Accident Analysis and Prevention 111 (2018) 266–270

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

# A new approach for assessing and training drivers' speed management

Noelle LaVoie[a,*], Yi-Ching Lee[b], Anna Allison[a], James Parker[a]

[a] Parallel Consulting, 10 Arlene Court, Petaluma, CA 94952, United States
[b] George Mason University, United States

ARTICLE INFO

*Keywords:*
Speed management
Teen driving
Driving safety

ABSTRACT

Motor vehicle crashes are the leading cause of death and injury for teens and speeding is a major contributor, particularly driving too fast for conditions (CDC, 2015, 2013; NHTSA, 2012; Lam, 2003; McKnight & McKnight, 2003). Speed management is a type of tacit knowledge learned through experience that combines speed perception with decisions about safety. Effective training and assessment of speed management requires a safe method for accumulating practice that includes realistic perceptual cues. This study investigated whether speed can be manipulated in an online environment using special effects technology without distorting speed perception. A forced-choice experiment revealed that drivers' perception of speed was not influenced by the special effects technology, indicating that critical perceptual information was not altered by the speed manipulation of the videos. The experiment also looked at the role of experience in detecting speed differences and found that experienced drivers were able to make judgments about speed more quickly than inexperienced drivers. Implications of these findings for training and assessment are discussed.

## 1. Introduction

Motor vehicle crashes are the leading cause of death and injury for teens accounting annually for nearly 3000 deaths, 100 times as many injuries, and over 14 billion dollars in associated costs in the U.S. (Insurance Institute for Highway Safety [IIHS], 2016; CDC, 2015, 2013). Speeding contributes to over 30% of teen driving crashes, as compared to 19% of crashes among adult drivers (NHTSA, 2012). Speeding includes driving too fast for conditions as well as exceeding the speed limit. Driving too fast for conditions includes failure to slow down to compensate for reduced visibility (e.g., rain) or vehicle handling (e.g., ice) as well as driving faster than other vehicles on the road (Aarts and Van Schagen, 2006).

Among teens, driving too fast for conditions is the primary cause of speed-related accidents, rather than intentionally risky driving (Lam, 2003; McKnight and McKnight, 2003). Curry et al. (2011) analyzed crashes involving 15–18 year old drivers from the National Motor Vehicle Crash Causation Survey (NMVCCS), a nationally representative sample of serious crashes. Driving too fast for conditions was the critical error leading to over 20% of crashes among teen drivers.

### 1.1. Speed perception

Human speed perception is a basic perceptual process, relying primarily on visual cues outside of the vehicle to estimate speed (Recarte and Nunes, 1996). Speed perception is highly sensitive to the amount of visual contrast in a scene, with reduced contrast leading to an underestimation of speed. Indeed, environmental conditions that obscure visual cues, such as darkness and fog, alter drivers' perception of speed (Recarte and Nunes, 1996; Chatziastoros and Pretto, 2006; Reinhardt-Rutland, 1992). While inexperienced drivers drive slower on average, they do not proportionally decrease their speed to account for poor visibility, leading to a higher rate of collision from this group (Mueller and Trick, 2012).

Speed perception is also influenced by the relative speed of road, vehicle and peripheral objects. When asked to estimate the speed at which a vehicle is traveling participants underestimated high speeds and overestimated low speeds (Hills, 1980; Recarte and Nunes, 1996). More experienced drivers are better able to use speed and distance information to estimate time to collision (Cavallo and Laurent, 1988). Chatziastoros and Pretto (2006) found that the optic flow coming from the road in front of the car was critical in estimating the speed at which a vehicle was traveling. When the speed of the road in front of the traveling car was altered in a driving simulator, drivers adjusted to the speed of the road in front despite the presence of peripheral cues (e.g., traffic signs) traveling at a slower speed. Drivers also experience closing speed adaptation when driving on a straight open road for several minutes before approaching a vehicle, causing drivers to underestimate how quickly they are approaching a vehicle ahead on the roadway (Gray and Regan, 2005).

* Corresponding author.
*E-mail address:* lavoie@parallel-consulting.com (N. LaVoie).

https://doi.org/10.1016/j.aap.2017.12.002
Received 31 December 2016; Received in revised form 4 October 2017; Accepted 3 December 2017
0001-4575/ 

Visual characteristics of the roadway have an impact on driver' decisions about what speed to drive, with drivers choosing slower speeds on narrower roads (Charlton and Starkey, 2016), hilly and curvy roads, when lane boundaries are difficult to see (Edquist et al., 2009) and at night (Kockelman and Ma, 2007). Experienced drivers are also better able to select appropriate speeds for conditions that require reduced speeds, such as slowing for objects on the side of the road and on congested freeways (Kockelman and Ma, 2007), when there is a high likelihood of vehicles entering the roadway (Edquist et al., 2009), and when there are complex visual scenes to process. Inexperienced drivers are less able to compensate for complex visual stimuli (Borowsky et al., 2010) and are more likely to fixate on actual hazards (such as a pedestrian) and underestimate the danger of potential hazards (such as low road visibility or closely following the car in front of them) which leads young drivers to underestimate the danger of decreased visibility, such as fog or darkness.

### 1.2. Social influences and driver characteristics

Social influences impact drivers' choice of driving speed. Drivers who report that both family and friends approve of speeding are more likely to exceed posted speed limits than drivers who believe their friends and families do not approve (Fleiter et al., 2006). Social influence interacts with driver characteristics such that young male drivers who believe their friends speed are more likely to speed (Moller and Haustein, 2014).

Drivers who experienced an incident that made them angry were more likely to speed in a driving simulator, even miles after the incident (Roidl et al., 2014). Drivers are also more likely to drive too fast for conditions under time pressure and the impact of time pressure may be explained by both the driver's emotional state and by a cognitive bias that leads drivers to underestimate their speed when under time pressure (Coeugnet et al., 2013). Experienced drivers are more likely to adopt strategies to mitigate the tendency to speed under time pressure than are novice drivers (LaVoie et al., 2008).

Driver characteristics are consistently associated with speed choice, with males tending to drive somewhat faster than females (Hassan et al., 2017; Anastasopolous and Mannering, 2016), drivers under 40 years of age driving faster than older drivers (Anastasopolous and Mannering, 2016), and driver's with a high income driving faster than those with low or middle incomes (Kweon and Kockelman, 2006; Hassan et al., 2017; Anastasopolous and Mannering, 2016).

### 1.3. Speed and tacit knowledge

Foss et al. (2011) determined that driving too fast for conditions declines during the first 24 months of driving, closely following a power curve and declining more quickly than overall crash rates. This indicates that learning, rather than intentional risk-taking, aggressive driving or overconfidence, is the cause of improvement.

The Safe Speed Knowledge Test measures drivers' tacit knowledge (knowledge gained through experience) about appropriate speeds in a variety of contexts (Legree et al., 2003). These include environmental conditions such as bad weather or road conditions known to increase crash risk as well as personal conditions such as emotional states (e.g., anger, anxiety) or fatigue, factors that are prevalent and associated with increased risks of traffic accidents (Alonso et al., 2017; Useche et al., 2017). Novice drivers experience a greater detriment from these factors than more experienced drivers (Paxion et al., 2014). The Safe Speed Knowledge Test successfully distinguished between drivers with a safe driving history and those with a history of car crashes, establishing that knowledge of appropriate speed is associated with reduced crashes. Thus, training which improves speed management has significant potential to reduce crashes among teen drivers.

Few options exist for providing novice drivers with opportunities to acquire tacit knowledge of safe speeds. Digital video editing and special effects techniques, such as those used in television and movies, may be used to manipulate videos of vehicles driving so that vehicles appear to moving at different speeds. Advances in web browsers have increased the amount of interaction users have with videos embedded in web sites. Recent changes include the ability to speed up or slow down a video. Changing the speed of a video of a vehicle taken from a driver's point of view makes the vehicle appear to moving at faster or slower speeds.

This paper describes an experiment conducted to determine whether digital video editing and special effects techniques can be used to manipulate vehicle speed in digital videos designed to be shown in a web-based environment while maintaining perceptual realism. This was tested using a forced-choice perception experiment and a series of driver's point of view videos, either edited with VFX to increase and decrease speed, or left unedited. A secondary question was whether experienced drivers would be more sensitive to differences in speed than inexperienced drivers. A third question was whether there would be an interaction between VFX editing and driving experience, such that experienced drivers would be more likely to detect differences in vehicle speeds in the edited videos.

## 2. Method

### 2.1. Participants

Participants were recruited from the community and through email blasts sent to parents of adolescents who received care at a large pediatric care network. Sixteen teens (10 females) and 16 adults (9 females) participated in the experiment. Participants met the following requirements: teens were between 14 and 17 years old and had less than one year of driving experience, and adults were between 28 and 55 years old and had at least 10 years of driving experience with no moving violations or at-fault accidents in the past 5 years.

Consent to participate was obtained in-person: teen participants provided written assent and adult participants provided written consent. Upon consenting, eligibility of participation was verified. The recruitment, enrollment, and screening processes were approved by the large pediatric care network's Institutional Review Board.

### 2.2. Stimuli. Baseline and manipulated videos

Digital video editing and special effects techniques were used to manipulate vehicle speed in a series of digital videos. Baseline videos were filmed from a driver's point of view through the front windshield of a vehicle on a closed course track at a steady speed that captured the forward roadway and the sides of the road. Videos were created using a camera mounted inside a vehicle. Videos were filmed at vehicle speeds of 15 mph, 20 mph, 25 mph, 30 mph, 35 mph, 40 mph and 45 mph. These original videos were then manipulated to create a series of videos where the vehicle appears to be moving at different speeds. Videos were cleaned of minor artifacts (e.g., windshield dust) and trimmed of initial acceleration and final deceleration, prior to applying any speed manipulation effect. No adjustments were made for exposure, color, or contrast to any of the footage in order to avoid confounding the speed manipulation. Manipulated videos were created from each baseline video by adjusting the speed in 5mph increments. For example, the baseline 20 mph video was manipulated to create several new videos in which the vehicle appears to travel at 15 mph, 25 mph, 30 mph, 35 mph, 40 mph and 45 mph. Manipulated videos were created by applying a time adjustment effect to the baseline video that best described how each pixel changed from frame to frame in order to create the most realistic speed adjustment (as opposed to just removing or blending whole frames together). In order to accomplish this, a commercial off-the-shelf video effects system was used to adjust the pixel motion (i.e., parts of the image that are in motion). The manipulated videos appear to be identical to the baseline videos except that the vehicle is moving