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Effects of Mobile Internet Use On College Student Pedestrian Injury Risk

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Abstract

Background—College-age individuals have the highest incidence of pedestrian injuries of any age cohort. One factor that might contribute to elevated pedestrian injuries among this age group is injuries incurred while crossing streets distracted by mobile devices.

Objectives—Examine whether young adult pedestrian safety is compromised while crossing a virtual pedestrian street while distracted using the internet on a mobile "smartphone."

Method—A within-subjects design was implemented with 92 young adults. Participants crossed a virtual pedestrian street 20 times, half the time while undistracted and half while completing an email-driven "scavenger hunt" to answer mundane questions using mobile internet on their cell phones. Six measures of pedestrian behavior were assessed during crossings. Participants also reported typical patterns of street crossing and mobile internet use.

Results—Participants reported using mobile internet with great frequency in daily life, including while walking across streets. In the virtual street environment, pedestrian behavior was greatly altered and generally more risky when participants were distracted by internet use. While distracted, participants waited longer to cross the street ($F = 42.37$), missed more safe opportunities to cross ($F = 42.63$), took longer to initiate crossing when a safe gap was available ($F = 53.03$), looked left and right less often ($F = 124.68$), spent more time looking away from the road ($F = 1959.78$), and were more likely to be hit or almost hit by an oncoming vehicle ($F = 29.54$; all ps < 0.01). Results were retained after controlling for randomized order; participant gender, age, and ethnicity; and both pedestrian habits and mobile internet experience.

Conclusion—Pedestrian behavior was influenced, and generally considerably riskier, when participants were simultaneously using mobile internet and crossing the street than when crossing the street with no distraction. This finding reinforces the need for increased awareness concerning the risks of distracted pedestrian behavior.

Keywords

pedestrian; safety; injury; cell phone; mobile internet; distraction

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Introduction

In 2009, 215,188 Americans suffered pedestrian injuries requiring hospital treatment. An additional 4,109 were killed. Among the injured, young adults of college age had the highest incidence of any age group (NCIPC, 2012). Young adults may have elevated pedestrian injury risk for a few reasons. First, they are frequent pedestrians (Sisson, McClain, & Tudor-Locke, 2008), and therefore have greater exposure to risk. Second, they may walk more frequently at night and while intoxicated, both risk factors (Atkins, Turner, Duthie, & Wilde, 1988; Zegeer & Bushell, 2012). Third, and the focus of the current study, they may walk while distracted by mobile devices.

The risk of distraction from mobile devices has grown dramatically over recent years. According to data from Pearson Education (http://www.infoplease.com/ipa/A0933563.html), mobile phone use in the United States has increased steadily over the past decade. Making causal assumptions based on annual data trends must be conducted cautiously, but it is curious that nonfatal pedestrian injury rates also show a trend of increasing over the past decade. The average crude rate of medically-attended pedestrian injuries from 2001–2005, for example, was 60.2; the comparable rate from 2006–2010 was 62.1. Among young adults ages 17–24, the average crude rate from 2001–2005 was 95.2; it increased to 104.3, on average, from 2006–2010 (NCIPC, 2012). Fatal pedestrian injuries do not show the same trend, nor do most other types of unintentional injury rates.

One reason distracted pedestrian activity is particularly dangerous is because multitasking – attempting to complete two cognitively complex tasks simultaneously – causes attention to and performance on one or both tasks to decrease (Kahneman, 1973). The human brain suffers when tasked with multiple complex activities simultaneously. Given the consequence of error while crossing streets and the need for safe pedestrians to simultaneously attend to multiple complex stimuli (Schwebel et al., 2009; Thompson, 2007; Whitebread & Neilson, 1999), one might presume that distraction by using mobile devices while crossing streets is dangerous.

In fact, empirical research suggests pedestrians distracted by a range of factors – ranging from eating to text messaging – may take greater risks than undistracted pedestrians (Bungum et al., 2005; Hatfield & Murphy, 2007; Nasar, Hecht, & Werner, 2008; Neider, McCarley, Crowell, Kaczmarski, & Kramer, 2010; Schwebel, Stavrinos, Byington, Davis, O’Neal, & de Jong, 2012; Stavrinos, Byington, & Schwebel, 2009, 2011). Poorly understood, however, is the influence of mobile internet, a technologically-based distraction that is being used with increasing frequency, especially among younger pedestrians and that uniquely involves two aspects of distraction.

Recent data from the Pew Research Center suggest that about half of Americans ages 18–29 (49%) own a smartphone that can access the internet (Smith, 2011). Of Americans who own a smartphone, 87% use their phone to access the internet regularly, and 68% of them on a daily basis (Smith, 2011). Further, 60% of cellphone owners ages 18–29 have downloaded internet-based applications to their phones, and 90% of those individuals use the apps at least weekly (Purcell, 2011). Using mobile internet while crossing a street creates a unique and particularly distracting situation because pedestrians using the mobile internet are distracted in two ways, both cognitively and visually. Those distracted by a telephone conversation – perhaps the best-understood cognitive distraction for pedestrians – are distracted cognitively but not visually. With both visual and cognitive attention compromised, both the cognitive processes in the brain and the perceptual processes of the visual system are impacted. Pedestrians might be at even greater risk for error when engaged in a task like browsing the internet than when distracted cognitively but not visually, for example, by a phone conversation.

Given the rapidly increasing use of mobile internet by young adults, and the potential distraction it creates in pedestrian environments, the present study tested whether pedestrian safety is compromised while using the internet on a smartphone. A within-subjects experimental design was implemented whereby college-aged participants crossed a virtual pedestrian street both while distracted by mobile internet and while undistracted. Pedestrian behavior was assessed through six outcome measures. We hypothesized that participants would take greater risks and be less attentive to traffic while distracted by mobile internet in the virtual pedestrian environment. We also hypothesized these effects would remain after covarying demographic factors, frequency of crossing streets, and experience using mobile internet.

Methods

Participants

Ninety-two participants (mean age = 19.05 years, *SD* = 1.18; 74% female; 41% Caucasian, 46% African-American) were recruited from Introductory Psychology classes at the University of Alabama at Birmingham. Inclusion criteria were age (17 to 25 years), owning a cell phone with 3G or faster internet connection, and use of a cell phone to access mobile internet applications at least 5 times per week on average. Participating students received credit as one way to fulfill a course requirement.

Procedure

Students participated in a single lab session comprised of several components. First, participants completed self-report questionnaires on various topics (detailed in Measures section below) while the experimenter sent ten separate emails to participants' primary email address for use during the upcoming virtual environment (VE) trials (details below). Participants' cell phones were removed to a different room so the emails were left unread.

Second, participants' walking speedwa s assessed by having them walk a distance of 25 feet four times "at the speed [they] would use to cross the street." The four walking times were averaged to compute individualized pedestrian walking speeds. Third, participants were introduced to the 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. Previous work established pedestrian behavior in this VE to possess construct, convergent, and face validity, plus internal reliability, based on correlations with behavior in the real-road environment, self-report of perceived realism, and other metrics (Schwebel, Gaines, & Severson, 2008). The environment consists of three large computer monitors, arranged in a semi-circle, which display bi-directional traffic in a 180° field-of-view on a two-lane virtual suburban road. For this study, traffic moved at a constant speed of 30 miles per hour with an average density of 525 feet between vehicles. Environmental sounds (e.g., bird chirping) and the sounds of cars approaching and passing are delivered through speakers. Figure 1 displays a screenshot of the virtual environment.

During the study, participants stood in front of the VE monitors on a raised platform that replicates a street-side curb. They were asked to step down off the curb when they felt 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 the 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.

Prior to engaging participants in the VE, the experimenter demonstrated two crossing trials – one 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 familiarization trials and experimental trials, participants completed further self-report measures (detailed below). They then engaged in a series of 20 simulated crossings split into two separate 10-crossing sessions with a short (< 10 minute) 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. During the brief break between sessions, participants completed two additional questionnaires (details below).

During the distraction condition, participants were instructed to open and reply to the emails previously sent by the experimenter. 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?”). To find information for responses to the emails, participants were permitted to use any mobile internet application to which they had access. Upon finding an answer, participants were to respond to the original email and then answer the next email in sequence. Participants were instructed to use the internet to answer the questions throughout the street-crossing task, including both while waiting to cross the street and while actually crossing the virtual street. If an experimenter noticed a participant was focused on the road and not using the internet for more than 10 seconds, the experimenter reminded that participant to continue the internet-based task. Such reminders were never necessary during the experiment, as all participants adhered to the instructions.

Measures

Self-Report Measures—Participants completed brief questionnaires assessing basic demographic information, their experience using a cell phone in general and while crossing the street, and their typical walking patterns.

Pedestrian Behavior—The following six variables, adapted from previous research (Schwebel et al., 2011; Stavrinos et al., 2011), were computed to evaluate street crossing behavior:

- **a.** Hits/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.** Start delay - the amount of time between a car passing the crosswalk and participants initiating crossing;
- **c.** Wait time - the amount of time participants waited to cross the street;
- **d.** Missed opportunities - when participants viewed a gap greater than or equal to 1.5 times their pre-determined crossing speed but did not cross within it;

e. Looks at traffic - the number of times participants looked left and right before beginning to cross the street, divided by time waiting to cross;

f. Eyes off road - 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.

The first five variables were computed automatically by the computerized VE. Time looking away from traffic was computed by reviewing video recordings of the sessions. Two independent researchers coded videos for 20% of the sample and achieved excellent interrater reliability ($r > 0.99$). The primary coder then completed the full sample and data from the primary coder were used in analyses.

All pedestrian data were compiled across the 10 distracted trials and the 10 undistracted trials to yield single scores of pedestrian behavior while distracted and while undistracted. Data from eyes off road, looks at traffic, start delay, and wait time, were averaged across the ten trials for each condition. Counts of hits/close calls and missed opportunities were summed and totaled across the ten trials. Together, therefore, there were two sets (distracted and undistracted) of six pedestrian outcome measures (hits/close calls, start delay, wait time, missed opportunities, looks at traffic, eyes off road).

Data Analysis—Data were analyzed in four steps. First, descriptive data were considered, including self-reported pedestrian behavior, mobile phone internet usage, and mobile phone internet usage while crossing the street. Second, to test our primary hypothesis that pedestrian behavior would be different across the distraction and no distraction conditions, repeated measures ANOVAs were conducted with condition (distracted versus undistracted) as the independent variable and pedestrian scores as the dependent variable. Third, to test for demographic covariate influences, repeated measures ANOVAs were conducted predicting pedestrian behavior, with distracted versus undistracted as a within subjects factor and randomized order, gender, ethnicity, and age as between subjects factors. Finally, to test for pedestrian habits and mobile internet experience as covariates, repeated-measures ANOVAs were conducted predicting pedestrian behavior with condition (distracted versus undistracted) as a within subjects factor and general pedestrian habits, general mobile internet experience, and mobile internet while crossing experience as between-subjects factors.

Results

Descriptive data from the self-report instruments showed that all participants from the urban campus reported crossing at least 3 streets daily on average, with 41.3% reporting 6 or fewer streets crossed per day, 30.4% between 6 and 9 streets per day, and 27.2% more than 9 streets per day. Daily mobile internet usage data showed 25.3% of participants used mobile internet less than 7 times per day, 47.3% used it 8 to 16 times per day, and 27.5% used it over 16 times a day - at least once per waking hour. Regarding frequency of using mobile internet while crossing the street, 10.9% of the sample reported “never” using mobile internet while crossing the street, 39.1% reported “rarely” doing so, 30.4% endorsed “sometimes” using mobile internet while crossing the street, and 19.6% endorsed “often,” “almost always,” or “always.”

We also considered why participants choose to use mobile internet while crossing the street. In response to an inquiry about the most common reason participants use mobile internet while crossing streets, 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%.

To test our primary hypothesis that pedestrian behavior would differ across the distraction and no distraction conditions, repeated measures ANOVAs were conducted with condition (distracted versus undistracted) as the independent variable and pedestrian scores as the dependent variable. A main effect for condition emerged across all six pedestrian variables, revealing more risky behavior for the distraction condition than the no distraction condition (See Table 1). While distracted, participants waited longer to cross, $F(1,90) = 42.37$, $p < 0.01$, missed more safe opportunities to cross, $F(1,90) = 42.63$, $p < 0.01$, and took longer to initiate crossing when a safe gap was available, $F(1,90) = 53.03$, $p < 0.01$. Distracted participants also looked left and right less, $F(1,90) = 124.68$, $p < 0.01$, spent more time looking away from the road, $F(1,89) = 1959.78$, $p < 0.01$, and were more likely to be hit or almost hit by an oncoming vehicle, $F(1,90) = 29.54$, $p < 0.01$.

Next, repeated measures ANOVAs were conducted to test for possible covariate influences. First, we ran repeated measures ANOVAs with demographic factors included as between-subjects covariates. Distracted versus undistracted group served as the within-subjects factor and randomized order (distracted first versus undistracted first), gender (male versus female), ethnicity (African American vs. Caucasian vs. Other), and age (17.92–18.49 years versus 18.50–19.04 years versus 19.05–25.99 years) as between subjects factors. Main effects for condition were retained across all pedestrian variables, suggesting more risky pedestrian behavior occurred when distracted by mobile internet regardless of randomized order, gender, ethnicity, or age. No significant effects of ethnicity, gender, or age emerged between subjects for any of the pedestrian variables. However, within the hits/close calls variable, effects of randomized order, $F(1,71) = 7.84$, $p < 0.05$, and the order by condition interaction, $F(1,71) = 15.25$, $p < 0.01$, were significant. The significant difference in hits/close calls within the distracted first condition, $t(43) = -5.61$, $p < 0.01$, and the distracted second condition, $t(46) = -2.06$, $p = 0.05$ were both 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 were distracted first had a more substantial effect of distraction causing risky pedestrian behavior than did those who were distracted second.

Finally, to determine if either pedestrian habits or mobile internet experience influenced pedestrian behavior, additional ANOVAs were conducted using condition (distracted versus undistracted) as a within subjects factor and the following three variables as between subjects factors: pedestrian habits (average streets crossed per day: ≤6 versus 6.01–9.00 versus ≥9.01), general mobile internet experience (average number of times using mobile internet daily: <8 versus 8–16 versus >16), mobile internet while crossing experience (frequency of using mobile internet while crossing the street: never/rarely versus sometimes versus often/almost always/always). No significant effects or interactions emerged for any of the three variables, suggesting similar pedestrian behavior regardless of reported habits crossing streets or experience using mobile internet.

Discussion

This study examined differences in college students' pedestrian behavior while distracted by mobile internet applications and while not distracted. Findings confirmed our hypotheses: pedestrian behavior was influenced, and generally riskier, when participants were simultaneously using mobile internet and crossing the street than when crossing the street without distraction. While distracted in the VE, participants looked to the left and right less before crossing, spent a greater percentage of time looking away from the road, took longer to initiate crossing when a safe gap was available, and were hit or almost hit by oncoming vehicles more often. They also waited longer to cross and missed more safe opportunities to cross. These findings were not influenced by the covariates we studied, including gender, habits crossing the street, or experience using mobile internet.

Previous research has reported similar findings regarding the effects of listening to music, holding a cell phone conversation, and text messaging on pedestrian safety (Hatfield & Murphy, 2007; Neider et al., 2010; Stavrinos et al., 2009, 2011). The presumed mechanism for impaired pedestrian safety is due to the increased cognitive load of a distracting device that reduces efficacy of the cognitive process of perceiving and processing relevant environmental stimuli at a roadside location, and then making a safe decision to initiate motoric processes. This study extends those findings to a different medium of distraction, browsing the internet, that involves both visual and cognitive distraction. Text messaging is the only previously-studied distraction that includes some of those same cognitive and visual distractive properties, although text messaging rarely includes the appealing pictorial stimuli of the internet. Listening to music and talking on the telephone involve minimal visual distraction. Taken together, these and previous findings suggest that increased use of handheld technological devices – while positive influences to safety and health in many ways – may cause a decrease in pedestrian safety.

Descriptive data indicate that mobile internet use, both in general and while crossing the street, was common among our sample of college student mobile internet users. Nearly half the sample reported 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. Half our sample (50%) reported using mobile internet while crossing the street at least sometimes and nearly 20% reported doing so "often" or more than often. Experience did not seem to aid pedestrian safety, either. Regardless of experience using the internet on their phones or crossing streets frequently, all participants were distracted by mobile internet in the VE.

One interesting pattern in our results was the fact that participants tended to wait longer to cross and miss more safe opportunities to cross while distracted. These behaviors do not increase pedestrian injury risk, of course, but they do represent inefficiency and distraction. The delayed crossing did not improve safety either (hits and close calls increased despite longer wait times), nor did they correlate with better attention (both measures of attention, looks at traffic and eyes off road, were poorer while distracted). Thus, as participants were distracted by the mobile internet tasks, they ended up missing more safe opportunities and attending less to the situation, but still chose riskier times to cross.

Our findings have implications for practice. First, they reinforce the urgent need to increase public awareness about the risks of pedestrian distraction. Effective driving safety campaigns tend to be short-term, presented through personal communication, and occur in physical proximity to where the targeted behavior occurs (Phillips, Ulleberg, & Vaa, 2011). Similar strategies might be effective for pedestrian safety campaigns. For example, signs posted where pedestrians might approach intersections or crosswalks while distracted could help. Additionally, laws to prohibit cell phone use while crossing the street may decrease risky behavior. Although it may be very difficult to enforce such policies fully, just as it is to enforce laws banning text messaging while driving, having formal laws in place may help individuals realize the importance of the issue and could help reduce the behavior.

Three other prevention strategies may also be worthwhile. First, driver awareness campaigns might be considered. If drivers are more aware that pedestrians could be distracted, they may take caution and yield when a distracted pedestrian crosses inappropriately. Second, continued attention must be paid to the role of the built environment for pedestrian safety. Initiatives such as traffic calming, building pedestrian bridges and islands, and restricted crossing areas are likely to reduce injuries to all pedestrians, including distracted ones (Ewing & Durnbaugh, 2009; Sleet, Pollack, Rivara, Frattaroli, & Peek-Asa, 2010). Last, Intelligent Transport Systems technology is rapidly improving. As engineering innovations continue, we may see the broad introduction of electronic devices in vehicles that detect pedestrians and warn drivers to take caution.

The present findings also have implications for future research. Our results suggest crossing a street while distracted by the internet is risky. Pedestrian behavior was more dangerous while distracted than while not distracted. What our results fail to address is the magnitude of risk. We cannot determine from these results, for example, if crossing a street while distracted by the internet is more dangerous than crossing a street while distracted by talking on the phone. Theoretical evidence suggests that may be the case, as pedestrians distracted by the internet suffer from both cognitive and visual distraction whereas pedestrians distracted by a telephone call suffer only from cognitive distraction, but future research is needed to evaluate this hypothesis.

Additional research investigating why individuals choose to engage in risky pedestrian behavior would also be helpful for intervention development. Our findings concerning why participants use mobile internet while crossing the street suggest three of the four most common reasons were for non-urgent social interaction or entertainment (e.g., email, Facebook). Gaining a better understanding of why individuals continue behaviors that they recognize as unsafe, a pattern so frequent in many domains of health behavior (e.g., Steele, Steele, & Hunter, 2009; Svenningsson, Marklund, Attvall, & Gedda, 2011), could inform policy making and safety campaigns.

Like all research, this study had strengths and weaknesses. One strength was the use of a validated virtual pedestrian environment that allowed participants to engage in a potentially dangerous activity without risk. Additionally, this study was among the first to consider a newly emerging technology, mobile internet use, and its impact on distracted pedestrians. There also were study limitations. The experimental methodology did not permit precise assessment of the level of participants' mobile internet engagement while crossing; some participants may have been more engaged than others. In addition, the study focused only on mid-block pedestrian crossings. It is unclear if the results might generalize to other crossing scenarios (e.g., at a signaled intersection where the pedestrian can use lighted signals to help determine crossing safety). Also limiting was the focus on simulated behavior. Although there are strong data suggesting validity of behavior in the virtual pedestrian environment (Schwebel et al., 2008), simulated behavior can never be equated exactly to real-world behavior and evidence from naturalistic or observational research might be useful to replicate the findings we report based on simulated behavior in a virtual pedestrian environment. Further, this study was limited to young adult college students. Although this is a population at particular risk due to their use of mobile internet and their frequent walking habits, it would be valuable to replicate and extend the findings to different age groups.

One final limitation of the study concerns the participants' walking speed. Walking speed was assessed while participants were undistracted and prior to entering the virtual environment; that speed was used to dictate the avatar's walking speed in the virtual environment. Previous work suggests drivers move more slowly when distracted (e.g., Rakauskas, Gugerty, & Ward, 2004), and distracted pedestrians may do so as well. Walking more slowly creates increased pedestrian exposure to traffic while crossing, of course; walking while distracted increases risk due to failure to engage in appropriate avoidant behavior if traffic was initially misjudged. Our research design did not include measurement of walking speed while distracted, and therefore represents a situation where a pedestrian is distracted by mobile internet use while deciding to cross the street but becomes attentive during the actual crossing. In instances when the pedestrian remains distracted by the internet while crossing, results may or may not differ. Parallel issues emerged in previous work studying the influence of carrying a heavy backpack while crossing the street. In that case, pedestrians walked more slowly while carrying the heavy pack, and had increased risk due to the slower walking speed (Schwebel, Pitts, & Stavrinos, 2009). Future research should investigate whether distraction by using mobile internet, and perhaps other types of distraction, has similar consequences.

In conclusion, although the practical function of mobile access to the internet is entertaining and often advantageous, the current findings suggest it may also result in risky pedestrian behavior. Cell phones may present as tools that can provide safeguards to users, but evidence from recent transportation research suggests more lives are lost due to cell phone use than are saved (Loeb & Clark, 2009). Despite the convenience and wealth of information provided by mobile internet, our results suggest that distraction in a pedestrian environment can reduce the cognitive and visual capacity required to cross the street safely.

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References

Atkins RM, Turner WH, Duthie RB, Wilde BR. Injuries to pedestrians in road traffic accidents. BMJ. 1988; 297:1431–1434. [PubMed: 3147003]

Bungum TJ, Day C, Henry LJ. The association of distraction and caution displayed by pedestrians at a lighted crosswalk. Journal of Community Health. 2005; 30:269–279. [PubMed: 15989209]

Drews FA, Yazdani H, Godfrey CN, Cooper JM, Strayer DL. Text messaging during simulated driving. Human Factors. 2009; 51:762–770. [PubMed: 20196300]

Ewing R, Durnbaugh E. The built environment and traffic safety: A review of empirical evidence. Journal of Planning Literature. 2009; 23:347–367.

Hatfield J, Murphy S. The effects of mobile phone use on pedestrian crossing behavior at signalized and unsignalised intersections. Accident Analysis and Prevention. 2007; 39:197–205. [PubMed: 16919588]

Hosking SG, Young KL, Regan MA. The effects of text messaging on young drivers. Human Factors. 2009; 51:582–592. [PubMed: 19899366]

Kahneman, D. Attention and effort. Englewood Cliffs, NJ: Prentice-Hall; 1973.

Liang Y, Lee JD. Combining cognitive and visual distraction: Less than the sum of its parts. Accident Analysis and Prevention. 2010; 42:881–890. [PubMed: 20380916]

Loeb PD, Clarke WA. The cell phone effect on pedestrian fatalities. Transportation Research Part E. 2009; 45:69–75.

Nasar J, Hecht P, Werner R. Mobile telephones, distracted attention, and pedestrian safety. Accident Analysis and Prevention. 2008; 40:69–75. [PubMed: 18215534]

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

Neider MB, McCarley JS, Crowell JA, Kaczmarski H, Kramer AF. Pedestrians, vehicles, and cell phones. Accident Analysis and Prevention. 2010; 42:589–594. [PubMed: 20159083]

Phillips RO, Ulleberg P, Vaa T. Meta-analysis of the effect of road safety campaigns on accidents. Accident Analysis and Prevention. 2011; 43:1204–1218. [PubMed: 21376920]

Purcell, K. Half of adult cell phone owners have apps on their phones. Washington, DC: Pew Research Center; 2011. Available from http://pewinternet.org/~/media//Files/Reports/2011/PIP_Apps-Update-2011.pdf

Rakauskas ME, Gugerty LJ, Ward NJ. Effects of naturalistic cell phone conversations on driving performance. Journal of Safety Research. 2004; 35:453–464. [PubMed: 15474548]

Schwebel DC, Gaines J, Severson J. Validation of virtual reality as a tool to understand and prevent child pedestrian injury. Accident Analysis and Prevention. 2008; 40:1394–1400. [PubMed: 18606271]

Schwebel DC, Pitts DD, Stavrinos D. The influence of carrying a backpack on college student pedestrian safety. Accident Analysis and Prevention. 2009; 41:352–356. [PubMed: 19245896]

Schwebel DC, Stavrinos D, Byington KW, Davis T, O'Neal EE, de Jong D. Distraction and pedestrian safety: How talking on the phone, texting, and listening to music impact crossing the street. Accident Analysis and Prevention. 2012; 45:266–271.10.1016/j.aap.2011.07.011 [PubMed: 22269509]

Sisson SB, McClain JJ, Tudor-Locke C. Campus walkability, pedometer-determined steps, and moderate-to-vigorous physical activity: A comparison of 2 university campuses. Journal of American College Health. 2008; 56:585–592. [PubMed: 18400673]

Sleet DA, Pollack K, Rivara F, Frattaroli S, Peek-Asa C. It wouldn't hurt to walk: Promoting pedestrian injury research. Injury Prevention. 2010; 16:211–212. [PubMed: 20570990]

Smith, A. 35% of American adults own a smartphone. Washington, DC: Pew Research Center; 2011. Available from http://pewinternet.org/~/media//Files/Reports/2011/PIP_Smartphones.pdf

Stavrinos D, Byington KW, Schwebel DC. Effect of cell phone distraction on pediatric pedestrian injury risk. Pediatrics. 2009; 123:e179–185. [PubMed: 19171568]

Stavrinos D, Byington KW, Schwebel DC. Distracted walking: Cell phones increase injury risk for college pedestrians. Journal of Safety Research. 2011; 42:101–107. [PubMed: 21569892]

Steele MM, Steele RG, Hunter HL. Family adherence as a predictor of child outcome in an intervention for pediatric obesity: Different outcomes for self-report and objective measures. Children's Health Care. 2009; 38:64–75.

Svenningsson I, Marklund B, Attvall S, Gedda B. Type 2 diabetes: Perceptions of quality of life and attitudes towards diabetes from a gender perspective. Scandinavian Journal of Caring Sciences. 2011; 25:688–695. [PubMed: 21362008]

Thompson, JA. Negotiating the urban traffic environment: Pedestrian skill development in young children. In: Allen, GL., editor. Applied spatial cognition: From research to cognitive technology. Mahwah, NJ: Lawrence Erlbaum Associates; 2007. p. 203-227.

Whitebread D, Neilson K. Learning to cross the road: Cognition in action. The Psychologist. 1999; 12:403–405.

Zegeer CV, Bushell M. Pedestrian crash trends and potential countermeasures from round the world. Accident Analysis and Prevention. 2012; 44:3–11. [PubMed: 22062330]

Highlights

- College students use mobile internet frequently, including while crossing streets
- Mobile internet use impacts pedestrian safety
- Demographics, pedestrian habits, mobile internet experience not relevant to results

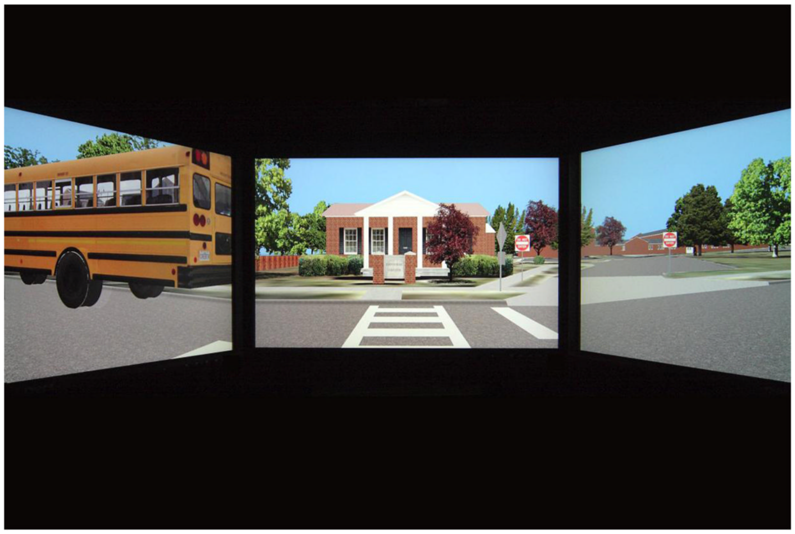

Figure 1.
Screen shot of the virtual pedestrian environment

Table 1

Virtual Environment Pedestrian Outcomes for No Distraction and Distraction Crossings (N = 92)

	No Distraction	Distraction		
	Mean (SD)	**Mean (SD)**	***F***	η^2
Hits/Close Calls	0.56 (0.79)	1.35 (1.41)	29.54*	0.25
Start Delay (sec)	1.11 (0.53)	1.68 (0.69)	53.03*	0.37
Wait Time (sec)	14.25 (9.30)	24.46 (19.97)	42.37*	0.32
Missed Opportunities	1.72 (2.53)	4.63 (5.36)	42.63*	0.32
Looks at Traffic (per min)	35.86 (8.79)	25.69 (9.07)	124.68*	0.58
Eyes off Road (% of time)	0.69 (1.68)	59.75 (12.56)	1959.78*	0.96

Note.

* $p < 0.01$; for Eyes off Road variable $df = 89$, for all other variables $df = 90$.