 (15.2)	10 (15.9)	4 (13.8)	8 (17.0)	1 (8.3)	
Hispanic or Latino	7 (4.6)	5 (7.9)	0 (0.0)	2 (4.3)	0 (0.0)	
White or Caucasian	60 (39.7)	21 (33.3)	15 (51.7)	19 (40.4)	5 (41.7)	
Two or More	8 (5.3)	4 (6.3)	0 (0.0)	4 (8.5)	0 (0.0)	
Other or Unknown	4 (2.6)	3 (4.8)	0 (0.0)	1 (2.1)	0 (0.0)	
Driving Experience, Years [*M* (SD)]	4.25 (1.96)[a]	4.10 (1.91)[b]	4.02 (2.44)[c]	4.51 (1.81)	4.58 (1.69)	Kruskal-Wallis H(3, N = 148) = 3.95, p = .266

Characteristic	Manipulated Cases Subsample (N = 151)	Factual Messaging Group (n = 63)	PBC Messaging Group (n = 29)	Risk Messaging Group (n = 47)	PBC+Risk Messaging Group (n = 12)	Between Group Comparisons
Driving Frequency [*n* (%)]						
At least one a month	84 (55.6)	38 (60.3)	15 (51.7)	25 (53.2)	6 (50.0)	χ^2 (3, N = 151) = 1.01, p = .799
Every Day	67 (44.4)	25 (39.7)	14 (48.3)	22 (46.8)	6 (50.0)	
Annual Miles Driven [*n* (%)]						
Less than 5,000 miles	39 (25.8)	19 (30.2)	4 (13.8)	13 (27.7)	3 (25.0)	χ^2 (12, N = 149) = 8.52, p = .743
5,000 to 10,000 miles	58 (38.4)	20 (31.7)	15 (51.7)	18 (38.3)	5 (41.7)	
10,000 to 15,000 miles	33 (21.9)	12 (19.0)	8 (27.6)	10 (21.3)	3 (25.0)	
15,000 to 20,000 miles	14 (9.3)	6 (9.5)	2 (6.9)	5 (10.6)	1 (8.3)	
More than 20,000 miles	5 (3.3)	4 (6.3)	0 (0.0)	1 (2.1)	0 (0.0)	
Unknown/Missing	2 (1.3)	2 (3.2)		0 (0.0)	0 (0.0)	
Drowsy Driving Experience, Lifetime [*n* (%)]						
Never	26 (17.2)	12 (19.0)	2 (6.9)	9 (19.1)	3 (25.0)	χ^2 (9, N = 150) = 8.27, p = .507
Rarely	71 (47.0)	26 (41.3)	16 (55.2)	23 (48.9)	6 (50.0)	
Sometimes	47 (31.1)	23 (36.5)	8 (27.6)	13 (27.7)	3 (25.0)	
Frequent	6 (4.0)	2 (3.2)	3 (10.3)	1 (2.1)	0 (0.0)	
Unknown/Missing	1 (0.7)	0 (0.0)	0 (0.0)	1 (2.1)		

Note. Percentages may not add up to 100% because of rounding errors. n = Responses included in calculations of descriptive statistics; M = Mean; PBC = Perceived Behavioral Control; SD = Standard Deviation.

[a] Calculated with 3 missing cases. [b] Calculated with 1 missing case. [c] Calculated with 2 missing cases.

Table 4.4

Descriptive Statistics for Neurocognitive Measures Among Successfully Manipulated Cases, by Messaging Group

Variable	Factual Messaging Group (n = 63)		PBC Messaging Group (n = 29)		Risk Messaging Group (n = 47)		PBC+Risk Messaging Group (n = 12)		Between Group Comparisons (Kruskal-Wallis Test)
	n	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	
Perceived Behavioral Control									
Baseline	63	3.70 (1.26)	29	4.23 (1.21)	47	3.65 (1.21)	12	3.72 (1.32)	H = 4.51, p = .211
Post-Intervention	62	3.51 (1.25)	29	3.15 (1.04)	47	3.15 (1.35)	12	2.83 (1.31)	H = 4.20, p = .241
30-Day Follow-Up	23	2.99 (1.43)	14	3.10 (1.16)	22	3.11 (1.19)	7	2.48 (1.17)	H = 1.44, p = .697
Risk Perception									
Baseline	63	3.86 (1.80)	29	4.00 (1.74)	47	3.75 (1.72)	12	4.25 (1.74)	H = 0.79, p = .852
Post-Intervention	62	4.33 (1.97)	29	4.64 (1.78)	47	5.31 (1.46)	12	5.72 (1.33)	H = 10.1, p = .017
30-Day Follow-Up	23	4.77 (1.84)	14	5.24 (1.14)	22	5.45 (1.46)	7	5.90 (0.85)	H = 2.78, p = .426
Behavioral Intention									
Baseline	63	2.56 (1.46)	29	2.87 (1.46)	47	2.39 (1.43)	12	2.17 (1.31)	H = 3.29, p = .349
Post-Intervention	62	2.51 (1.57)	29	2.22 (1.12)	47	1.94 (1.06)	12	1.67 (0.77)	H = 4.90, p = .180
30-Day Follow-Up	23	2.49 (1.52)	14	2.29 (0.97)	22	2.05 (1.15)	7	2.19 (1.43)	H = 1.11, p = .776
Behavioral Willingness									
Baseline	63	4.19 (1.18)	29	4.16 (1.12)	47	3.95 (1.44)	12	4.50 (1.37)	H = 1.65, p = .649
Post-Intervention	62	3.64 (1.39)	29	3.40 (1.46)	47	3.26 (1.32)	12	3.83 (1.06)	H = 3.23, p = .357
30-Day Follow-Up	23	3.57 (1.46)	14	3.57 (1.30)	22	3.68 (1.73)	7	3.43 (1.67)	H = 0.25, p = .969

Note. n = Responses included in calculations of descriptive statistics; M = Mean; PBC = Perceived Behavioral Control; SD = Standard Deviation.

Table 4.5a

Drowsy Driving Behavior at 30-Day Follow-Up in the Study Sample

Characteristic	Study Sample (N = 275)	Factual Messaging Group (n = 63)	PBC Messaging Group (n = 70)	Risk Messaging Group (n = 74)	PBC+Risk Messaging Group (n = 68)	Between-Group Comparisons
Drowsy Driving Experience, 30-Day Post-Intervention Follow-Up [*n* (%)]						
Never	78 (28.4)	14 (22.2)	26 (37.1)	18 (24.3)	20 (29.4)	χ^2 (6, N = 116) = 8.18, p = .225
Rarely	29 (10.5)	7 (11.1)	2 (2.9)	9 (12.2)	11 (16.2)	
Sometimes	9 (3.3)	2 (3.2)	2 (2.9)	3 (4.1)	2 (2.9)	
Frequent	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Unknown/Missing	159 (57.8)	40 (63.5)	40 (57.1)	44 (59.5)	35 (51.5)	

Table 4.5b

Drowsy Driving Behavior at 30-Day Follow-Up in the Subsample of Successfully Manipulated Cases

Characteristic	Manipulated Cases Subsample (N = 151)	Factual Messaging Group (n = 63)	PBC Messaging Group (n = 29)	Risk Messaging Group (n = 47)	PBC+Risk Messaging Group (n = 12)	Between-Group Comparisons
Drowsy Driving Experience, 30-Day Post-Intervention Follow-Up [*n* (%)]						
Never	46 (30.5)	14 (22.2)	13 (44.8)	13 (27.7)	6 (50.0)	χ^2 (6, N = 66) = 6.68, p = .352
Rarely	16 (10.6)	7 (11.1)	1 (3.4)	7 (14.9)	1 (8.3)	
Sometimes	4 (2.6)	2 (3.2)	0 (0.0)	2 (4.3)	0 (0.0)	
Frequent	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Unknown/Missing	85 (56.3)	40 (63.5)	15 (51.7)	25 (53.2)	5 (41.7)	

PBC, intentions, and willingness decreased compared to baseline at 30-day follow-up, while risk perceptions increased compared to baseline at 30-day follow-up across all four messaging groups among the successfully manipulated cases. No significant differences in the 30-day change in PBC [Kruskal-Wallis H(3, $N = 66$) = 3.41, $p = .333$], risk perception [Kruskal-Wallis H(3, $N = 66$) = 4.10, $p = .251$], intentions [Kruskal-Wallis H(3, $N = 66$) = 4.19, $p = .242$], or willingness [Kruskal-Wallis H(3, $N = 66$) = 3.35, $p = .340$] were observed across the four messaging groups. However, when participants from the three Intervention Messaging Groups (PBC Messaging Group, Risk Messaging Group, and PBC+Risk Messaging Group) were compared together against the participants in the Factual Messaging Group, the increase in risk (Mann-Whitney U Test, $U = 359.5$, $z = -1.82$, $p < .05$, one-tailed) and decrease in intentions (Mann-Whitney U Test, $U = 369.5$, $z = -1.69$, $p < .05$, one-tailed) over 30-days was significantly greater in the Intervention Messaging Groups compared to the Factual Messaging Group.

4.2.3 Drowsy Driving Behavior at 30-Day Post-Intervention Follow-Up

No significant difference was observed between the four groups in self-reported drowsy driving behavior at 30-day follow-up in either the Study Sample (see Table 4.5a) or the subsample of successfully manipulated cases (see Table 4.5b).

4.3 Study #1 Conclusions

Despite the ineffectiveness of the PBC messages in this study, the results from Study #1 suggest that messaging strategies targeting PBC or risk perception of drowsy driving behavior could nonetheless have some impact on these and other cognitive antecedents to drowsy driving behavior. Such messaging strategies may be especially efficacious in enhancing perceptions of risk relating to drowsy driving. From a practical perspective, it is noteworthy that even factual messaging strategies appeared to have enhanced risk perception over time, suggesting that any anti-drowsy driving messaging strategy may have an impact in changing young adult's perceptions of the dangers of drowsy driving. Thus, the results of Study #1 provide some support for Hypotheses 1 and 2 concerning the impact of messages targeting PBC and perceptions of risk relating to drowsy driving.

Chapter 5: Study #2 – Exploration of Cognitive Antecedents to Drowsy Driving Behavior

5.1 Analysis Plan for Study #2

Originally, the classic approach of Baron and Kenny (Baron & Kenny, 1986) was intended to be applied to the RCT data to assess the mediational role of drowsy driving risk perception on the impact of messages targeting perceived control and risk regarding drowsy driving on subsequent drowsy driving-related outcomes (*i.e.*, drowsy driving intentions, willingness, and behavior; see Hypothesis 3). More specifically, regression analyses were to be used to assess the significance of: (1) the relationships between perceived behavioral control and subsequent drowsy driving-related outcomes; (2) the relationships between perceived behavioral control and drowsy driving risk perception; (3) the relationships between perceived behavioral control and subsequent drowsy driving-related outcomes when controlling for drowsy driving risk perception; and (4) the relationship between drowsy driving risk perception and subsequent drowsy driving-related outcomes when controlling for perceived behavioral control. The Sobel test would have been applied using the latest internet version of MedGraph (Jose, 2013) to assess the significance of the indirect effects between perceived behavioral control and subsequent drowsy driving-related outcomes through drowsy driving risk perception.

In addition, the differential impact of the RCT messaging strategies targeting drowsy driving-related perceptions of control and risk had on drowsy driving willingness versus drowsy driving intentions was to be analyzed using hierarchical multiple linear regression (see Hypothesis 4). More specifically, drowsy driving willingness and intentions measurements collected at 30-day post-intervention follow-up from participants in the three Intervention Messaging Groups were to be regressed on to the drowsy driving-related perceptions of control

and risk measurements collected at immediate post-intervention follow-up after controlling for demographic characteristics and driving habits (*i.e.*, age, sex, race and ethnicity, driving exposure, and past history of drowsy driving behavior). Finally, hierarchical multiple linear regression was to be used to assess the respective contributions of drowsy driving willingness and drowsy driving intentions to the prediction of drowsy driving behavior (see Hypothesis 5). For all participants, drowsy driving behavior measurements collected at 30-day post-intervention follow-up were be regressed on to the drowsy driving willingness and intentions measurements collected at immediate post-intervention follow-up after controlling for demographic characteristics and driving habits (*i.e.*, age, sex, race and ethnicity, driving exposure, and past history of drowsy driving behavior).

Unfortunately, the ineffectiveness of the messages targeting PBC to influence PBC in the RCT participants and the largely non-normally distributed data collected from the RCT made it unfeasible to conduct multiple regression and mediational analyses of the measurement data collected from the RCT. Consequently, alternative methods were used to explore aspects of Hypotheses 3 through 5 using the available RCT data.

5.2 Study #2 Results

5.2.1 Hypothesis 3: Impact of Perceived Control Messaging on Perception of Risk

Portions of the hypothesized mediational relationships could be explored by examining bivariate correlations between change score variables in the full RCT Study Sample (see Table 5.1) and the subsample of successfully manipulated participants (see Table 5.2). In the full Study Sample, significant negative correlations were observed between PBC change scores and Risk change scores from baseline to immediate post-intervention follow-up, $\rho(271) = -.265$, $p < .001$, two-tailed. In addition, significant negative correlations were observed between Risk

change scores from baseline to immediate post-intervention follow-up and 30-day change scores in intention, $\rho(114) = -.270$, $p < .01$, two-tailed, and willingness $\rho(114) = -.280$, $p < .01$, two-tailed. By contrast, significant positive correlations were observed between PBC change scores from baseline to immediate post-intervention follow-up and 30-day change scores in intention, $\rho(114) = .324$, $p < .001$, two-tailed, and willingness $r(114) = .190$, $p < .05$, two-tailed. Significant positive point biserial correlations were observed between PBC change scores from baseline to immediate post-intervention follow-up and drowsy driving behavior at 30-day follow-up, $r(114) = .184$, $p < .05$, one-tailed, and significant negative point biserial correlations were observed between Risk change scores from baseline to immediate post-intervention follow-up and drowsy driving behavior at 30-day follow-up, $r(114) = -.217$, $p < .01$, one-tailed.

Among participants in the subset of successfully manipulated cases, significant negative correlations were observed between PBC change scores and Risk change scores from baseline to immediate post-intervention follow-up, $\rho(148) = -.283$, $p < .001$, two-tailed). Non-significant negative correlations were observed between Risk change scores from baseline to immediate post-intervention follow-up and 30-day change scores in intentions, $\rho(64) = -.164$, $p > .05$, one-tailed). In addition, significant negative correlations were observed between Risk change scores from baseline to immediate post-intervention follow-up and 30-day change scores in willingness, $\rho(64) = -.225$, $p < .05$, one-tailed. By contrast, significant positive correlations were observed between PBC change scores from baseline to immediate post-intervention follow-up and 30-day change scores in intentions, $\rho(64) = .333$, $p < .01$, two-tailed, and willingness, $\rho(64) = .269$, $p < .05$, two-tailed.

Significant positive point biserial correlations were observed between PBC change scores from baseline to immediate post-intervention follow-up and drowsy driving behavior at 30-day

follow-up, $r(64) = .341$, $p < .01$, one-tailed, and significant negative point biserial correlations were observed between Risk change scores from baseline to immediate post-intervention follow-up and drowsy driving behavior at 30-day follow-up, $r(114) = -.315$, $p < .05$, one-tailed.

Table 5.1

Zero-Order Correlation Coefficients Between Variables Collected in Study Sample (N=275)

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*M*	*SD*	*n*
1. Change in PBC (Baseline to Post-Intervention)	1	-.265**	.492**	-.155	.324**	.190*	.184*	-0.172	0.964	273
2. Change in Risk (Baseline to Post-Intervention)		1	-.234*	.530**	-.270**	-.280**	-.217*	0.562	1.25	273
3. 30-Day Change in PBC from Baseline			1	-.312**	.176	.204*	.214*	-0.224	1.14	116
4. 30-Day Change in Risk from Baseline				1	-.132	-.392**	-.207*	0.537	1.70	116
5. 30-Day Change in Intention from Baseline					1	.220*	.078	-0.267	1.30	116
6. 30-Day Change in Willingness from Baseline						1	.238*	-0.394	1.03	116
7. Drowsy Driving Behavior at 30-Day Follow-Up (Dichotomous)							1	-	-	116

Note. Correlation coefficients calculated after listwise deletion of missing values. Point-biserial correlation coefficients (*r*) provided for bivariate comparisons with Drowsy Driving Behavior at 30-day follow-up; Spearman correlation coefficients (ρ) provided for all other bivariate comparisons. *M* = Mean; *SD* = Standard Deviation; n = Number of cases included in analysis; PBC = Perceived Behavioral Control.

* $p < .05$ level, two-tailed. ** $p < .01$, two-tailed.

Table 5.2

Zero-Order Correlation Coefficients Between Variables Collected in Successfully Manipulated Cases (N=151)

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*M*	*SD*	*n*
1. Change in PBC (Baseline to Post-Intervention)	1	-.283**	.563**	-.338**	.333**	.269*	.341**	-0.500	1.00	150
2. Change Risk (Baseline to Post-Intervention)		1	-.321**	.685**	-.164	-.225^	-.315*	0.907	1.32	150
3. 30-Day Change in PBC from Baseline			1	-.328**	.273*	.258*	.221	-0.460	1.13	66
4. 30-Day Change in Risk from Baseline				1	-.198	-.361**	-.233	0.798	1.61	66
5. 30-Day Change in Intention from Baseline					1	.248*	.054	-0.581	1.40	66
6. 30-Day Change in Willingness from Baseline						1	.186	-0.636	1.14	66
7. Drowsy Driving Behavior at 30-Day Follow-Up (Dichotomous)							1	0.303	0.463	66

Note. Correlation coefficients calculated after listwise deletion of missing values. Point-biserial correlation coefficients (*r*) provided for bivariate comparisons with Drowsy Driving Behavior at 30-day follow-up; Spearman correlation coefficients (ρ) provided for all other bivariate comparisons. *M* = Mean; *SD* = Standard Deviation; TPB = Theory of Planned Behavior.

* $p < .05$ level, two-tailed. ^ $p < .05$ level, one-tailed. ** $p < .01$, two-tailed.

5.2.2 Hypothesis 4: Impact of Messaging on Subsequent Willingness and Intentions

Change scores in intentions and willingness between baseline and 30-day follow-up were both dichotomized (decreased after 30 days vs. unchanged and increased after 30 days). Using these dichotomous variables for 30-day change in intentions and willingness in the full RCT Study Sample, no significant differences were observed between the proportion of participants receiving one of the three intervention messages (*i.e.*, members of the PBC Group, Risk Group, and PBC+Risk Group; $n = 93$) and the proportion of participants receiving factual knowledge-based messages (n = 23) with regard to decreased intentions at 30-day follow-up, χ^2 (1, $N = 116$) = 0.488, $p = .485$, and decreased willingness at 30-day follow-up, χ^2 (1, $N = 116$) = 1.17, $p = .279$. Similar results were observed in the subsample of successfully manipulated cases: [30-day change in intentions] χ^2 (1, $N = 66$) = 3.56, $p = .06$; [30-day change in willingness], χ^2 (1, $N = 66$) = 0.314, $p = .575$.

5.2.3 Hypothesis 5: Comparing Intention and Willingness as Predictors of Drowsy Driving Behavior

The drowsy driving data at 30-day follow-up was non-normally distributed (Shapiro-Wilk test, W = .597, $p < .001$) and skewed towards the lower end of the scale (see Table 4.5a). Consequently, the data from the drowsy driving measure at 30-day follow-up was converted to a dichotomous variable (*No Drowsy Driving Behavior in the Past 30 Days* vs. *Drove Drowsy at Least Once in the past 30 Days*) for use in binary logistic regression analyses against measures of intentions and willingness immediately after receiving a messaging intervention and at 30-day follow-up. Due to their narrow range in values, the data on intentions and willingness at the end of the initial study day and the data on 30-day changes in intention and willingness were divided into terciles (1st Tercile = *Lower*, 2nd Tercile = *Moderate*, 3rd Tercile = *Higher*) for logistic regression analysis purposes.

When drowsy driving behavior at 30-day follow-up was regressed onto the tercile data for intentions and willingness at the end of the initial study day (see Table 5.3), only the third tercile in intentions were significant (*OR* = 9.97, 95% CI [2.74, 36.3], $p < .001$). However, when demographic and past driving behavior variables were entered into the model, intentions and willingness at the end of Study Day 1 were no longer significant.

When drowsy driving behavior at 30-day follow-up was regressed onto 30-day changes in intentions and willingness (see Table 5.4), 30-day change in willingness was significant (*OR* = 1.80, 95% CI [1.11, 2.92], $p < .05$). This significance remained even after demographic and past driving behavior variables were entered into the model (*OR* = 3.80, 95% CI [1.35, 10.7], $p < .05$).

Table 5.3

Binomial Logistic Regression Analyses Predicting Drowsy Driving Behavior from Intentions and Willingness (Entered Together)

	Block 1 Entered Only					*Blocks 1 and 2 Entered Sequentially*				
Predictor	*B*	*SE B*	Wald χ^2	*OR*	*95% CI OR*	*B*	*SE B*	Wald χ^2	*OR*	*95% CI OR*
Block 1										
Lower Intention			13.0**					3.27		
Moderate Intention	1.08	.602	3.23	2.95	.906, 9.60	1.74	1.03	2.83	5.69	.751, 43.1
Higher Intention	2.30	.659	12.2***	9.97	2.74, 36.3	1.79	1.11	2.60	5.96	.682, 52.1
Lower Willingness			.015					2.24		
Moderate Willingness	-.066	.576	.013	0.94	.303, 2.90	.833	1.07	.604	2.30	.281, 18.8
Higher Willingness	-.063	.585	.012	0.94	.298, 2.95	-.512	1.13	.204	0.60	.065, 5.53
Block 2										
Control Variables[a]								p >.05 for all control variables		
n			116					109		

Note. Hierarchical (sequential) logistic regression performed after listwise deletion of missing values. The dichotomous dependent variable for drowsy driving behavior used was No Drowsy Driving in the past 30 days at 30-day follow-up vs ≥1 Drowsy Driving Incidents in the past 30 days at 30-day follow-up. The ratings for intentions and willingness at the end of the initial study day (immediate post-intervention follow-up) were grouped into terciles (Lower = 1st Tercile, Moderate = 2nd Tercile, Higher = 3rd Tercile) before being entered into the logistic regression model as categorical independent variables in Block 1.

[a] Control variables include age, gender, race, driving exposure (monthly driving frequency and average miles driven per year), and past (lifetime) drowsy driving experience.

** $p < .01$. *** $p < .001$.

Table 5.4

Binomial Logistic Regression Analyses Predicting Drowsy Driving Behavior from 30-Day Changes in Intentions and Willingness (Entered Together)

	Block 1 Entered Only					*Blocks 1 and 2 Entered Sequentially*				
Predictor	*B*	*SE B*	Wald χ^2	*OR*	*95% CI OR*	*B*	*SE B*	Wald χ^2	*OR*	*95% CI OR*
Block 1										
30-Day Change in Intention	.010	.178	.003	1.01	.713, 1.43	.118	.309	.145	1.13	.614, 2.06
30-Day Change in Willingness	.589	.247	5.68*	1.80	1.11. 2.92	1.33	.526	6.42*	3.80	1.35, 10.7
Block 2										
Control Variables[a]						p >.05 for all control variables				
n	116					109				

Note. Hierarchical (sequential) logistic regression performed after listwise deletion of missing values. The dichotomous dependent variable for drowsy driving behavior used was No Drowsy Driving in the past 30 days at 30-day follow-up vs ≥1 Drowsy Driving Incidents in the past 30 days at 30-day follow-up. The change in ratings for intentions and willingness from baseline to 30-day post-intervention follow-up were entered into the logistic regression model as continuous independent variables in Block 1.

[a] Control variables include age, gender, race, driving exposure (monthly driving frequency and average miles driven per year), and past (lifetime) drowsy driving experience.

* $p < .05$.

5.3 Study #2 Conclusions

The results of Study #2 provide some supporting evidence for Hypotheses 3 through 5. Significant negative correlations were observed between changes in perceived behavioral control and risk perception, and changes in risk perception were significantly negatively correlated with changes in intentions and willingness. The negative correlation observed between 30-day changes in risk perception and 30-day changes in willingness ($\rho = -.392$, $p < .01$) was stronger than that observed between 30-day changes in risk perception and 30-day changes in intentions ($\rho = -.132$, $p > .05$). Finally, logistic regression analyses indicated that willingness (or changes in willingness) was a stronger predictor of drowsy driving behavior than intentions (or changes in intentions).

Chapter 6: Summary

6.1 Summary of Dissertation Findings

Study #1 provided supporting evidence of short-term cognitive effects but not short-term behavioral effects in a sample of young adult U.S. drivers after exposure to messaging interventions designed to influence perceptions of control and risk related to drowsy driving behavior. Perceptions of risk were especially influenced by the messaging strategies examined, including those that provided only factual, knowledge-based information about drowsy driving instead of messages aimed at influencing cognitive antecedents to drowsy driving behavior.

Study #2 provided supporting evidence that in a sample of young adult U.S. drivers, perceived behavioral control influenced more proximate cognitive antecedents to drowsy driving behavior indirectly through perceptions of risk. Among these more proximate cognitive antecedents to behavior, willingness to drive drowsy was observed to be a stronger predictor of actual drowsy driving behavior than intentions to drive drowsy.

These findings were generally consistent with those previously reported by Lee and Beck (Beck et al., 2018; Lee, 2014; Lee & Beck, 2019; Lee et al., 2016), as well as with other published impaired driving research indicating that messaging-based interventions alone rarely change driving behavior (Kirley et al., 2023). Traffic safety experts have found that in order to succeed, stand-alone communication-based traffic safety campaigns must be carefully pre-tested, communicate health information not previously known, be long-term, and have substantial funding (National Academies of Sciences Engineering and Medicine, 2007). Thus, the studies comprising this dissertation represent an early stage in a multi-step effort to develop more effective messaging strategies against drowsy driving for young adult U.S. drivers that are grounded in behavioral change theories (Kirley et al., 2023; Zakrajsek et al., 2023).

6.2 Limitations

6.2.1 Shortcomings in the Study Design and Execution

Certain aspects of the RCT's study design may have impacted the findings of both studies comprising this dissertation. The RCT's single longer-term follow-up timepoint at 30-days post-intervention may not have been sufficient to detect the complex neurocognitive and behavioral changes over time that were the focus of this dissertation. In addition, the relatively short duration of the messaging interventions developed and used in this dissertation (< 5 minutes total for all groups) may have provided insufficient intervention dosage to meaningfully affect the targeted cognitive factors and behavior. Moreover, inadequacies in the scale-based measures used to assess cognitive constructs may have resulted in inaccurate measurement of certain key variables of interest in this dissertation. Of particular note, the scale-based measure used for behavioral willingness demonstrated substantially lower reliability (Cronbach's alpha ranging from .369 to .671) than the other scale-based measures used in this dissertation. The ratings for the second willingness item relating to a more moderate drowsy driving decision (*i.e.*, willingness to drive a little further before stopping to get some rest) consistently deviated from the other two willingness items relating to more extreme drowsy driving decisions (*i.e.*, willingness to stop driving immediately to get some rest and willingness to continue driving until reaching the destination, respectively). More specifically, ratings for the second willingness item ("Drive a little further," $M \approx 4.3$) were higher than the ratings for the other two items ("Stop immediately," $M \approx 3.2$; "Reach destination," $M \approx 3.7$) at both immediate post-intervention (n = 273) and 30-day post-intervention follow-up (n = 116).

Factors relating to the execution of the RCT protocol also may have impacted the outcomes of Studies #1 and #2. In particular, the apparent ineffectiveness of the PBC messages

used in the RCT to impact perceptions of behavioral control while seemingly enhancing perceptions of risk suggest that these "PBC messages" actually manipulated perceptions of risk and threat rather than perceptions of behavioral control and self-efficacy. Although experts in risk and strategic communications reviewed the four messaging interventions as part of the piloting process before the RCT was launched, experts specifically in motivational or behavioral communications were not consulted. In addition, the messaging interventions were piloted with some individuals who were slightly older than the age group (*i.e.*, between 18 and 25 years old) that was targeted in these dissertation studies. Additional efforts to develop and pilot the intervention messages with relevant experts and with the target population may have resulted in messages that were more efficacious in manipulating the desired cognitive antecedents to behavior in the RCT.

The timing of the data collection for the RCT also may have impacted the substance and quality of the data analyzed in this dissertation. Data collection for the RCT began on April 10, 2024, approximately one month before the end of the Spring 2024 Term at UMCP. The first 30-day follow-up questionnaires were administered on May 11, 2024, coinciding with the first day of final exams and end-of-term activities leading up to UMCP's Spring 2024 Commencement ceremonies. Furthermore, much of the data collection took place during the summer of 2024, when participants may have had different daily routines and exhibited different driving behaviors than they would during the rest of the calendar year. The summertime data collection period also may have contributed to the high attrition rate that occurred over the 30-day study period for this dissertation.

6.2.2 Representativeness of the Study Sample

Several factors undermined the representativeness of the participants analyzed in Studies #1 and #2, thereby limiting the external validity of the findings from this dissertation. Females and Asians or Pacific Islanders were overrepresented in the full Study Sample (59.3% Female, 33.5% Asian/Pacific Islander, $N = 275$ at baseline; 62.9% Female, 29.3% Asian/Pacific Islander at 30-day follow-up) and the subsample of successfully manipulated cases (55.6% Female, 32.5% Asian/Pacific Islander, $N = 116$ at baseline; at 30-day follow-up) in this dissertation compared to UMCP's undergraduate (48.9% Female, 24.2% Asian/Pacific Islander, $N = 29{,}219$) and graduate (48.7% Female, 9.3% Asian/Pacific Islander, $N = 9{,}442$) student bodies for the Spring 2024 Term (Office of Institutional Research, Planning and Assessment – University of Maryland College Park, 2024) and to the U.S. population (U.S. Census Bureau – U.S. Department of Commerce, 2023a, 2023b) in the 18- to 24-years age group (48.8% Female, ~7.6% Asian/Pacific Islander, $N = 30{,}475{,}255$). In addition, the response rate to recruiting efforts for this dissertation research was no better than 5.5% (*i.e.*, 275 respondents out of 5,000 UMCP students identified by the UMCP Office of the Registrar who were enrolled during the Spring 2024 Term, who were 18 to 25 years old, and whose local address did not include the ZIP code for the UMCP campus).

The 30-day attrition rates also varied between messaging groups in the full Study Sample (63.5% in the Factual Messaging Group, 57.1% in the PBC Messaging Group, 59.5% in the Risk Messaging Group, 51.5% in the PBC+Risk Messaging Group, 57.8% overall in the sample) and the subsample of successfully manipulated cases (63.5% in the Factual Messaging Group, 51.7% in the PBC Messaging Group, 53.2% in the Risk Messaging Group, 51.5% in the PBC+Risk Messaging Group, 41.7% overall in the subsample). Although these differential attrition rates

may not have drastically altered the demographic composition of the groups between baseline and 30-day follow-up, they may have impacted the driving habit profile composition of the groups between baseline and 30-day follow-up both in the full Study Sample and the subsample of successfully manipulated cases.

Because random sampling was not used and because of the low response rate and differential attrition rates between groups that were observed in this dissertation, several sources of bias may have been introduced into Studies #1 and #2**.** For example, the results of this dissertation research may have been influenced by self-selection bias among the participants, as UMCP students with past experience driving while drowsy or for whom the issue of drowsy driving was particularly important may have been more likely to participate in this study. These participants also may have been prone to recall bias and were more likely to recall and self-report their past drowsy driving experiences with accuracy compared to other RCT participants. Prevalence data on the past drowsy driving behavior of the enrolled student body at UMCP during the Spring 2024 Term was not available, so it was not possible to compare the percentage of participants with past drowsy driving experience in the full Study Sample and the subsample of successfully manipulated cases with that of the Spring 2024 enrolled student body at UMCP.

Finally, social desirability bias also could have impacted the results of this dissertation research, which largely relied on self-reported data. As previously discussed, U.S. drivers are generally aware of the dangers of drowsy driving and disapprove of this driving behavior (Sections 2.1.3 and 2.1.4), It is possible that the high attrition rate observed at 30-day follow-up could be attributed to participants refusing to self-report their recent drowsy driving behavior accurately or at all.

6.3 Implications for Future Research and Practice

The findings from this dissertation offer some promising avenues for future research and development in drowsy driving prevention. In particular, the observed efficaciousness of both theory-based and factual messaging strategies in enhancing drowsy driving risk perceptions warrants further investigation. If both of these messaging strategy types enhance drowsy driving risk perceptions and if neither has an effect on future drowsy driving behavior, then targeting risk perceptions may actually be an ineffective way to prevent drowsy driving behavior. Alternatively, both types of messaging strategies may provide cues to action sufficient to induce short-term cognitive effects. As indicated in other areas of impaired driving research, messages that provide cues to action may even induce short-term behavioral effects, especially when repeated (Lange et al., 2006).

Another area for research and development focuses on the development of messaging strategies that more precisely targets perceived behavioral control instead of risk perceptions. The impact that the PBC messages used in this dissertation had on risk perception instead of PBC suggests that traffic safety researchers and practitioners need to more clearly distinguish perceptions of behavioral control from perceptions of risk when developing theory-based drowsy driving prevention messages in the future.

Additional research and development efforts also are needed for better assessments of behavioral willingness in the drowsy driving context. The variation in ratings observed among the scenario-based items of the willingness measure used in this dissertation suggest that behavioral willingness as a cognitive construct may be particularly influenced by social or environmental factors. Both anecdotally and in research settings (Beck et al., 2018), the argument frequently has been made that people drive drowsy *because they have to* due to

professional, social, or personal obligations. Individuals conducting a personal risk-benefit analysis about driving drowsy may determine that the benefits outweigh the risks in a particular situation, especially if a moderately risky option (*e.g.*, drive a little further before stopping to get some rest *versus* stop driving immediately or continue driving until reaching the destination) is available to the driver. Although this risk-benefit analysis involving social and environmental factors also may influence behavioral intentions, willingness may be especially sensitive to these factors given its more reactive nature compared to the more deliberative nature of intentions. Additional research is also needed in this area to explore: (1) whether measures of drowsy driving willingness should de-emphasize extreme drowsy driving decisions (*e.g.*, "Stop driving immediately to get some rest") and focus more on moderate drowsy driving decisions that do not interfere with drivers' ability to reach their destination (*e.g.*, "Stop driving to get a cup of coffee before continuing the trip"); (2) whether drowsy driving willingness could be assessed more accurately with dichotomous measures (*e.g.*, "Willing" vs. "Not Willing") rather than multi-point continuous measures (like the ones used in this dissertation as described in Section 3.4.6); and (3) whether measuring drowsy driving risk prototypes results in better measurement of drowsy driving willingness (as theorized by the PWM).

These efforts for the future can build upon and improve the approach initially adopted for this dissertation research, while also addressing the limitations identified in the previous section. To that end, the RCT conducted for this dissertation could be repeated using higher-dose messages that more precisely target perceived behavioral control instead of risk perceptions (and vice versa) and that includes more follow-up measurements of drowsy driving cognitive antecedents and behavior over a longer period of time. Furthermore, additional investigation is needed on the relative impact of demographic factors and past drowsy driving behavior on

subsequent drowsy driving behavior compared to cognitive antecedents to behavior. The Study #2 logistic regression finding that intentions no longer significantly predicted drowsy driving behavior after controlling for various demographic factors and driving behaviors suggest that these personal factors may play a greater role in predicting and preventing drowsy driving behavior than cognitive factors.[3] Elucidating the relationship between demographic factors and past behavior in relation to drowsy driving would provide valuable information for future efforts to develop effective drowsy driving prevention interventions.

[3] Interestingly, the demographic composition and driving habit profile of the full Study Sample ($N = 275$; see Tables 4.1 and 4.5a) and the subsample of successfully manipulated cases ($N = 151$; see Tables 4.3 and 4.5b) were quite similar.

Appendices

Appendix 1a: Questionnaire (Initial Study Day)

Hyperlink to Online Questionnaire for Initial Study Day:
https://umdsurvey.umd.edu/jfe/form/SV_0xMDVT71OvpKCDc

CONSENT TO PARTICIPATE
[Initial Study Day]

Project Title	*Preventing Drowsy Driving in Young Adults Through Messaging Strategies that Influence Perceptions of Control and Risk*
Purpose of the Study	*This research is being conducted by **Clark J. Lee** under the supervision of **Dr. James Butler** at the University of Maryland, College Park. You are being invited to participate in this research project because you are a student at the University of Maryland, College Park who is between the ages of 18 and 25 years old and who drives at least once a month.* *The purpose of this research project is to understand the impact of different messaging strategies aimed at preventing drowsy driving in young adults. As used in this study, "drowsy driving" means the act of operating a motor vehicle while drowsy, sleepy, asleep, or fatigued.* *The results of this study may inform the development of more effective interventions against drowsy driving in young adults, who are particularly vulnerable to the health and safety hazards associated with drowsy driving behavior.* *Unfortunately, you are not eligible to participate in this study: (1) if you have a visual or hearing disability; or (2) if you cannot read, understand, or communicate in the English language.*
Procedures	*Today's procedures involve having you: (1) watch a short video and a recorded slide presentation with audio in English; and (2) complete a short online questionnaire about yourself and your perceptions, thoughts, and experiences related to drowsy driving. It should take about 20 to 25 minutes for you to watch the video/presentation and complete the questionnaire.*

	You will also be invited to complete a short online questionnaire about 30 days after you view the video/presentation. *Upon completing today's questionnaire, you will be asked whether you want to participate in a raffle to win one of thirty $50 electronic Gift Cards from your choice of Amazon, Apple, or Starbucks.*
Potential Risks and Discomforts	*There are no known risks to you for participating in this research study. Your responses will be kept anonymous to the greatest extent possible. However, there is a potential risk of a breach of confidentiality if you provide your e-mail address while participating in this study.* *You may feel discomfort or embarrassment reporting your experience with drowsy driving and its consequences. However, you may choose to not answer any question that makes you feel uncomfortable.*
Potential Benefits	*Although you will not benefit directly from participating in this study, your participation may enhance general understanding of the impact of different messaging strategies aimed at preventing drowsy driving in young adults. This knowledge could be used in the future to develop more effective interventions against drowsy driving by young adults, who are particularly vulnerable to the health and safety hazards associated with drowsy driving behavior.*
Confidentiality	*To enter the E-Gift Card raffle upon completing the questionnaire, you will be directed to a website where you can provide your name and an e-mail address separately from your questionnaire responses. Your personally identifiable information will not be collected if you do not wish to enter the raffle (other than the e-mail address you provide if you are interested in completing the 30-day follow-up questionnaire).* *Mr. Lee and Dr. Butler will do their best to minimize any potential loss of confidentiality. The data for this study will be collected via an online survey provider (Qualtrics) and stored in the survey provider's database, which is only accessible with a password. Information submitted to the online survey provider will be backed up daily on its secure servers, and the online survey provider will not use any of the information it receives.* *All data and information collected as part of this study will be downloaded from the online survey provider and saved on to a password-protected computer and secure cloud storage accounts (primarily UMD Box). Only Mr. Lee and Dr. Butler*

	will have access to the study data and information stored on the aforementioned computer and cloud storage accounts. *Any personally identifiable information collected from participants for purposes of study follow-up over time or the E-Gift Card raffle (e.g., your e-mail address) will be destroyed at the conclusion of this study. All other data and files pertinent to the research will be retained for a period of no less than 7 years after the completion of the research in accordance with the University of Maryland, College Park policy on records retention and disposal.* *No personally identifiable information will be used to analyze and interpret the data collected in this study, and all results from this study will be reported in aggregate form (e.g., group averages). Individual questionnaire responses will never be reported.* *If a report or article is written about this research project, your identity will be protected to the maximum extent possible. Importantly, your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if the researchers are required to do so by law.*
Medical Treatment	*Not applicable.*
Compensation	*Upon completing today's questionnaire, you will become eligible to participate in a raffle to win one of thirty $50 electronic Gift Cards from your choice of Amazon, Apple, or Starbucks. This study is expected to enroll 300 participants, with a maximum of 400 participants.* *If you would like to enter the E-Gift Card raffle, you will be directed to a site where you will be asked to provide your name and e-mail address. Your name and e-mail address will be held in confidence and will not be connected to your questionnaire responses.* *If you also complete the 30-day follow-up questionnaire, you will have the opportunity to make additional entries into the raffle to triple your chances of winning a gift card.* *If you are a raffle winner, you will be responsible for any taxes assessed on the compensation.*

Right to Withdraw and Questions	*Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify. Choosing to participate in the study will have no effect on your grades or standing at the University of Maryland, College Park.* *If you decide to stop taking part in the study, if you have questions, concerns, or complaints, or if you need to report an injury related to the research, please contact the following individuals:* **Clark J. Lee, JD, MPH, CPH** [*Student Investigator*] ***Doctor of Philosophy Candidate*** Phone: (301) 400-4208 E-Mail: cjlee@umd.edu **James Butler III, DrPH, MEd** [*Faculty Supervisor*] ***Associate Professor*** Phone: (301) 405-0757 E-Mail: jbutler9@umd.edu Department of Behavioral and Community Health School of Public Health University of Maryland 4200 Valley Drive, Suite 1234 College Park, Maryland 20742

Participant Rights	*If you have questions about your rights as a research participant or wish to report a research-related injury, please contact:* University of Maryland College Park Institutional Review Board Office 1204 Marie Mount Hall College Park, Maryland, 20742 E-mail: irb@umd.edu Telephone: (301) 405-0678 *For more information regarding participant rights, please visit:* https://research.umd.edu/research-resources/research-compliance/institutional-review-board-irb/research-participants *This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.*
Statement of Consent	*By selecting your choice below, you are indicating your right to consent or not consent electronically.* ***By selecting "YES, I Consent" and clicking on the "Continue" button below, you affirm that:*** 1. *YOU are between 18 and 25 years old, inclusive;* 2. *YOU drive at least once a month;* 3. *YOU are currently enrolled as a student at the University of Maryland, College Park;* 4. *YOU do not have a visual or hearing disability;* 5. *YOU are able to read, understand, and communicate in the English language;* 6. *YOU have read and understand the terms of this study; and* 7. *YOU are agreeing voluntarily to participate in this study.* *If you DO NOT wish to participate in this study, please select **"NO, I DO NOT Consent"** and click **"Continue"** to decline participation. You will not be eligible to enter into the E-Gift*

	Card raffle if you decline participation. ******You are advised to download or print a copy of this consent form for your files******

Do you consent to participate in this study?

- ❍ **YES,** I Consent
- ❍ **NO,** I DO NOT Consent

Note: Participant must answer this question to proceed to the next page of the questionnaire

If No Is Selected, Then Skip To the following end-of-questionnaire message:

Thank you for your interest in this study. Your responses have been recorded.

[Questionnaire for Clark Lee PhD Dissertation - RCT Day 1]

UNIVERSITY OF MARYLAND

Start of Block: Consent (Day 1)

CONSENT TO PARTICIPATE
[*Initial Study Day*]

[*Day 1 Consent Language Inserted Here*]

Q0 Do you consent to participate in this study?

- ❍ YES, I Consent
- ❍ NO, I DO NOT Consent

Skip To: End of Survey If Do you consent to participate in this study? = NO, I DO NOT Consent

End of Block: Consent (Day 1)

Start of Block: Part 1a

PART 1a: Demographic Information and Driving Habits

Please answer the following questions about yourself.

Q1 What is your age, in years?

_____

Q2 How do you currently describe yourself? Please select all that apply.

- ❍ Male
- ❍ Female
- ❍ Transgender
- ❍ I use a different term (Specify below if you wish)

_____

- ❍ Prefer not to answer

Q3 What is your ethnicity or race? Please select all that you identify with.

- ❑ American Indian or Alaska Native
- ❑ Asian or Pacific Islander
- ❑ Black or African-American
- ❑ Hispanic or Latino
- ❑ White or Caucasian
- ❑ Two or More Races (Specify below if you wish)

_____

- ❑ Prefer not to answer

Q4(a) How many years have you been driving?

_____

Q4(b) How often do you drive?

- ❍ Never
- ❍ Less than once a month
- ❍ At least once a month
- ❍ Every day

Q4(c) On average, how many miles do you drive each year?

- ❍ Less than 5,000 miles
- ❍ 5,000 to 10,000 miles
- ❍ 10,000 to 15,000 miles
- ❍ 15,000 to 20,000 miles
- ❍ More than 20,000 miles

Q5 How many times have you driven a motor vehicle while being so drowsy or sleepy that you had a hard time keeping your eyes open:

	Never	1 Time	2 to 4 Times	5 Times or More
(a) During the past 30 days?	❍	❍	❍	❍
(b) In your lifetime?	❍	❍	❍	❍

Q6 How many times have you fallen asleep or nodded off while driving a motor vehicle, even just for a second or two:

	Never	1 Time	2 to 4 Times	5 Times or More
(a) During the past 30 days?	❍	❍	❍	❍
(b) In your lifetime?	❍	❍	❍	❍

Q7 How many times have you been involved in a motor vehicle crash that resulted from you driving while drowsy or asleep:

	Never	1 Time	2 to 4 Times	5 Times or More
(a) During the past 30 days?	❍	❍	❍	❍
(b) In your lifetime?	❍	❍	❍	❍

End of Block: Part 1a

Start of Block: Part 1b

PART 1b: Baseline Behavioral and Psychometric Measurements

Please respond to each of the following questions by selecting the answer that best describes your beliefs. Some of the questions may appear to be similar, but each question addresses somewhat different issues. Please read each question carefully.

******As used in this study, "drowsy driving" means the act of operating a motor vehicle while drowsy, sleepy, asleep, or fatigued******

B12(a) How much do you agree with the statement: "In general, I believe that I have the ability to drive while feeling drowsy or sleepy"?

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Somewhat Disagree
- ❍ Neither Agree nor Disagree
- ❍ Somewhat Agree
- ❍ Agree
- ❍ Strongly Agree

B12(b) For me, how difficult is it to drive while feeling drowsy or sleepy?

- ❍ Extremely Difficult
- ❍ Difficult
- ❍ Somewhat Difficult
- ❍ Neither Difficult nor Easy
- ❍ Somewhat Easy
- ❍ Easy
- ❍ Extremely Easy

B12(c) How much do you agree with the statement: "Whether or not I drive while feeling drowsy or sleepy is completely up to me"?

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Somewhat Disagree
- ❍ Neither Agree nor Disagree
- ❍ Somewhat Agree
- ❍ Agree
- ❍ Strongly Agree

B13 If you were driving drowsy, how likely is it that:

	Extremely Unlikely	Unlikely	Somewhat Unlikely	Neither Unlikely nor Likely	Somewhat Likely	Likely	Extremely Likely
(a) You will crash your car into something?	❍	❍	❍	❍	❍	❍	❍
(b) You will drive in an unsafe manner?	❍	❍	❍	❍	❍	❍	❍
(c) You will injure yourself or others?	❍	❍	❍	❍	❍	❍	❍

B14(a) In the next 30 days, how likely is it that you will drive while feeling drowsy or sleepy?

- ❍ Extremely Unlikely
- ❍ Unlikely
- ❍ Somewhat Unlikely
- ❍ Neither Unlikely nor Likely
- ❍ Somewhat Likely
- ❍ Likely
- ❍ Extremely Likely

B14(b) In the next 30 days, do you intend to drive while feeling drowsy or sleepy?

- ❍ Definitely Not
- ❍ Probably Not
- ❍ Maybe Not
- ❍ Undecided
- ❍ Maybe Yes
- ❍ Probably Yes
- ❍ Definitely Yes

B14(c) In the next 30 days, how much will you try to avoid driving while feeling drowsy or sleepy?

- ❍ Extremely Little
- ❍ Little
- ❍ Somewhat Little
- ❍ Undecided
- ❍ Somewhat Great
- ❍ Great
- ❍ Extremely Great

B15 Suppose you are driving home at the end of the school year after getting very little sleep over the past 2 weeks due to final exams, writing papers, packing your belongings, *etc.*

As you drive, you find yourself having a hard time keeping your eyes open.

How willing would you be to do the following?

	Extremely Unwilling	Unwilling	Somewhat Unwilling	Neither Unwilling nor Willing	Somewhat Willing	Willing	Extremely Willing
(a) Stop driving immediately to get some rest	❍	❍	❍	❍	❍	❍	❍
(b) Drive a little further before stopping to get some rest.	❍	❍	❍	❍	❍	❍	❍
(c) Continue driving until you reached your destination.	❍	❍	❍	❍	❍	❍	❍

End of Block: Part 1b

Start of Block: Messaging Intervention - All Groups

Common Video Intro ***Please watch the video below. Be sure your audio is turned on.***

Go to the next page when you have finished watching the video.

[Please note that the button to advance to the next page will not appear until after you have watched the video.]

[***Embedded Common Video Appears Here***]

Common Vid Hyperlink ***If you have trouble watching the video on this page, please visit*** https://vimeo.com/179466897***; the video will open in a new tab or page on your browser.***

Return to this page when you have finished watching the video and go to the next page.

Common Vid Timing Timing
First Click
Last Click
Page Submit
Click Count

End of Block: Messaging Intervention - All Groups

Start of Block: Messaging Intervention - Control Group

Control Group Intro ***Please watch the video below. Be sure your audio is turned on.***

Go to the next page when you have finished watching the video.

[Please note that the button to advance to the next page will not appear until after you have watched the video.]

[***Embedded Control Group Messaging Video Appears Here***]

Control Group Link ***If you have trouble watching the video on this page, please visit*** https://youtu.be/p2UX6uusLZY***; the video will open in a new tab or page on your browser.***

Return to this page when you have finished watching the video and go to the next page.

Control Group Timing Timing
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Page Submit
Click Count

End of Block: Messaging Intervention - Control Group

Start of Block: Messaging Intervention - PBC

PBC Video Intro ***Please watch the video below. Be sure your audio is turned on.***

Go to the next page when you have finished watching the video.

[Please note that the button to advance to the next page will not appear until after you have watched the video.]

[*Embedded PBC Messaging Video Appears Here*]

PBC Video Link ***If you have trouble watching the video on this page, please visit*** https://youtu.be/0eU2mmdBGgQ***; the video will open in a new tab or page on your browser.***

Return to this page when you have finished watching the video and go to the next page.

PBC Video Timing Timing
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Last Click
Page Submit
Click Count

End of Block: Messaging Intervention - PBC

Start of Block: Messaging Intervention - Risk

Risk Video Intro ***Please watch the video below. Be sure your audio is turned on.***

Go to the next page when you have finished watching the video.

[Please note that the button to advance to the next page will not appear until after you have watched the video.]

[*Embedded Risk Messaging Video Appears Here*]

Risk Video Link ***If you have trouble watching the video on this page, please visit*** https://youtu.be/CbFmC0nsEmg***; the video will open in a new tab or page on your browser.***

Return to this page when you have finished watching the video and go to the next page.

Risk Video Timing Timing
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Last Click
Page Submit
Click Count

End of Block: Messaging Intervention - Risk

Start of Block: Messaging Intervention - PBC+Risk

PBC+Risk Video Intro ***Please watch the video below. Be sure your audio is turned on.***

Go to the next page when you have finished watching the video.

[Please note that the button to advance to the next page will not appear until after you have watched the video.]

[***Embedded PBC+Risk Messaging Video Appears Here***]

PBC+Risk Video Link ***If you have trouble watching the video on this page, please visit*** https://youtu.be/UMsghBghJz8***; the video will open in a new tab or page on your browser.***

Return to this page when you have finished watching the video and go to the next page.

PBC+Risk Vid Timing Timing
First Click
Last Click
Page Submit
Click Count

End of Block: Messaging Intervention - PBC+Risk

Start of Block: Part 2

PART 2: Participant Feedback Regarding Messaging Interventions

Please respond to each of the following questions with your honest opinions and thoughts in the space provided. There are no "right" or "wrong answers."

Q8 In a few sentences, please describe the video/presentation you have just viewed. What information or content do you remember about the video and presentation?

_____

_____

_____

_____

_____

Q9(a) What thoughts crossed your mind as you watched the video/presentation?

_____

_____

_____

_____

_____

Q9(b) How did you feel emotionally as you watched the video/presentation?

_____

_____

_____

_____

_____

Q10(a) What did you like about the video/presentation?

_____

_____

_____

_____

_____

Q10(b) What did you dislike about the video/presentation?

_____

_____

_____

_____

_____

Q10(c) What do you think were the main messages or goals of the video/presentation you viewed?

_____

_____

_____

_____

_____

Q10(d) In what ways did you find the video/presentation interesting or meaningful, if at all?

_____

_____

_____

_____

_____

Q10(e) If you did **not** find the video/presentation interesting or meaningful, why not?

_____

_____

_____

_____

_____

Q10(f) How well do you think the video/presentation communicated their main messages?

- ❍ Extremely Poorly
- ❍ Poorly
- ❍ Somewhat Poorly
- ❍ Neither Poorly nor Well
- ❍ Somewhat Well
- ❍ Well
- ❍ Extremely Well

Q11 How long did it take you to watch the video/presentation?

- ❍ Under 5 minutes
- ❍ 5 to 10 minutes
- ❍ 10 to 15 minutes
- ❍ More than 15 minutes (Please specify)

_____

End of Block: Part 2

Start of Block: Part 3

PART 3: Behavioral and Psychometric Measurements

Please respond to each of the following questions by selecting the answer that best describes your beliefs. Some of the questions may appear to be similar, but each question addresses somewhat different issues. Please read each question carefully.

******As used in this study, "drowsy driving" means the act of operating a motor vehicle while drowsy, sleepy, asleep, or fatigued******

P12(a) How much do you agree with the statement: "In general, I believe that I have the ability to drive while feeling drowsy or sleepy"?

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Somewhat Disagree
- ❍ Neither Agree nor Disagree
- ❍ Somewhat Agree
- ❍ Agree
- ❍ Strongly Agree

P12(b) For me, how difficult is it to drive while feeling drowsy or sleepy?

- ❍ Extremely Difficult
- ❍ Difficult
- ❍ Somewhat Difficult
- ❍ Neither Difficult nor Easy
- ❍ Somewhat Easy
- ❍ Easy
- ❍ Extremely Easy

P12(c) How much do you agree with the statement: "Whether or not I drive while feeling drowsy or sleepy is completely up to me"?

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Somewhat Disagree
- ❍ Neither Agree nor Disagree
- ❍ Somewhat Agree
- ❍ Agree
- ❍ Strongly Agree

P13 If you were driving drowsy, how likely is it that:

	Extremely Unlikely	Unlikely	Somewhat Unlikely	Neither Unlikely nor Likely	Somewhat Likely	Likely	Extremely Likely
(a) You will crash your car into something?	❍	❍	❍	❍	❍	❍	❍
(b) You will drive in an unsafe manner?	❍	❍	❍	❍	❍	❍	❍
(c) You will injure yourself or others?	❍	❍	❍	❍	❍	❍	❍

P14(a) In the next 30 days, how likely is it that you will drive while feeling drowsy or sleepy?

- ❍ Extremely Unlikely
- ❍ Unlikely
- ❍ Somewhat Unlikely
- ❍ Neither Unlikely nor Likely
- ❍ Somewhat Likely
- ❍ Likely
- ❍ Extremely Likely

P14(b) In the next 30 days, do you intend to drive while feeling drowsy or sleepy?

- ❍ Definitely Not
- ❍ Probably Not
- ❍ Maybe Not
- ❍ Undecided
- ❍ Maybe Yes
- ❍ Probably Yes
- ❍ Definitely Yes

P14(c) In the next 30 days, how much will you try to avoid driving while feeling drowsy or sleepy?

- ❍ Extremely Little
- ❍ Little
- ❍ Somewhat Little
- ❍ Undecided
- ❍ Somewhat Great
- ❍ Great
- ❍ Extremely Great

P15 Suppose you are driving home at the end of the school year after getting very little sleep over the past 2 weeks due to final exams, writing papers, packing your belongings, *etc.*

As you drive, you find yourself having a hard time keeping your eyes open.

How willing would you be to do the following?

	Extremely Unwilling	Unwilling	Somewhat Unwilling	Neither Unwilling nor Willing	Somewhat Willing	Willing	Extremely Willing
(a) Stop driving immediately to get some rest	❍	❍	❍	❍	❍	❍	❍
(b) Drive a little further before stopping to get some rest.	❍	❍	❍	❍	❍	❍	❍
(c) Continue driving until you reached your destination.	❍	❍	❍	❍	❍	❍	❍

Q17 **If you <u>are</u> interested in completing a short follow-up online questionnaire** related to this study about 30 days from now, **please provide an <u>E-Mail Address</u> where you can be reached next month in the box below.**

[***Note:*** *The e-mail address you provide here does not need to be a UMD address and will only be used to: (1) send you the link to the follow-up questionnaire in about 30 days; and (2) link your responses to this questionnaire with those of the 30-day follow-up questionnaire. E-mail addresses will be held in confidence and will not be used to identify you by name.*]

If you are <u>not</u> interested in completing a follow-up questionnaire, please enter "<u>N/A</u>" in the box below.

_____

End of Block: Part 3

Start of Block: Part 4

PART 4: Comments

Please feel free to comment on your experience with this study.

Q18 The questionnaire was easy to understand.

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Somewhat Disagree
- ❍ Neither Agree nor Disagree
- ❍ Somewhat Agree
- ❍ Agree
- ❍ Strongly Agree

Q19 Completing the questionnaire was:

- ❍ Extremely Difficult
- ❍ Difficult
- ❍ Somewhat Difficult
- ❍ Neither Difficult nor Easy
- ❍ Somewhat Easy
- ❍ Easy
- ❍ Extremely Easy

Q20 How long did it take you to complete this study (*i.e.*, to watch the video/presentation and complete the questionnaire)?

- ❍ Under 10 minutes
- ❍ 10 to 15 minutes
- ❍ 15 to 20 minutes
- ❍ 20 to 25 minutes
- ❍ 25 to 30 minutes
- ❍ More than 30 minutes (Please specify)

_____

Q21 How did you find out about this study? Select all that apply.

- ❑ Direct E-Mail
- ❑ E-Newsletter Announcement
- ❑ Social Media Posting (Please specify)

_____

- ❑ Announcement in a Class
- ❑ Announcement on a Course Site
- ❑ Paper Flyer
- ❑ Word-of-Mouth
- ❑ I was involved with the pilot-testing of materials used for this study
- ❑ Other (Please specify) _____

Q22(a) What kinds of messages do you think would be most effective at preventing drowsy driving in people like you?

_____

_____

_____

_____

_____

Q22(b) What would be the best way to deliver these messages to help prevent drowsy driving?

_____

_____

_____

_____

_____

Q22(c) What else would **you** include in a public service announcement or educational materials to prevent drowsy driving in people like you?

_____

_____

_____

_____

_____

Q23 Please use the space below to provide any additional comments:

_____

_____

_____

_____

_____

End of Block: Part 4

Start of Block: Raffle Entry Page

Q46 **Thank you for taking time to complete this questionnaire.**

You are eligible to enter into a raffle to win <u>one of thirty $50 E-Gift Cards</u> from your choice of Amazon, Apple, or Starbucks. If you are interested in entering the E-Gift Card raffle, please select the RAFFLE button below to be directed to a site where you can provide your name and e-mail address. As a reminder, your name and e-mail address provided for the raffle will not be connected to your responses in the questionnaire, and all files with your name and e-mail address created for your raffle entry will be deleted at the conclusion of this study.

If you are entering the raffle upon completing this questionnaire immediately after viewing the video/presentation, you can expect to have about a 1 in 10 chance of winning an E-Gift Card.

If you are entering the raffle a second time upon completing this questionnaire 30 days after viewing the video/presentation, you can expect to have about a 3 in 10 chance of winning an E-Gift Card.

If you are not interested in entering the raffle, please select the FINISH button below.

******If you are selected as a raffle winner, you will be responsible for reporting this information to the relevant tax authorities (including the U.S. Internal Revenue Service) and for paying any taxes assessed on this compensation.******
If you have any questions, please contact Clark Lee at cjlee@umd.edu.

- ❍ RAFFLE
- ❍ FINISH

End of Block: Raffle Entry Page

End-of-Questionnaire Message

Thank you for your interest in this study. Your responses have been recorded.

[Raffle Entries Collected at Immediate Post-Intervention Follow-Up and 30-Day Post-Intervention Follow-Up]

Thank you for taking time to complete this questionnaire.

You are eligible to enter into a raffle to win one of fifteen $10 E-Gift Cards from your choice of Amazon.com, Starbucks, or Apple App Store & iTunes. If you are interested in entering the E-Gift Card raffle, please select the RAFFLE button below to be directed to a site where you can provide your name and e-mail address. As a reminder, your name and e-mail address will not be connected to your responses in the questionnaire, and all files with your name and e-mail address created for your raffle entry will be deleted at the conclusion of this study.

If you are entering the raffle upon completing this questionnaire immediately after viewing the PSA videos, you can expect to have about a 1 in 20 chance of winning an E-Gift Card.

If you are entering the raffle a second time upon completing this questionnaire 30 days after viewing the PSA videos, you can expect to have about a 3 in 20 chance of winning an E-Gift Card.

If you are not interested in entering the raffle, please select the FINISH button below.

******If you are selected as a raffle winner, you will be responsible for reporting this information to the relevant tax authorities (including the U.S. Internal Revenue Service) and for paying any taxes assessed on this compensation.******

If you have any questions, please contact Clark Lee at cjlee@umd.edu.

- ❍ **RAFFLE**
- ❍ **FINISH**

If* RAFFLE *Is Selected, Then Redirect To Raffle Entry

If* FINISH *Is Selected, Then Skip To the following end-of-questionnaire message:

Thank you for your interest in this study. Your responses have been recorded.

RAFFLE ENTRY

[Collected at Immediate Post-Intervention Follow-Up and 30-Day Post-Intervention Follow-Up]

Please provide your name and an e-mail address where you can be contacted if you are a raffle winner. The raffle drawing is expected to take place no earlier than [Insert Date], so please provide an e-mail address where you can be reached at that time.

*****If you are selected as a raffle winner, you will be responsible for reporting this information to the relevant tax authorities (including the U.S. Internal Revenue Service) and for paying any taxes assessed on this compensation.*****

Name _____

E-Mail Address (*where you can be reached after [Insert Date]*)

_____

What type of E-Gift Card would you like if you are a raffle winner?

- ❍ Amazon.com
- ❍ Starbucks
- ❍ Apple App Store & iTunes

Thank you for your interest in this study. Your questionnaire responses have been recorded and your raffle entry has been received.

Raffle winners will be contacted directly by e-mail.

Note: Participant must provide their name and e-mail address in order to submit their raffle entry. The "Force Response" validation option will be used for these items (see https://www.qualtrics.com/university/researchsuite/basic-building/editing-questions/validation/#ForcingResponses)

Appendix 1b: Questionnaire (30-Day Follow-Up)

Hyperlink to Online Questionnaire for 30-Day Follow-Up:
https://umdsurvey.umd.edu/jfe/form/SV_7VaUjRmQ5iEYr5A

CONSENT TO PARTICIPATE
[30-Day Follow-Up]

Project Title	*Preventing Drowsy Driving in Young Adults Through Messaging Strategies that Influence Perceptions of Control and Risk*
Purpose of the Study	*This research is being conducted by **Clark J. Lee** under the supervision of **Dr. James Butler** at the University of Maryland, College Park. You are being invited to participate in this research project because: (1) you are a student at the University of Maryland, College Park who is between the ages of 18 and 25 years old and who drives at least once a month; and (2) you previously completed a questionnaire for this study and indicated your interest in completing a 30-day follow-up questionnaire.* *The purpose of this research project is to understand the impact of different messaging strategies aimed at preventing drowsy driving in young adults. As used in this study, "drowsy driving" means the act of operating a motor vehicle while drowsy, sleepy, asleep, or fatigued.* *The results of this study may inform the development of more effective interventions against drowsy driving in young adults, who are particularly vulnerable to the health and safety hazards associated with drowsy driving behavior.* *Unfortunately, you are not eligible to participate in this study: (1) if you have a visual or hearing disability; or (2) if you cannot read, understand, or communicate in the English language.*
Procedures	*Today's procedures involve the following activities:* *1. You will complete a short online questionnaire about your perceptions, thoughts, and experiences related to drowsy driving. It should take about 5 to 10 minutes for you to complete this questionnaire.*

	2. You will be asked to provide your e-mail address in the questionnaire so that we can link your responses today to those you provided in the questionnaire you completed previously for this study. Please enter the same e-mail address you provided in the previous questionnaire. *3. Upon completing today's questionnaire, you will be asked whether you want to participate in a raffle to win one of thirty $50 electronic Gift Cards from your choice of Amazon, Apple, or Starbucks.*
Potential Risks and Discomforts	*There are no known risks to you for participating in this research study. Your responses will be kept anonymous to the greatest extent possible. However, there is a potential risk of a breach of confidentiality if you provide your e-mail address while participating in this study.* *You may feel discomfort or embarrassment reporting your experience with drowsy driving and its consequences. However, you may choose to not answer any question that makes you feel uncomfortable.*
Potential Benefits	*Although you will not benefit directly from participating in this study, your participation may enhance general understanding of the impact of different messaging strategies aimed at preventing drowsy driving in young adults. This knowledge could be used in the future to develop more effective interventions against drowsy driving by young adults, who are particularly vulnerable to the health and safety hazards associated with drowsy driving behavior.*
Confidentiality	*To enter the E-Gift Card raffle upon completing the questionnaire, you will be directed to a website where you can provide your name and an e-mail address separately from your questionnaire responses. Your personally identifiable information will not be collected if you do not wish to enter the raffle (other than the e-mail address you provide to link your responses today to those you provided in the previous questionnaire).* *Mr. Lee and Dr. Butler will do their best to minimize any potential loss of confidentiality. The data for this study will be collected via an online survey provider (Qualtrics) and stored in the survey provider's database, which is only accessible with a password. Information submitted to the online survey provider will be backed up daily on its secure servers, and the online survey provider will not use any of the information it receives.*

	All data and information collected as part of this study will be downloaded from the online survey provider and saved on to a password-protected computer and secure cloud storage accounts (primarily UMD Box). Only Mr. Lee and Dr. Butler will have access to the study data and information stored on the aforementioned computer and cloud storage accounts. *Any personally identifiable information collected from participants for purposes of study follow-up over time or the E-Gift Card raffle (e.g., your e-mail address) will be destroyed at the conclusion of this study. All other data and files pertinent to the research will be retained for a period of no less than 7 years after the completion of the research in accordance with the University of Maryland, College Park policy on records retention and disposal.* *No personally identifiable information will be used to analyze and interpret the data collected in this study, and all results from this study will be reported in aggregate form (e.g., group averages). Individual questionnaire responses will never be reported.* *If a report or article is written about this research project, your identity will be protected to the maximum extent possible. Importantly, your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if the researchers are required to do so by law.*
Medical Treatment	*Not applicable.*
Compensation	*Upon completing today's questionnaire, you will become eligible to participate in a raffle to win one of thirty $50 electronic Gift Cards from your choice of Amazon, Apple, or Starbucks. This study is expected to enroll 300 participants, with a maximum of 400 participants.* *If you previously completed a questionnaire for this study and entered into this raffle, you will have the opportunity today to make additional entries into the raffle to triple your chances of winning a gift card.* *If you would like to enter the E-Gift Card raffle, you will be directed to a site where you will be asked to provide your name and e-mail address. Your name and e-mail address will be held in confidence and will not be connected to your*

	questionnaire responses. *If you are a raffle winner, you will be responsible for any taxes assessed on the compensation.*
Right to Withdraw and Questions	*Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify. Choosing to participate in the study will have no effect on your grades or standing at the University of Maryland, College Park.* *If you decide to stop taking part in the study, if you have questions, concerns, or complaints, or if you need to report an injury related to the research, please contact the following individuals:* **Clark J. Lee, JD, MPH, CPH** [*Student Investigator*] ***Doctor of Philosophy Candidate*** Phone: (301) 400-4208 E-Mail: cjlee@umd.edu **James Butler III, DrPH, MEd** [*Faculty Supervisor*] ***Associate Professor*** Phone: (301) 405-0757 E-Mail: jbutler9@umd.edu Department of Behavioral and Community Health School of Public Health University of Maryland 4200 Valley Drive, Suite 1234 College Park, Maryland 20742

Participant Rights	*If you have questions about your rights as a research participant or wish to report a research-related injury, please contact:* University of Maryland College Park Institutional Review Board Office 1204 Marie Mount Hall College Park, Maryland, 20742 E-mail: irb@umd.edu Telephone: (301) 405-0678 *For more information regarding participant rights, please visit:* https://research.umd.edu/research-resources/research-compliance/institutional-review-board-irb/research-participants *This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.*
Statement of Consent	*By selecting your choice below, you are indicating your right to consent or not consent electronically.* ***By selecting "YES, I Consent" and clicking on the "Continue" button below, you affirm that:*** 8. *YOU are between 18 and 25 years old, inclusive;* 9. *YOU drive at least once a month;* 10. *YOU are currently enrolled as a student at the University of Maryland, College Park;* 11. *YOU do not have a visual or hearing disability;* 12. *YOU are able to read, understand, and communicate in the English language;* 13. *YOU have read and understand the terms of this study; and* 14. *YOU are agreeing voluntarily to participate in this study.* *If you DO NOT wish to participate in this study, please select* ***"NO, I DO NOT Consent"*** *and click* ***"Continue"*** *to decline participation. You will not be eligible to enter into the E-Gift*

	Card raffle if you decline participation. ******You are advised to download or print a copy of this consent form for your files******

Do you consent to participate in this study?

- ❍ **YES,** I Consent
- ❍ **NO,** I DO NOT Consent

Note: Participant must answer this question to proceed to the next page of the questionnaire

If No Is Selected, Then Skip To the following end-of-questionnaire message:

Thank you for your interest in this study. Your responses have been recorded.

[Questionnaire for Clark Lee PhD Dissertation - RCT Day 30]

Start of Block: Consent (30-Day Follow-Up)

CONSENT TO PARTICIPATE
[30-Day Follow-Up]

[*Day 30 Consent Language Inserted Here*]

Q0 Do you consent to participate in this study?

- ❍ YES, I Consent
- ❍ NO, I DO NOT Consent

Skip To: End of Survey If Do you consent to participate in this study? = NO, I DO NOT Consent

End of Block: Consent (30-Day Follow-Up)

Start of Block: 30-Day Follow-Up Questionnaire

Questionnaire Header **Behavioral and Psychometric Measurements**

Please respond to each of the following questions by selecting the answer that best describes your beliefs. Some of the questions may appear to be similar, but each question addresses somewhat different issues. Please read each question carefully.

******As used in this study, "drowsy driving" means the act of operating a motor vehicle while drowsy, sleepy, asleep, or fatigued******

Q12(0) Please enter the e-mail address where you received the link to this questionnaire.

[***Note:*** *The e-mail address you enter here should be the same e-mail address you provided last month when you indicated your interest in completing a follow-up questionnaire. This e-mail address will only be used to link your responses to this questionnaire with those of the previous questionnaire you completed for this study.*]

_____

Q12(a) How much do you agree with the statement: "In general, I believe that I have the ability to drive while feeling drowsy or sleepy"?

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Somewhat Disagree
- ❍ Neither Agree nor Disagree
- ❍ Somewhat Agree
- ❍ Agree
- ❍ Strongly Agree

Q12(b) For me, how difficult is it to drive while feeling drowsy or sleepy?

- ❍ Extremely Difficult
- ❍ Difficult
- ❍ Somewhat Difficult
- ❍ Neither Difficult nor Easy
- ❍ Somewhat Easy
- ❍ Easy
- ❍ Extremely Easy

Q12(c) How much do you agree with the statement: "Whether or not I drive while feeling drowsy or sleepy is completely up to me"?

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Somewhat Disagree
- ❍ Neither Agree nor Disagree
- ❍ Somewhat Agree
- ❍ Agree
- ❍ Strongly Agree

Q13 If you were driving drowsy, how likely is it that:

	Extremely Unlikely	Unlikely	Somewhat Unlikely	Neither Unlikely nor Likely	Somewhat Likely	Likely	Extremely Likely
(a) You will crash your car into something?	❍	❍	❍	❍	❍	❍	❍
(b) You will drive in an unsafe manner?	❍	❍	❍	❍	❍	❍	❍
(c) You will injure yourself or others?	❍	❍	❍	❍	❍	❍	❍

Q14(a) In the next 30 days, how likely is it that you will drive while feeling drowsy or sleepy?

- ❍ Extremely Unlikely
- ❍ Unlikely
- ❍ Somewhat Unlikely
- ❍ Neither Unlikely nor Likely
- ❍ Somewhat Likely
- ❍ Likely
- ❍ Extremely Likely

Q14(b) In the next 30 days, do you intend to drive while feeling drowsy or sleepy?

- ❍ Definitely Not
- ❍ Probably Not
- ❍ Maybe Not
- ❍ Undecided
- ❍ Maybe Yes
- ❍ Probably Yes
- ❍ Definitely Yes

Q14(c) In the next 30 days, how much will you try to avoid driving while feeling drowsy or sleepy?

- ❍ Extremely Little
- ❍ Little
- ❍ Somewhat Little
- ❍ Undecided
- ❍ Somewhat Great
- ❍ Great
- ❍ Extremely Great

Q15 Suppose you are driving home at the end of the school year after getting very little sleep over the past 2 weeks due to final exams, writing papers, packing your belongings, *etc.*

As you drive, you find yourself having a hard time keeping your eyes open.

How willing would you be to do the following?

	Extremely Unwilling	Unwilling	Somewhat Unwilling	Neither Unwilling nor Willing	Somewhat Willing	Willing	Extremely Willing
(a) Stop driving immediately to get some rest	❍	❍	❍	❍	❍	❍	❍
(b) Drive a little further before stopping to get some rest.	❍	❍	❍	❍	❍	❍	❍
(c) Continue driving until you reached your destination.	❍	❍	❍	❍	❍	❍	❍

Q16 During the past 30 days, how many times have you:

	Never	1 Time	2 to 4 Times	5 Times or More
(a) Driven a motor vehicle while being so drowsy or sleepy that you had a hard time keeping your eyes open?	❍	❍	❍	❍
(b) Fallen asleep or nodded off while driving a motor vehicle, even just for a second or two?	❍	❍	❍	❍
(c) Been involved in a motor vehicle crash that resulted from you driving while drowsy or asleep?	❍	❍	❍	❍

End of Block: 30-Day Follow-Up Questionnaire

Start of Block: Raffle Entry Page

Q46 **Thank you for taking time to complete this questionnaire.**

You are eligible to enter into a raffle to win <u>one of thirty $50 E-Gift Cards</u> from your choice of Amazon, Apple, or Starbucks. If you are interested in entering the E-Gift Card raffle, please select the RAFFLE button below to be directed to a site where you can provide your name and e-mail address. As a reminder, your name and e-mail address provided for the raffle will not be connected to your responses in the questionnaire, and all files with your name and e-mail address created for your raffle entry will be deleted at the conclusion of this study.

If you are entering the raffle upon completing this questionnaire immediately after viewing the video/presentation, you can expect to have about a 1 in 10 chance of winning an E-Gift Card.

If you are entering the raffle a second time upon completing this questionnaire 30 days after viewing the video/presentation, you can expect to have about a 3 in 10 chance of winning an E-Gift Card.

If you are not interested in entering the raffle, please select the FINISH button below.

******If you are selected as a raffle winner, you will be responsible for reporting this information to the relevant tax authorities (including the U.S. Internal Revenue Service) and for paying any taxes assessed on this compensation.******

If you have any questions, please contact Clark Lee at cjlee@umd.edu**.**

- ❍ RAFFLE
- ❍ FINISH

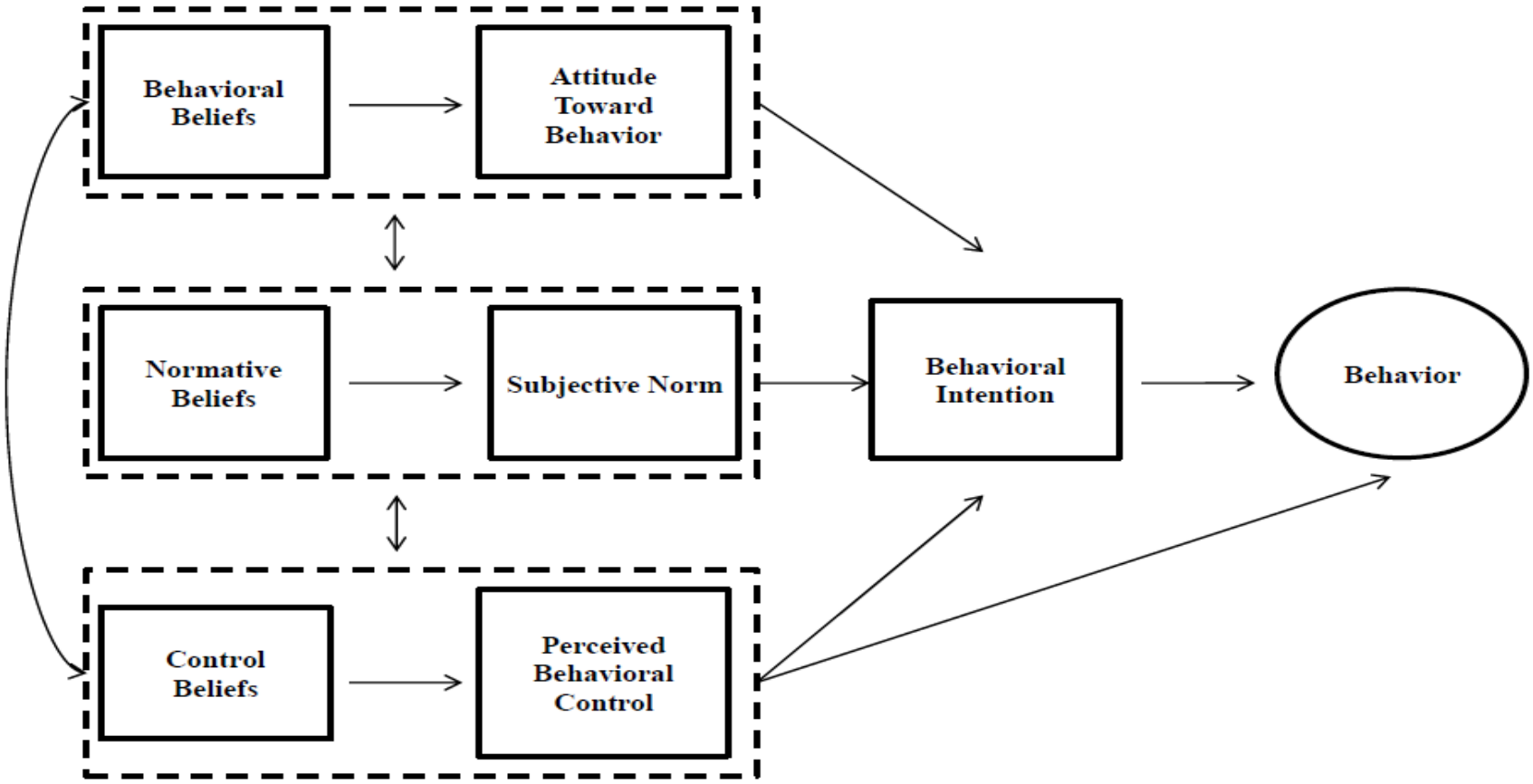
End of Block: Raffle Entry Page

Thank you for your interest in this study. Your responses have been recorded.

Appendix 2: Theoretical Models and Conceptual Framework

Figure 1.1

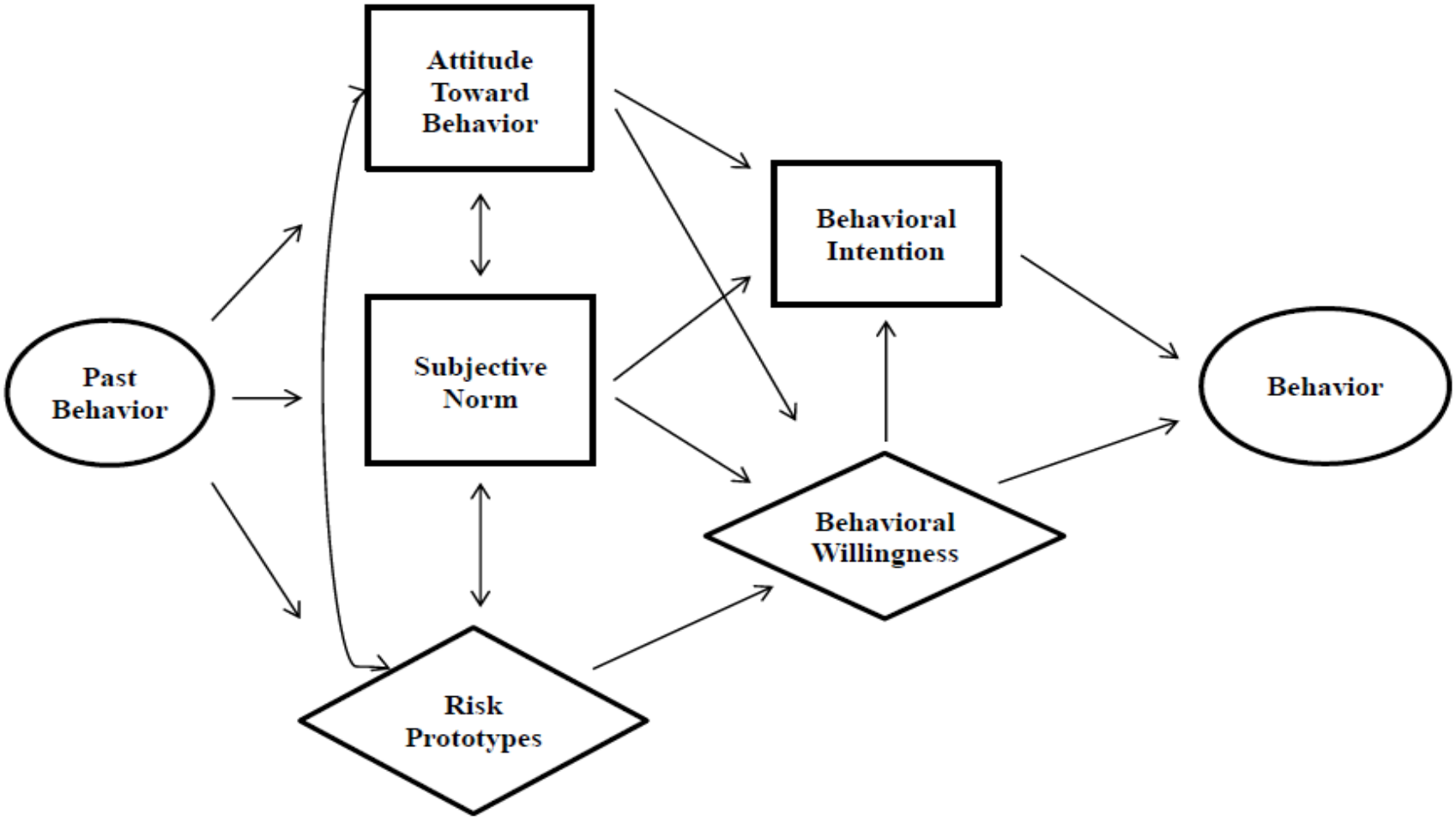
The Theory of Planned Behavior (TPB)



Note. Figure reproduced from Lee (2014, Figure 2.1).

Figure 1.2

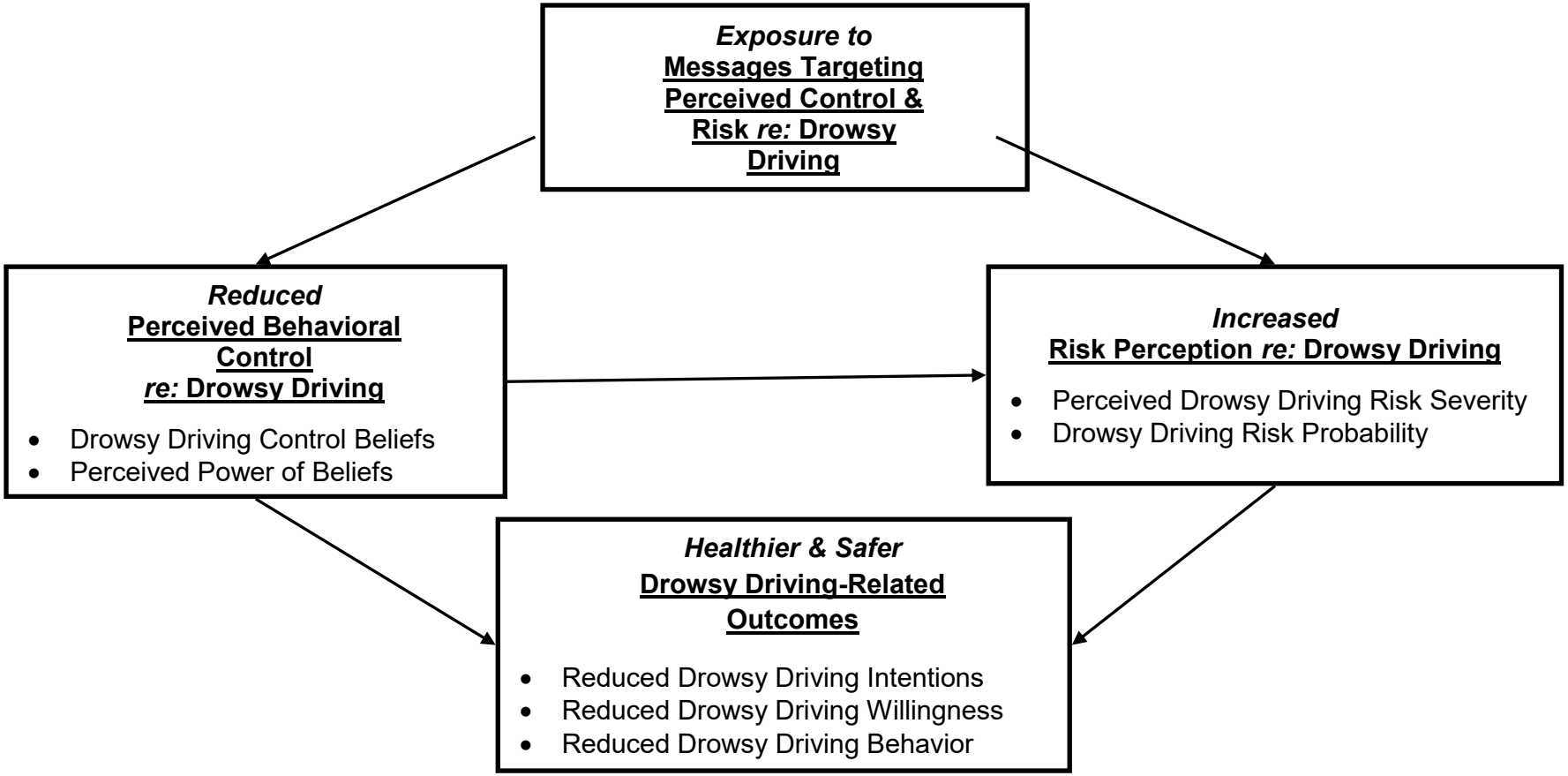
The Prototype Willingness Model (PWM)



Note. Rectangles represent constructs in the "reasoned path" and diamonds represent constructs in the "social reaction path" of the model. Figure reproduced from Lee (2014, Figure 2.2).

Figure 1.3

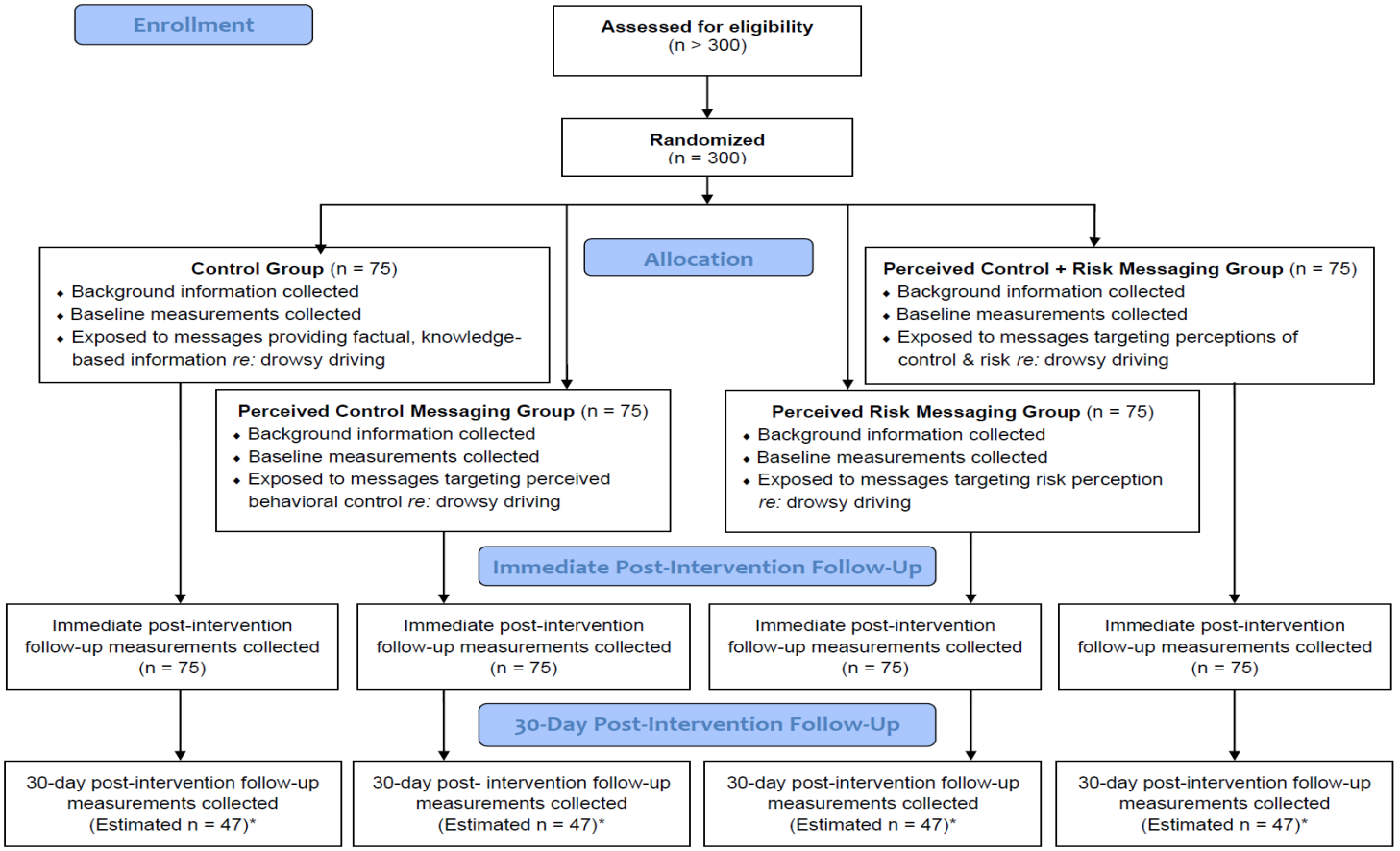
Conceptual framework for reducing drowsy driving intentions, willingness, and behavior through messages targeting drowsy driving-related perceptions of control and risk



Appendix 3: Study Design Figures

Figure 3.1

Randomized controlled trial for assessing drowsy driving messaging strategy efficacy



Note. Asterisks (*) indicate estimates based on an anticipated manipulation check failure rate of 25 percent and an attrition rate of 15 percent.

Appendix 4: Experts Who Reviewed Messaging Interventions during Piloting

Name	Affiliation	Area of Expertise
Kenneth H. Beck, PhD*	University of Maryland, College Park	• Traffic Safety • Social Psychology
James Butler III, DrPH*	University of Maryland, College Park	• Health Education • Evaluation
Jonathan Freed, MA	Freed Strategy	• Strategic Communications and Public Affairs
Lynn C. Cook, MA, CHES	Montgomery Co. (Md.) Department of Health and Human Services	• Health Crisis and Emergency Risk Communication
Betsy Rebert, BA	Montgomery Co. (Md.) Department of Health and Human Services	• Health Crisis and Emergency Risk Communication
Terra Ziporyn Snider, PhD	Start School Later, Inc.	• Adolescent Sleep Health Advocacy
Charles A. Czeisler, PhD, MD	Harvard University	• Drowsy Driving • Sleep Health

* Dissertation Committee member.

Appendix 5: Hyperlinks to Qualtrics Sites and Messaging Intervention Videos

Qualtrics Pages

RCT (Initial Study Day): https://umdsurvey.umd.edu/jfe/form/SV_0xMDVT71OvpKCDc

RCT (30-Day Follow-Up): https://umdsurvey.umd.edu/jfe/form/SV_7VaUjRmQ5iEYr5A

Intervention Videos

All Groups: https://vimeo.com/179466897

Factual Messaging Group: https://youtu.be/p2UX6uusLZY

PBC Messaging Group: https://youtu.be/0eU2mmdBGgQ

Risk Messaging Group: https://youtu.be/CbFmC0nsEmg

PBC + Risk Messaging Group: https://youtu.be/UMsghBghJz8

Appendix 6: Institutional Review Board Approval Letters

UNIVERSITY OF MARYLAND
INSTITUTIONAL REVIEW BOARD

1204 Marie Mount Hall
College Park, MD 20742-5125
TEL 301.405.4212
FAX 301.314.1475
irb@umd.edu
www.umresearch.umd.edu/IRB

DATE:	August 2, 2023
TO:	Clark Lee, JD, MPH
FROM:	University of Maryland College Park (UMCP) IRB
PROJECT TITLE:	[2074553-1] Preventing Drowsy Driving in Young Adults Through Messaging Strategies that Influence Perceptions of Control and Risk
SUBMISSION TYPE:	New Project
ACTION:	APPROVED
APPROVAL DATE:	August 2, 2023
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category #7. Waiver of Consent Documentation, 45 CFR 46.117(c).

Thank you for your submission of New Project materials for this project. The University of Maryland College Park (UMCP) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

Prior to final approval of this project scientific review was completed by the IRB Member reviewer.

This submission has received Expedited Review based on the applicable federal regulations.

This project has been determined to be a MINIMAL RISK project.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Unless a consent waiver or alteration has been approved, Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate Amendment forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others (UPIRSOs) and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed. All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

Please note that all research records must be retained for a minimum of seven years after the completion of the project.

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If you have any questions, please contact the IRB Office at 301-405-4212 or irb@umd.edu. Please include your project title and reference number in all correspondence with this committee.

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DATE:	April 9, 2024
TO:	Clark Lee, JD, MPH
FROM:	University of Maryland College Park (UMCP) IRB
PROJECT TITLE:	[2074553-3] Preventing Drowsy Driving in Young Adults Through Messaging Strategies that Influence Perceptions of Control and Risk
SUBMISSION TYPE:	Amendment/Modification
ACTION:	APPROVED
APPROVAL DATE:	April 9, 2024
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category #7. Waiver of Consent Documentation - 45 CFR 46.117(c).

Thank you for your submission of Amendment/Modification materials for this project. The University of Maryland College Park (UMCP) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

Prior to final approval of this project scientific review was completed by the IRB Member reviewer.

This submission has received Expedited Review based on the applicable federal regulations.

This project has been determined to be a MINIMAL RISK project.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Unless a consent waiver or alteration has been approved, Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate Amendment forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others (UPIRSOs) and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed. All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

Please note that all research records must be retained for a minimum of seven years after the completion of the project.

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