Meta- Risk Taking
Awareness of risks and its effects on driving performance of young adults

Final Project Report --- October 2014

The Brain and Decision Making Laboratory

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Introduction

Motor vehicle accident (MVA) is known to be a leading cause of death for 15- to 20-year-olds. Compared to older drivers, younger drivers are 3 to 4 times more likely to be involved in crash accidents due to “impaired, distracted, and aggressive driving.”[1] While the effects of fatigue[2] and cell phone use[3] on driving have been studied separately in the past, their combined effects on young drivers have received less systematic investigation. In addition, the relationship between driving performance and drivers’ self-awareness of the effects of fatigue and cellphone use on their own driving is poorly understood. In the current project, we examined how texting using a cellphone and sleepiness may separately and jointly affect performance of young drivers in Ohio between 18 to 30 years of age on a driving simulator. We also examined the relationship between indicators of poor driving and drivers’ self-awareness of the extent to which different risk factors could affect their own driving. Use of the driving simulator allowed us to observe how drivers react to dangerous conditions on the road without compromising their safety.

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[1] Smith, G. A. (2012).

[2] Matthews, G., Neubauer, C. E., Saxby, D. J., & Langheim, L. K. (2012).

[3] Strayer, D. L. & Drews, F. A. (2007).

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Executive Summary

This study explored the separate and combined effects of texting and sleepiness on performance of Ohio drivers aged 18 to 30 on a driving simulator. Drivers were tested over two sessions in the laboratory, once when their sleep state was *normal* (i.e., length of sleep the night before = 8 hours or more) and once when sleep-*deprived* (i.e., they restricted their sleep to 4 hours or less the night before). Within each session, they used a cellphone to respond to questions by texting while driving taking a 15-min drive (*text*), while they did not engage in any texting during another 15-min drive (*no_text*). The results showed that crash rates were not elevated in the *normal-text* condition or in the *deprived-no_text* condition relative to the normal-no_text condition. However, crash rates almost doubled in the deprived-texting condition for the younger drivers, suggesting that two risk factors could combine to have a significant adverse effect on the younger drivers' driving, even when neither risk factor alone did by itself. Drivers passed slow-moving cars more when they were not texting compared to when they were texting, but sleep state did not affect passing behaviors. Specifically, younger drivers did not change their driving style (at least insofar as passing is concerned) in the texting and sleep-deprived condition relative to the texting and normal sleep, showing an apparent insensitivity to changes in riskiness of driving conditions. Finally, we had not found strong evidence for a self-other bias in self-assessment of driving; in fact, drivers who affirmed more strongly that they drove worse than their peers ***were*** the ones who showed an elevated crash rates, and this relationship holds both for young drivers aged 18 to 20 only and for the entire

dataset as a whole. Young drivers who affirmed more strongly that they worry more their peers when they drink alcohol had fewer crashes. These results point to a knowledge – performance disparity in younger drivers that does not reflect a simple over-confidence in their own driving ability.

Qualifications of Project Personnel

This study was led by two experimental psychologists, Drs. C.-Y. Peter Chiu and Gerald Matthews, and a clinical psychologist, Dr. Giao Tran.

Principal Investigator – C.- Y. Peter Chiu, PhD. Dr. Peter Chiu, Director of the Brain and Decision Making Laboratory at the University of Cincinnati, is an experimental psychologist and Associate Professor in the Depts. of Psychology and Communication Sciences and Disorders at the University of Cincinnati. For the past decade, he has studied how the brain works in young adults and adolescents in multiple domains, including risk taking, attention, inhibitory control, decision making and other areas of cognition using behavioral and brain imaging methods. His work has been supported by the National Institute of Health and the Air Force Office of Sponsored Research.

Co-Investigator - Gerald Matthews, PhD. Dr. Gerald Matthews, Director of the Laboratory of Stress and Human Performance, is an experimental psychologist and Professor in the Dept. of Psychology at the University of Cincinnati. Dr. Matthews has been conducting driver simulator research since the late 1980s and is an internationally and nationally recognized expert in the assessment of stress and cognition and human performance. He has published extensively on the topic of the effects of stress on driving performance and behaviors for the past 15 years. His work has been supported by the Air Force Office of Sponsored Research.

Co-Investigator – Giao Tran, PhD. Dr. Giao Tran, Director of the Behavioral Health Lab at the University of Cincinnati, is a clinical psychologist and Associate Professor in the Dept. of Psychology. She is a nationally known expert in the treatment of alcohol use in college students who are socially anxious. Her work shows that a brief and effective cognitive behavioral therapy treatment could reduce self-reported drinking behaviors, but that the magnitude of such reduction is strongly affected by "alcohol expectancy" (i.e., the conscious awareness and expectation on the part of patients of how much alcohol use can reduce anxiety and stress). Her work has received support from the National Institute of Health.

Project Managers – Cathy Neubauer PhD and Julia Smith, BA. Dr. Neubauer and Ms. Smith, former and current graduate students in the Dept. of Psychology at the University of Cincinnati respectively, have extensive experience in conducting behavioral research, project management and data analyses.

Literature Review, Background & Current Status of topic in Ohio and Nationally

According to the Younger Drivers Traffic Safety Fact Sheet[4] released by the National Highway Traffic Safety Administration (NHTSA), the most common cause of death nationally for 15- to 20-year olds is motor vehicle crashes. In 2009, about 200,000 young (15- to 20-year-old) drivers in the US were injured in motor vehicle crashes, and an additional 5,000 young drivers were involved in fatal crashes nationally, representing roughly 11% of all drivers involved in such incidents. In comparison, these young drivers represent only 5-7 % of all licensed drivers (about 6.3% in 2006). Among the 5,000 young drivers involved in crashes with fatalities, approximately 2,300 of them were killed. Ohio ranks the 6th in the absolute number of such young driver deaths (84 deaths, about 4% of national total), behind such states as Pennsylvania (96 deaths), North Carolina (114), Florida (136), California (149) and Texas (241) but ahead of States such as Indiana (47), Illinois (54) and Kentucky (57). For individuals age 15-24 in Ohio, motor vehicle accident is the leading cause of (1) injury-related deaths[5] in 2002-2005 and in 2007, and (2) of traumatic brain injuries[6]. Clearly, the issue of teen driver crashes is a major concern both at the national and at the state level. Thus, a better understanding of the antecedent conditions of what makes young drivers err or drive in an unsafe fashion is an extremely important part of all injury prevention efforts directed at young drivers.

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[4] DOT-HS-811-400, available at http://www-nrd.nhtsa.dot.gov/Pubs/811400.pdf

[5] "The Injury Problem" document is available at http://www.odh.ohio.gov

[6] The Brain Injury Association of Ohio, at http://www.biaoh.org.

Previous research reports[7] have documented that younger drivers indeed are more likely than older drivers to engage in speeding, frequent and close passing, and close following, forms of behaviors that might be considered especially risky[8]. As a group, younger drivers appear to show a specific impairment in judging risk and in evaluating their own competence as drivers[9-10]. Young drivers ages 16-24 are much more likely than older drivers to use cell phones while driving[11-12], even though they are unlikely to be able to multi-task as well as older drivers. There is a general tendency for teenagers to be more interested in experimenting with risk behaviors and to seek experiences that are thrilling, a tendency known as sensation seeking. Teenagers who score higher on the sensation seeking scale report an increase in behaviors such as speeding, racing another car, or passing in a no-pass zone[13]. Cestac, Paran, and Delhomme[14] found that, within a sample of young drivers, sensation-seeking was most strongly related to speeding intentions in novice drivers, suggesting that this trait may be an especially important risk factor in preteens. Fatigue or routine sleep losses experienced by teenagers have been

[7] Jonah, B. (1986).

[8] Jonah, B. A. (1987).

[9] Glendon, A. I., Dorn, L., Davies, D. R., Matthews, G., & Taylor, R.G. (1996).

[10] Gregersen, N. P., & Bjurulf, P. (1996).

[11] Neyens, D.M., & Boyle, L.N. (2007).

[12] Neyens, D.M., Boyle, L.N., & Hanley, P. (2008).

[13] Arnett, J. J., Offer, D., & Fine, M. A. (1997).

[14] Cestac, J., Paran, F., & Delhomme, P. (2011).

cited as another risk factor associated with teen car crashes[15]. In 2009, according to the Fatality Analysis Reporting System (FARS) Database on the NHTSA web site (www.nhtsa.gov), some of the driver-related factors in motor vehicle crashes leading to fatalities most commonly cited in traffic / police reports include: (i) under the influence of alcohol, drugs or medication, (ii) careless or inattentive driving, (iii) failure to yield right of way or keep in proper lane, (iv) failure to obey traffic signals or directions, (v) over-correcting, (vi) reckless operation of vehicles or road rage, and (vii) drowsiness or fatigue (see Shope[16] for a detailed analysis of the multiple influences on youthful driving behavior).

In the context of young drivers, however, it seems equally clear that not all young drivers are alike and that some young drivers are more vulnerable than others to motor vehicle accidents. In addition to more objective factors such as driver experience or skill level, it seems reasonable to assume that young drivers differ in the extent to which they appreciate risk in relation to their own driving abilities, and that this subjective self-awareness and evaluation of driving risks may be related to how safely they drive. Drivers who are sleepy, but who underestimate how risky it is for them to drive while sleepy, should be at higher risk for accidents than equally sleepy drivers who appropriately determine that they need to take a break. Someone may know that in general on-road cell-phone use is hazardous, but if such person believes that he or she is immune from such effects, he or she may still be at higher risks

[15] Groeger, J. A. (2006).

[16] Shope, J. T. (2006).

for motor vehicle accidents. We use the term Driving Risk Expectancies (DRE) to refer to an individual's estimate of the effects of various risk factors on their own driving. In this sense, DRE is a form of meta-cognition (i.e., knowledge about how one's cognition or how one thinks); specifically, it is a form of meta-risk taking (i.e., the knowledge and beliefs about how risky one's actions or choices is). Studies of cognition show that adolescence is a period in brain and cognitive development in which, relative to older adults, teenagers are less accurate in understanding how and how well they think. Adolescents tend to be less likely to accurately monitor and report their own behaviors compared to the reports from knowledgeable informants (e.g., parents)[17], and less likely to be able to inhibit or stop their behaviors even when they know such behaviors are inappropriate[18]. These observations are consistent with the idea that young driver may possess knowledge about safe driving and effects of various risk factors in general, even though such knowledge does not translate into appropriate actions, because the young drivers believe that they are less subject to these effects themselves as compared to other drivers[19]. The tendency to apply more favorable appraisal to oneself than to others is called the self-other bias[20] and can be thought of as a form of over-confidence. In this context, one might hypothesize that, all else being equal (including vehicle control ability), a

[17] MacCann, C., Wang, L., Matthews, G., & Roberts, R. D. (2010).

[18] Tlustos, S. J., Chiu, C.-Y. P., Walz, N. C., Holland, S. K., Bernard, L., & Wade, S. L. (2011).

[19] Wahlberg, A., & Dorn, L. (2012).

[20] Pronin, E. (2007).

young driver whose DRE is accurately reflecting their own driving ability may drive more safely than another driver who is over-confident in the presence of risk factors.

In the present study, we observed on a driving simulator how young Ohio drivers handled driving in 2 adverse conditions, when they were texting and when they were sleep deprived. We then tested to see if their answers on a separate 15-item questionnaire regarding their judgment of how much their driving will be affected by adverse conditions such as these are related to their driving performance.

Data Issues and Considerations

Our project design targeted those eligible participants who lived close to University of Cincinnati campus (and therefore could safely return home to rest after the sleep-deprived session of testing). Recruitment of these eligible drivers were more challenging than expected, particularly in the two winter periods (December to February, 2012 & 2013) during which adverse weather had sometimes led to campus closing or made it difficult for participants or personnel to come to campus for the testing sessions.

Summary and Analysis of Findings

Method. All drivers were tested in the same driving scenario, which occurred on a two-lane highway, on a Systems Technology, Inc., STISIM Model 400 simulator, version 2.08.10, equipped with a 38” NEC XM3760 monitor. The driving simulator is capable of a wide range of programming capabilities, which can mimic realistic driving scenarios that are intended to elicit stress and fatigue in the driver. The simulation was displayed via a 42” Westinghouse LCD flat screen television. A Logitech MOMO Racing Force Feedback Wheel was used to evoke realistic driving feedback via gas and brake pedals and an adjustable car seat. In addition, the steering component is capable of 360 degree steering with speed sensitive “steering feel” provided by a computer controlled torque motor. Figure 1 illustrates the experimental setup.

Figure 1. Experimental setup using a System Technologies, Inc., STISIM Drive, build 2.08.10, a Westinghouse 42-inch LCD monitor and Logitech MOMO racing force feedback wheel.

The main drive consisted of occasional oncoming traffic, pedestrian crossings and intersection stops, as well as red lights and stop signs. Transitions from rural (small town) to city (urban) driving occurred approximately every few minutes. Drivers were instructed to drive “as they normally would” and to adhere to the speed limit signs, which ranged from rural scenery speed

(40 mph minimum, 50 maximum) and city driving (50 minimum, 60 maximum); they were also asked to refrain from making any gratuitous stops or turning down any side streets.

The driving scenario used in the two sessions were comparable and structured identically. In each session, following a 5-min practice drive, all drivers drove along a two-lane straight section of the road with a double yellow marking at 35 mph, and the road changed periodically from a straight section to a curved section. A few minutes into the drive, the speed limit changed to 55 mph and the yellow marking changed to a dashed yellow line to afford passing. A vehicle would then move in front of the driver and became slow-moving, while a series of vehicles were launched in the other lane. The spacing of these vehicles afforded risky as well as non-risky passing. Periodically, vehicle or pedestrian situations presented driving challenges to the driver to maneuver the vehicle through without being involved in any accidents. Session 2 was similar to Session 1 except that the sleep state condition of the participant was different.

In addition to the drive data, participants also provided answers on a 15-item questionnaire designed to assess the self-other bias in driving and other areas of performance and daily living. Participants indicated on a rating scale of 1-9 how they felt about their driving ability. These questions included:

1. Compared to other drivers like me, sleeping for 5 hrs or less the night before does not affect my driving
2. I manage my finances better than my peers

3. I drove worse than my peers
4. I worry more when I drink (alcohol) than my peers
5. When I sleep for less than 5 hrs the night before, I drive better than my peers who also slept less than 5 hrs the night before
6. When I drive and talk on the cellphone, I had worse control of my car than my peers who drive and talk on the cellphone at the same time.
7. I have better grades than my peers
8. As far as I know, I have fewer traffic accidents than my peers
9. I have more speeding tickets than my peers
10. I have fewer parking violations than my peers
11. When I drink and drive, I manage my vehicle worse than my peers
12. I am more hurried and keep a busier schedule than my peers
13. I get to class / work on time more often than my peers.
14. I hand in work / class assignments on time less than my peers
15. I pay my bills on time more than my peers.

Results on Driving Performance. Overall and across all ages, with respect to the control condition (i.e., when they were not sleep deprived and were not texting), the crash rates of drivers was elevated (crashing an average of 0.6 times during the drive) only when they were **sleep deprived and texting**. Texting alone and sleep deprivation alone did not cause a significant shift in crash rates relative to the normal condition (crashing an average of about 0.35 times during the drive)[21]. In term of passing behaviors, drivers who were texting passed slower moving drivers in front of them less frequently than when they were not texting --- which is expected given that they have less time and attention to devote to vehicle maneuvering during texting. On the other hand, sleep state did not have a discernable effect on passing.[22] These two findings were of particular interest, because they suggest that drivers are maintaining essentially the same driving style, and that they drive no more defensively in the texting conditions when they are sleep deprived than when they are not.

Table 1. *Mean rates of crashing and passing as a function of texting and their subjective state. Standard deviations are in parenthesis.*

		Texting	No Texting
Driver Behaviors	Driver State		
Number of Crashes	Sleep-Deprived	**0.62** (1.3)	0.35 (.91)
	Normal	0.37 (0.8)	0.37 (1.0)
Number of Passes	Sleep-Deprived	2.07 (2.6)	2.81 (3.6)
	Normal	2.07 (2.8)	2.76 (3.4)

[21] Significant interaction between driver state and texting, $F(1, 138) = 3.83$, $p = 0.052$, and significant effect of texting, $F(1,138) = 4.10$, $p = 0.045$, but no significant effect of Subject State, $F(1,138) = 2.03$, $p = 0.16$.

[22] Significant main effect of texting, $F(1, 138) = 23.3$, $p < 0.001$, with no other effects being statistically significant, all $F < 1$.

Table 2. *Mean rates of crashing as a function of age group, texting and their subjective state. Standard deviations are in parenthesis.*

		Texting	No Texting
Driver Behaviors	Driver State		
Age 18-20 (N=82)	Sleep-Deprived	**0.77** (1.5)	0.35 (1.1)
	Normal	0.35 (0.7)	0.41 (1.2)
Age 21-29 (N=57)	Sleep-Deprived	0.40 (2.6)	0.35 (0.7)
	Normal	0.39 (0.9)	0.30 (0.8)

We then divided the dataset by age into 2 groups --- those who were between 18 and 20 years of age (where previous research suggests a heightened vulnerability to motor vehicle accidents; N=82) and those who were between 21 and 29 (N=57). The corresponding data are presented in Table 2. It is apparent that the crash rate results described above is strongly qualified by an age effect[23]: crash rates were roughly comparable across all conditions for the older drivers, whereas crash rates were elevated only in the texting and sleep-deprived condition relative to the other conditions for the younger drivers aged 18 to 20.

Results on Relationship between questionnaire items and driving. Correlation coefficients were calculated between answers on the 15 items and the number of total crashes

[23] The 3-way interaction effect of age, state, and texting was marginally significant, $F(1, 137) = 3.47$, $p = 0.06$, as was the main effect of texting, $F(1, 137) = 3.41$, $p = 0.07$. No other effects were statistically significant.

participants committed across both driving sessions. Answers on 1 item (item 3) showed a relationship with total number of crashes: those who more strongly affirmed item 3 had an elevated total number of crashes, $r = +0.3$ ($N=133$, $p < 0.001$). Restricting to the number of crashes committed in the sleep deprived texting condition, answers on item 4 showed a mild negative relationship, $r = -0.17$ ($N=132$, $p = 0.047$). These results remain the same even if we restrict the data sample to include only those who are 20 years of age or younger. Answers on all other items showed no relationship to number of crashes (total or in specific drive conditions).

These results suggest that our younger drivers in Ohio who had higher number of crashes during the simulated drives also rated themselves as worse drivers than their peers. Those who affirmed more strongly that they worried more than their peers when using alcohol had fewer crashes in the texting and sleep-deprived condition. Both observations did not support the notion that young drivers had elevated crash rates because they were over confident in their own driving ability.

Study Limitations. It is important to bear in mind that the current findings are specific to the driving scenario we chose. In our driving simulation, the slower moving vehicle ahead of the participant never changed speed: if it did, then we expect more crashes might occur certainly in the texting conditions. The drives were relatively short (15 min each) and were more similar to the typical length of daily drives of many of our participants, but the results might not be applicable to longer drives. We chose a period of sleep deprivation (i.e., sleeping for 4 hours or less the night before) to be realistic for the study population (i.e., college students living close to campus) and yet allow some degree of vehicle control. Certainly, the results are likely to be very different if participants are more fatigued after much longer periods of wakefulness. Finally, it is gratifying to note that even though we required participants to text in the current study, many voiced strong concerns and affirmed that they would not normally text while driving.

Conclusions and Recommendations

The key findings of the present study, within the context of the driving conditions set in the simulated drives, can be summarized as follows:

1. Whereas drivers older than 20 years of age showed the same number of crashes whether or not they were sleep deprived or texting, younger drivers aged 18 to 20 showed an elevated level of crashes when they were fatigued and texting at the same time. However, either factor alone, within the context of our drive scenario, did not lead to higher number of crashes.
2. All drivers tended to engage in more passing behaviors when they were blocked by slower moving vehicles in their lane, and only did so less when they were pre-occupied

with texting. They engaged in passing about as often whether or not they were sleep deprived.

3. The data did not offer strong support to the over confidence hypothesis: drivers who rated themselves as driving worse than their peers were the ones who indeed crashed more than their peers. However, drivers who did not think they worried more than their peers when drinking alcohol had more crashes.

If younger drivers are aware of their own driving ability relative to their peers, which did predict the number of crashes that they had, why are so many of them still involved in traffic accidents? First, younger drivers might endorse the general fact that they can only drive at a certain level of proficiency, perhaps lower than their peers, but they might not be aware of the conditions on the road or their subjective states that specifically predicted how well they could maintain vehicle control. Some risk factors may not be sufficient to cause more crashes in isolation, but they could do so when in combination. Young drivers might hold the belief that their driving was not adversely affected by texting alone or sleep deprivation alone in some conditions, which would not be inaccurate in the context of the current study, but they might not know that their driving would be adversely affected when the risk factors are combined (in which case, all too often it is too late). Here educational effort that focuses on the specific conditions that might affect younger drivers more or less can be extremely valuable[24]. Second, there might be a persistent knowledge – performance discrepancy for younger drivers, in that they do know what risk factors might adversely affect their driving, but that awareness and knowledge simply did not get translated into more defensive actions. Drivers in our study did not pass other vehicles less when they were sleep deprived compared to when they were not fatigued. This observation relates to the broader pattern of failure in inhibition that characterize the late adolescence / early adulthood period, in which young men and women tend to find it more difficult to inhibit and stop behaviors that become mal-adaptive given changes in subjective states or environmental conditions. Here, in-vehicle warning or monitoring may help provide timely feedback to young drivers to alter their behaviors.

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