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Effects of Mobile Internet Use on College Student Pedestrian Injury Risk

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EFFECTS OF MOBILE INTERNET USE ON COLLEGE STUDENT PEDESTRIAN INJURY RISK

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ABSTRACT

Unintentional pedestrian injury is a leading cause of death in the United States. Given the complexity of accurately judging the safety of a street crossing, the task likely becomes even more challenging when pedestrians become distracted by attempting to multitask. Newly introduced cell phone functionalities such as mobile internet may introduce distraction that goes beyond the basic cognitive demand of a phone conversation or even text messaging, both of which distract pedestrians and increase unsafe behavior. The present study examined participants' pedestrian behavior while distracted by mobile internet applications. In addition, we aimed to explore college students' perceptions of the risks of multitasking while crossing the street and the frequency with which they engage in such behaviors. Using a safe and ethical virtual environment (VE), 93 college students completed ten simulated street crossings while distracted by internet applications and ten while not distracted. Given the negative impact of cognitive and visual distraction, we expected participants crossing the virtual street to behave in a riskier manner when using mobile internet applications than when not. To explore risk perceptions and unsafe behavior patterns, we examined responses to several self-report measures. We expected participants would rate the risk of crossing while multitasking as more unsafe for others than for themselves, would report still engaging in the behavior despite being aware of the risk involved, and would report feeling more distracted in the VE while using mobile internet than they thought they would. Results were generally consistent with expectations. Pedestrian behavior was more risky when participants were using mobile internet and crossing the street than when crossing undistracted. Even participants who frequently crossed streets, used mobile internet, or did both simultaneously were as unsafe in the VE as those with less experience. As expected, participants believed using mobile internet while crossing was more unsafe for others than for themselves. However, fewer students than expected recognized the risk of multitasking while crossing. After participating, the majority of participants reported feeling more distracted than they thought they would. Conclusions and implications are discussed.

Keywords: pedestrian safety, virtual environment, mobile internet, risk perception, multitasking, distraction

DEDICATIONS

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INTRODUCTION

Unintentional injury is a leading cause of death in the United States, and pedestrian injury falls within that category. The most recent data from the National Center for Injury Prevention and Control (NCIPC) reported that in the year 2007, 165,944 people suffered serious injuries from pedestrian accidents resulting in treatment at a hospital. An additional 5,958 were killed. Among those injured, college-age individuals (17 to 24 years old) had the highest incidence of non-fatal pedestrian injuries of any other age group (NCIPC, 2011).

One reason college students may have the highest pedestrian injury incidence rate is that they tend to be frequent pedestrians. In an empirical research study of 40 college students from two different campuses, Sisson, McClain, and Tudor-Locke (2008) found that participants walked significantly more during week days, when they were more likely to be on campus, than weekend days. This suggests that due to being on a campus, college students may have more opportunities and a greater need to walk (e.g., between class buildings, from on-campus housing). This increased exposure could put them at higher risk for pedestrian injury.

Processes Involved in Making Street-Crossing Decisions

Although it may seem fairly simple, the task of crossing a street is a complex cognitive and perceptual task (Thompson, 2007; Whitebread & Neilson, 1999). When crossing a street, pedestrians must simultaneously and accurately perceive the speed, distance, and acceleration of one or more vehicles. That information must then be interpreted as a cue to how much time is available before the vehicle(s) arrive(s) to the crossing area. Pedestrians must also consider other important environmental constraints such as the width of the road and how quickly they need to walk that distance to cross safely (Thompson, 2007).

While processing the various environmental stimuli, pedestrians must also possess the attentional capacity to remain focused on crossing and ignore irrelevant stimuli in order to make a safe decision about when to cross (Thompson, 2007). In fact, when examining the behavior of 245 college students crossing a simulated street in a virtual environment, Schwebel, Stavrinos, and Kongable (2009) suggested that the safety of participants' pedestrian decisions was likely influenced by individual differences in self-reported attentional control. Specifically, participants with higher levels of attentional control waited longer before crossing the virtual street. This is important to consider because pedestrians who wait to cross until there is a safe gap in traffic are more likely to cross safely (Schwebel et al., 2009).

Given the complexity of accurately judging the safety of a street crossing, along with the necessity of devoting careful attention to key stimuli, the task of crossing a street likely becomes even more challenging when pedestrians become distracted by attempting to multitask (e.g., use a cell phone). If attention is directed elsewhere, the cognitive processing needed to make a safe street-crossing decision may become disrupted and may be less effective.

Increasing Electronic Distraction

There are many distractions for pedestrians, such as eating, smoking, or listening to music. Among the most common is a cell phone (Bungum, Day, & Henry, 2005; Hatfield & Murphy, 2007; Nasar, Hecht, & Werner, 2008). Cell phones have become increasingly advanced, allowing users to do much more than just make a phone call or send a text message. Providers have recently begun marketing cell phones that provide access to advanced functions through the use of mobile internet. "Smartphones" have created the capacity for cell phone users to access email, social networking sites, websites of interest, and a number of other sources found through the internet. In addition to website access through a mobile internet browser, a constantly growing library of downloadable applications is now available, allowing users to do things such as obtain a map and follow directions to a location, check the weather, find the closest fast food restaurant, check scores of sporting events, or even track their diet and exercise for the day (PC Magazine Encyclopedia, 2010a).

The use of mobile internet applications appears to be on the rise. In May 2010, results from a survey of 2,252 adults (ages 18 and over) revealed that since December 2007, the percentage of Americans who use a cell phone to access the internet, send email, or use instant messaging has increased from 19% to 40% (Smith, 2010). Considering the rapid increase in mobile internet use and given that a number of pedestrians use cell phones for talking or text messaging while crossing the street (Bungum et al., 2005; Hatfield & Murphy, 2007; Nasar et al., 2008), it seems that they would be likely to use mobile internet while crossing as well. Although no published research could be found regarding how mobile internet use may affect pedestrian safety, these newly introduced cell phone functionalities may introduce an aspect of distraction that goes beyond the basic cognitive demand of engaging in a conversation, and even beyond the cognitive and visual demands of text messaging.

Attention and Distraction

Research suggests that multitasking increases distraction (Kahneman, Ben-Ishai, & Lotan, 1973; Ophir, Nass, & Wagner, 2009; Strayer & Drews, 2007b). In a comprehensive review of attentional processing, Kahneman (1973) discusses that attending to and perceiving environmental stimuli is a complex, multi-stage process. From the initial moment of sensing a stimulus through auditory, visual, or other sensory processes, information about the stimulus is registered and temporarily stored in one's sensory memory. Next, the information is quickly divided into groups of similar perceptual units and a subconscious decision is made regarding which groups should receive the most attention. At that point, attention to stimuli is especially important and can affect subsequent processing because the subconsciously chosen groups of perceptual units are the most likely to be perceived more consciously and in more detail. Thus, it is more likely that the chosen perceptual units will be the ones to elicit and direct subsequent responses (Kahneman, 1973).

When considering how this complex process may work in the context of the multiple inputs requiring attention in a street-crossing situation, one might theorize that if an individual attempts to complete an additional task, the added stimuli may demand extra attention and take away from the process of determining which important street-crossing information receives the most attention. Kahneman (1973) notes that in situations where multiple stimuli are present, primary input can at times be effectively attended to and processed by ignoring additional or secondary stimuli. However, the natural response to devote extra attention to recognizing and processing the secondary stimuli cannot be completely prevented. Therefore, in a street-crossing setting, even if pedestrians consciously attempt to cease interacting with a cell phone, it may be difficult for them to completely ignore the phone and focus fully on crossing.

The human capacity for attending to multiple stimuli is limited. If the demands of even two tasks surpass that limit, attention to and performance on one or both tasks will suffer (Kahneman, 1973). This is especially concerning for multitasking pedestrians, given research suggesting that a number of complex stimuli must be carefully attended to in order to make a safe crossing decision (Schwebel et al., 2009; Thompson, 2007; Whitebread & Neilson, 1999).

Effects of Cognitive Distraction on Injury Risk

Very little published research exists regarding how pedestrian safety may be compromised by distraction (Bungum, et al., 2005; Nasar et al., 2008; Neider, McCarley, Crowell, Kaczmarski, & Kramer, 2010; Schwebel, Stavrinos, Byington, Davis, O’Neal, & de Jong, under review; Stavrinos, Byington, & Schwebel, 2009, 2011). There is, however, a more substantial body of evidence suggesting that distraction from cell phone use interferes with safely driving an automobile both in a driving simulator (Strayer & Drews, 2006, 2007a; Strayer & Johnston, 2001; Törnros & Bolling, 2005) and during real-road driving experiments (Blanco, Biever, Gallagher, & Dingus, 2006; Patten, Kircher, Östlund, & Nilsson, 2004).

Driving and street crossing are comparable in that they both require cognitive and perceptual processing while attending to a number of environmental stimuli. Therefore, research examining how multitasking may compromise the attention and safety of drivers is also relevant to understanding how multitasking may compromise the attention and safety of pedestrians crossing a street. To provide a more complete picture of how cell phone use may distract pedestrians, we will discuss research on driver distraction first, followed by a review of available research on pedestrian distraction.

Cognitive Distraction in Drivers

A number of empirical studies suggest that using a cell phone while driving can cause distraction and thus negatively impact safety and driving performance (e.g., Blanco et al., 2006; Patten, Kircher, Östlund, & Nilsson, 2004; Strayer & Drews, 2006, 2007a; Strayer & Johnston, 2001; Törnros & Bolling, 2005). Although it might seem that manipulating or holding a cell phone could be the main factor in decreasing safe driving, it has been suggested that due to the cognitive distraction involved in cell phone conversations, drivers are just as distracted and make similar driving errors when using a hands-free phone as when using a handheld (Patten et al., 2004; Strayer, Drews, & Crouch, 2006; Törnros & Bolling, 2005).

As an example, Törnros and Bolling (2005) used a driving simulator to examine differences in the behavior of 24 drivers using a handheld cell phone and 24 drivers using a hands-free cell phone. While conversing on a phone, both groups showed slower reaction times in the driving simulator regardless of whether they were holding the phone or using the hands-free device. The authors suggest that the increased mental workload of talking on the cell phone resulted in a decreased attentional capacity to focus on surrounding traffic and other important environmental stimuli.

In a similar study, Strayer et al. (2006) used a within-subjects design in which 40 participants engaged in both a simulated driving session using a hands-free cell phone and a simulated driving session using a handheld cell phone. Order was randomly counterbalanced. Results again revealed that driving impairments (i.e., decreased reaction times, more accidents, greater lag in following a pace car, and more time to regain speed after braking) were similar for both the hands-free and handheld phone conditions. These impairments were attributed to the fact that in both cases, the phone conversation diverted attention away from the necessary information processing required for safely operating the vehicle.

Patten et al. (2004) found comparable results in a real-road driving task. While driving a pre-planned experimental road course with a research assistant present, 40 participants conversed on both a handheld and a hands-free phone at separate points during the course of the drive. Results showed that driving performance was compromised (i.e., slower reaction times, decreased detection of changes in environment) for both phone modes.

Patten et al. (2004) explain that regardless of phone mode, drivers tend to reprioritize and redirect their attention to the secondary task of conversation such that attention to the primary task of driving is compromised. When experiencing this increased cognitive workload, the brain is unable to process and respond to important information as quickly as usual, which can become detrimental in a situation such as driving where the speed of reaction time is crucial for safety (see also Levy & Pashler, 2008). These findings are consistent with Kahneman's (1973) theory that if attention is interrupted during the subconscious sequence involved in processing environmental stimuli, those stimuli may not receive the detailed consideration necessary, which may result in less informed decision making. Results of these studies provide evidence that the increased cognitive workload is likely a major contribution to the distraction of a cell phone conversation.

Cognitive Distraction in Pedestrians

Like driving a motor vehicle, crossing a street is a complex perceptual and cognitive task that requires adequate attention to environmental stimuli and quick reactions to maintain safety. When attention is compromised by another task, such as a cell phone conversation, pedestrians are more likely to become distracted and engage in more risky or unsafe street-crossing behavior (Neider et al., 2010; Stavrinos et al., 2009, 2011).

Two observational studies suggest adult pedestrians might be more distracted and less safe while talking on a cell phone than while undistracted (Bungum et al., 2005; Nasar et al., 2008). Bungum et al. (2005) observed 866 pedestrians near a university campus (large majority of the sample was college-age) and found that when distracted by cell phone conversation, pedestrians used less cautionary behaviors (e.g., looking left and right, waiting for a crossing signal) before crossing the street. Nasar et al. (2008) discovered that of 127 pedestrians observed on a university campus, 72% of those talking on a cell phone stepped into the crosswalk when a car was approaching while only 47% without a cell phone did so. Similar to distracted drivers (Patten et al., 2004; Strayer et al., 2006; Törnros & Bolling, 2005), the increase in unsafe behavior for pedestrians talking on a cell phone was attributed to their attention being distracted from crossing and the surrounding environment.

More recently, three experimental research studies found that samples of college students and pre-adolescent children were less safe when crossing the street and talking on a cell phone than when undistracted (Neider et al., 2010; Stavrinos et al., 2009, 2011). Previous work in our laboratory examined the performance of 77 children ages 10 to 11 years old crossing a simulated street in a virtual environment while talking on a cell phone versus not talking on a cell phone. When using the phone, the children paid less attention to traffic, left smaller gaps between themselves and oncoming vehicles, took more time to initiate crossing, and were more likely to be hit or almost hit by virtual vehicles (Stavrinos et al., 2009).

We later conducted a similar study with 108 college student participants using the same virtual environment (Stavrinos et al., 2011). All students participated in six simulated crossing trials while engaged in conversation on a cell phone and six simulated crossing trials while not using a cell phone. The order of distraction presentation was randomized across participants. Results for college students were similar to results for children, suggesting more risky pedestrian behavior when engaged in a cell phone conversation than when not. However, for college students, attention to traffic was not altered by the conversation as it was for children. Specifically, college students looked left and right before crossing just as frequently when on a cell phone than when not, but nonetheless still crossed at times that put them at greater risk for an unsafe crossing. A possible explanation is that although they looked for important roadway information, participants may have actually failed to capture and appropriately process information when making a crossing decision (Stavrinos et al., 2011).

Neider et al. (2010) also used a within-subjects experimental design to examine the street-crossing behavior of 36 college students using cell phones in a virtual pedestrian environment. Findings indicate that participants made fewer successful crossings when talking on a cell phone than when not, providing further evidence that distracted pedestrians may be at higher risk for injury than undistracted pedestrians. Thus, it appears that similar difficulties with increased cognitive workload from the added task of a cell phone conversation are likely detrimental to street crossing as they are to driving.

Effects of Visual Distraction on Injury Risk

In addition to the cognitive distraction that emerges from engaging in conversation on a cell phone, newer methods of communicating by cell phone (e.g., text messages, email, mobile internet) may add a new component of visual distraction. If visual attention is compromised by looking away from the road to engage in another task such as text messaging or emailing, pedestrians might miss important environmental information necessary for making a safe crossing decision.

Despite the growing popularity of mobile internet applications, a comprehensive literature review found no published empirical research regarding its distracting effects on drivers or pedestrians. The most comparable cell phone function involving a visual component that has been examined as a distracter is text messaging. Text messaging (also referred to as Short Messaging Service [SMS]) is a service with which cell phone users can exchange brief written messages of 160 characters or less by using the phone's keyboard or number pad to enter text (PC Magazine Encyclopedia, 2010b). As with cell phone conversation, the majority of literature exploring the risk of distraction by text messaging focuses on driving safety.

Visual Distraction in Drivers

Recent research suggests that text messaging has a negative impact on driving performance (Hosking, Young, & Regan, 2009) and is even more dangerous than basic cell phone conversation alone (Drews, Yazdani, Godfrey, Cooper, & Strayer, 2009). Drews et al. (2009) examined the driving performance of 40 college students while text messaging and while not text messaging in a driving simulator. Friend dyads were recruited to participate in the study together. One in the pair was randomly chosen to be the text-messaging driver while the other sent and responded to the texts as they made plans for a mock evening activity. Results showed that while text messaging, participants displayed significant impairments in driving performance. Specifically, they took longer to respond to the brake lights of a preceding car, made more departures from the driving lane, and caused more collisions with other vehicles.

Interestingly, the authors note that when compared to their previous studies of distracted driving (Cooper & Strayer, 2008), a clear difference emerges between the pattern of drivers' simultaneous attention to talking on a cell phone when driving versus their attention to text messaging when driving. While it appears that during cell phone conversation drivers *divide* their attention between conversing and driving, during a text messaging exchange, the added visual demands seem to result in drivers *switching* their attention more fully to either texting or driving alone. Thus, when attention is focused on texting, attention to driving is decreased even more than when conversing on a cell phone (Drews et al., 2009). This is consistent with Kahneman's (1973) theory that the natural tendency to devote extra attention to a secondary stimulus cannot always be prevented. For drivers, adding the combined cognitive and visual demands of texting introduces a second and third stimulus that may make fully attending to the primary task of driving even more difficult.

Hosking et al. (2009) used a similar protocol in a driving simulator requiring 20 college student participants to send one-word responses to text messages that were pre-loaded on a provided cell phone (e.g., "What day is it?"). In contrast to participants in the Drews et al. (2009) study, who had an average of 4.75 years driving experience, these participants had less than 6 months of driving experience. The results of the two studies were similar. Hosking et al. (2009) also found that important aspects of driving performance such as vehicle control and visual attention to the road were compromised when text messaging. Notably, Hosking et al. (2009) found that when texting, drivers were 50% more likely to veer from the designated driving lane and spent around 400% more time looking away from the road (i.e., "in-vehicle glances"). The authors concluded that the increased demand of visual attention when text messaging seems to contribute greatly to diminished driving performance and increased risk for automobile accidents.

The results from Hosking et al. (2009) and Drews et al. (2009) demonstrate the increased negative impact of adding the visual distraction of text messaging. Because text messaging combines cognitive processing (e.g., processing information in a text message, producing a response) *and* visual processing (e.g., reading a text message, looking to type or edit a response), it seems likely that the combination of the two creates greater distraction and is even more detrimental to driving performance than cognitive distraction alone.

One other study focuses on the impact of combined cognitive and visual distraction while driving as well as the impact of each separately. Although they did not study text messaging directly, Liang and Lee (2010) examined the effects of cognitive and visual distraction on the performance of 16 participants (ages 35 to 55 years) in a driving simulator. Each participant completed eight 8-minute driving sessions: two included visual distraction, two included cognitive distraction, two included combined cognitive and visual distraction, and two included no distraction. All cognitive and visual tasks were experimental in nature (e.g., matching the image of an arrow to its replica in a matrix, listening to an audio clip describing a person walking on a path and verbally responding with the direction in which the person would be facing at the end, or listening to a similar directional audio clip and using a visual display to select the direction at the end) and did not involve conversation or any other type of exchange with another person. The order of presentation of the experimental tasks was counterbalanced across conditions.

Results suggest that for both the visual only task and the combined cognitive and visual task, participants made more errors in driving (i.e., slow braking response, veering from the driving lane, poor detection of hazards in the roadway) than when completing a cognitively distracting task alone. Participants also looked away from the road more frequently and for longer time periods in the visual and combined conditions than in the cognitive distraction condition (Liang & Lee, 2010). This provides evidence that both the visual and cognitive aspects of text messaging or browsing mobile internet could possibly increase distraction.

Visual Distraction in Pedestrians

The few published studies examining cell phone distraction among pedestrians (Bungum et al., 2005; Nasar et al., 2008; Neider et al., 2010; Stavrinos et al., 2009, 2011) only consider conversation and do not include results regarding more advanced cell phone functions such as text messaging. As was stated previously, pedestrians must attend carefully to traffic using both cognitive and visual processes in order to determine a safe crossing gap. Therefore, it may be expected that compromising visual attention would be distracting to pedestrians crossing the street as it is to drivers.

A recent study in our laboratory which is currently under review for publication examined the effects of text messaging on pedestrian behavior in a virtual reality environment (Schwebel et. al, under review). A sample of 138 college student participants were randomly divided into four groups to either converse on a cell phone (n = 33), text message (n = 30), listen to music on an mp3 player (n = 34), or have no distraction (n = 31). Results show that the number of times that participants in the texting and mp3 player conditions would have been hit or almost hit by a virtual vehicle was greater than that of participants in the conversation or no distraction conditions (Schwebel et. al, under review). Given the small sample size of this study, statistical power was low. Thus, it is possible that larger effect sizes may have been obtained with a larger sample and greater statistical power. Results from the study are the first to suggest the possibility that the added visual distraction of text messaging could result in more risky street crossing behavior for pedestrians.

Given that using mobile internet applications is somewhat similar to text messaging in that it involves cognitive processing and attention to visual stimuli, it seems that using mobile internet while crossing the street might result in comparable distraction effects. There is no available literature regarding how this advanced cell phone function may affect pedestrian distraction; however, there are several factors that might make the distraction of mobile internet greater than that of text messaging.

First, in contrast to text messaging, using mobile internet applications does not require the engagement of another person. Therefore, users typically have access to the web-based content at virtually any time. This leaves more opportunities to use the distracting device, including while crossing the street. However, it also allows the opportunity to postpone internet use until a safe time when not actually crossing (e.g., while waiting on the sidewalk). Second, the content accessible through mobile internet (e.g., websites, emails, social networking) can include a variety of visually distracting media such as pictures, lengthy blocks of text, or video clips, among countless other items. This might require users to spend more time looking through a larger quantity of visual material before finding the information they are seeking. It may also tempt them to spend time browsing through unrelated information that catches their attention but is not immediately necessary. As Hosking et al. (2009) suggested that text messaging drivers spent 400% more time looking away from the road, it is possible that when larger quantities of information are available, mobile internet users may spend even more time looking away from the road. This could set the stage for decreased attention to the street-crossing environment and increased unsafe behavior.

Multitasking and Its Effects

Given the serious consequences that can occur from distracted street-crossing, it is important to understand how often multitasking occurs along with factors that may help determine why individuals engage in the behavior.

Frequency of Multitasking

When it comes to electronic media such as cell phones, it has been suggested that college students tend to be frequent multitaskers. Ophir et al. (2009) explored this idea by having 262 college students complete a questionnaire indicating the number of hours per week they spend using each of 12 forms of media (e.g., cell phone, web surfing, television, print media). Aside from print media, all other forms were electronically based. Participants were also asked to rate how often they use each of the 12 media simultaneously with one of the other 12 media.

A Media Multitasking Index (MMI) was created by assigning numeric values to the ratings of how often multiple media are used simultaneously (i.e., 1 = “Most of the time;” 0.67 = “Some of the time;” 0.33 = “A little of the time;” and 0 = “Never”). Responses for each of the 12 media were summed to produce a mean score of how many media are used concurrently with each of the other media. The sum across each medium was then weighted by the percentage of hours using each. The resulting index represented each participant’s level of multitasking per typical hour of mediaconsumption. The mean MMI score was 4.38 (*SD* = 1.52), suggesting that many college students use multiple media simultaneously.

Ophir et al. (2009) suggest that frequent multitasking is common among college students, but they did not examine driving patterns. Multitasking while driving seems to be a frequent problem among college students (Pew Research Center, 2010). A recent poll found that 75% of college-age individuals (18 to 29 years old) have had a cell phone conversation while driving and 64% have received or sent a text message while driving, which is more than any other age group (Pew Research Center, 2010).

Interestingly, among 18 to 29 year olds, a higher percentage of those who had attended college reported talking on a cell phone while driving (84%) than those who had not attended (64%). Similar patterns were found for text messaging while driving (74% versus 52%; Pew Research Center, 2010). Based on these findings, it appears that college students may be particularly prone to multitasking while driving. Although college students tend to be frequent pedestrians (Sisson et al., 2008), no research could be found regarding their rate of multitasking while crossing the street. However, given their high frequency of multitasking while driving, it seems likely that findings would be similar for multitasking while crossing.

Multitasking Experience

College students may be frequent and experienced multitaskers, but they may still sacrifice performance on one or both simultaneous tasks when doing so. A sample of 101 college students from Ophir et al.'s (2009) study whose MMI scores fell either one standard deviation above or below the mean were identified as "heavy media multitaskers" (i.e., those who use many forms of media simultaneously when multitasking) or "light media multitaskers" (i.e., those who use fewer forms of media simultaneously when multitasking). The two groups completed several tasks assessing how well they could use cognitive control in the presence of distracting stimuli (e.g., Stroop Task, task-switching assignment, filtering task, stop-signal task). For example, the task-switching procedure presented participants with both a letter and a number. Immediately before presentation, a cue indicated whether to classify the letter (vowel vs. consonant) or the number (even vs. odd). Depending on the cue, participants had to focus on only one of the stimuli while ignoring the other. Surprisingly, when compared to light multitaskers, the heavier multitaskers generally had a harder time filtering out extraneous environmental stimuli and were less successful at switching completely from processing one stimulus to processing another.

Ophir et al. (2009) explain that light multitaskers appear to have a top-down approach to attentional control, making it easier for them to purposefully remain focused on one task, even when distractions are present. Heavy multitaskers, on the other hand, are more prone to respond to interfering stimuli unrelated to an immediate task. This group is described as having a bottom-up approach to attentional control, in that they are more exploratory instead of restrictive in what information they process. As a result, heavy multitaskers may sacrifice performance on a primary task to allow processing of additional sources of information.

Ophir et al.'s (2009) results suggest that more experienced multitaskers may be worse than less experienced multitaskers at attending to simultaneous tasks successfully.

This may be detrimental in street-crossing situations, where the effects of becoming distracted and sacrificing attention to environmental stimuli can introduce danger.

Pedestrian and Driver Experience

There is only one study to our knowledge examining how experience talking on a cell phone or crossing streets may influence pedestrian behavior. An experimental study examined the pedestrian behavior of 108 college students crossing a simulated street in a virtual environment while distracted by a cell phone conversation and while undistracted. Participants reported their amount of experience using a cell phone (other activities conducted while using the phone were not specified) and amount of experience crossing streets (multitasking while crossing was not assessed). Results suggested that even those who reported frequently using a cell phone and frequently crossing streets were affected by the distraction of combining the two and talking on a cell phone while crossing in the simulator (Stavrinos et al., 2011).

For drivers, research findings examining how experience with multitasking affects driving performance are inconsistent. Shinar, Tractinsky, and Compton (2005) examined the performance of thirty participants in a driving simulator. Three age groups with different levels of driving experience and different frequencies of cell phone use while driving were examined: (1) 18 years old with less than 6 months driving experience and 0.75 average hours using a cell phone while driving per week, (2) 30 to 33 years with 8 to 15 years driving experience and 1.2 average hours using a cell phone while driving per week, and (3) 60 to 71 years with 35 years driving experience and 0.75 average hours using a cell phone while driving per week. Results revealed that the older group of drivers performed worse overall while distracted by a cell phone conversation in a driving simulator. For the two younger groups of drivers, the older group, who had both more years of driving experience and more hours of experience talking on a cell phone while driving, performed better in the simulator. Conversely, Cooper and Strayer (2008) reported that in a study of 60 college student participants, self-reported number of minutes using a cell phone while driving per day did not influence performance in a driving simulator while talking on a cell phone. It is possible that the inconsistency between the two studies' findings could be due to the large age variation between groups in the first study and the lack of age variation in the second study. For example, an 18-year-old likely reacts differently than a 60-year-old regardless of years of driving experience.

Perception of Risk

Perception of Personal Risk and Skill Level

A large-scale national survey found that 94% of college-age Americans (18 to 29 years old) have a cell phone. Of those, 83% consider their phone to be "necessary" and endorse keeping it with them at all times – even next to the bed while sleeping (Pew Research Center, 2010). Because college students carry cell phones quite often, it seems the opportunity to use the phone in inappropriate situations would be rather prevalent. As such, college students likely have to inhibit themselves from using a cell phone when attention to a more important task is required. However, whether or not they do so may depend on how risky they perceive the situation to be.

Holland and Hill (2007) examined whether pedestrians' intentions to cross a street would differ depending on their perception of the risk involved in crossing. A sample of 293 participants between the ages of 17 and 92 were asked to imagine themselves in specific pedestrian situations. Upon reading a description of each situation, participants used a 7-point Likert scale to indicate their perception of safety in the situation and report how likely they would be to cross. Situations presented did not include multi-tasking, but did include risky street crossing circumstances such as crossing mid-street during a traffic gap despite access to a crosswalk at an intersection less than a block away, crossing during heavy traffic, and crossing when visibility was poor. In all situations, the pedestrian had motivation to cross the road (e.g., seeing a friend across the street).

Results showed that when pedestrians perceived the risk of crossing to be higher based on environmental conditions (e.g. mid-street, heavy traffic, low visibility), they reported being able to resist crossing. This suggests that if faced with a situation that is perceived as dangerous, pedestrians may be able to delay or avoid crossing, even when they have a reason to want to cross sooner. Therefore, one may hypothesize that a pedestrian who uses a cell phone while crossing the street must not perceive doing so as risky or unsafe.

Such misperception of risk may be particularly true of college students, who do not tend to perceive themselves as being at risk for negative events and tend to see themselves as invulnerable. In a study of 258 college students, Weinstein (1980) found that when participants were asked to consider their chances of experiencing specific negative events (e.g., falling and breaking a bone, being injured in a car accident) compared to their classmates, they believed their own attributes, plans, or actions decreased their chances of experiencing the events. The author describes this error in judgment as “unrealistic optimism” because although in some cases an individual’s chances of experiencing a negative event may truly be less than average, it is rather impossible that that is true for an entire group of college students.

Results from a recent poll suggest this type of perceived invulnerability may be prevalent in drivers of all ages faced with the opportunity to multitask. In a sample of 2,049 American drivers ages 18 and older, 89% indicated that they think text messaging or emailing while driving causes distraction; however, 66% of the same sample reported that they still engage in the behavior (PR Newswire United Business Media, 2007). It seems that people realize multitasking while driving can be distracting, but overlook that information and take the risk of driving distracted.

To our knowledge, no existing literature examines whether pedestrians may be more likely to multitask while crossing the street, as drivers do on the road, despite knowing the danger that could be involved. However, in all cases, what people may not realize is that regardless of experience or skill level, when engaged in concurrent attention-demanding tasks, they will likely show deficits in performance, as human capacity for performing two tasks at once is limited (Patten et al., 2004; Strayer et al., 2006). Thus, it is possible that if people believe they are skilled at operating a cell phone and skilled at crossing the street, they may not perceive that combining those activities potentially increases their risk for injury.

Prioritizing Simultaneous Tasks

Another factor that may increase multitasking behavior while crossing the street is that pedestrians may have a hard time disengaging from a cell phone when approaching a street-crossing situation. Levy and Paschler (2008) explored whether individuals would forfeit a less important secondary task when faced with the important primary task of driving. A sample of 40 college students completed a simulated driving task (primary task) and also attended to a secondary task. For the secondary task, either a single or double tone was randomly presented via a standard headset and participants indicated whether they heard one or two tones. Responses were made by pressing a button located conveniently at the 3-o'clock position on the steering wheel. Participants were to attend to this task but continue trying to drive safely. However, when brake lights of the car in front of them illuminated, they were to ignore the secondary task and focus instead on braking to maintain safety.

Study participants consistently failed to reprioritize and focus fully on the more important task of stopping, but instead continued completing the secondary task. In doing this, participants significantly compromised braking response time which could have jeopardized safety on a real road. No results were presented for other driving behaviors or outcomes such as number of collisions in the simulator. The authors explain that participants appeared to have difficulty terminating the low-priority task, as only a small number successfully attended to the high-priority task in an appropriate time frame (Levy & Paschler, 2008). If individuals have difficulty shifting attention from a basic experimental task to driving, it is possible that they would have even more difficulty ceasing to engage with a mobile device to access more personally relevant information (e.g., emails, social networking messages) or to look for immediately necessary information (e.g., the address of or directions to a location).

In the Levy and Paschler (2008) study, it is unclear exactly why participants who had been told to withhold the secondary response and were aware that attention to driving safely was most important failed to withhold a response to the low priority task. The authors suggest that when serial processing is necessary for tasks of planning or response selection, any other task arising simultaneously will likely be deferred. For most people, when one task is already ongoing (here, the identification of tone task), the brain will continue the serial process, even if only momentarily, before being interrupted by completing a newly presented task (here, the braking task). This is consistent with Kahneman's (1973) theory that at times, a new or secondary stimulus may be temporarily ignored to continue processing a primary task, but it will not always be completely prevented.

Browsing through mobile internet applications seems to be such a task that would require serial processing and may be difficult to interrupt. Although one might assume that in an automobile, drivers would always give priority to the task of driving due to the need to remain safe, the authors explain that if a less important task is already being carried out, the split-second instinct to continue with that task before shifting attention to or sharing attention with driving may dominate.

It is unclear whether pedestrians crossing streets would also have trouble switching tasks. Unlike drivers, pedestrians can take time to complete another task while remaining safely on the sidewalk before attending to crossing or entering the street. However, there could be situations in which there is an urgency to cross (e.g., walking with another person who does not want to wait, late for an appointment) and the pedestrian may try to process both simultaneously. Thus, pedestrians already engaged with a cell phone who are approaching a street crossing likely experience similar difficulty shifting focus and fully attending to the more important task of crossing.

Present Research

Despite the increasing use of cell phones and other electronic devices in recent years, there is a rather glaring gap in pedestrian safety research. To our knowledge, there is no existing literature regarding pedestrian safety while using a cell phone to access mobile internet applications. Given the public health prominence of pedestrian injury, the very active marketing of cell phones with internet access, and the fact that the use of even basic cell phone functions is believed to cause significant distraction in motor vehicle drivers and pedestrians, the present study was designed to expand upon previous pedestrian research by employing an experimental design using a safe and ethical virtual reality system to examine participants' pedestrian behavior while distracted by mobile internet applications. In addition, we aimed to explore college students' perceptions of the risks of multitasking while crossing the street and the frequency with which they engage in such behaviors.

To evaluate how using mobile internet while crossing the street affects pedestrian safety, this study utilized a virtual environment (VE). The immersive and interactive VE validly represents real-world behavior while offering the advantage of a safe research environment that simulates real pedestrian risks. A previous study of 74 adults and 102 children found pedestrian behavior in the VE to be significantly correlated with behavior in the real-road environment (Schwebel, Gaines, & Severson, 2008).

The current project used a within-subjects design to compare differences in pedestrian behavior while crossing the virtual street and using mobile internet applications versus while not using any distracting device. Specifically, participants completed twenty simulated street crossings in the VE, ten while using internet applications on their cell phones and ten while not using a cell phone or any distracting device. Pedestrian behavior was measured through several different variables (e.g., times participant would have been hit or almost hit by a vehicle, gap of time between the participant and an oncoming vehicle, how often the participant looked away from the road).

Given the negative impact of cognitive and visual distraction discussed previously, we expected participants crossing the virtual street to behave in a riskier manner overall when using mobile internet applications than when not. There was one hypothesis related to participants' pedestrian performance in the VE:

(1) We hypothesized that when using mobile internet while crossing in the VE, participants would display more risky pedestrian behavior, even when controlling for randomized order (distraction first versus distraction second), gender, ethnicity, age, and previous pedestrian and mobile internet experience. Specifically, all distracted participants would:

   a. be more likely to wait longer to cross the street
   b. miss more opportunities to cross safely
   c. delay initiating a street crossing once conditions were safe

d. be less attentive to traffic (i.e., look to the left and right less frequently and look away from the street more frequently)

e. be more likely to be hit or almost hit by a vehicle

f. leave less safe time between themselves and oncoming vehicles

To explore participants' risk perceptions and unsafe behavioral patterns, we examined their responses to several self-report measures (detailed in the Measures section below). There were three hypotheses related to this aim:

(2) We expected that although most participants would report believing that the use of mobile internet applications while crossing the street is distracting and unsafe, the majority would still report engaging in the behavior.

(3) We expected that participants would rate the risk of crossing a street while multitasking as more unsafe for others than for themselves.

(4) We expected that after the experimental session, participants would report that they felt more distracted in the VE while using mobile internet than they thought they would.

METHOD

Participants

Participants for the current study were recruited from Introductory Psychology (PY101) classes at the University of Alabama at Birmingham. PY101 students are permitted to participate in research as one way to satisfy requirements for the course. At the beginning of the term the students complete screening forms in order to determine their eligibility to participate in different research studies.

For the current study, 557 students completed a questionnaire assessing their cell phone usage patterns. Those who endorsed owning a cell phone with 3G or faster internet connection, and with which they access mobile internet applications five or more times per week, were eligible to participate. Students outside of the 17 to 25 year old range and those with significant visual or motor disabilities that would prohibit valid participation in the experimental protocol (e.g., uncorrected vision problems that would interfere with accurately viewing a computer screen, unable to stand for at least twenty minutes, unable to walk up or down a single step) were excluded. We obtained a waiver allowing participants ages 17 and 18 to provide consent for themselves without having to obtain parental consent. Of the 239 participants who were eligible and contacted to participate, 93 agreed to participate in the study (mean age = 19.05, *SD* = 1.18; 73% female; 43% African-American). The remaining eligible students either did not respond to our attempts to contact them, did not wish to participate due to having already obtained their required PY101 research credits, or were found to be ineligible during the scheduling call (i.e., no longer having a smartphone or being outside of the age range).

Procedure

After completing the screening measure, eligible PY101 students were contacted by phone or email with information about the study and given the option to participate. Interested students received information concerning the consent process and scheduled a time to participate in a single one-hour laboratory session.

In preparation for the administration of the experimental tasks, a team of graduate and undergraduate researchers were trained. Standardized protocols were developed for use in administering the tasks. Upon arrival for a scheduled appointment, participants were greeted by a researcher who reviewed the consent document in detail. Any questions were answered and the researcher allowed the participant time to read the document and decide whether or not to participate.

After obtaining consent, participants completed a brief questionnaire (detailed in the Measures section below) while the experimenter sent ten separate emails (numbered 1 through 10) to participants' primary email address for use during the upcoming VE trials. See Appendix A for a list of the ten questions sent via email. Participants were told not to open or read the emails until instructed and were asked to leave their cell phones in the VE room until needed to decrease temptation to read the emails. Next, experimenters measured participants' walking speeds by having them walk along a distance of 25 feet four times "at the speed [they] would use to cross the street" while the experimenter recorded the time of each walk. The four times were averaged to compute participants' pedestrian walking speed. Participants were then escorted to the VE room.

The VE consists of three large computer monitors, arranged in a semi-circle, which display bi-directional traffic on a virtual suburban road. Replicating the real environment displayed in the simulation, traffic moves at a constant speed of 30 miles per hour with a density of 525 feet on average between vehicles. Environmental sounds (e.g., birds chirping) and the sounds of cars approaching and passing are delivered through speakers.

During the study, participants stood in front of the monitors on a raised platform that replicates a street-side curb. Participants were asked to step down off the curb when they felt that it was safe to cross the street. Stepping down activated a pressure plate which caused a race- and gender-matched avatar to begin crossing the virtual street using participants' previously-assessed walking speed. If the avatar safely reached the other side of the street, it stopped walking and an animated character appeared on the screen to provide one of two brief positive responses. If the avatar safely reached the other side, but was almost hit (i.e., there was less than one second between the participant and a vehicle), a cautionary response was offered. When the avatar was "hit" by a car, the screen froze briefly before the animated character appeared and offered a different cautionary response.

Upon arriving in the VE room, the experimenter demonstrated two crossing trials in the VE – one resulting in a successful crossing and one purposely demonstrating a pedestrian being "hit" to avoid intentional unsafe crossings due to participant curiosity. Participants then stepped onto the wooden curb and completed a set of ten virtual reality trials to allow for familiarization with the VE.

Next, in order to provide a break between the familiarization trials and the true experimental trials, participants completed a brief questionnaire (detailed in the Measures section below). They then engaged in a series of 20 simulated crossings split into two separate 10-crossing sessions with a short break between. For one set of 10 crossings, participants were asked to use their cell phones to access internet applications (i.e., the distraction condition) and for one set of 10 crossings participants did not use a cell phone or any other distracting device (i.e., the no distraction condition). The order in which the distraction and no distraction conditions were carried out was randomized across participants. Following each of the distracted and undistracted sessions, participants completed two additional questionnaires (detailed in the Measures section below) to assess fatigue in the VE.

During the distraction condition, participants were asked to open and reply to the emails sent by the experimenter starting with number 1 and proceeding numerically. Each email contained a question which required accessing a mobile internet application (e.g. “Find the forecasted high temperature for tomorrow in Chicago, Illinois,”, “What is the current number one song on iTunes?”; see Appendix A). To find information for responses to the emails, participants were asked to use any mobile phone application to which they had access. Upon finding an answer, participants were to return to the original email and respond appropriately.

At the end of the session, participants completed a brief questionnaire (detailed in the Measures section below) regarding their perception of how distracted they felt during the task. The experimenter then conducted debriefing, answered any questions, and provided PY 101 research credit slips.

Measures

Pedestrian Behavior

The following seven variables, adapted from previous research, were computed to indicate the safety of the street crossing (Barton & Schwebel, 2007; Demetre, Lee, Pitcairn, Grieve, Thompson, & Ampofo-Boateng, 1992; Lee, Young, & McLaughlin, 1984; Schwebel et al., 2008; Stavrinos et al., 2009):

(a) hits or close calls - when participants would have been hit by a vehicle in a real street or when the gap between participants and an oncoming vehicle is less than one second

(b) time to contact - the smallest gap of time between the avatar and any oncoming vehicle during the cross

(c) start delay - the amount of time between a car passing the crosswalk and participants initiating crossing

(d) missed opportunities - when participants allow a gap greater than or equal to 1.5 times their pre-determined crossing speed

(e) wait time - the amount of time participants wait to cross the street

(f) attention to traffic - the number of times participants look left and right before beginning to cross the street, divided by time waiting to cross

(g) looks away from traffic - the ratio of time participants spent looking away from the monitors (e.g., at their cell phone) to time spent looking at the monitors/traffic before beginning to cross

While start delay, missed opportunities, and wait time may not appear to be more risky, they do represent a change in pedestrian behavior. Having a delayed start response, missing safe opportunities, or waiting longer to cross could result in participants initiating a cross after conditions have again become unsafe.

Cell Phone Use Screening

To determine eligibility for the study, participants completed a brief screening questionnaire regarding their access to mobile internet and the frequency with which they use it (see Appendix B). Those who indicated owning a cell phone with a 3G or faster mobile internet connection with which they access mobile applications at least four times a week were eligible to participate. The first lab session was completed within three weeks of the screening administration and sessions continued over the next ten weeks. Prior to scheduling an appointment, researchers ensured that participants still met the eligibility criteria.

Demographics

Participants completed a brief questionnaire assessing basic demographic information about age, gender, and ethnicity (see Appendix C).

Risk Perception

Participants used a 5-point scale to indicate their perception of the safety of multitasking while crossing the street and while driving for themselves and for others (e.g., "While talking on a cell phone and driving, I feel ____"; "While using mobile internet applications and driving, other people are ____"). Rating options include "very unsafe," "somewhat unsafe," "neither safe nor unsafe," "somewhat safe," and "very safe" (see Appendix C).

Cell Phone Use History

Participants completed a questionnaire concerning their experience using a cell phone (see Appendix D). Responses provided insight into average usage per day including frequency of text messaging, using mobile internet, and making or receiving calls.

Walking and Driving History

Participants completed a measure regarding their typical walking patterns (see Appendix E). Within the measure they completed a "Walking Diary" which asked them to outline each time they typically walk on Mondays and Thursdays. This outline was to include all outdoor walking (e.g., to restaurants/bars, to UAB campus, between classes, in a park, walking for exercise, walking with a pet) and the length of each walk in minutes as well as the number of streets crossed during each walk. Next, without describing any specifics, participants estimated how many minutes they typically spend walking outside and how many streets they cross on average for the remaining five days of the week. All responses were summed to create a score indicating total pedestrian experience (Pitts, Stavrinos, Byington, Fanaei & Schwebel, 2008; Stavrinos et al., 2009). Participants were also asked to report how often, on average, they talk, text, or use internet on a cell phone while crossing streets and while driving.

Post-Virtual Environment Perception

Immediately following completion of the simulated street crossings in the VE, participants completed a brief questionnaire to assess their perceived distraction (see Appendix F). They indicated how distracted they felt while crossing the virtual street and using mobile internet and how much more distracted they felt compared to what they expected. They also indicated which mobile internet applications they used to obtain the responses to emails during the VE session. In order to better understand why participants choose to use a cell phone in inappropriate real-world situations (i.e., when crossing a street or when driving), they indicated the most common reason they multitask while crossing or driving.

Data Analysis

Preliminary Analyses

In order to code participants' looks away from traffic, VE sessions were recorded by video. Number of looks to the left and right per trial (attention to traffic) were provided by computer-generated data from a head tracking device. Data that appeared to be incorrect due to hardware malfunction (e.g., multiple values of zero across ten trials), were coded by hand using the video files. Previous work verified validity between hand-coding and computer coding. Data for the other five pedestrian variables were generated electronically through output from the VE software.

Descriptive statistics were obtained for all measures to analyze the distribution of scores, look for outliers, and investigate patterns of missing data. Regarding missing data, two participants were unable to receive the emails due to a malfunction with their cell phone service. One participant had already completed the familiarization trials and the no distraction trials, but the other participant had only completed the familiarization trials. Thus, for all VE variables, sample size was 92 for analyses of the no distraction trials, and 91 for analyses of the distraction trials. Missing data points from the VE software output were rare (i.e., six individual trials among three participants for the no distraction condition and eight individual trials among five participants for the distraction condition) and were in all cases due to software or equipment malfunction. Additional missing data points within the VE variables resulted from one participant's cell phone losing battery power (four trials lost) and two participants completing all the emails before the end of the ten trials (three trials lost for one participant, one trial lost for the other). Due to a video camera malfunction, we were not able to code looks away from traffic for thirteen trials (ten for one participant and three for another) in the no distraction condition and five trials (four for one participant and one each for two other participants) in the distraction condition.

To account for missing data from the 5 pedestrian variables that were averaged across all ten trials (looks away from traffic, attention to traffic, start delay, time left to spare, and wait time), missing data were replaced with the mean of all available data points within the corresponding variable for that participant. For the two pedestrian variables that were summed across the ten trials (hits/close calls and missed opportunities), missing data points were replaced with the mean of all available data points multiplied by ten to account for all ten expected trials. Participants with missing data on other variables (e.g., ethnicity, frequency of using mobile internet while crossing streets), were excluded from the particular analyses for which those data were required on a pairwise basis.

Primary Analyses

Pedestrian Behavior. The first hypothesis was that when distracted by mobile internet, all participants would show riskier and more unsafe pedestrian behaviors across all seven pedestrian variables than when undistracted. To test this hypothesis, seven repeated measures Analyses of Variance (ANOVAs) were conducted first, with condition (distracted versus undistracted) as the independent variable and one of the seven pedestrian scores as the dependent variable. Next, additional ANOVAs were conducted for each of the seven pedestrian variables to include randomized order, gender, ethnicity, age, pedestrian experience (number of streets crossed per day), mobile internet experience (average number of times using mobile internet daily), and mobile internet while crossing experience (frequency of using mobile internet while crossing the street). This check of covariate influences was conducted in two steps. First, order, gender, ethnicity, and age were included together in each of the seven ANOVAs and then seven additional ANOVAs were conducted for each of the three experience variables separately.

Risk Perception. The second hypothesis was that although participants would endorse that using mobile internet applications while crossing the street is distracting and unsafe, they would still report engaging in the behavior. To test this hypothesis, we examined descriptive statistics for participant responses to the following statements: (1) "while using mobile internet applications and crossing a street, I feel ___" and (2) "while using mobile internet applications and crossing a street, other people are ___". Response options for both were: 1 = very unsafe, 2 = somewhat unsafe, 3 = neither safe nor unsafe, 4 = somewhat safe, and 5 = very safe. We also examined responses to the item, "Select the option indicating how often, on average, you use any mobile internet applications (e.g., internet browser, email, Facebook, Twitter, maps, instant messaging, weather, etc.) on your smartphone," which had twelve response options ranging from never to more than once per waking hour. We then used a chi-square test of independence to determine whether participants' perception of safety while using mobile internet and crossing the street was different than their actual use of mobile internet while crossing the street. We also examined the relationship between perception of self and others' safety and frequency of mobile internet use while crossing by computing bivariate correlations. Participants' report of the most common reason they use mobile internet while crossing the street was examined as well.

The third hypothesis was that participants would rate the risk of crossing a street while multitasking as more unsafe for others than for themselves. To test this hypothesis, a repeated measures ANOVA was conducted using type of rating (perception of self versus perception of others) as the independent variable and rating scores on the following items as the dependent variable: (1) "while using mobile internet applications and crossing a street, I feel ___" and (2) "while using mobile internet applications and crossing a street, other people are ___". Response options for both were: 1 = very unsafe, 2 = somewhat unsafe, 3 = neither safe nor unsafe, 4 = somewhat safe, and 5 = very safe. Two additional ANOVAs were conducted for each variable to include gender and ethnicity. Because no significant effects or interactions emerged for either, the gender and ethnicity variables were excluded from further analyses of perception scores.

Perceived Distraction. The fourth hypothesis was that after the experimental session, the majority of participants would report feeling more distracted by mobile internet while crossing the virtual street than they thought they would. To test this hypothesis, we examined participant response to the statement, “Please circle how distracted you felt in the virtual street, compared to what you expected before starting,” that was completed after engaging in the virtual environment. The five response options ranged from “much less than expected” to “much more than expected.” We explored descriptive statistics for all participants. An independent-samples t-test was also performed to determine if any gender or ethnicity differences existed.

As another test of this hypothesis, we compared responses to the pre-VE statement, "While using mobile internet applications and crossing the street, I feel ____" (five response options ranged from “very unsafe” to “very safe”) with responses to the post-VE statement, “Please circle how distracted you felt while crossing the virtual street” (five response options ranged from “very distracted” to “not at all distracted”). We conducted a repeated measures ANOVA using time of rating (pre-VE session versus post-VE session) as the independent variable and rating scores on the two questions as the dependent variable. Two additional ANOVAs were conducted to include gender and ethnicity.

RESULTS

Preliminary Analyses

Two independent researchers coded participants' time looking away from the virtual street during each trial using video files of 20% of the sample. Interrater reliability between coders was high (*r* > 0.99). In the case of discrepancies, data were used from the primary coder, who coded the full sample. Data from looks away from traffic, attention to traffic, start delay, time left to spare, and wait time, were averaged across the ten distracted trials and the ten undistracted trials. Number of hits/close calls and missed opportunities were summed and totaled across the ten distracted trials and the ten undistracted trials. The result was seven pedestrian scores for behavior in the distracted condition and seven in the undistracted condition for each participant.

Next, we explored descriptive statistics for the pedestrian and mobile internet experience variables. We examined responses to two separate items addressing frequency of mobile internet use. To measure general mobile internet use, we considered responses to the item, "Select the option indicating how often, on average, you use <u>any</u> mobile internet applications (e.g., internet browser, email, Facebook, Twitter, maps, instant messaging, weather, etc.) on your smartphone," which had twelve response options ranging from "never" to "more than once per waking hour". Overall, reported usage was high, with only 25.3% using mobile internet less than 7 times per day, 47.3% using it 8 to 16 times per day, and 27.5% using it over 16 times a day - at least once per waking hour). See Figure 1.

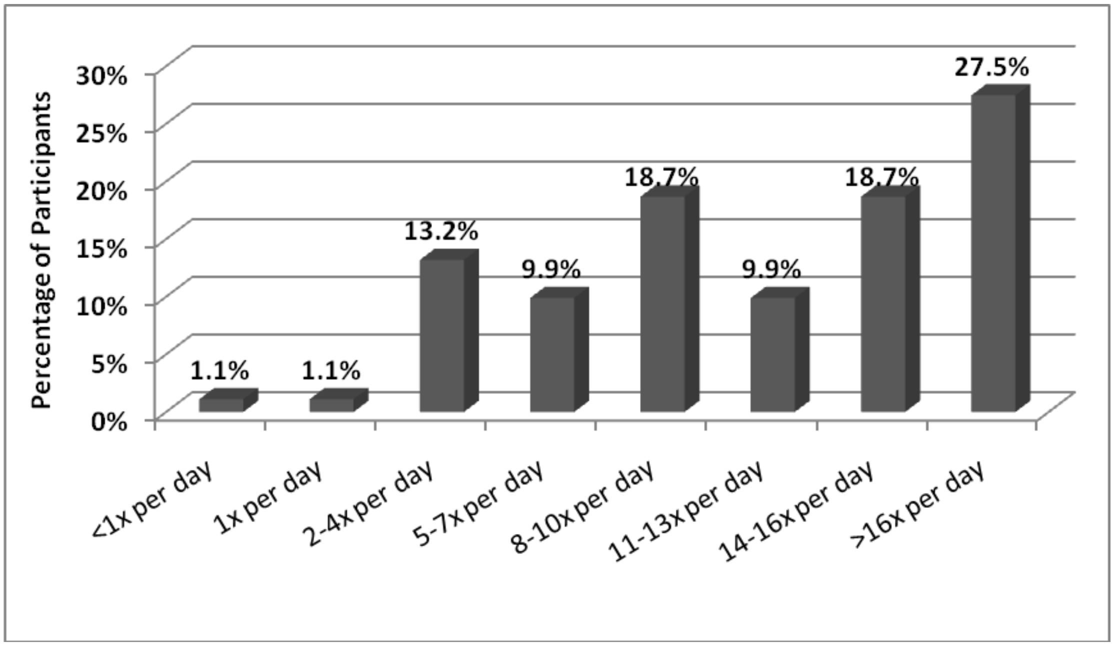

Figure 1. Self-reported frequency of mobile internet usage: Percentage of participants (*N* = 90)

To examine frequency of using mobile internet while crossing the street, we considered responses to the question, “On average, how often do you use mobile internet applications while crossing streets?” with six response options ranging from “never” to “always”. Only 10.9% of the sample reported “never” using MI while crossing the street, and 39.1% reported “rarely” doing so. However, 30.4% endorsed using MI while crossing the street “sometimes” and 19.6% endorsed “often,” “almost always,” or “always.” See Figure 2.

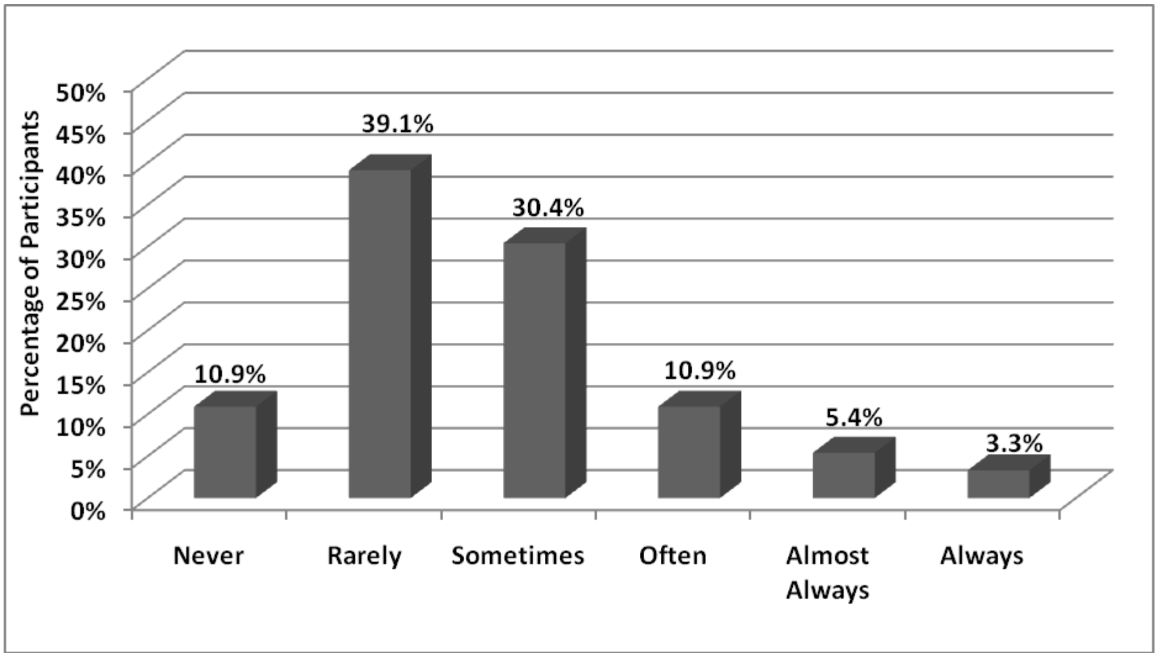

Figure 2. Self-reported frequency of mobile internet usage while crossing the street: Percentage of participants (*N* = 90)

We also considered pedestrian experience based on participants' report of the number of streets they cross each day on the Walking and Driving Questionnaire. The average number of streets crossed per day was computed for each participant. All participants crossed at least 3 streets daily on average, with 41.3% reporting 6 or fewer streets crossed per day, 30.4% reporting between 6 and 9 streets per day, and 27.2% reporting more than 9 streets per day.

Primary Analyses

Pedestrian Behavior

To examine differences in pedestrian behavior between the distraction and no distraction conditions on each of the seven VE variables, we first conducted separate repeated measures ANOVAs with condition (distracted versus undistracted) as the independent variable and one of the seven pedestrian scores as the dependent variable. As predicted, a main effect for condition emerged across all seven pedestrian variables in the first set of analyses, revealing more risky behavior for the distraction condition than the no distraction condition. Specifically, while distracted, participants waited longer to cross, F (1,90) = 42.37, $p < 0.0005$, missed more safe opportunities to cross, F (1,90) = 42.63, $p < 0.0005$, and took longer to initiate crossing when a safe gap was available, F (1,90) = 53.03, $p < 0.0005$. Distracted participants also looked left and right less, F (1,90) = 124.68, $p < 0.0005$, spent more time looking away from the road, F (1,89) = 1959.78, $p < 0.0005$, were more likely to be hit or almost hit by an oncoming vehicle, F (1,90) = 29.54, $p < 0.0005$, and left smaller gaps between themselves and oncoming vehicles, F (1,90) = 46.86, $p < 0.0005$. Means for pedestrian variables are presented in Table 1.

Next, ANOVAs were conducted for each of the seven pedestrian variables to include four additional between-subjects variables - randomized order, gender, ethnicity, and age. To examine the age variable, participants were divided into three groups: 17.92-18.49 years, 18.50-19.04 years, and 19.05-25 years. Main effects for condition were retained across all seven pedestrian variables, as expected, suggesting more risky pedestrian behavior when distracted by mobile internet regardless of randomized order, gender, ethnicity, or age.

Table 1

Virtual Environment Pedestrian Outcomes for No Distraction and Distraction Crossings (N = 90)

	No Distraction			Distraction				
	Mean (SD)	Range	Median	Mean (SD)	Range	Median	*F*	η^2
Hits / Close Calls	0.56 (0.79)	0–4	0	1.35 (1.41)	0–5.56	1	24.63*	0.29
Waittime (seconds)	14.25 (9.30)	3.95–57.19	12.68	24.46 (19.97)	6.21–142.64	18.94	12.78**	0.15
Missed Opportunities	1.72 (2.53)	0–13	1	4.63 (5.36)	0–30	3	13.10**	0.18
Start Delay (seconds)	1.11 (0.53)	0.28–2.84	1.02	1.68 (0.69)	0.42–3.41	1.67	14.58*	0.20
Looks at Traffic (per min)	35.86 (8.79)	17.79–55.64	36.02	25.69 (9.07)	5.88–50.61	25.36	51.10*	0.46
Eyes off Road (% of time)	0.69 (1.68)	0–8.68	0	59.75 (12.56)	20.56–92.47	61.85	713.07*	0.92
Time to Contact (seconds)	4.89 (1.10)	2.78–7.68	4.85	4.05 (1.02)	1.64–6.52	4.11	16.79*	0.22

Note. *$p < 0.0005$; **$p = 0.001$; gender, ethnicity, and randomized order were included as between subjects factors; for Eyes off Road variable $df = 70$, for all other variables $df = 71$.

Regarding between-subjects variables, no significant ethnicity, gender, or age effects emerged, but effects of order emerged for two of the pedestrian variables. Within the hits/close calls variable, effects of order, F (1,71) = 7.84, $p = 0.01$, and the order by condition interaction, F (1,71) = 15.25, $p < 0.0005$, were significant (See Figure 3). Pair-wise comparisons revealed that the significant difference in hits/close calls within the distracted first condition, t (43) = -5.61, $p < 0.0005$, and the distracted second condition, t (46) = -2.06, $p = 0.05$ both were retained when examining the groups separately. This suggests that while all participants tended to be hit or almost hit more often in the distraction condition, those who engaged in the distraction condition first sustained even more hits than those who engaged in the distraction condition second.

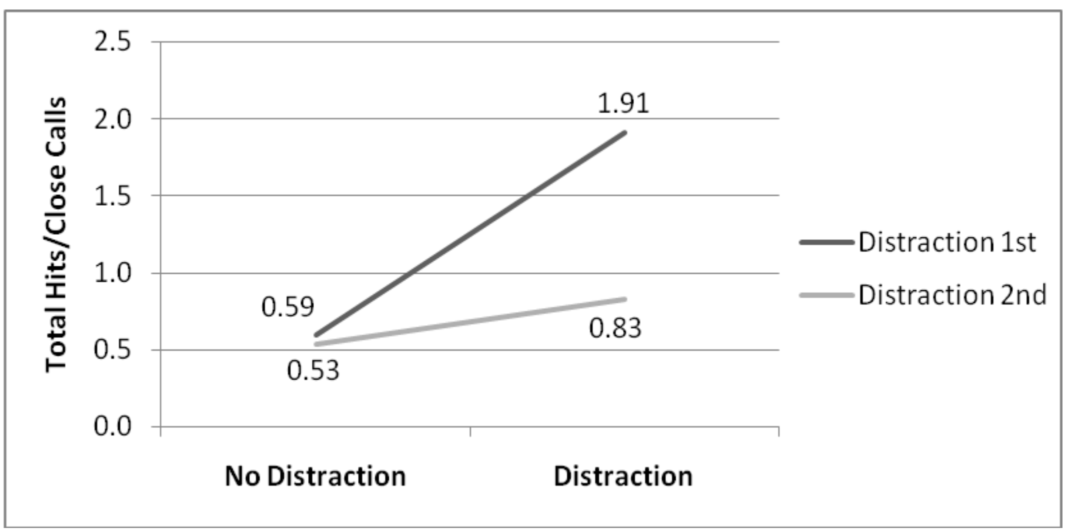

Figure 3. Illustration of randomized order effect on hits/close calls ($N = 90$)

Within the time to contact variable, the order by condition interaction, F (1,71) = 10.67, $p = 0.002$, was significant (See Figure 4). Pair-wise comparisons revealed that the significant differences in time to contact within the distracted first condition, t (43) =

5.83, $p < 0.0005$, and the distracted second condition, $t\ (46) = 3.94$, $p < 0.0005$ were retained when examining the groups separately. This suggests that while all participants tended to leave less safe time between themselves and oncoming vehicles in the distraction condition, those who were distracted first tended had even smaller time to contact than those distracted second while in the distraction condition. However, time to contact was similar for all participants in the no distraction condition regardless of randomized order.

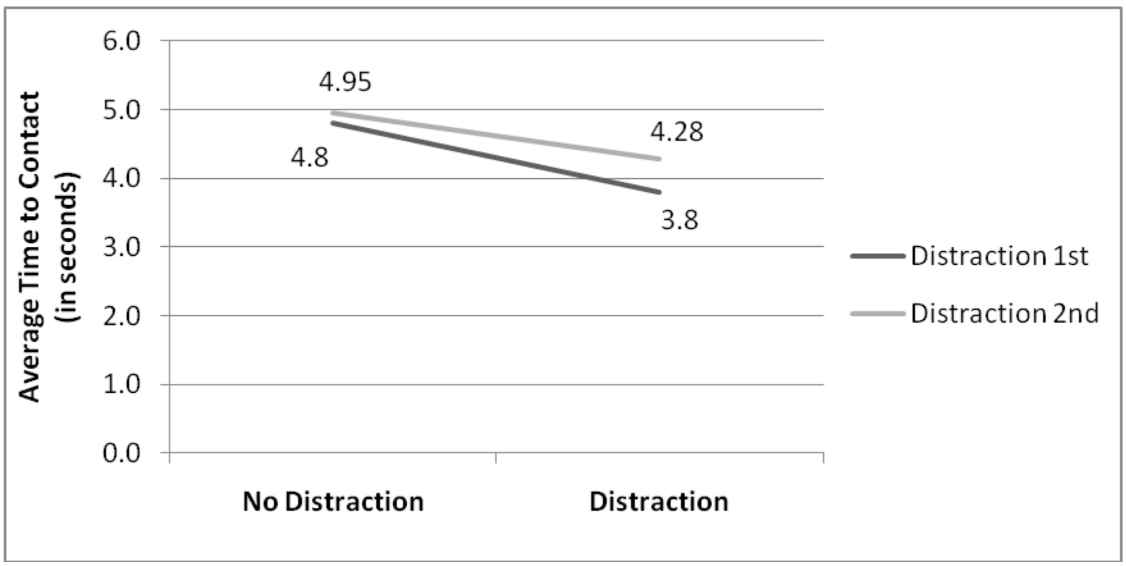

Figure 4. Illustration of randomized order effect on time to contact ($N = 90$)

For the next set of pedestrian variable analyses, seven additional ANOVAs were conducted for each of the three experience variables. For the purpose of these analyses, data for each of the experience variables were grouped into three categories as follows: (1) pedestrian experience (average streets crossed per day) - 6 or fewer, 6.01 to 9, 9.01 or more; (2) general mobile internet experience (average number of times using mobile internet daily) – less than 7 times per day, 8 to 16 times per day, more than once per waking hour; (3) mobile internet while crossing experience (frequency of using mobile internet while crossing the street) – never or rarely, sometimes, often or almost always or always. As expected, across all seven pedestrian variables, no significant effects or interactions emerged for any of the three experience variables, suggesting similar pedestrian behavior regardless of reported experience crossing streets or using mobile internet.

Risk Perception

Descriptive statistics regarding participants' self-reported risk perception and pedestrian behavioral patterns were explored. Contrary to what we expected, the majority of participants did not believe using mobile internet while crossing the street to be unsafe for themselves or for others. Data for responses to the statements "While using mobile internet applications and crossing a street, I feel ___" and "While using mobile internet applications and crossing a street, other people are ___" are presented in Figure 5 below. While a number of those who did believe it to be unsafe still endorsed engaging in the behavior, the majority reported that they did not. Of the 35.5% who believed themselves to be "very unsafe" or "somewhat unsafe" while using mobile internet and crossing the street, 30.3% reported that they still engage in the behavior at least sometimes. Of the 45.2% who believed others to be "very unsafe" or "somewhat unsafe," 31.7% reported still engaging in the behavior at least sometimes.

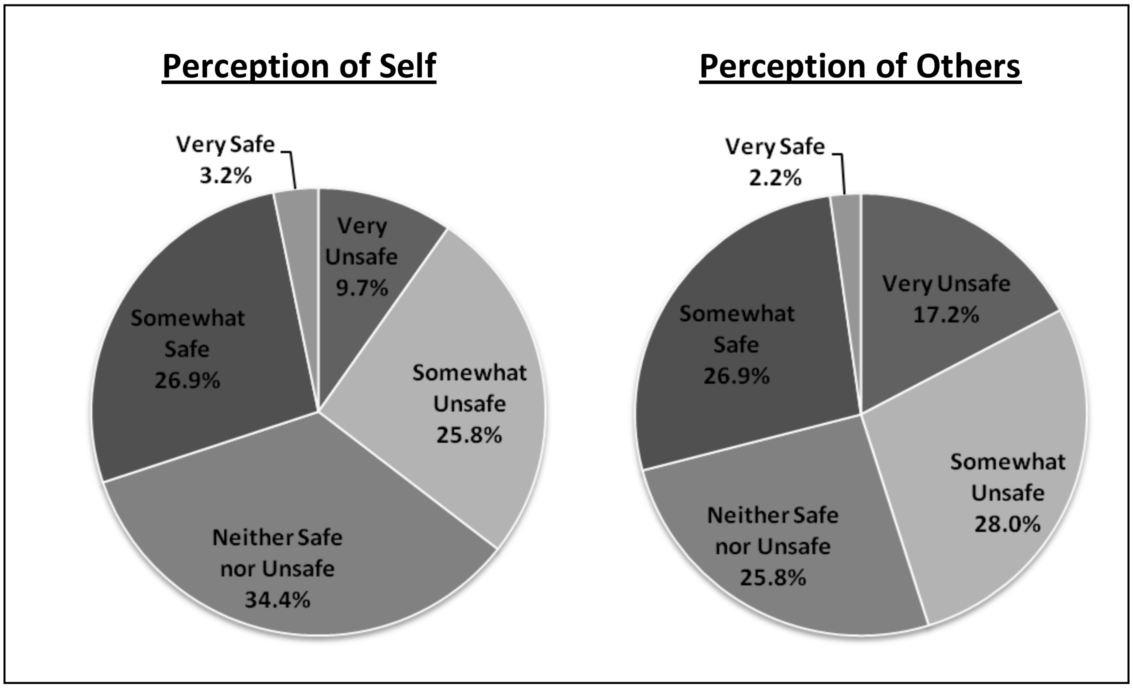

Figure 5. Self-reported perception of personal risk for using mobile internet while crossing the street: Percentage of participants ($N = 90$)

A chi-square test of independence revealed a significant difference between perception of personal risk and frequency of using mobile internet while crossing, x^2 (4, $n = 92$) = 15.58, $p = 0.004$. This suggests that although participants are endorsing that using mobile internet while crossing is unsafe, their behavior is different than what would be expected as many are still engaging in the behavior. Next we investigated the relationship between risk perception and frequency of using mobile internet while crossing the street using Spearman correlation. Perception of personal safety was strongly correlated with frequency of using mobile internet while crossing ($r = 0.37$, $p < .001$) with greater perception of safety associated with more frequent mobile internet use while crossing. In other words, those who perceive using mobile internet while crossing to be safer tend to engage in the behavior more often.

When participants were asked to select the most common reason they use mobile internet while crossing, the most frequently chosen responses were: “I want to see what my friends are doing (e.g., on Facebook or other social networks),” 23.9%; “I need to read or respond to emails or other messages (e.g., Facebook) that may be important,” 17.4%; and “I need to find important information,” 15.2%. Additional responses are listed in Table 2.

Table 2

Self-reported Reasons for Using Mobile Internet While Crossing: Percentage of Participants (N = 92)

Response	%
I want to see what my friends are doing (e.g., on Facebook or other social networks)	23.9%
I need to read or respond to emails or other messages (e.g., Facebook) that may be important	18.5%
I need to find important information	15.2%
I want to update my Facebook or other social networking status or information	12.0%
It is a convenient time to check emails or other messages	12.0%
I need to get directions or information about a location	9.8%
I do not use mobile internet while crossing the street	3.3%
It is a habit / I do not think much about doing it	2.2%
I need to contact someone with important information	1.1%
I want to listen to music	1.1%
It gives me something to do while waiting to cross	1.1%

To investigate differences between participants’ perception of their own safety and others’ safety, a repeated measures ANOVA was conducted using type of rating (perception of self versus perception of others) as the independent variable and rating scores as the dependent variable. Results suggest that, as expected, participants rated using MI while crossing the street as significantly more unsafe for others (M = 2.69, *SD*

= 1.11) than for themselves (M = 2.88, *SD* = 1.02), *F* (1,92) = 4.08, *p* = 0.05, where a rating of 1 meant "very unsafe" and a rating of 5 meant "very safe."

Perceived Distraction

Descriptive statistics were examined for participants' report of perceived distraction following the VE session (See Figure 6 for overall percentages). Confirming our expectation, the majority of participants (60.5%) reported feeling more distracted by mobile internet while crossing the virtual street than they thought they would. A one-way between-groups ANOVAs found no difference among gender, *F* (1,91) = 3.10, n.s., or ethnicity *F* (2,91) = 0.36, n.s.

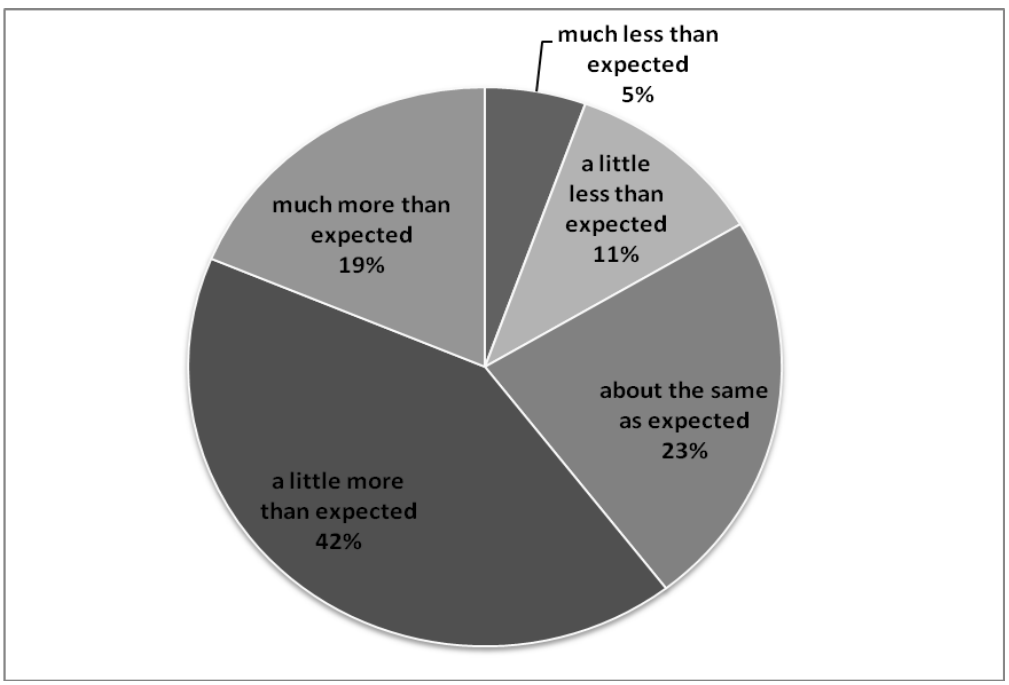

Figure 6. How distracted post-VE compared to expected (*N* = 91)

We also conducted a repeated measures ANOVA using pre-VE ratings of perceived safety, and post-VE ratings of perceived distraction. Time of rating (pre versus post) served as the independent variable and rating scores as the dependent variable. As expected, there was a significant effect for perception, F (1, 90) = 4.04, p = 0.05, which suggests that participants rated using mobile internet while crossing the street safer before the VE session (M = 2.87, SD = 1.02) than they did after (M = 2.54, SD = 1.20). An additional ANOVA was conducted to include gender and ethnicity. For ethnicity, no significant effects or interactions were found. However, effects of gender, F (1,85) = 5.18, p = 0.03, and perception by gender, F (1,85) = 4.40, p = 0.04, emerged (See Figure 7). In the model with gender included, the perception effect was no longer significant, F (1,85) = 1.01, n.s. Before engaging in the VE, perception ratings were similar for males and females, but after engaging in the VE, males rated using mobile internet while crossing the virtual street as more distracting than females did.

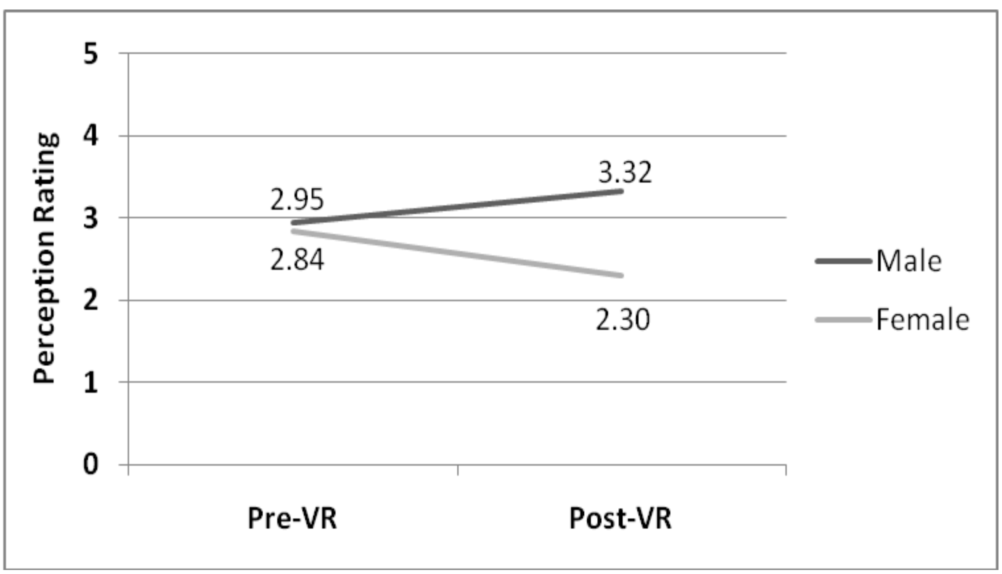

Figure 7. Illustration of gender effects on pre-VE vs. post-VE perception (N = 91)

DISCUSSION

Pedestrian Behavior

The current study aimed to examine differences in college students' pedestrian behavior while distracted by mobile internet applications and while not distracted. Findings confirmed our hypotheses that pedestrian behavior would be more risky when participants were simultaneously using mobile internet and crossing the street than when crossing the street with no distraction. While multitasking in the VE, participants looked to the left and right less before crossing, spent a greater percentage of time looking away from the road, waited longer to cross, missed more safe opportunities to cross, took longer to initiate crossing when a safe gap was available, left smaller safe gaps between themselves and oncoming vehicles, and were more often hit or almost hit by oncoming vehicles.

While waiting longer to cross and missing more safe opportunities does not necessarily suggest more risky crossing, they do represent a change in pedestrian behavior. It seems that by waiting longer, participants would have more time to decide on a safe crossing gap. However, the longer wait did not appear to increase the likelihood of crossing safely, as safe gaps between the avatar and oncoming vehicles decreased and hits and close calls increased despite longer wait times. Considering that participants gave less attention to traffic before crossing (i.e., less time with eyes on the road, fewer looks left and right) during the distraction condition, it is apparent that the increased time spent waiting to cross was not spent carefully considering the crossing decision. As participants were distracted by the mobile internet tasks, they ended up missing more safe opportunities and choosing riskier times to cross.

The current study is the first to examine mobile internet distraction, but the findings are consistent with previous research regarding the effects of listening to music, holding a cell phone conversation, and text messaging on pedestrian safety (Neider et al., 2010; Stavrinos et al., 2009, 2011). The current data also support Kahneman's (1973) theory that it is very difficult to ignore secondary stimuli (here, the mobile internet) and continue allocating the attention necessary to process primary stimuli (here, the street crossing environment). Kahneman described that as soon as a stimulus is detected, its information is temporarily stored in memory and an individual subconsciously makes a decision regarding which pieces, or groups, of the stimulus should receive the most attention. The perceptual groups chosen are the ones most likely to be attended to most consciously and in more detail as subsequent responses are made. During the distraction condition, even when participants looked away from the phone and appeared to devote full attention to the traffic, it seems that the cognitive processing necessary to make a safe street-crossing decision was limited and thus less effective as they were still mentally attending to and processing information related to the ongoing mobile internet task. Thus, it seems that participants were unable to completely ignore the ongoing internet task to devote adequate attention to the crossing decision.

Experience

The current study also explored college students' experience crossing streets, using mobile internet, and simultaneously using mobile internet while crossing the street as well as their perceptions of the risk involved. Previous research has examined the frequency with which college students report multitasking in general (Ophir et al., 2009) and while driving (Pew Research Center, 2010). The current study was the first to examine frequency of mobile internet usage in general and mobile internet usage while crossing the street. Overall, general mobile internet usage was high, with nearly half of the sample reporting accessing mobile internet applications from their phones 8 to 16 times per day and over a quarter accessing it at least once per waking hour. However, it should be noted that as a requirement for the study, all participants had previously endorsed using mobile internet more than four times per week.

Regarding participants' pedestrian experience, average number of streets crossed per day ranged from 3.14 to 23.14. We found that only a small percentage (10.9%) of participants had never used mobile internet while crossing the street but 50 percent reported doing so at least sometimes. However, regardless of previous pedestrian experience or experience using mobile internet (in general or while crossing the street), all participants were equally distracted by mobile internet in the VE. In other words, participants who frequently crossed streets, used mobile internet, or did both simultaneously appeared to be just as unsafe in the VE as those with less experience.

This finding is consistent with previous research which suggested that pedestrian experience and experience with cell phone conversation did not decrease distraction for pedestrians holding a cell phone conversation while crossing a virtual street (Stavrinos, et. al, 2011). This is noteworthy because it challenges any assumption pedestrians may have that they are less at risk for distraction if they use mobile internet or cross the street frequently and are "skilled" at doing so. As with other types of multitasking (Patten et al., 2004; Strayer et al., 2006), it appears that using mobile internet compromises the cognitive and visual attention needed to safely cross a street even for individuals expected to be "experts" due to substantial previous experience.

Risk Perception

Findings regarding perception of risk were generally consistent with our expectations in that participants believed using mobile internet while crossing the street was more unsafe for others than for themselves. This is likely due to an error in judgment described by Weinstein (1980) as "unrealistic optimism" in which individuals erroneously believe their personal attributes or perceived skills are such that their chances of experiencing a negative event is decreased. However, we were surprised to find that overall, fewer students than expected recognized the risk of multitasking while crossing the street. Only 35.5% reported that they generally feel "very unsafe" or "somewhat unsafe" while crossing the street and using mobile internet and 45.2% believed others were "very unsafe" or "somewhat unsafe." Even more surprising was that nearly one third of participants described using mobile internet while crossing the street as "very safe" or "somewhat safe" for themselves (30.1%) or others (29.1%).

That finding is concerning because previous research has suggested that pedestrians may avoid crossing in situations that they believe to be unsafe (Holland & Hill, 2007). However, if students misjudge using mobile internet while crossing to be a safe behavior, it seems there would be less incentive to avoid doing it. We found this to be true as students with greater perception of safety, both for themselves and others, reported using mobile internet while crossing the street more frequently. Among participants who believed themselves or others to be "very unsafe" or "somewhat unsafe" while using mobile internet and crossing the street, the majority reported rarely or never doing so, but close to one third reported that they still engaged in the behavior at least sometimes.

Upon examining responses for why students use mobile internet while crossing the street, we found that three of the four most common reasons were directly related to social interactions with other people: “I want to see what my friends are doing (e.g., on Facebook or other social networks)” (23.9% of participants), “I need to read or respond to emails or other messages (e.g., Facebook) that may be important” (17.4% of participants), and “I want to update my Facebook or other social networking status or information” (12.0% of participants). Thus, it appears that choosing to use mobile internet in a risky situation is not just done to access immediately necessary information, but mainly for non-urgent internet browsing, socializing, or entertainment.

Although many pedestrians may not perceive multitasking as unsafe, we found that after participating in the distraction condition, the majority of participants reported feeling more distracted than they thought they would. It seems that they may have initially overestimated their ability to complete two tasks at once and not realized how difficult it would be to devote adequate attention to both tasks simultaneously. Perhaps the participants were initially basing their ratings of safety on only their experience or skill with navigating mobile internet or street crossing alone, but did not realize that combining the two would require combining the two skill sets and demand more attention. Results from a recent driving study found that participants had difficulty terminating engagement in an experimental task to focus on driving (Levy & Paschler, 2008) and it seems that our participants may have had difficulty with this too.

Participating in the virtual environment appeared to give participants some insight into the real dangers as 60.5% reported their experience in the distraction condition to be more distracting than they expected.

Implications

These data provide initial insight into college pedestrians' multitasking habits and perceptions of personal injury risk. More importantly, they are also the first to demonstrate the effect that mobile internet distraction can have on pedestrian safety. Taken together, this research emphasizes the importance of not only educating experienced college students of the risks of using mobile internet while crossing the street, but highlighting the real risk involved for everyone – not just for individuals who cross streets or use mobile internet less frequently. How can we help pedestrians – especially college students who frequently cross busy streets while navigating their campus – better understand the risk of multitasking?

Both driving and pedestrian safety campaigns tend to focus on educating individuals about the dangers of distraction in general. However, the focus may need to be shifted as it seems that regardless of understanding the dangers, individuals may tend to continue the unsafe behavior anyway. As mobile internet is becoming more accessible and being used by more people as they go from place to place, the opportunity to use it in risky situations is becoming more common.

A recent meta-analysis of 67 research studies examining the effectiveness of driving safety campaigns on accident reduction describes the types of public messages that are most successful (Phillips, 2011). Overall, findings suggest that the most effective campaigns are short-term and presented through personal communication (i.e., seminars; personal letters; two-way or group discussions with a safety expert, peer, teacher, or campaign distributor) and in physical proximity to where the targeted behavior occurs (Phillips, 2011). Similar strategies might also be effective for pedestrian safety campaigns. For example, signs posted around areas where pedestrians would approach intersections or crosswalks may be effective.

Given that students who participated in the current study reported that crossing the street while using mobile internet in the VE was more distracting than they originally expected, it might also be beneficial to give students a chance to practice doing so in a safe manner, such as in a virtual environment. This could be carried out during a campus event such as a health fair or could simply be set up in a common area of campus to give students the opportunity to try crossing the virtual street safely while using their cell phones to access the internet. After engaging, a brief verbal exchange and/or flyer could be given to students informing them about the real dangers of multitasking pedestrians. This first-hand, immersive experience may help individuals understand that even though they may look up from the phone at traffic occasionally, their minds are still not fully engaged in and focused on the oncoming traffic.

Because these findings suggest that pedestrians sometimes continue to cross streets while distracted even when they report knowing it is unsafe, laws to prohibit cell phone use while crossing the street may also help decrease the behavior. While it may be difficult to enforce such policies, as it is to enforce laws banning text messaging while driving, having formal laws in place may reduce the behavior and help individuals to realize the importance of the issue.

In order to better understand how to decrease the use of mobile internet in pedestrian environments, additional research investigating why individuals choose to engage in the behavior is needed. College student self-report from the current study suggests that while crossing the street, pedestrians often use mobile internet for non-pressing social interactions (e.g., facebook, email). While many realize they are unsafe while doing so, some report feeling very safe. Gaining a better understanding of why individuals would continue a behavior they feel is unsafe, or why they would feel safe engaging in this distracting behavior could help inform policy making and safety campaigns.

Conclusions

Although the practical function of having easy access to internet communication through a cell phone is often an advantage, the current findings suggest that it may also result in increased risky behavior. Some people may think of a cell phone as a tool that can provide safeguards to users, but evidence from recent transportation research suggests that more lives are lost due to cell phone use than are saved (Loeb & Clark, 2009). The current study findings revealed that some pedestrians do not realize that multitasking while crossing is unsafe, and of those who do, many continue to engage in the behavior. Despite the convenience and wealth of information provided by mobile internet, our results suggest that multitasking in a pedestrian environment can reduce the cognitive and visual capacity required to safely cross the street.

REFERENCES

Barton, B.K. & Schwebel, D.C. (2007). The roles of age, gender, inhibitory control, and parental supervision in children's pedestrian safety. *Journal of Pediatric Psychology, 32*, 517-526.

Blanco, M., Biever, W.J., Gallagher, J.P., & Dingus, T.A. (2006). The impact of secondary task cognitive processing demand on driving performance. *Accident Analysis and Prevention, 38*, 895-906.

Bungum, T.J., Day, C., & Henry, L.J. (2005). The association of distraction and caution displayed by pedestrians at a lighted crosswalk. *Journal of Community Health, 30*, 269-279.

comScore, Incorporated (2010, May 10). *Use of Social Media via Mobile Device Continues to Post Strong Gains*. Retrieved from http://www.comscore.com/Press_Events/Press_Releases/2010/4/comScore_Reports_February_2010_U.S._Mobile_Subscriber_Market_Share/(language)/eng-US.

Cooper, J.M. & Strayer, D.L. (2008). Effects of simulator practice and real-world experience on cell-phone–related driver distraction. *Human Factors, 50*, 893-902.

Cramer, S., Mayer, J., & Ryan, S. (2007). College students use cell phones while driving more frequently than found in government study. *Journal of American College Health, 56*, 181-184.

Cellular Telecommunications Industry Association [CTIA] (2009). *Wireless quick facts: Year end figures*. Retrieved June 12, 2010, from http://www.ctia.org/advocacy/research/index.cfm/ AID/10323.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2^{nd} Ed.). Hillsdale, NJ: Erlbaum.

Demetre, J.D., Lee, D.N., Pitcairn, T.K., Grieve, R., Thomson, J.A., & Ampofo-Boateng, K. (1992). Errors in young children's decisions about traffic gaps: Experiments with roadside simulations. *British Journal of Psychology, 83*, 189-202.

Drews, F.A., Yazdani, H., Godfrey, C.N., Cooper, J.M. & Strayer, D.L. (2009). Text messaging during simulated driving. *Human Factors, 51*, 762-770.

Hatfield, J. & Murphy, S. (2007). The effects of mobile phone use on pedestrian crossing behavior at signalized and unsignalised intersections. *Accident Analysis and Prevention, 39*, 197-205.

Holland, C. & Hill, R. (2007). The effect of age, gender and driver status on pedestrians' intentions to cross the road in risky situations. *Accident Analysis and Prevention, 39*, 224-237.

Hosking, S.G., Young, K.L., & Regan, M.A. (2009). The effects of text messaging on young drivers. *Human Factors, 51,* 582-592.

Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice-Hall.

Kahneman, D., Ben-Ishai, R., & Lotan, M. (1973). Relation of a test of attention to road accidents. *Journal of Applied Psychology, 58,* 113-115.

Lee, D.N., Young, D.S., & McLaughlin, C.M. (1984). A roadside simulation of road crossing for children. *Ergonomics, 12*, 1271-1281.

Lee, J.D. (2007). Technology and teen drivers. *Journal of Safety Research, 38,* 203-213.

Levy, J. & Pashler, H. (2008). Task prioritisation in multitasking during driving: Opportunity to abort a concurrent task does not insulate braking responses from dual-task slowing, *Applied Cognitive Psychology, 22,* 507-525.

Liang, Y. & Lee, J.D. (2010). Combining cognitive and visual distraction: Less than the sum of its parts. *Accident Analysis and Prevention, 42,* 881-890.

Loeb, P.D. & Clarke, W.A. (2009). The cell phone effect on pedestrian fatalities. *Transportation Research Part E, 45,* 69-75.

Nasar, J., Hecht, P., & Werner, R. (2008). Mobile telephones, distracted attention, and pedestrian safety. *Accident Analysis and Prevention, 40*, 69-75.

National Center for Injury Prevention and Control [NCIPC] (2011, June 19). W*ISQARS™ (Web-based Injury Statistics Query and Reporting System)*. Retrieved from http://www.cdc.gov/ncipc/wisqars

Neider, M.B., McCarley, J.S., Crowell, J.A., Kaczmarski, H., & Kramer, A.F. (2010). Pedestrians, vehicles, and cell phones. *Accident Analysis and Prevention*, *42,* 589-594.

Ophir, E., Nass, C., Wagner, A.D. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences of the United States of America, 106,* 15583-15587.

Patten, C.J.D., Kircher, A.K., Östlund, J., & Nilsson, L. (2004). Using mobile telephones: Cognitive workload and attention resource allocation. *Accident Analysis and Prevention, 36,* 341-350.

PC Magazine Encyclopedia (11 June, 2010). *Definition of: Smartphone.* Retrieved from http://www.pcmag.com/encyclopedia_term/0,2542,t=Smartphone&i=51537,00.asp

PC Magazine Encyclopedia (21 June, 2010). *Definition of: Short Message Service.* Retrieved from http://www.pcmag.com/encyclopedia_term/0,2542,t=SMS&i=51563,00.asp

Pew Research Center (2010). *The millennials: Confident. Connected. Open to change.* Retrieved June 17, 2010, from http://pewsocialtrends.org/assets/pdf/millennials-confident-connected-open-to-change.pdf

Phillips, R.O., Ulleberg, P., & Vaa, T. (2011). Meta-analysis of the effect of road safety campaigns on accidents. *Accident Analysis and Prevention, 43,* 1204-1218.

Pitts, D. D., Stavrinos, D., Byington, K. W., Fanaei, K., & Schwebel, D. C. (2008, April). *Epidemiology of walking in 10-to 12-year olds*. Poster presented at the National Conference in Child Health Psychology, Miami Beach, FL.

PR Newswire United Business Media (2007). *Nine of 10 Americans Would Support New Laws to Ban Driving While Texting, According to New Poll*. Retrieved June 3, 2010, from http://media.prnewswire.com/en/jsp/includes/contents/printable.jsp?resourceid=3530793

Schwebel, D.C., Gaines, J., & Severson J. (2008). Validation of virtual reality as a tool to understand and prevent child pedestrian injury. *Accident Analysis and Prevention, 40,* 1394-1400.

Schwebel, D.C., Stavrinos, D., Byington, K.W., Davis, T., O'Neal, E., & de Jong, D. (2011). *Distraction and pedestrian safety: How talking on the phone, texting, and listening to music impact crossing the street.* Unpublished manuscript under review.

Schwebel, D.C., Stavrinos, D., & Kongable, E.M. (2009). Attentional control, high intensity pleasure, and risky pedestrian behavior in college students. *Accident Analysis and Prevention, 41,* 658-661.

Shinar, D., Tractinsky, N., & Compton, R. (2005). Effects of practice, age, and task demands, on interference from a phone task while driving. *Accident Analysis and Prevention, 37,* 315-326.

Sisson, S.B., McClain, J.J., & Tudor-Locke, C. (2008). Campus walkability, pedometer-determined steps, and moderate-to-vigorous physical activity: A comparison of 2 university campuses. *Journal of American College Health, 56,* 585-592.

Smith, A. (2010). Mobile Access 2010. Retrieved June 20, 2011, From http://www.pewinternet.org/~/media//Files/Reports/2010/PIP_Mobile_Access_2010.pdf

Stavrinos, D., Byington, K.W., & Schwebel, D.C. (2009). Effect of cell phone distraction on pediatric pedestrian injury risk. *Pediatrics, 123,* e179-185.

Stavrinos, D., Byington, K.W., & Schwebel, D.C. (2011). Distracted walking: Cell phones increase injury risk for college pedestrians. *Journal of Safety Research, 42,* 101-107.

Strayer D.L. & Drews, F.A. (2007a). Cell phone induced driver distraction. *Current Directions in Psychological Science, 16,* 128-131.

Strayer, D.L., & Drews, F.A. (2007b). Multitasking in the automobile. In A.F. Kramer, D.A. Wiegmann, & A. Kirlik (Eds.), *Attention: From theory to practice* (pp. 121-133). New York, NY: Oxford University Press.

Strayer, D.L., Drews, F.A., & Crouch, D.J. (2006). A comparison of the cell phone driver to the drunk driver. *Human Factors, 48,* 381-391.

Strayer, D.L. & Johnston, W.A. (2001). Driven to distraction: Dual-task studies of simulated driving and conversing on a cellular telephone. *Psychological Science, 12,* 462-466.

Thompson, J.A. (2007). Negotiating the urban traffic environment: Pedestrian skill development in young children. In G.L. Allen (Ed.), *Applied spatial cognition: From research to cognitive technology* (203-227). Mahwah, NJ: Lawrence Erlbaum Associates.

Törnros, J.E.B. & Bolling, A.K. (2005). Mobile phone use—Effects of handheld and handsfree phones on driving performance. *Accident Analysis and Prevention, 37,* 902-909.

US Department of Transportation Federal Highway Administration [USDOT FHWA] (2005). *2005 Traveler Opinion and Perception (TOP) Survey.* Retrieved June 10, 2010, from http://www.fhwa.dot.gov/reports/traveleropinions/1.htm.

Weinstein, N.D. (1980). Unrealistic optimism about future life events. *Journal of Personality and Social Psychology, 30,* 806-820.

Whitebread, D. & Neilson, K. (1999). Learning to cross the road: Cognition in action. *The Psychologist, 12,* 403-405.

APPENDIX A

EMAIL QUESTIONS USED DURING DISTRACTION CONDITION

1) Give the headline of any current news story (can include sports, entertainment, celebrities, world, local, etc.)

2) What is the phone number for the Starbucks on 11th Avenue South in Birmingham?

3) What is the forecasted high temperature for tomorrow in Chicago, Illinois?

4) Give the name and address of any Chinese restaurant in Birmingham.

5) On what DAY of the week is Earth Day in 2011?

6) What is the #1 song on iTunes right now?

7) How many yards are in 1 kilometer?

8) How many miles is it from Campbell Hall (address: 1300 University Blvd / Birmingham, AL 35233) to the nearest Wal-mart?

9) Take a picture of the step ladder on the ground to your right and email it back.

10) What is the first name of the director of the movie *Turtles Can Fly* (2005)?

APPENDIX B

CELL PHONE USE SCREENING QUESTIONNAIRE

PY101 Screening

Name: ____

Phone Number: ____________________________________

Email address: ____________________________________

ID# _____

Cell Phone Use Questionnaire

A **"smartphone"** is defined as: *A cellular phone which includes mobile internet applications (or "apps") allowing access to things like e-mail, web browsing, Facebook, or instant messaging in addition to basic phone-calling and text messaging features.* Please consider that definition when answering the following questions.

1. Do you have a smartphone (circle one)? YES NO

2. Does your current cell phone plan include 3G or faster mobile internet access?

   YES NO NOT SURE

3. Select the option below indicating how often, on average, you use any mobile internet applications (e.g., internet browser, email, Facebook, Twitter, maps, instant messaging, weather, etc.) on your smartphone. **Please select only one response.**

____ Never or very rarely
____ Less than once per **week**
____ 1-2 times per **week**
____ 3-4 times per **week**
____ 5-6 times per **week**
____ 1 time per **day**
____ 2-4 times per **day**
____ 5-7 times per **day**
____ 8-10 times per **day**
____ 11-13 times per **day**
____ 14-16 times per **day**
____ More than once per waking hour

APPENDIX C

DATA COLLECTION SHEET QUESTIONNAIRE

ID #: __________

Data Collection Sheet

Today's Date: ____________

Your Birthdate (including year): ____________

Gender:

______ Male
______ Female

Ethnicity (check all that apply):

______ African-American or Black
______ Asian-American or Pacific Islander
______ Caucasian or White
______ Hispanic or Latino
______ Native American, American Indian, or Alaskan Native
______ Other: ______________________________________

Pedestrian and Driving Data:

Please use the following scale to rate the statements below:

1	2	3	4	5
very unsafe	somewhat unsafe	neither safe nor unsafe	somewhat safe	very safe

1. While talking on a cell phone and **driving**, I feel _______
2. While text messaging and **driving**, I feel _______
3. While using mobile internet applications and **driving**, I feel _______
4. While talking on a cell phone and **crossing a street**, I feel _______
5. While text messaging and **crossing a street**, I feel _______
6. While using mobile internet applications and **crossing a street**, I feel _______

ID #: __________

Please use the following scale to rate the statements below:

1	2	3	4	5
very unsafe	**somewhat unsafe**	**neither safe nor unsafe**	**somewhat safe**	**very safe**

7. While talking on a cell phone and **driving**, other people are _______
8. While text messaging and **driving**, other people are _______
9. While using mobile internet applications and **driving**, other people are _______
10. While talking on a cell phone and **crossing a street**, other people are _______
11. While text messaging and **crossing a street**, other people are _______
12. While using mobile internet applications and **crossing a street**, other people are _______

APPENDIX D

CELL PHONE USE HISTORY QUESTIONNAIRE

ID# ______

Cell Phone Use History

1. What brand and model smartphone do you own? ________________________________

2. Does your current cell phone plan include 3G or faster mobile internet access (circle one)?

   YES NO NOT SURE

3. How long have you owned your current smartphone (in months)? ___________________________

4. What type of keyboard does your smartphone have?

   ____ Touch-screen
   ____ Full slide-out or flip-out QWERTY keyboard (i.e., set up like a computer keyboard)
   ____ Exposed (do not have to slide or flip to access) full QWERTY keyboard
   ____ Partial keyboard with shared letters (e.g., each button contains 2 letters)
   ____ Both touch-screen and full keyboard access
   ____ Other (please specify): ________________________________

5. How long have you been using the type of keyboard that you are using today (in months)? _________

6. When did you first begin using **any** smartphone with mobile internet access (best estimate of month & year)? ___________, 20____

7. During a 24 hour day, how many **hours**, on average, do you keep your cell phone within reach (e.g., in your pocket/purse/backpack, on your desk while working, by your bed while sleeping, in your car while driving, etc.)? ________________________

8. Select the option below indicating how often, on average, you use <u>any</u> mobile internet applications (e.g., internet browser, email, Facebook, Twitter, maps, instant messaging, weather, etc.) on your smartphone. **Please select only one response.**

   ____ Never or very rarely
   ____ Less than once per **week**
   ____ 1-2 times per **week**
   ____ 3-4 times per **week**
   ____ 5-6 times per **week**
   ____ 1 time per **day**
   ____ 2-4 times per **day**
   ____ 5-7 times per **day**
   ____ 8-10 times per **day**
   ____ 11-13 times per **day**
   ____ 14-16 times per **day**
   ____ More than once per waking hour

9. Name the 3 mobile internet applications that you use most frequently.

____

____

____

10. Select the option below indicating how often, on average, you text message on your smartphone. **Please select only one response.**

____ Never or very rarely	____ 2-4 times per **day**
____ Less than once per **week**	____ 5-7 times per **day**
____ 1-2 times per **week**	____ 8-10 times per **day**
____ 3-4 times per **week**	____ 11-13 times per **day**
____ 5-6 times per **week**	____ 14-16 times per **day**
____ 1 time per **day**	____ More than once per waking hour

11. Select the option below indicating how often, on average, you make or receive phone calls on your smartphone. **Please select only one response.**

____ Never or very rarely	____ 2-4 times per **day**
____ Less than once per **week**	____ 5-7 times per **day**
____ 1-2 times per **week**	____ 8-10 times per **day**
____ 3-4 times per **week**	____ 11-13 times per **day**
____ 5-6 times per **week**	____ 14-16 times per **day**
____ 1 time per **day**	____ More than once per waking hour

Driving and Cell Phone History:

12. How old were you when you first got your driver's license? _____________

13. In the past 5 years, how many traffic tickets have you received (do not count parking tickets)? ______

14. When you received those tickets, for how many were you:

a) talking on a cell phone? __________

b) text messaging? __________

c) using mobile internet applications? _________

15. In the past 5 years, how many accidents have you been in while driving? _________

16. When those accidents occurred, for how many were you:

a) talking on a cell phone? __________

b) text messaging? __________

c) using mobile internet applications? _________

APPENDIX E

WALKING AND DRIVING HISTORY QUESTIONNAIRE

ID #: ________

Walking & Driving Questionnaire

WALKING HISTORY

Look at the chart below. This provides an example of the beginning of a "walking diary." We would like you to make a "walking diary" of your typical Monday and your typical Thursday. We realize each day is a little different, but please do your best to reproduce an estimate of how you would walk outside on a typical Monday and a typical Thursday. **Consider all walking outside (e.g., to restaurants/bars, to UAB campus, between classes, in a park, walking for exercise, walking with a pet) when completing this section.**

	DESTINATION	TIME WALK BEGINS	MINUTES WALKED	# STREET CROSSINGS
1.	first class – Campbell Hall	8:20 am	15	4
2.	Sterne Library	9:25 am	5	1
3.	to parking lot from Sterne	10:30 am	5	2
4.	neighborhood walk with dog	11:00 am	20	6

[continued through the full day]

YOUR "TYPICAL" **MONDAY** WALKING DIARY:

	DESTINATION	TIME WALK BEGINS	MINUTES WALKED	# STREET CROSSINGS
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

ID #: ________

YOUR "TYPICAL" **THURSDAY** WALKING DIARY:

	DESTINATION	TIME WALK BEGINS	MINUTES WALKED	# STREET CROSSINGS
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

The walking diary above gives us specifics about your walking patterns on 2 days of the week. However, we would also like to know how much you walk on other days of the week. Without recording specifics, walk through the remaining 5 days of the week *in your head* as you did for the walking diary. Please estimate below how many minutes you typically spend walking outside and how many streets you cross, on average, for the remaining days of the week. *Remember to consider all walking outside (e.g., to restaurants/bars, between classes, to UAB campus, in a park, walking for exercise, walking with a pet) in your estimate.*

	MINUTES WALKED	# STREET CROSSINGS
1. Tuesday		
2. Wednesday		
3. Friday		
4. Saturday		
5. Sunday		

ID #: ________

Please use the following scale to answer the questions below:

1	2	3	4	5	6
Never	**Rarely**	**Sometimes**	**Often**	**Almost always**	**Always**

1. On average, how often do you **talk** on your cell phone while crossing streets? ________
2. On average, how often do you **text message** while crossing streets? ________
3. On average, how often do you **use mobile internet applications** while crossing streets? ________

DRIVING HISTORY

4. How much time do you spend driving in an average weekday (in minutes)? ____________________
5. How much time do you spend driving in an average weekend day (in minutes)? ________________

Please use the following scale to answer the questions below:

1	2	3	4	5	6
Never	**Rarely**	**Sometimes**	**Often**	**Almost always**	**Always**

6. On average, how often do you **talk** on your cell phone while driving? ________
7. On average, how often do you **text message** while driving? ________
8. On average, how often do you **use mobile internet applications** while driving? ________

APPENDIX F

POST VIRTUAL ENVIRONMENT QUESTIONNAIRE

ID#:______

Post Virtual Environment Questionnaire

1. Please circle how distracted you felt while crossing the virtual street:

1	2	3	4	5
not at all distracted	**a little distracted**	**somewhat distracted**	**pretty distracted**	**very distracted**

2. Please circle how distracted you felt in the virtual street, compared to what you expected before starting:

1	2	3	4	5
much less than expected	**a little less than expected**	**about the same as expected**	**a little more than expected**	**much more than expected**

3. How many emails did you successfully respond to during the virtual reality session? __________

4. How many emails did you attempt to respond to without success? ___________

Why were you unable to respond to the emails noted above? ____________________________
____
____
____

5. Please list all mobile applications that you used while in the virtual environment:

_______________________________ _______________________________
_______________________________ _______________________________
_______________________________ _______________________________
_______________________________ _______________________________
_______________________________ _______________________________
_______________________________ _______________________________

6. When in a real-world setting, what is the **most common** reason that you **talk** on your cell phone while <u>crossing a street</u> *(please select only one)*?

____ I need to check voicemails that may be important
____ It is a convenient time to make phone calls
____ I need to get directions to a location
____ The phone rings and I have to answer
____ Other (please specify): ____
____

ID#:______

7. When in a real-world setting, what is the **most common** reason that you **text message** while crossing a street *(please select only one)*?

____ I need to read or respond to text messages that may be important
____ It is a convenient time to text message
____ I need to get directions to a location
____ I need to contact someone with important information
____ Other (please specify): ____
____

8. When in a real-world setting, what is the **most common** reason that you **use mobile internet** while crossing a street *(please select only one)*?

____ I need to read or respond to emails or other messages (e.g., Facebook) that may be important
____ It is a convenient time to check emails or other messages
____ I need to get directions or information about a location
____ I need to contact someone with important information
____ I need to find important information
____ I want to see what my friends are doing (e.g., on Facebook or other social networks)
____ I want to update my Facebook or other social networking status or information
____ Other (please specify): ____
____

9. When in a real-world setting, what is the **most common** reason that you **talk** on your cell phone while driving *(please select only one)*?

____ I need to check voicemails that may be important
____ It is a convenient time to make phone calls
____ I need to get directions to a location
____ The phone rings and I have to answer
____ Other (please specify): ____
____

10. When in a real-world setting, what is the **most common** reason that you **text message** while driving *(please select only one)*?

____ I need to read or respond to text messages that may be important
____ It is a convenient time to text message
____ I need to get directions to a location
____ I need to contact someone with important information
____ Other (please specify): ____
____

ID#:______

11. When in a real-world setting, what is the **most common** reason that you **use mobile internet** while driving *(please select only one)*?

____ I need to read or respond to emails or other messages (e.g., Facebook) that may be important
____ It is a convenient time to check emails or other messages
____ I need to get directions or information about a location
____ I need to contact someone with important information
____ I need to find important information
____ I want to see what my friends are doing (e.g., on Facebook or other social networks)
____ I want to update my Facebook or other social networking status or information
____ Other (please specify): ____
____

APPENDIX G

IRB APPROVAL

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Institutional Review Board for Human Use

Form 4: IRB Approval Form
Identification and Certification of Research
Projects Involving Human Subjects

UAB's Institutional Review Boards for Human Use (IRBs) have an approved Federalwide Assurance with the Office for Human Research Protections (OHRP). The Assurance number is FWA00005960 and it expires on October 26, 2010. The UAB IRBs are also in compliance with 21 CFR Parts 50 and 56 and ICH GCP Guidelines.

Principal Investigator: BYINGTON, KATHERINE W

Co-Investigator(s):

Protocol Number: **X100730005**

Protocol Title: *Mobile Internet and Street Crossing*

The IRB reviewed and approved the above named project on 8/23/10. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services. This Project will be subject to Annual continuing review as provided in that Assurance.

This project received EXPEDITED review.

IRB Approval Date: 8-23-10

Date IRB Approval Issued: 8/23/10

Marilyn Doss

Marilyn Doss, M.A.
Vice Chair of the Institutional Review
Board for Human Use (IRB)

Investigators please note:

The IRB approved consent form used in the study must contain the IRB approval date and expiration date.

IRB approval is given for one year unless otherwise noted. For projects subject to annual review research activities may not continue past the one year anniversary of the IRB approval date.

Any modifications in the study methodology, protocol and/or consent form must be submitted for review and approval to the IRB prior to implementation.

Adverse Events and/or unanticipated risks to subjects or others at UAB or other participating institutions must be reported promptly to the IRB.

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