The Effects of Cell Phone and Text Message Conversations on Simulated Street Crossing

Sarah E. Banducci, **Nathan Ward**, University of Illinois at Urbana-Champaign, **John G. Gaspar**, University of Iowa, Iowa City, **Kurt R. Schab**, **James A. Crowell**, **Henry Kaczmarski**, and **Arthur F. Kramer**, University of Illinois at Urbana-Champaign

Objective: A fully immersive, high-fidelity street-crossing simulator was used to examine the effects of texting on pedestrian street-crossing performance.

Background: Research suggests that street-crossing performance is impaired when pedestrians engage in cell phone conversations. Less is known about the impact of texting on street-crossing performance.

Method: Thirty-two young adults completed three distraction conditions in a simulated street-crossing task: no distraction, phone conversation, and texting. A hands-free headset and a mounted tablet were used to conduct the phone and texting conversations, respectively. Participants moved through the virtual environment via a manual treadmill, allowing them to select crossing gaps and change their gait.

Results: During the phone conversation and texting conditions, participants had fewer successful crossings and took longer to initiate crossing. Furthermore, in the texting condition, smaller percentage of time with head orientation toward the tablet, fewer number of head orientations toward the tablet, and greater percentage of total characters typed before initiating crossing predicted greater crossing success.

Conclusion: Our results suggest that (a) texting is as unsafe as phone conversations for street-crossing performance and (b) when subjects completed most of the texting task before initiating crossing, they were more likely to make it safely across the street.

Application: Sending and receiving text messages negatively impact a range of real-world behaviors. These results may inform personal and policy decisions.

Keywords: pedestrian safety, mobile technology, distraction, texting, virtual environments, simulation

Address correspondence to Sarah E. Banducci, University of Illinois at Urbana-Champaign, 405 N. Matthews Street, Urbana, IL 61801, USA; e-mail: banducc2@illinois.edu.

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INTRODUCTION

In recent years there has been a proliferation in mobile technology. In 2013, 97% of American adults under 35 were using cell phones (Rainie, 2013). Beyond making calls, these devices offer the ability to perform a range of tasks, including sending text messages, checking e-mail, and playing video games.

This growth in mobile technology has increased the extent to which people's collective attention is regularly divided between their phones and other tasks, such as driving or walking. Multitasking in the vehicle has a negative impact on both driving performance (e.g., Caird, Willness, Steel, & Scialfa, 2008; Horrey & Wickens, 2006) and secondary-task performance (Becic et al., 2010; He, McCarley, & Kramer, 2014). Evidence suggests that texting while driving may be even more dangerous. On-road and simulator studies have shown an increase in crash likelihood when drivers are texting, in addition to delayed response times and impaired lane keeping, relative to driving undistracted (Drews, Yazdani, Godfrey, Cooper, & Strayer, 2009; Owens, McLaughlin, & Sudweeks, 2011). Naturalistic driving data also confirm an inflated crash risk when young adult drivers are texting (National Highway Traffic Safety Administration [NHTSA], 2013).

The cost associated with texting is theorized to result from a combination of factors. Texting physically diverts a driver's eyes from the road, increasing the chance of missing critical information. Texting drivers spend 400% more time looking away from the driving scene compared to undistracted drivers (Hosking, Young, & Regan, 2009). Importantly, texting also imposes a significant cognitive demand that diverts a subset of the driver's attention away from driving, similar to a cell phone conversation (Yager, Cooper, & Chrysler, 2012).

The prevalence and impact of distraction is not limited to driving. The influence of cognitive load on mobility has been well established (Woollacott & Shumway-Cook, 2002; Yogev, Hausdorff, & Giladi, 2008). Walking and simultaneously performing a cognitive task has shown a detrimental effect on obstacle avoidance (Weerdesteyn, Schillings, Van Galen, & Duysens, 2003) as well as gait (Kemper, Herman, & Lian, 2003; Lindenberger, Marsiske, & Baltes, 2000).

Along those lines, distraction-related pedestrian injuries represent a significant public health issue. In 2013, approximately 66,000 pedestrians were injured and over 4,700 were killed in traffic incidents throughout the United States (NHTSA, 2015). Preliminary observational data suggest that the number of distraction-related pedestrian injuries is rising (Nasar & Troyer, 2013), which is likely because pedestrians are less aware of their environment when distracted by a cell phone (Nasar, Hecht, & Wener, 2008). Recently, laboratory studies demonstrated the cost of conversing on a cell phone while crossing a busy simulated street. Using a high-fidelity street-crossing simulator, Neider, McCarley, Crowell, Kaczmarski, and Kramer (2010) showed that naturalistic cell phone conversations impair crossing performance and increase crash rates (see also Chaddock, Neider, Voss, Gaspar, & Kramer, 2011; Gaspar et al., 2013; Nagamatsu et al., 2011; Neider et al., 2011). Similarly, Stavrinos, Byington, and Schwebel (2009, 2011) demonstrated significant costs to simulated crossing performance while conversing on a cell phone.

Considerably less is known, however, about the impact of texting on pedestrian behavior. Schwebel and colleagues (2012) studied the effect of multimedia distraction, including texting, on pedestrian safety using a simulator. Participants stood in front of three computer monitors watching two-way traffic pass through a virtual crosswalk. Participants indicated by stepping off of a wooden “curb” the time selected to initiate crossing and then watched an avatar complete the crossing on the screens. They found that participants looked away from the screens of the crossing task more with the multimedia distraction conditions, including texting, which led them to select more crossing opportunities that may have resulted in a possible collision compared to undistracted participants.

The goal of the present study was to further examine the effect of reading and sending text messages on street-crossing performance using a high-fidelity, immersive street-crossing simulator. We compared the effects of naturalistic hands-free phone and text messaging conversations against a no-distraction baseline. Whereas the simulator used by Schwebel and colleagues (2012) assumed a fixed crossing speed and a computerized avatar finished the street crossing, in the present study, participants walked on a treadmill yoked to the immersive virtual environment to cross the street, allowing them to account for their individual gait when selecting gaps and to vary walking speed within the context of a crossing maneuver. This design enabled participants to engage in both the street-crossing task as well as the distractions throughout the three phases of the task.

Thus, we were able to examine the effect of distraction on pedestrian behaviors at each stage of crossing (approach, preparation, crossing). Previous research has established the sensitivity of this paradigm to detect dual-task effects related to cell phone conversations, including group differences, such as age (Neider et al., 2011), falls risk (Nagamatsu et al., 2011), athletic experience (Chaddock et al., 2011), fitness (Chaddock, Neider, Lutz, Hillman, & Kramer, 2012), and action video game experience (Gaspar et al., 2013). An additional benefit of the street-crossing simulator is that stereo goggles provided the impression of depth in the virtual environment, creating an immersive simulation and allowing for a realistic assessment of distance and speed judgments.

We predicted that both cell phone conversations and text messaging would impair street crossing relative to the no-distraction condition. We predicted that these dual-task costs would manifest in both fewer successful crossings and impaired decision making, as measured by slower decisions to initiate crossings. Furthermore, on the basis of data comparing the effects of cell phone conversations and texting on driving performance (e.g., Drews et al., 2009), we predicted that text messaging would result in

TABLE 1: Likely Phone Usage Behaviors

Multimedia Behavior	Mean Rating
Talk on the phone while walking	3.73 (1.17)
Talk on the phone while crossing a busy street	2.70 (1.31)
Initiate a phone call while crossing a busy street	2.00 (1.78)
Text while walking	4.11 (0.94)
Read a text while crossing a busy street	2.30 (1.35)
Send a text while crossing a busy street	2.05 (1.34)

Note. Mean values from Likert scale ratings (1–5) indicating likelihood to engage in phone behaviors are shown with standard deviations in parentheses. Greater values indicate greater likelihood of engaging in that behavior.

larger dual-task impairments than would hands-free conversations.

METHOD

Participants

Thirty-seven young adults from the University of Illinois were recruited for the study. Five participants were excluded due to technical issues during the experiment. The final sample consisted of 32 participants (mean age = 22.28, *SD* = 3.04, range = 18–30, 12 male). Participants provided written consent before the testing session, and the procedure was approved by the Institutional Review Board of the University of Illinois, Urbana-Champaign. We administered a brief questionnaire to assess the likelihood of participants to engage in phone behaviors while walking or crossing a busy street. The results from this questionnaire are in Table 1.

Street-Crossing Paradigm

The street-crossing environment was developed in the virtual reality Cave Automatic Virtual Environment (CAVE) at the University of Illinois (see Figure 1; http://www.isl.uiuc.edu/Labs/CAVE/CAVE.html). The CAVE consists of three screens measuring 303 cm wide by 273 cm high, on which images were projected. Participants walked on a Woodway "Curve" manual treadmill that was linked with the virtual environment. On each trial, the participant started from an alleyway before a busy street, approached the roadway, and crossed when deemed safe (see Figure 2). Each trial ended when the participant made it to the other side of the street, an oncoming car hit the participant, or the participant took longer than 90 s to complete the trial. Participants were visually and audibly informed regarding crossing success or failure. In the virtual environment, the subject is represented by a rectangle 50 cm wide by 40 cm in the direction of travel and centered on the midpoint of the eyes; the car models are also expressed as horizontal rectangles, and a collision occurs if the two intersect. All cars had a fixed velocity of 33 mph (14.75 m/s), but the intervehicle distance (IVD) varied between trials: either 75 m or 90 m. Head position and orientation was measured with a Flock of Birds 6-degrees-of-freedom electromagnetic tracker (Ascension Technology Corporation). Further details of this paradigm can be found in previous work (Gaspar et al., 2013).

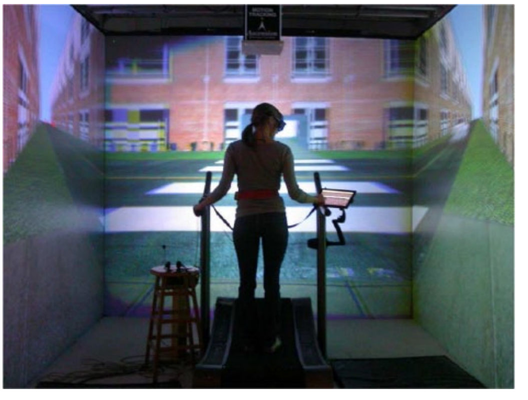

Figure 1. Photograph of virtual environment where the particpant's head was oriented away from the tablet (left) and toward the tablet (right).

A within-subjects design compared the effects of three task conditions. In the no-distraction condition, participants crossed the street undistracted.

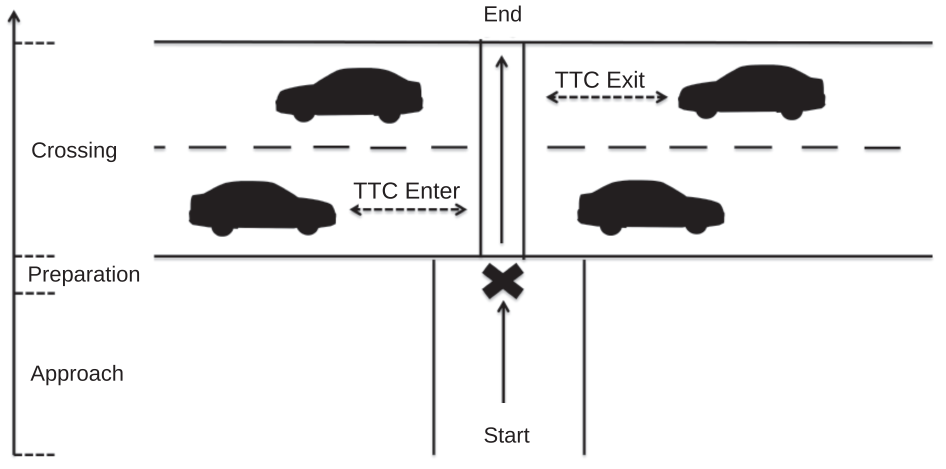

Figure 2. Street-crossing paradigm and outcome variables.

This condition served as a baseline for street-crossing performance. In the phone condition, participants crossed the street while engaging in a naturalistic conversation with a confederate research assistant using a hands-free headset. These conditions were replicated from previous studies using versions of the CAVE paradigm (Chaddock et al., 2011; Gaspar et al., 2013; Nagamatsu et al., 2011; Neider et al., 2010, 2011). In the novel texting condition, participants engaged in a naturalistic texting conversation with an experimenter on a tablet mounted to the side arm of the treadmill (see Figure 1). Participants were alerted to the receipt of a text message via an audible beep and a red block obscuring the text on the tablet. Messages were sent and received throughout all phases of the street-crossing trials to replicate a naturalistic continuous exchange. The message remained obscured until the participant touched the screen, after which a keyboard appeared allowing the participant to type and send a response to the experimenter. The initial conversation prompts (e.g., "What classes are you taking?" "Have you seen any movies lately?" "Where is your home town?") for both the phone and texting conversations were taken from previous studies (i.e., Neider et al., 2010, 2011). Figure 3 displays a sample conversation that took place over one block of texting trials. During phone and texting conditions, participants were asked to complete the street-crossing task while engaging in a conversation via phone or text with the experimenter. Participants were not provided any further information on how they should complete the distraction trials.

Participants completed 60 trials in blocks of 10 trials and were allowed to rest between blocks. Two blocks were assigned to each condition, and the order of blocks was counterbalanced across participants. A total of seven trials, across all participants and conditions, were discontinued because the participant took longer than 90 s to complete the trial. These time-out trials were excluded from all analyses.

Participants were trained on the tasks in a three-step process. First, participants typed 10 predefined sentences on the texting interface while standing on the unmoving sides of the treadmill. Participants then used the treadmill to propel themselves through a virtual forest to acclimate to the manual treadmill. Finally, each participant completed eight practice trials of the street-crossing task. Data from the typing phase of this training were used to calculate a baseline typing speed for each participant.

Data Processing

Crossing data. Trials were divided into three sections based on location in the virtual world: approaching the street from the alleyway (approach), at the curb prior to initiating crossing from where to evaluate crossing safety

Messages	Crossing event	Time (s)
	Trial starts	0
E: What's your favorite movie?		6
	Subject stops at curb	7
	Subject starts crossing	17
	Subject finishes crossing	24
	Trial starts	38
S: Hmmm... there are so many.		41
S: I like sci fi movies.		54
	Subject stops at curb	55
E: Like Star Wars?		60
	Subject starts crossing	60
	Subject finishes crossing	64
	Trial starts	71
	Subject stops at curb	79
S: More like Star Trek.		82
E: Ahhh. The new ones or the old ones?		89
Opened		91
S: The older ones.		100
	Subject starts crossing	107
	Subject finishes crossing	113
	Trial starts	118
E: Who's? Did you watch all the series of it?		119
Opened		124
	Subject stops at curb	124
S: Yea, except for the original.		140
	Subject starts crossing	144
	Subject finishes crossing	148
E: What oth[er] sci-fi do you watch?		152
	Trial starts	154
	Subject stops at curb	159
	Subject starts crossing	160
	Subject finishes crossing	165
	Trial starts	170
	Subject stops at curb	176
S: Firefly.		181
	Subject starts crossing	185
	Subject hit by car	188
	Trial starts	196

(continued)

Figure 3. (continued)

Messages	Crossing event	Time (s)
E: I've seen the movie but not the series. It['s] good?		197
Opened		199
	Subject stops at curb	203
S: Yeah, it's just short.		213
E: How many seasons?		219
	Subject starts crossing	220
	Subject finishes crossing	224
	Trial starts	233
S: 14 episodes.		243
	Subject stops at curb	246
	Subject starts crossing	252
E: Not very short. It got canceled, right?		258
	Subject finishes crossing	258
	Trial starts	264
S: Yup.		265
	Subject stops at curb	270
	Subject starts crossing	273
E: And then the movie was made?		276
	Subject finishes crossing	278
	Trial starts	283
	Subject stops at curb	290
S: Yup, for the fans.		295
	Subject starts crossing	301
E: Oh, kind of like Veronica Mars, I think?		305
	Subject finishes crossing	305

Figure 3. Sample transcript from one block of texting. *S* indicates a response made by the subject and *E* indicates a response made by the experimenter.

(preparation), and crossing the street until successfully reaching the other side (crossing). Motion of the participant throughout the trial, restricted to one dimension, was recorded and time stamped. The intertrial period after the current trial ended and during which the new trial loaded was excluded from all analyses.

Several variables of interest were derived from the street-crossing trials and averaged within each distraction condition. A trial was deemed "successful" if the participant made it across the street to the end of the trial without collision. Thus, for purposes of this study, the success variable was defined as the percentage of trials that were successful. As with previous studies, for ease of interpretation and due to limitations of data collection, we have limited our definition of the following variables to trials deemed successful (see Neider et al., 2010). Preparation duration was defined as the length of time the participant stood at the curb before entering the street on successful trials. Average approach, preparation, and crossing durations, defined as the total time within each segment of the trial, were examined for successful trials across the three distraction conditions. Additionally, time to

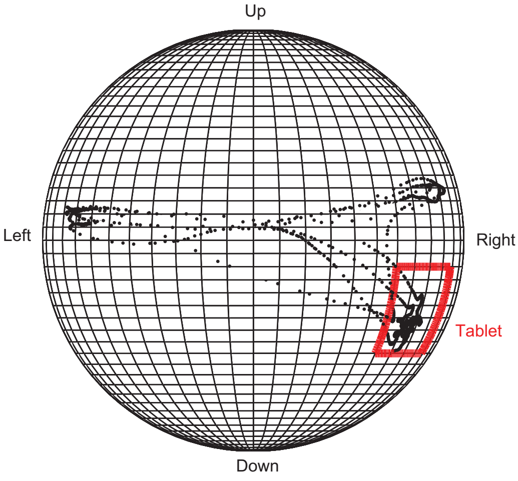

Figure 4. Sample head position data from one texting trial. Head positions within the box are categorized as looking away from the street.

contact (TTC) was defined as the distance between the participant and oncoming vehicle, measured from the front bumper, divided by the speed of the oncoming vehicle. "TTC enter" was calculated for the car approaching from the left as the participant entered Lane 1. "TTC exit" was calculated for the car approaching from the right as the participant exited Lane 2.

Texting data. The primary variables used to assess texting behaviors and performance included the percentage of time the head was oriented toward the tablet, the number of times the head was oriented toward the tablet, and the percentage of characters typed. To determine when participants were looking forward versus at the texting display, head orientation data were exported in azimuth-elevation form at every frame (Metz & Krueger, 2010). A rectangle below the equator (outlined in red) was defined as the region of head orientations in the direction of the texting display. The angular size of the region (50° in azimuth by 35° in elevation) was fixed across all subjects. This region was manually assigned for each participant by identifying a cluster of head position points below eye level and independently checked by two experimenters (see Figure 4). The box location varied between participants with participant height and head movements. Using these designated regions, we classified each frame as "head oriented toward the tablet" or "head oriented away from the tablet" (see Figure 5). We used head orientation in relation to the screen as a proxy for looking toward or away from the street scene. Although eye position may differ from head position, Metz and Krueger (2010) compared head and eye movements in assessing distracted versus attentive driving and concluded that head movement could be used as a proxy for inferring eye movement or glances.

RESULTS

Crossing performance was analyzed using repeated-measures ANOVAs with distraction condition (no distraction, phone distraction, or texting distraction) as a within-subjects factor. Consistent with previous studies (e.g., Nagamatsu et al., 2011; Neider et al., 2011), we also analyzed performance differences between the two IVDs (75 m and 90 m). Although the shorter IVD resulted in lower success rates overall, we found no interactions of IVD with distraction condition; subsequently, for all of the following analyses, values were collapsed across IVD. In addition to traditional null hypothesis significance testing, we calculated Bayes factors (BF) using JASP (Love et al., 2015) to quantify the strength of the evidence for the null hypothesis (i.e., distraction conditions did not differ) compared to the alternative hypothesis (i.e., distraction conditions differed; Rouder, Morey, Speckman, & Province, 2012). A BF less than 0.33 indicates evidence for the alternative hypothesis, whereas a BF greater than 3 indicates evidence for the null (values between 0.33 and 3 suggest that the evidence in support of the null versus in support of the alternative is inconclusive; Sprenger, 2013).

Crossing measures are presented in Table 2.

Crossing Performance

Success. There was no main effect of distraction on the rate of successfully crossing the road, $F(2, 62) = 1.91$, $p = .16$, $\eta_p^2 = .06$, BF = 2.33.

Approach duration. There was a main effect of distraction on approach duration, $F(2, 62) = 35.24$, $p < .001$, $\eta_p^2 = .53$, BF < .05. Planned pairwise comparisons indicated that pedestrians approached fastest in the no-distraction condition, followed by the phone condition and the texting condition. All conditions were significantly different from each other (ps < .01).

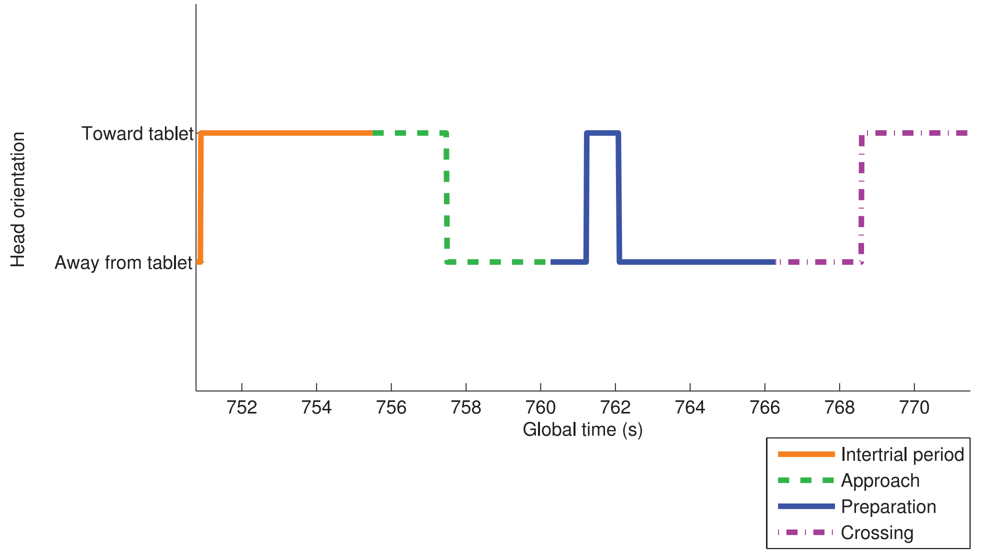

Figure 5. Sample data of head orientation from one texting trial.

TABLE 2: Crossing Performance Measures

Condition	Approach Duration (seconds)	Preparation Duration (seconds)	Crossing Duration (seconds)	Success Rate (%)	TTC Enter (seconds)	TTC Exit (seconds)
No distraction	4.63 (1.32)	6.66 (3.70)	5.12 (0.59)	82 (10)	4.16 (0.29)	1.44 (0.32)
Phone	5.30 (1.12)	9.79 (6.91)	5.25 (0.76)	78 (16)	4.15 (0.28)	1.26 (0.27)
Texting	8.97 (3.91)	13.53 (8.18)	5.27 (0.69)	78 (16)	4.11 (0.27)	1.32 (0.30)

Note. Mean values are shown with standard deviations in parentheses.

Preparation duration. There was also a main effect of distraction on preparation duration, $F(2, 62) = 19.11$, $p < .001$, $\eta_p^2 = .38$, BF < .05. Again, pairwise comparisons indicated that pedestrians spent the least amount of time at the curb in the no-distraction condition, followed by the phone condition and then by the texting condition. All conditions were significantly different from each other (*ps* < .01).

Crossing duration. There was no effect of distraction on crossing duration, $F(2, 62) = 1.72$, $p = .19$, $\eta_p^2 = .05$, BF = 2.74.

TTC. There was no main effect of distraction on TTC at enter, $F(2, 62) = .90$, $p = .41$, $\eta_p^2 = .03$, BF = 5.30; however, there was a main effect of distraction on TTC at exit, $F(2, 62) = 5.90$, $p < .05$, $\eta_p^2 = .16$, BF = .12. Pairwise comparisons indicated that TTC at exit was greater in the no-distraction condition than in the phone or texting condition (*ps* < .05); however, TTC was equivalent in both the phone and the texting conditions ($p = .27$).

Texting Behaviors

Three descriptive variables were extracted from the texting data: percentage of total trial time the head was oriented toward the tablet, number of times the head was oriented toward the tablet, and percentage of total characters typed. These variables were calculated by averaging performance in only successful crossing trials, as with previous studies, and were divided into approach, preparation, and crossing periods (see Table 3). The percentage of time the head was oriented toward the tablet was significantly different across all three distraction conditions,

TABLE 3: Texting Measures

Variable	Approach	Preparation	Crossing
Average number of head orientations to tablet	0.83 (0.51)	0.68 (0.38)	0.66 (0.41)
Percentage of total characters	31.47 (18.39)	44.13 (24.80)	5.21 (11.03)
Percentage of time the head was oriented toward tablet	37.24 (0.18)	26.96 (0.15)	17.17 (0.18)

Note. Mean values are shown with standard deviations in parentheses.

$F(2, 62) = 271.37$, $p < .0001$. There was a significantly greater percentage of time oriented toward the tablet during the texting condition compared with both the phone ($p < .0001$) and no-distraction conditions ($p < .0001$). These analyses confirm the efficacy of the texting manipulation by checking that participants were orienting their head away from the roadway in order to send and receive texts.

Relation between texting and crossing performance. To determine whether engagement in certain components of the texting task predicted crossing success rates, hierarchical linear regressions were performed with crossing success rate as the outcome variable and texting behaviors (percentage of time the head was oriented toward the tablet, number of times the head was oriented toward the tablet, and percentage of total characters typed) as predictors while controlling for baseline texting ability. Separate regressions were performed using texting behaviors from the approach, preparation, and crossing periods (see Table 4).

The preparation and crossing models reached significance in predicting crossing success. During the preparation period, percentage of total characters typed significantly contributed to the model, and the number of head orientations toward the tablet and percentage of time with head orientated toward the tablet trended toward significance in the model. No individual variables of interest included in the crossing model significantly contributed to the model.

DISCUSSION

Mobile technology provides the potential for distraction in everyday activities, like driving or crossing a busy street. The implications of distraction on pedestrian behaviors remain relatively unstudied. Several simulator studies have shown the detrimental effects of phone conversations on street-crossing performance, and one previous simulator study showed a negative effect of texting on gap acceptance decisions (Schwebel et al., 2012). The present study replicated and extended these results by examining the distraction potential of texting in a highly immersive and challenging street-crossing simulator and by comparing texting to no-distraction and phone conversation conditions.

First, we compared crossing performance under no-distraction, hands-free phone conversation, and texting conditions. Previous simulator studies have established the negative impact of phone conversations on crossing performance compared with no distraction in a number of groups, including children (Chaddock et al., 2011), young adults (Gaspar et al., 2013; Neider et al., 2010), and older adults (Nagamatsu et al., 2011; Neider et al., 2011). Despite trends in the expected direction, no significant differences were observed in success rates as a function of distraction condition. However, participants did make riskier crossing choices in both the phone conversation and texting conditions compared with no distraction. Shorter TTC upon exiting the road in the phone and texting conditions suggests impaired planning and greater risk in evaluating the second-lane traffic while distracted.

Furthermore, as expected, participants took significantly longer to initiate crossings (i.e., longer preparation durations) in the phone and texting conditions compared to the no-distraction condition. The preparation period is a critical component of the street-crossing task. Pedestrians need to assess traffic and initiate appropriate decisions about when to begin crossing. Previous research demonstrated that decision making during this preparation state was particularly sensitive to cognitive distraction from cell phones

TABLE 4: Hierarchical Linear Regression Models

	Approach				Preparation				Crossing			
	B	*SE B*	β	*p*	*B*	*SE B*	β	*p*	*B*	*SE B*	β	*p*
Step 1												
Constant	1.056 [0.567, 1.545]	.240		.000	1.056 [0.567, 1.545]	.240		.000	1.056 [0.567, 1.545]	.240		.000
Baseline typing ability	–0.009 [–0.026, 0.008]	.008	–.201	.270	–0.009 [–0.026, 0.008]	.008	–.201	.270	–0.009 [–0.026, 0.008]	.008	–.201	.270
Step 2												
Constant	1.027 [0.520, 1.535]	.247		.000	1.071 [0.593, 1.548]	.223		.000	1.092 [0.688, 1.496]	.197		.000
Baseline typing ability	–0.009 [–0.026, 0.009]	.009	–.186	.360	–0.008 [–0.024, 0.007]	.008	–.183	.281	–0.008 [–0.022, 0.005]	.007	–.177	.221
Number of head orientations to tablet	–0.036 [–0.181, 0.109]	.071	–.114	.601	–0.164 [–0.341, 0.013]	.086	–.382	.069	0.029 [–0.147, 0.205]	.086	.073	.739
% Characters	0.264 [–0.145, 0.673]	.199	.299	.203	0.539 [0.124, 0.954]	.202	.822	.013	–0.506 [–1.450, 0.330]	.434	–.370	.208
% Time head oriented to tablet	–0.117 [–0.537, 0.303]	.205	–.126	.629	–0.607 [–1.283, 0.070]	.330	–.573	.077	–0.333 [–1.004, 0.338]	.327	–.375	.317

Note. Approach phase Step 1, ΔR^2 = .040, p = .270; Step 2, ΔR^2 =.060, p = .624. Preparation phase Step 1, ΔR^2 = .040, p = .270; Step 2, ΔR^2 = .249, p = .041. Crossing phase Step 1, ΔR^2 = .040, p= .270; Step 2, ΔR^2= .463, p= .000.

(Gaspar et al., 2013; Neider et al., 2010, 2011). The present results extend these findings by showing that texting has a similarly detrimental effect on decision making prior to crossing. Importantly, TTC upon entering did not differ significantly across the conditions, suggesting that participants were not simply becoming more conservative with their crossing decisions in either the phone or texting condition. Instead, this finding suggests that the main cost associated with distraction is to decision making prior to executing a crossing. Furthermore, the lack of a dual-task cost to crossing duration in either the phone or texting condition suggests that these secondary tasks affected crossing performance primarily by impairing decision making, not necessarily by disrupting gait.

The cost to decision making and planning was significantly greater in the texting condition than in the phone condition. In addition to diverting cognitive resources similarly to a conversation, texting required participants to physically divert their gaze from the crossing scene. This is evident in the percentage of time participants oriented their head toward the tablet. More head orientations toward the tablet likely reduced situational awareness, thereby increasing decision-making difficulty. Indeed, research from the driver distraction literature suggests that texting is associated with significant eyes-off-road time, resulting in increased distraction potential relative to cell phone conversations (NHTSA, 2013).

To further explore the relationship between texting and crossing, we assessed the relationship between texting behaviors during each period of the crossing task and crossing success. Texting behavior in the preparation and crossing phases significantly predicted crossing success. During each phase of crossing, participants' behaviors were vastly varied (e.g., walking or standing still, not yet able to see traffic or looking side to side). For this reason, comparison of individual variables between phases may not be wholly indicative of behavior. Therefore, in lieu of examining each variable individually, we created overall models for each phase of crossing to facilitate some understanding of how texting distracts from pedestrian behaviors. The preparation and crossing models both significantly predicted crossing success. The results indicate that more time taken to prepare to cross the street positively predicted success.

These data have important theoretical and practical implications. From a theoretical perspective, the data suggest that, in addition to the cognitive cost associated with a conversation, diverting the participants' eyes might further reduce situation awareness and impair decision making. From a practical standpoint, these data speak to the distraction potential of texting relative to undistracted crossing as well as that of a well-studied comparison task, talking on a cell phone. Just as previous studies have demonstrated an additional cost to driving performance of conversing on a cell phone, the present results indicate that texting may produce larger dual-task costs to decision making than conversing alone. Indeed, the present study also shows that when participants were heavily engaged in the texting task (i.e., typing more characters and spending more time with their head oriented toward the tablet), they were more likely to be involved in a collision during crossing. The results suggest that, much like texting and driving, regulation of distracting behaviors might be considered in other real-world tasks.

The present study had several strengths. The fully immersive environment maximized how realistic the simulation could be without endangering participants. Additionally, the use of a manual treadmill allowed participants not only to choose the precise moment to initiate crossing but also the speed at which to cross both lanes of traffic. The main limitation of this design was in the hardware for the texting paradigm. Texts were sent and received on a mounted tablet in place of a fully handheld device. This replacement was necessary for safety while on the treadmill. Additionally, the low mounting of the tablet also forced participants' gaze further from the road, potentially limiting the use of peripheral vision to complete the crossing task. Although using a tablet does not replicate how participants would be texting in the real world, it allows for consistency between the sample and a high level of experimental control. Another limitation of the study was the highly educated student sample. Because university students were used, the present sample may not be truly representative of the average multitasking pedestrian.

However, other groups, such as older adults, may in fact be more susceptible to dual-task costs than younger adults (e.g., Neider et al., 2011). Authors of future studies should attempt to use a handheld texting device as well as a voice-activated texting condition to compare to current knowledge of texting as a distraction.

KEY POINTS

- We examined the effects of phone and texting conversations on performance in a high-fidelity street-crossing task.
- Both talking on the phone and texting impaired planning and decision making during street crossing.
- More time taken during preparation predicted greater crossing success.

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Sarah E. Banducci is a PhD student studying cognitive neuroscience in the Department of Psychology and Beckman Institute at the University of Illinois at Urbana-Champaign. She earned her MA in psychology from the University of Illinois at Urbana-Champaign in 2015.

Nathan Ward is a postdoctoral fellow at the Beckman Institute at the University of Illinois at Urbana-Champaign. He earned his PhD in psychology from the University of Utah in 2013.

John G. Gaspar is an assistant research scientist at the National Advanced Driving Simulator at the University of Iowa. He earned his PhD in psychology from the University of Illinois at Urbana-Champaign in 2014.

Kurt R. Schab is a PhD student in the Department of Electrical and Computer Engineering at the University of Illinois at Urbana-Champaign. He earned his MS in electrical engineering at the University of Illinois at Urbana-Champaign in 2013.

James A. Crowell is a visualization programmer at the Illinois Simulator Laboratory of the Beckman Institute at the University of Illinois at Urbana-Champaign. He earned his PhD in cognitive psychology from the University of California, Berkley in 1993.

Henry Kaczmarski is the director of the Illinois Simulator Laboratory of the Beckman Institute at the University of Illinois at Urbana-Champaign. He earned his BSEE in electrical engineering from the Illinois Institute of Technology in 1972.

Arthur F. Kramer is the director of the Beckman Institute and the Swanlund Endowed Chair in Neuroscience and Psychology at the University of Illinois at Urbana-Champaign. He earned his PhD in cognitive/experimental psychology from the University of Illinois at Urbana-Champaign in 1984.

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