Mobile device use while crossing the street: Utilizing the theory of planned behavior

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ABSTRACT

Every year, thousands of pedestrians are killed and tens-of-thousands are nonfatally injured as a result of traffic crashes. The year 2016 holds the record for the most pedestrians killed in one year since 1990. Mobile device use while crossing the street has been associated with unsafe crossing behaviors and gait abnormalities, potentially increasing the risk of pedestrian injury or death. Expanding upon the small body of literature, the present study utilized the theory of planned behavior to guide the development of a questionnaire used to collect data from 480 adults on predictors of intentions to use a mobile device while crossing the street. Questionnaire development involved one round of expert panel review ($N = 4$), subsequent pilot testing of a revised questionnaire, and a test-retest reliability assessment. Results demonstrate that attitude toward the behavior, subjective norm, and perceived behavioral control significantly predicted the intention to use a mobile device while crossing the street in this population. Such a questionnaire can be used in the design and evaluation of TPB-based interventions to decrease distracted mobile device use while crossing the street.

1. Introduction

Since 2009, the overall number of traffic-related pedestrian fatalities has steadily increased (National Center for Statistics and Analysis, 2018). According to the National Highway Transportation Safety Administration (NHTSA), 5987 pedestrians were killed in 2016 as a result of traffic crashes; the highest number of pedestrians killed in one year since 1990 (National Center for Statistics and Analysis, 2018). Data from 2015 estimate 70,000 pedestrians were injured in motor vehicle traffic crashes (National Center for Statistics and Analysis, 2017). The economic cost of unintentional pedestrian fatalities in 2010 is estimated to be over $4.85 billion (National Center for Injury Prevention and Control, 2014). The costs, in 2010, of nonfatal pedestrian injuries among those hospitalized and those treated and released from the emergency department are estimated at $6.75 billion and $1.06 billion, respectively (National Center for Statistics and Analysis, 2018). Additionally, a concerning trend is illustrated by the proportion of pedestrian deaths expressed as a percentage of total traffic fatalities. In 2007, pedestrian fatalities in traffic crashes ($N = 4699$) made up 11% of total ($N = 41,259$) traffic fatalities. Since 2008, the number of

pedestrian fatalities from traffic crashes has increased and, in 2016, made up 16% of total motor vehicle-related traffic fatalities (National Center for Statistics and Analysis, 2016).

Despite mixed evidence across some observational pedestrian studies, a greater proportion of studies found that with distractions, including mobile device use, there was an increase in unsafe crossing behaviors and gait abnormalities, potentially increasing the risk of pedestrian injury or death (Bungum et al., 2005; Hatfield and Murphy, 2007; Lamberg and Muratori, 2012; Lin et al., 2007; Russo et al., 2018; Schabrun et al., 2014; Thompson et al., 2013). In addition to traffic-related incidents, it is important to consider the impact of non-traffic related injuries that can occur because of distracted walking. Through analysis of U.S. emergency department data obtained from the National Electronic Injury Surveillance System (NEISS), Nasar and Troyer (2013) estimated that 1506 nonfatal injuries occurred in 2010 due to mobile phone use among pedestrians in public places; an estimate which includes traffic-related and non-traffic-related events (e.g., a distracted pedestrian collides with a tree). Nasar and Troyer (2013) found that the frequency of such injuries increased with statistical significance between 2004 and 2010. Injuries included concussions, seizures,

fractures, contusions, lacerations, dislocations, abrasions, sprains, strains, and pain in various parts of the body. Overall, more injuries related to talking than texting; with talking accounting for 69.5% of injuries and texting accounting for 9.1%. Pedestrian injuries more frequently involved people under the age of 31 (54.7%) and more men (52.9%) than women.

Concerning nonfatal, non-traffic, distraction-related incidents, Nasar and Troyer (2013) argue that such incidents are underreported for a variety of reasons including some injury victims visiting a primary care doctor or other provider, not seeking treatment, not reporting a cell phone as the cause, or dying. To illustrate the plausibility of underreporting, Nasar and Troyer (2013) contrast their 2008 estimate of 1099 nonfatal driver injuries to a NHTSA estimate of 515,000 injuries and 5870 fatalities related to some form of distraction for the same year.

While the study by Nasar and Troyer (2013) focused on injuries occurring in public spaces, a comparable study by Smith, Schreiber, Saltos, Lichenstein, and Lichenstein (2013) expanded their case selection criteria to include injuries in all settings (instead of public places only). Based on the modified criteria, an additional 280 estimated cell phone-related cases were revealed in the year 2010. For the year 2011, Smith et al. (2013) reported an increase to an estimated 2197 cases while also acknowledging a likely underreporting of cases. Like Nasar and Troyer (2013); Smith et al. (2013) report a statistically significant upward trend in estimated cases during the study period.

1.1. Study aim

The aim of this study was to examine the utility of the Theory of Planned Behavior (TPB) to predict behavioral intention to engage in the behavior of crossing the street while using a mobile device. The TPB has been useful in predicting a multitude of behaviors including condom use (Albarracin et al., 1998), healthy eating (Conner et al., 2002), clinical treatment adherence (Manning and Bettencourt, 2011), organ donation (Bresnahan et al., 2007), smoking (Gantt, 2001), and vaccinations (Askelson et al., 2010). The TPB has also been used to investigate pedestrian behaviors (Barton et al., 2016; Díaz, 2002; Evans and Norman, 1998, 2003; Holland and Hill, 2007; Lennon et al., 2017; Xu et al., 2013; Zhou and Horrey, 2010; Zhou et al., 2009). Most existing research using the TPB to explore pedestrian behavior does not focus on distraction; possibly because it predates widespread adoption of smartphones. The present study aims to add to the small number of studies detailing theory-based psychometric investigation of distracted walking (Barton et al., 2016; Lennon et al., 2017).

2. Material and methods

2.1. Theory of planned behavior

The present study utilized the theory of planned behavior (TPB) to guide the development of a questionnaire for the purpose of predicting mobile device use while crossing the street. Appropriately applied health behavior theory provides a framework by which practitioners can articulate assumptions and hypotheses about a strategy or target of intervention (National Cancer Institute, 2005). The TPB considers a person's intention to perform a behavior to be the immediate antecedent to performance (Ajzen, 2018). Thus, the ability to predict behavioral intention is useful in determining whether one will engage in the behavior. According to TPB, behavioral intention is determined by attitude toward the behavior, subjective norm, and perceived behavioral control. Attitude toward the behavior is the degree to which performance of the behavior is positively or negatively valued. Subjective norm is an individual's perceived social pressure to engage or not to engage in a behavior. Perceived behavioral control involves a person's perception of their ability to perform a given behavior (Ajzen, 2018). Therefore, the TPB as employed in the present study posits that a

person's attitude toward the behavior, subjective norm, and perceived behavioral control will determine behavioral intention, which ultimately predicts behavior.

Early studies employing the TPB to investigate pedestrian behavior took place in a variety of locations outside of the U.S. such as Chile (Díaz, 2002), China (Xu et al., 2013; Zhou and Horrey, 2010; Zhou et al., 2009), and the United Kingdom (Evans and Norman, 1998, 2003; Holland and Hill, 2007). Perhaps because many of these studies were conducted before the steady and substantial increase in mobile device voice, message, and data traffic (CTIA-The Wireless Association, 2018), early studies focused on street-crossing violations or group conformity and did not focus on distraction. Only recently has investigation begun using the TPB in relation to distracted walking within the U.S. (Barton et al., 2016). In a sample of 80 undergraduate college students, Barton et al. (2016) found that TPB constructs explained 61% of the variance in behavioral intention. Further, attitude toward the behavior and perceived behavioral control significantly predicted behavioral intention to cross the street while distracted with perceived behavioral control emerging as the strongest predictor of behavioral intention. A study of 362 adults conducted in Australia by Lennon et al. (2017) found that TPB constructs explained 55% of the variance in behavioral intention to engage in distracted street-crossing among participants aged 18–30 years. Attitude toward the behavior and subjective norm emerged as significant predictors with attitude toward the behavior being the strongest predictor.

In the earliest study known to use the TPB to examine pedestrian behavior (Evans and Norman, 1998), 210 adult participants completed a questionnaire about hazardous street-crossing scenarios. Perceived behavioral control was found to be the strongest predictor of behavioral intention, explaining 37%–49% of the variance (across three scenarios) in behavioral intention to cross the street in a hazardous manner. Another study of 1833 schoolchildren by Evans and Norman (2003) used a similar hazardous crossing scenario but focused on adolescents' intentions and found similarly high variance explained.

A study by Díaz (2002) surveyed 146 city residents about intention to engage in hazardous crossing behavior. Analyses revealed that all TPB constructs were significantly correlated with behavioral intention and behavioral intention significantly correlated with "behavior" as measured by another questionnaire administered during the study.

In another study designed to measure behavioral intention as it pertains to crossing in a hazardous manner, Holland and Hill (2007) measured the TPB constructs in 293 participants within the context of three scenarios pertaining to hazardous street-crossing. Across the scenarios, a statistical model of TPB constructs accounted for 46%–51% of the variance. The TPB construct of attitude toward the behavior emerged as the strongest predictor of behavioral intent.

Past studies have also used the TPB to investigate pedestrians' intentions to conform to the behaviors of other pedestrians in given street-crossing scenarios (Zhou and Horrey, 2010; Zhou et al., 2009). Zhou et al. (2009) recruited 426 adults to complete a questionnaire that aimed to measure behavioral intention across two different scenarios pertaining to conformity. The TPB was useful in predicting behavioral intention across the scenarios. Further, it was found that attitude toward the behavior was the strongest predictor in the non-conformity group and perceived behavioral control was the strongest predictor in the conformity group. A subsequent study by Zhou and Horrey (2010) aimed to perform a similar investigation using the TPB to predict intention related to conformity in a sample of 510 adolescents across two conformity scenarios. In the resulting statistical model, TPB variables helped explain from 30% to 40% of the variance in conformity intention.

Another study by Xu et al. (2013) examined pedestrian's intentions to illegally cross the street. A questionnaire administered to a sample of 323 adult participants revealed that the TPB constructs led to the explanation of 43% of the variance in behavioral intention to cross the street illegally.

2.2. Sample

Prior to performing the procedures described herein, Institutional Review Board (IRB) approval was obtained. Study data were collected from a sample of undergraduate students between the ages of 18 and 24 years enrolled at a large Southeastern university. This population may be at risk of distracted walking injury due to regular street-crossing on campus (Pucher et al., 2011), high regard for text-based messaging (texting) as a socially acceptable means of communication (Rainie and Zickuhr, 2015), and the frequent use of mobile communication technology among this age group (Lenhart, 2010; Pettijohn et al., 2015). Recruitment yielded an initial sample of 515 participants. Of those participants, 35 did not meet eligibility criteria because they were under 18 years of age (0.2%; $n = 1$), over 24 years of age (3.3%; $n = 17$), or did not report age (0.3%; $n = 2$). An additional 20 (3.9%) participants were missing data for one or more of the TPB constructs and were excluded from analyses. The final sample size was 480 participants who were majority non-Hispanic (96.3%; $n = 462$), White (76.0%; $n = 365$), and female (68.5%; $n = 329$). Overall previous injury exposure (the definition of which contained a range of exposure scenarios including ever being hit as a pedestrian to knowing a pedestrian who ever had a close call) was 77.3%. Mean age was 20.18 ($SD = 1.50$). Demographic characteristics of the sample are displayed in Table A.1.

2.3. Theory of planned behavior questionnaire

A paper-based TPB questionnaire was created to measure behavioral intention to engage in the behavior of crossing the street on campus while using a mobile device in the next week, followed by one round of expert panel review ($N = 4$), and subsequent pilot testing of a revised TPB questionnaire. Administration of the final TPB questionnaire followed and a test-retest procedure assessed stability reliability of the questionnaire. See Supplementary file for a copy of the questionnaire.

When performing research utilizing the TPB, Fishbein and Ajzen (2010) emphasize the importance of carefully defining the behavior of interest in terms of Target, Action, Context, and Time (TACT). For the purpose of this study, the target was defined as college students between 18 and 24 years of age. The action was defined as crossing the street while using a mobile device. Use of a mobile device was defined as using a mobile device to: (1) send or view text messages or email messages, (2) view content from the internet (such as a web page or email attachment), (3) view content using mobile apps including but not limited to Blackboard, Snapchat, Facebook, Instagram, Twitter, or Yik Yak, or (4) engage in a phone or video call (whether to the ear or through headphones/Bluetooth/speakerphone). Context was defined as while on campus. Time was defined as in the next week. A screening form was used to ensure that participants met the demographic requirements of the target, had the opportunity to engage in the action (i.e, own a mobile device and cross the street on foot), and were situated within the context (i.e., visit campus) during the specified time (i.e., at least once per week). After screening, eligible participants were instructed to complete the remainder of the questionnaire which contained items to measure the TPB constructs of attitude toward the behavior, subjective norm, perceived behavioral control, and behavioral intention. Demographic and descriptive information was also collected.

The TPB questionnaire was created consistent with previous work (Barton et al., 2016; Fishbein and Ajzen, 2010; Lennon et al., 2017). Items measuring TPB constructs were presented using 7-point semantic differential scales. For the seven items measuring attitude toward the behavior, one stem statement preceded all items that made up this subscale and read as follows, "For me to use a mobile device on campus while crossing the street in the next week would be." Bipolar adjectives were used at the ends of each 7-point semantic differential scale item. Fishbein and Ajzen (2010) posit that attitude toward the behavior can be placed into one of two categories termed "instrumental" and

"experiential." In the present questionnaire, four items measuring instrumental aspects of attitude toward the behavior, or aspects that relate to functionality of the behavior, contained the following adjective pairs: "extremely useless-extremely useful," "extremely unnecessary-extremely necessary," "extremely impractical-extremely practical," and "extremely unsafe-extremely safe." The remaining three attitude toward the behavior items measured experiential aspects of attitude toward the behavior, or aspects that tend to be emotional in nature, and contained the following adjective pairs: "extremely unsatisfying-extremely satisfying," "extremely boring-extremely fun," and "extremely bad-extremely good." The overall construct score was determined by calculating the mean of the item scores. Higher scores indicated a more favorable attitude toward the behavior.

Seven items measured the TPB construct of subjective norm. Consistent with two types of norms ("injunctive" and "descriptive") described by Fishbein and Ajzen (2010) five of the seven items addressed injunctive norms which relate to what a person ought not or ought to do. Two of the seven items addressed descriptive norms which relate to perceptions of whether others perform or do not perform the behavior. The overall construct score was determined by calculating the mean of the item scores. Higher scores indicated more social pressure to engage in the behavior.

Four items measured the TPB construct of perceived behavioral control. Given the current incentive structure of the mobile technology market, technology companies have been implicated in the use of strategies to maximize the time users spend engaging with their respective platforms (Bosker, 2016; Center for Humane Technology, 2018). Given the presence of these strategies, it was decided to frame the measurement of perceived behavioral control in the context of abstaining from the behavior. Fishbein and Ajzen (2010) describe two types of perceived behavioral control ("capacity" and "autonomy"). Two of the four items addressed capacity, or the perceived ability to abstain from the behavior. The other two items addressed autonomy, or the perception of the degree of control over abstaining from the behavior. Since perceived behavioral control was measured in the context of abstaining from the behavior, reverse-coding was employed before scoring these items. The overall construct score was determined by calculating the mean of the item scores after reverse coding. Lower scores after reverse-coding indicated greater perceived control over abstaining from the behavior.

Three items measured the TPB construct of behavioral intention. For each item, one of the three phrases, "I intend," "I plan," and "I expect" preceded a statement of the behavior of crossing the street on campus while using a mobile device in the next week. The overall construct score was determined by calculating the mean of the item scores. Higher scores indicated greater intent to cross the street on campus while using a mobile device in the next week.

Two demographic items placed at the beginning of the survey measured past behaviors related to mobile device use on a typical day and mobile device use while crossing the street in the last week. The remaining demographic items were placed at the end of the questionnaire and pertained to previous exposure to pedestrian injury, age in years, current year in school, race, and gender. For the item measuring previous exposure to pedestrian injury, respondents were instructed to select any of the following statements that applied to them: (1) "As a *pedestrian*, I have had a close call with a vehicle where I was almost hit," (2) "As a *pedestrian*, I have been hit by a vehicle," (3) "I know a pedestrian who has been hit by a vehicle," (4) "As a *driver*, I have had a close call where I almost hit a pedestrian," (5) "As a *driver*, I have hit a pedestrian," (6) "I know a driver who has hit a pedestrian," and (7) "none of the above statements fit me."

2.4. Procedure

Participants were recruited during a spring semester from a selection of undergraduate classes at a large university in the Southeastern

United States. Potential participants were read a recruitment script providing details of the study before being presented with an informed consent document and a copy of the TPB questionnaire. Participants were asked to keep the consent document for their records. TPB questionnaire completion time was 10–15 minutes. Before full administration of the questionnaire, stability of the questionnaire was assessed by performing a test-retest reliability analysis on the subscales of attitude toward the behavior (r (34) = 0.798, $p <$ .001), subjective norm (r (34) = 0.852, $p <$ .001), perceived behavioral control (R_s (34) = 0.566 $p <$ .001) and behavioral intention (r (34) = 0.686 $p <$ .001). The time from initial questionnaire administration to the follow-up administration was two weeks and a total of 34 participants completed the test-retest process. Although perceived behavioral control and behavioral intention returned lower correlation coefficients, stability was deemed adequate based on the novelty of the subscales and assertions that coefficients greater than .50 are indicative of acceptable reliability (Bowling, 2005; Cronbach, 1951; Helmstadter, 1964).

2.5. Analyses

Multiple regression analyses were used to determine the utility of the TPB constructs for predicting behavioral intention. A series of one-way Analyses of Variance (ANOVA) were conducted to test for differences in behavioral intention between participants grouped by mobile device use on a typical day, mobile device use while crossing the street in the last week, previous exposure to pedestrian injury, and gender.

3. Results

Table A.2 provides a summary of the raw score mean, standard deviation, possible range, observed range, and reliability statistics for the TPB constructs. A proportion of participants (6.3%; $n = 30$) attained the minimum possible score on the construct of attitude toward the behavior; indicating the most unfavorable representation of attitude toward crossing the street on campus while using a mobile device in the next week. Only a small number of participants (0.625%; $n = 3$) attained the minimum possible score on the construct of subjective norm (a lower score indicates lower perceptions of social pressure to engage in the behavior of crossing the street on campus while using a mobile device in the next week). A considerable proportion of participants (40.6%; $n = 195$) attained the minimum possible score on the construct of perceived behavioral control; indicating the greatest possible representation of perceived behavioral control over refraining from crossing the street on campus while using a mobile device in the next week.

Table A.3 summarizes mean TPB construct scores for males and females. None of the mean differences between males and females were statistically significant at the $p <$ .05 level.

3.1. Predictive utility of theory of planned behavior constructs

Results of multiple regression analyses indicated that all three TPB constructs significantly predicted behavioral intention, $F(3, 476) = 148.96$, $p <$ .001. These results are summarized in Table A.4. The three independent TPB constructs combined resulted in a Pearson correlation of .696 and the model explained 48.4% of the variance in behavioral intention, $p <$ .001. In the present study, attitude toward the behavior emerged as the strongest predictor of behavioral intention while perceived behavioral control was the weakest predictor.

3.2. Differences in behavioral intention among descriptive variables

For the variable of mobile device use on a typical day, questionnaire participants had the opportunity to select from one of eleven categories ranging from one minute of use to eight hours or more of use. Before

testing for differences in behavioral intention across this variable, k-means clustering analyses were used to reduce the variable to three groups. The resultant groups and associated descriptive statistics are contained in Table A.5. One-way ANOVA analysis revealed no significant difference between the means among participants grouped by typical daily device use, $F(2, 477) = 1.68$, $p =$ .187.

For the variable of past mobile device use while crossing the street in the last week, questionnaire participants had the opportunity to select from one of six categories ranging from never to nearly every time. Before performing inferential analyses on this variable, k-means clustering analyses were used to reduce the variable to three groups. The resultant groups and associated descriptive statistics are contained in Table A.5. Due to violations of normality and homogeneity of variance of the data, Kruskal-Wallis nonparametric analyses were performed to test for differences between the group medians. Results indicated a statistically significant difference between groups, $H(2) = 142.909$, $p = < .001$. The proportion of variability in the ranked dependent variable of behavioral intention that was explained by past device use while crossing was 29.8% ($\eta^2 = .298$). Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction. Statistical significance of post-hoc tests was determined using an adjusted p-value based on the number of comparisons and adjusted p-values are reported herein. Post-hoc analyses revealed significant differences in median behavioral intention scores between all group comparisons ($p <$ .001). Median scores and mean ranks are as follows: never or almost never ($Mdn = 1.67$, $Mrank = 129.16$); less than half or about half ($Mdn = 3.00$, $Mrank = 245.06$); and more than half but not all or nearly every time ($Mdn = 4.33$, $Mrank = 333.35$).

For the previous exposure to pedestrian injury variable, the groups and associated descriptive statistics are contained in Table A.5. One-way ANOVA analyses revealed no significant difference among the means, $F(1, 478) = 3.37$, $p =$ .067.

For the gender variable, the groups and associated descriptive statistics are contained in Table A.5. One-way ANOVA analyses revealed no significant difference among the means, $F(1, 476) = 0.71$, $p =$ .399.

4. Discussion

The purpose of this study was to utilize the TPB to examine behavioral intention to engage in the behavior of crossing the street while using a mobile device. The questionnaire development process produced a theory-based tool that was able to predict behavioral intention.

In the present study, attitude toward the behavior emerged as the strongest predictor of behavioral intention while perceived behavioral control was the weakest. This is in contrast to results of one recent investigation where perceived behavioral control was the strongest predictor (Barton et al., 2016), yet similar to another where perceived behavioral control was the weakest predictor (Lennon et al., 2017); results from both studies were derived from populations between 18 and 30 years of age. In the aforementioned studies, perceived behavioral control was explored in terms of engaging in the behavior of interest while the present study explored the construct in terms of refraining from the behavior. As indicated previously, the idea to frame these items in the context of refraining from the behavior was informed by strategies technology companies use to persuade users to engage with their respective platforms (Bosker, 2016; Center for Humane Technology, 2018). One study examining risky pedestrian behavior by Holland and Hill (2007) that measured perceived behavioral control in terms of refraining from the behavior also found perceived behavioral control to be the weakest predictor of behavioral intention. As a possible explanation of this finding related to the particular behavior of distracted street-crossing, Lennon et al. (2017) suggest that persons who are heavy users of smart phones may feel so strongly in control of when and how they use their phones that it exerts little influence on their intention to use the phone while crossing the street.

In the few studies focusing solely on the pedestrian behavior of

distracted mobile device use, the predictive ability of the other TPB constructs of attitude toward the behavior and subjective norm were inconsistent. Barton et al. (2016) found attitude toward the behavior to be the second-strongest predictor of behavioral intention while subjective norm was not a significant predictor. Similar to the present investigation, Lennon et al. (2017) found attitude toward the behavior to be the strongest predictor of behavioral intention and subjective norm to be the second-strongest predictor. It should be noted that the studies exploring distracted pedestrian behavior were conducted in different locales and involved populations with different characteristics. Like the present study, Barton et al. (2016) investigated college students. While a proportion of the sample studied by Lennon et al. (2017) was recruited from a college campus, a larger proportion of participants was recruited from a non-college-student population. Fishbein and Ajzen (2010) state that differences in the relative contributions of the TPB constructs to the prediction of intention are expected across populations.

Regarding differences in behavioral intention among participants grouped by demographic characteristics, greater frequency of past distracted crossing behavior over the past week was positively and significantly associated with greater intention to perform the same behavior in the future. This relationship is common among TPB studies that assess previous behavior and intention (Fishbein and Ajzen, 2010).

Though no significant difference was found between participants reporting any previous injury exposure and those not reporting previous injury exposure, related analyses in the present study were very close to statistical significance at the $p < .05$ level. Despite the lack of significance, the inverse relationship between previous injury exposure and behavioral intention is worth noting given findings by Barton et al. (2016) who also reported a measure of previous injury exposure. In their study, Barton et al. (2016) found significant differences such that participants who had both experienced a close call and knew someone who had been struck by a vehicle had significantly higher scores on the TPB constructs of subjective norm and perceived behavioral control than participants at lower levels of previous injury exposure. Though they concede that the limited body of research in this area makes causal inferences impossible, Barton et al. (2016) suggest that those with previous injury exposure might also hold the belief that they maintain adequate control over the behavior of distracted street-crossing despite the occasional injury. Thus, more research is needed to investigate the relationship between previous injury exposure and the behavior of distracted street-crossing (Barton et al., 2016).

4.1. Implications for practice

Results from this study indicate that there is utility in using the TPB to predict behavioral intention to cross the street on campus while using a mobile device in the next week. Fishbein and Ajzen (2010) state, "… we believe that if we can bring about change in one or more of the theory's three major components [attitude toward the behavior, perceived social norm, and perceived behavioral control], we should observe changes in intentions and, in the presence of adequate volitional control, changes in behavior as well" (p. 322). Because of the relationship between TPB constructs and behavioral intention, the questionnaire resulting from the present study can be used to estimate the relative importance of each TPB construct being considered as targets of an intervention (Fishbein and Ajzen, 2010; Holland and Hill, 2007; Stead et al., 2005). Fishbein and Ajzen (2010) recommend the use of TPB construct means, standard deviations, regression weights, and correlation with behavioral intention to identify constructs as good candidates for change. Following the recommendation of Fishbein and Ajzen (2010), an overall assessment of the values for each construct highlight attitude toward the behavior and subjective norm as good candidates for change in the present sample.

The aforementioned characteristics of a TPB-based questionnaire also lend themselves to the utility of the questionnaire to serve as a

measure of intervention effectiveness (Fishbein and Ajzen, 2010; Holland and Hill, 2007; Stead et al., 2005). Initial administration of the questionnaire at baseline can be followed-up with subsequent administrations in order to look for meaningful change in the TPB constructs over the course of an intervention.

Attitude toward the behavior was the strongest predictor of behavioral intention in this study. In an effort to reduce behavioral intention, interventions in the population from which the sample was obtained could utilize strategies to increase negative attitudes toward using a mobile device while crossing the street on campus. Challenging existing behavioral beliefs that crossing in such a manner is fun, useful, or offers practical advantages is one way to influence behavioral beliefs. Emphasizing disadvantages of using a device while crossing is another way to influence behavioral beliefs. Appropriate messages that highlight the safety risk of device use while crossing could be used.

Many existing interventions with the goal of improving pedestrian safety focus largely on the driver's role in protecting pedestrian safety, engineering improvements to the built environment, or safety education aimed at young children (Brookshire et al., 2016; Candappa et al., 2014; Richard et al., 2018). While the most recent edition of the NHTSA's *Countermeasures That Work* publication calls for a reduction in "distracted walking or driving behaviors" (Richard et al., 2018, pp. 8-8), readers are referred to the chapter on distracted and drowsy driving for countermeasures aimed at drivers. Evaluated interventions that focus on distracting pedestrian behaviors were not identified.

Despite a lack of evaluated interventions, efforts that might have an influence on attitude toward the behavior exist. Reports of municipalities conducting awareness campaigns have surfaced in recent years (Cortez, 2012). In Delaware, safety officials have used sidewalk decals at busy intersections in an attempt to get the attention of pedestrians who may be looking down at their mobile devices. Such decals read, "Look up. Drivers aren't always looking out for you." In Philadelphia, as part of a safety campaign disguised as an April Fool's Day joke, an "e-lane" was created for the exclusive use of distracted pedestrians on a sidewalk. Experiments with in-ground pedestrian signals have even been reported (Noack, 2016). A campaign in San Francisco was launched in response to a series of adverse events related to distracted walking. The campaign included outdoor, radio, and television ads that aimed to raise awareness of the dangers of using a mobile device while walking. Safety advice to the public also appears in the San Francisco Municipal Railway Rider's Guide and reads, "Avoid using your cell phone, texting or other multitasking while walking" (San Francisco Municipal Transportation Agency, 2016). Further, an awareness-raising prank in New Yok City involved the use of people wearing orange safety vests with the words "Seeing Eye Person" written on them. The idea behind the prank was to make it appear as if a service existed that allowed distracted pedestrians to be guided by a human in order to safely text and walk (Improv Everywhere, 2013).

A number of social media awareness campaigns relating to distracted walking have been launched in the recent past. Examples of social media awareness campaigns include #devicedown and #walksafely (Safe Kids Worldwide, 2013), #eyesup (Interbrand North America, 2015), and #digitaldeadwalker (American Academy of Orthopaedic Surgeons, 2015).

Subjective norm was also a strong predictor of behavioral intention in the present study. Intervention strategies aimed at changing subjective norms can focus on either injunctive norms (what others expect a person to do) or descriptive norms (what others are doing) (Fishbein and Ajzen, 2010). Social marketing campaigns that aim to change subjective norms have shown promise when applied to college students and alcohol use (Glassman et al., 2010). Further, prioritizing focus on injunctive norms in college student populations might be more efficacious due to participants' desire for social approval (Glassman et al., 2010). It is also posited that when descriptive norms pertaining to a negative behavior are the focus of an intervention, a reverse effect can take place where the negative behavior is normalized (Cialdini, 2003;

Lawrence, 2015; Schultz et al., 2007). One intervention study focusing on injunctive norms associated with the behavior of texting and driving used the placement of signs as an attempt to change injunctive norms (Lawrence, 2015). Signs that simply communicated "do not text and drive" were found to be ineffective while signs with a stronger focus on injunctive norms, such as, "97% of Dukes [Dukes refers to faculty, staff, and students that make up the university community] disapprove when you text and drive" were found to create a short-term effect of reducing observed distracted driving behavior (Lawrence, 2015). Given similarities between distracted driving and distracted walking, similar messaging strategies targeting distracted pedestrians could positively influence injunctive norms. As part of a larger pedestrian safety campaign conducted at a large university, messaging in the form of signs affixed to various sidewalks around campus was used (Neff-Henderson, 2016). Though the campaign's slogan of "heads up Hokies" weakly addressed injunctive norms as described by Lawrence (2015), such programs should be evaluated to gauge their effectiveness. Messages used in such campaigns should have a strong focus on injunctive norms.

The present study identified perceived behavioral control as the weakest predictor of behavioral intention. Overall, the mean score for this construct score was low, indicating strong perceived behavioral control over refraining from the behavior. Further, a large percentage (40.6%) of participants attained the lowest possible score on the perceived behavioral control scale; indicating the greatest possible representation of perceived behavioral control over refraining from crossing the street on campus while using a mobile device in the next week. While participants' perception that they can refrain from the behavior of using a mobile device while crossing the street can be advantageous, it's value can be diminished by favorable attitude and subjective norm toward performing the negative behavior. Additionally, Fishbein and Ajzen (2010) differentiate between perceived behavioral control and actual behavioral control. Actual behavioral control reflects the idea that when an individual's perception of factors affecting performance of the behavior is inaccurate, actual factors dictate the influence that behavioral control has over performance of the behavior (Fishbein and Ajzen, 2010). Given the suggestion that technology companies are incentivized to covertly steer users toward maximizing time engaging with their platform (Bosker, 2016; Center for Humane Technology, 2018), intervention strategies to increase public awareness of these practices should be explored as a means to influence perceived behavioral control.

In populations where perceived behavioral control is identified as a strong predictor of behavioral intention, interventions could focus on raising awareness of how the human brain handles "multitasking" situations. For example, multitasking is often defined as a frequent switching between multiple tasks rather than a process where multiple tasks are completed in a truly simultaneous fashion (Salvucci et al., 2009). Thus, it is posited that those who perceive themselves to be skilled at multitasking are only good at placing multiple activities on a temporary hold until they return to them. The term "task switching" has been used as an appropriate alternative to the word "multitasking" because of its emphasis on the brain's frequent switching between tasks when it is responsible for processing multiple streams of information at the same time (Avcı, 2015; Salvucci et al., 2009). One skill found to be important for efficient task switching is a good "working memory." A well-functioning working memory allows an individual to minimize the time it takes to reorient with various tasks as they switch back to them (König et al., 2005). While an efficient working memory might be advantageous when switching back and forth between a text message and a task in an office setting, working memory is, arguably, of little use in such a dynamic environment as a pedestrian crosswalk. The term "inattentional blindness" has been used by some pedestrian distraction researchers (Hyman et al., 2010) to describe the loss of situational awareness that happens when pedestrians are distracted in dynamic environments. Thus, education aimed at reframing the utility of multitasking among the target population might decrease levels of perceived behavioral control over performing the behavior.

Policy combined with highly visible enforcement has been has been successful at reducing many high-risk driving behaviors (Richard et al., 2018). Creating similar barriers to distracting pedestrian behaviors may be effective in decreasing perceived behavioral control over using a mobile device while crossing the street. Though there exist many cities and states with laws banning types of distracted driving, there is a paucity of legislation aimed at pedestrian behaviors such as mobile device use while walking. Lack of evaluation (Richard et al., 2018) makes it difficult to gauge the effectiveness of such policies aimed at pedestrians.

4.2. Future research

As mentioned previously, published empirical evaluation of countermeasures to curb distracted street-crossing is not known to exist and the use of behavioral theory as an intervention framework is not common. Well-crafted TPB questionnaires have utility in both the development and evaluation phases of behavioral intervention (Fishbein and Ajzen, 2010) and should be utilized in future intervention research.

Although behavioral intention is a necessary precursor to behavior, it is not a direct measure of actual behavior. Since the ultimate goal of a behavior change intervention is to influence actual behavior, exploring methods to measure behavior is an important area of future research. In early 2015, the maker of the popular iPhone smartphone, Apple, Inc. announced a project called ResearchKit. ResearchKit gives researchers the ability to collect data from iPhone users through the installation of a research application on the device (Apple Incorporated, 2015). Once the application is installed, consenting participants can be notified to complete follow-up questionnaires at regular intervals. Such measurement of self-reported behavior could take place daily for the duration of a study to limit participant recall issues. Such smartphone-based data collection has the potential to alleviate issues with attrition as well. A similar data collection framework, called ResearchStack exists with the also popular Android mobile operating system common on many non-Apple smartphones (Haddad, 2016). For participants with incompatible devices or for those not consenting to complete study procedures on their device, an option to collect data through an online survey or in paper format should be available.

In the present study, measures of mobile device use were obtained using self-report methods. Since the implementation of this study, Apple, Inc. has released a new feature for its mobile devices called *Screen Time* (Apple Incorporated, 2018). *Screen Time* is a native feature of the device's operating system that, if activated by the user, generates reports of the amount of time the screen is on. Future research exploring the utility of using *Screen Time* data to estimate objective use of a device could be explored. We are not aware of an equivalent feature of the Android mobile operating system.

Given the limited understanding of the motives behind distracted walking behaviors, future research should continue to work toward a comprehensive understanding of the behavior. Qualitative or mixed-method studies may be appropriate to explore how other variables (such as previous behavior, previous injury exposure, or environmental factors) might influence the behavior.

Direct observation is another avenue for future research. In a recent study, Russo et al. (2018) used observation to explore a broad range of pedestrian behaviors, including distraction. Feasibility of pedestrian observation for the purpose of intervention evaluation should also be explored.

4.3. Limitations

Several limitations are important to consider when interpreting results of the present study. Data related to the TPB were collected in the context of a very specific behavior and population (college students between 18 and 24 years of age, crossing the street on campus while

using a mobile device in the next week). It is possible that responses to TPB constructs would be different with inquiry in the context of off-campus crossing locations, with inquiry that involves participants of a different age group, or with inquiry that utilizes a broader operationalization of the behavior of mobile device use (activities that constitute mobile device use likely extend beyond the criteria set by the current questionnaire). Though the specific operationalization of the behavior limits generalizability to broader populations, Fishbein and Ajzen (2010) argue that the influence of each TPB construct on behavioral intention is likely to differ among populations and that specific operationalization increases the TPB's predictive utility. Fishbein and Ajzen (2010) make no argument that the TPB should be used to generalize to a broadly-defined population.

As a result of convenience sampling, some participants were recruited from health-related courses. Though courses such as "Personal Health" are requirements of several majors outside of the health field, many courses from which participants were recruited were majority health science majors at varying stages of their degree program. It is possible that the results of the present study were influenced by participants who were more cognizant of risk associated with various behaviors due to their academic background in health science. To limit the influence of coursework delivered during the semester in which the main TPB questionnaire was administered, all data collection was completed within four weeks of the semester start date. Courses outside of health sciences were also included in recruitment.

Though several documented pedestrian incidents take place outside of crosswalks, this investigation did not explore those crossing the street outside of crosswalks. While a number of victims of documented fatal and nonfatal pedestrian injuries are under the influence of alcohol at the time of injury, questionnaire items did not ask about situations where respondents were under the influence of alcohol.

Questionnaire responses involved self-reporting of information while participants were near each other and the researcher. Thus, it was possible that some participants felt inclined to respond in a way that was perceived to be socially acceptable instead of providing authentic information. To reduce the potential for social desirability bias, participants were asked to not write their name on the questionnaire and to not share their answers. The researcher also assured participants that their responses would be kept confidential. Another limitation is borne

out of the cross-sectional design of the present study. Since such a design is limited to conclusions based on data collected from a single point in time, it was impossible to infer causation between variables.

Though the perceived behavioral control subscale returned the lowest value for Cronbach's alpha and test-retest reliability, this value was deemed acceptable based on arguments that Cronbach's alpha values higher than 0.50 are indicative of acceptable reliability (Bowling, 2005; Cronbach, 1951; Helmstadter, 1964). Regardless, future research should explore ways to improve these measures. Though regression analyses have been used in similar studies examining relationships between TPB constructs (Glanz et al., 2008), regression analyses used in the present study cannot address measurement error. Structural equation modeling can be utilized in future studies to address this limitation.

5. Conclusions

The present study contributed to the literature by further exploring the ability of the TPB to predict behavioral intention to use a mobile device while crossing the street; an important risk factor for pedestrian injury. The results of this study bolster the need for further exploration in this emerging area of research. In the present sample of undergraduate college students, all three TPB constructs were significant predictors of behavioral intention to cross the street on campus while using a mobile device in the next week. Attitude toward the behavior and subjective norm were the strongest predictors and should be prioritized in behavioral interventions aimed at this population. According to the TPB, all constructs are modifiable and the TPB questionnaire is useful not only in the design of interventions but can be used as a component of evaluation.

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Declarations of interest

None.

Appendix A

Table A.1
Participant demographic characteristics (N = 480).

Variable	Frequency	% of total ($N = 480$)
Age (years)		
18	71	14.8
19	103	21.5
20	104	21.7
21	114	23.8
22	58	12.1
23	17	3.5
24	13	2.7
Year in school		
First year	121	25.2
Second year	93	19.4
Third year	135	28.1
Fourth year	119	24.8
Other	12	2.5
Gender		
Male	149	31.0
Female	329	68.5
Transgender	0	0.0
Prefer not to answer	2	0.4

(continued on next page)

Table A.1 (*continued*)

Variable	Frequency	% of total (N = 480)
Ethnicity		
Hispanic or Latino	13	2.7
No response	5	1.0
Race		
White	365	76.0
Black	79	16.5
American Indian or Alaska Native	2	0.4
Asian	11	2.3
Variable		
Native Hawaiian or other Pacific Islander	1	0.2
Other/multiple races	16	3.3
Prefer not to answer	3	0.6
No response	3	0.6
Daily mobile device use [hours:minutes]		
0:01–0:29	1	0.2
0:30–0:59	11	2.3
1:00–1:59	39	8.1
2:00–2:59	80	16.7
3:00–3:59	76	15.8
4:00–4:59	83	17.3
5:00–5:59	68	14.2
6:00–6:59	38	7.9
7:00–7:59	16	3.3
8:00 or more	68	14.2
Device use while crossing in the last week		
Never	23	4.8
Almost never	101	21.0
Less than half of the time	113	23.5
About half of the time	105	21.9
More than half but not all times	83	17.3
Nearly every time	55	11.5
Overall previous injury exposure		
Yes	371	77.3
No	109	22.7
Previous injury exposure by type[*]		
Close call as a pedestrian	205	42.7
Hit as a pedestrian	10	2.1
Know a pedestrian with previous close call	175	36.5
Close call with pedestrian as a driver	216	45.0
Hit a pedestrian as a driver	4	0.8
Know a driver who has hit a pedestrian	80	16.7
Behavioral intention category[**]		
High	75	15.6
Low	405	84.4

Note.

  * Total exceeds sample size due to possibility of multiple previous injury exposures.

  ** Participants with mean intention scores > 5.00 = high behavioral intention and participants with mean intention scores ≥ 5.00 = low behavioral intention.

Table A.2

Raw score ranges, means, standard Deviations, Cronbach's Alpha Coefficients, and Test-Retest Correlation Coefficients for the Theory of Planned Behavior Constructs (N = 480).

Construct	Descriptive statistics				Reliability statistics	
	Possible range	Observed range	M	SD	Cronbach's α	Pearson's r[*]
Behavioral intention	3–21	3–21	9.42	4.99	0.88	.686[**]
Attitude toward the behavior	7–49	7–45	21.37	7.61	0.87	.798[**]
Subjective norm	7–49	7–49	25.55	7.43	0.82	.852[**]
Perceived behavioral control	4–28	4–20	7.00	3.85	0.64	.566†[**]

Note.

  * Correlation coefficients were calculated to assess test-retest reliability using a sample of 34 undergraduate students.

  ** Correlation coefficient is significant at the p < .01 level. †Spearman rank correlation (R_s) reported due to nonparametric data for the perceived behavioral control construct.

Table A.3

Theory of Planned Behavior Construct Means and Standard Deviations of Males (n = 149), Females (n = 329), and the Total Sample (N = 480).

Variable	M			SD		
	Male	Female	Total	Male	Female	Total
Behavioral intention	3.24	3.11	3.14	1.78	1.60	1.66
Attitude toward the behavior	3.15	3.02	3.05	1.12	1.07	1.09
Subjective norm	3.60	3.69	3.65	1.14	1.01	1.06
Perceived behavioral control*	1.82	1.72	1.75	0.99	0.95	0.96

Note. None of the mean differences between males and females were statistically significant at the $p < .05$ level.

 * Lower mean values for perceived behavioral control indicate increased control over abstaining from the behavior.

Table A.4

Coefficients of Multiple Regression Model for Behavioral Intention and Theory of Planned Behavior Construct Variables (N = 480).

Model	Unstandardized coefficients		Standardized coefficients		
	B	Std. Error	Beta	t	p
(Constant)	− 1.058	.215	–	− 4.923	< .001
Attitude toward the behavior	.604	.065	.395	9.228	< .001
Subjective norm	.514	.066	.328	7.782	< .001
Perceived behavioral control	.274	.058	.158	4.709	< .001

Table A.5

Behavioral Intention Construct Means, Standard Deviations, and Percent of Total of Select Demographic Subgroups.

Variable	M (Mdn)	SD	% of total	p
Typical daily device use (N = 480)				0.187
0:01–2:59 (n = 131)	3.04	1.70	27.3	
3:00–5:59 (n = 227)	3.07	1.59	47.3	
6:00 or more (n = 122)	3.38	1.75	25.4	
Past use while crossing (N = 480)				< .001
Never or almost never (n = 124)	1.88 (1.67)	1.10	25.8	< .001
About half/less than half (n = 218)	3.13 (3.00)	1.42	45.4	< .001
Nearly every time/ > half but not all (n = 138)	4.30 (4.33)	1.61	28.8	< .001
Previous injury exposure (N = 480)				0.067
Yes (n = 371)	3.22	1.63	77.3	
No (n = 109)	2.89	1.75	22.7	
Gender (N = 478)				0.399
Male (n = 149)	3.24	1.78	31.0	
Female (n = 329)	3.11	1.60	68.5	

Note. % of total column is the percentage of the total sample (N = 480).

Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.aap.2019.02.006.

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