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Warn me now or inform me later: Drivers' acceptance of real-time and post-drive distraction mitigation systems

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Abstract

Vehicle crashes caused by driver distraction are of increasing concern. One approach to reduce the number of these crashes mitigates distraction by giving drivers feedback regarding their performance. For these mitigation systems to be effective, drivers must trust and accept them. The objective of this study was to evaluate real-time and post-drive mitigation systems designed to reduce driver distraction. The real-time mitigation system used visual and auditory warnings to alert the driver to distracting behavior. The post-drive mitigation system coached drivers on their performance and encouraged social conformism by comparing their performance to peers. A driving study with 36 participants between the ages of 25 and 50 years old ($M=34$) was conducted using a high-fidelity driving simulator. An extended Technology Acceptance Model captured drivers' acceptance of mitigation systems using four constructs: perceived ease of use, perceived usefulness, unobtrusiveness, and behavioral intention to use. Perceived ease of use was found to be the primary determinant and perceived usefulness the secondary determinant of behavioral intention to use, while the effect of unobtrusiveness on intention to use was fully mediated by perceived ease of use and perceived usefulness. The real-time system was more obtrusive and less easy to use than the post-drive system. Although this study included a relatively narrow age range (25 to 50 years old), older drivers found both systems more useful. These results suggest that informing drivers with detailed information of their driving performance after driving is more acceptable than warning drivers with auditory and visual alerts while driving.

Keywords: Driver distraction; Distraction mitigation; Feedback; Technology Acceptance Model

1. Introduction

According to the Centers for Disease Control and Prevention, traffic-related crashes are the leading cause of death for those from 8 to 24 years old (Subramanian, 2012). Risky behaviors such as speeding, seat belt disuse, and alcohol consumption are predominant contributors to traffic-related fatalities (Sivak et al., 2007). Adding to these contributors is driver distraction—"the diversion of attention from activities critical for safe driving toward a competing activity" (Regan et al., 2009, p. 7). This is particularly true as ubiquitous computing introduces many new devices into the car, ranging from navigation aids to social networking applications. Even such common tasks as selecting a song from a playlist can lead drivers to look away from the road for a dangerously long time (Lee et al., 2012). Interface modality is also an important consideration because compared to visual interfaces, auditory interfaces can be less distracting and easier to use, but can increase task completion times (Sodnik et al., 2008).

As the number of devices carried into the vehicle increases, so does the potential for distraction to contribute to crashes. For example, 40% of drivers report using add-on media devices, 50% use hand-held cell phones, and 60% read text messages while driving (Lansdown, 2012). Even though many drivers believe engaging in these activities is not dangerous (Wogalter and Mayhorn, 2005), using a cell phone results in a fourfold increase in crash likelihood (McEvoy et al., 2005) and texting while

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driving is associated with a 23-fold increase in crash likelihood (Olson et al., 2009). In 2009 alone, distraction associated with these and other activities contributed to 5,474 deaths and nearly 448,000 injuries in the United States (NHTSA, 2010). To the extent that drivers fail to recognize the risk of distraction, providing drivers with feedback might help mitigate the adverse consequences of distraction.

1.1. Feedback to reduce driver distraction

The large number of distraction-related deaths and injuries has prompted many potential solutions, ranging from legislation that outlaws activities to design guidelines that minimize distraction (Regan et al., 2009). One approach to alleviate this issue uses in-vehicle technology to give drivers feedback on their performance. Feedback has substantial promise as a way of shaping safer behavior. According to Schmidt and Bjork (1992), "it [is] understood that any variation of feedback…that makes the information more immediate, more accurate, more frequent, or more useful for modifying behavior will contribute to learning" (p. 212). Hence, more accurate knowledge of skills and capabilities should enable drivers to make accurate assessments of their ability to use a device while driving and adjust behavior accordingly. This suggests that feedback might be a powerful way to reduce distraction-related crashes (Lee, 2009).

Evidence from several other driving studies confirms the promise of using feedback to reduce risky driving behaviors. For example, giving feedback about compliance of traffic laws led both young and older drivers to commit 3.5 fewer speed violations per 15–20 min drive and to stop 25% more often at stop signs and signalized intersections (de Waard et al., 1999). For traffic officers, feedback and supervisory inspections reduced the physical injury accident rate from 0.75 accidents to zero accidents per 100,000 miles (Larson et al., 1980). A feedback system warning drivers that they were following too closely reduced the amount of time drivers spent in short headways (<0.8 s) from 20% to 15% and increased the time spent in long headways (>1.2 s) from 57% to 65% (Shinar and Schechtman, 2002).

The effect of feedback has also been examined with driver distraction. A series of studies by Donmez et al. (2007, 2008) assessed how different types of feedback affected driving performance. Real-time feedback influences immediate performance, but does not provide detailed information that might be needed to affect long-term behavior (Donmez et al., 2008). Post-drive feedback is provided after the driver completes the trip and contains more detailed information that might change long-term behavior by helping drivers to be more aware of dangerous situations (Donmez et al., 2008). Real-time feedback led drivers to glance less toward the distracting device, thereby modulating their engagement in distracting activities (Donmez et al., 2007). When real-time feedback was combined with post-drive feedback, drivers responded to a braking lead vehicle more quickly and made longer glances to the roadway (Donmez et al., 2008).

Although real-time and post-drive feedbacks have proven to be beneficial in some instances, giving feedback does not always improve driving performance. For example, some characteristics of a driving coaching system (e.g., negatively framed feedback) led to no change or even undermined driving performance (Arroyo et al., 2006). Hence, only certain types of feedback actually increase safety.

One feedback approach that has yet to be tested relies on using social norm conformance to promote safe driving behavior. A powerful way to change behavior is to change attitudes towards the behavior and the subjective norm regarding the behavior (Ajzen, 1991; Fishbein and Ajzen, 1975). As stated by Bernheim (1994), "individual behavior is motivated by social factors such as the desire for prestige, esteem, popularity, and acceptance. As these factors are so widespread, they also produce conformism and those who do deviate from the norm are often penalized" (p. 842).

The notion of modifying one's behavior according to those within the same social network has been seen within the Framingham Heart Study with obesity (Christakis and Fowler, 2007), smoking (Christakis and Fowler, 2008), and happiness (Fowler and Christakis, 2008). Feedback enforcing social norms can also reduce binge drinking among college students (Agostinelli et al., 1995; Neighbors et al., 2004) and can encourage safe driving behaviors among pizza deliverers (Ludwig et al., 2002). Using social norm conformance to promote a behavior change can prove to be a particularly powerful form of feedback to deter driver distraction. Therefore, one of the goals of this study was to assess how different forms of feedback influence driver's acceptance of the feedback technology. In particular, following the methodology of Donmez et al. (2007, 2008), both real-time auditory and visual alerts were to be compared to post-drive reports that use social norm conformance to change behavior. While potentially powerful, such feedback must be accepted by drivers if it is to realize its potential.

1.2. Technology acceptance

Feedback effectiveness depends on drivers' acceptance and trust. Several frameworks and methodologies exist that describe how people adopt and accept new technology. Of particular prominence within the driving domain is a simple method that assesses system usefulness and satisfaction (Van Der Laan et al., 1997). Among the more advanced models, the Technology Acceptance Model (TAM) has proven to successfully predict technology use and is broadly used after more than three decades since its introduction. The TAM (Davis et al., 1989), built upon the Theory of Reasoned Action (TRA) of Fishbein and Ajzen (1975), posits that perceived usefulness (PU) and perceived ease of use (PEOU) are the main determinants of attitude toward a technology, which in turn predicts behavioral intention to use (BI) and actual use. Further research has shown that attitude only partially mediates the effect of PU on BI, thus suggesting that attitude could be excluded from the model (Davis and Venkatesh, 1996; Venkatesh