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The effects of driver identity on driving safety in a retrospective feedback system

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ABSTRACT

Background: Retrospective feedback that provides detailed information on a driver's performance in critical driving situations at the end of a trip enhances his/her driving behaviors and safe driving habits. Although this has been demonstrated by a previous study, retrospective feedback can be further improved and applied to non-critical driving situations, which is needed for transportation safety.
Objectives: To propose a new retrospective feedback system that uses driver identity (i.e., a driver's name) and to experimentally study its effects on measures of driving performance and safety in a driving simulator.
Method: We conducted a behavioral experimental study with 30 participants. "Feedback type" was a between-subject variable with three conditions: no feedback (control group), feedback without driver identity, and feedback with driver identity. We measured multiple aspects of participants' driving behavior. To control for potential confounds, factors that were significantly correlated with driving behavior (e.g., age and driving experience) were all entered as covariates into a multivariate analysis of variance. To examine the effects of speeding on collision severity in driving simulation studies, we also developed a new index – momentum of potential collision – with a set of equations.
Results: Subjects who used a feedback system with driver identity had the fewest speeding violations and central-line crossings, spent the least amount of time speeding and crossing the central line, had the lowest speeding and central-line crossing magnitude, ran the fewest red lights, and had the smallest momentum of potential collision compared to the groups with feedback without driver identity and without feedback (control group).
Conclusions: The new retrospective feedback system with driver identity has the potential to enhance a person's driving safety (e.g., speeding, central-line crossing, momentum of potential collision), which is an indication of the valence of one's name in a feedback system design.

1. Introduction

Road traffic crashes are consistently one of the top ten causes of death worldwide, leading to more than 1.27 million deaths in 2004 and between 20 and 50 million non-fatal injuries annually (Peden et al., 2004; World Health Organization, 2009). Importantly, approximately 92% of traffic accidents result from a violation of at least one traffic law (Rothengatter, 1991). For example, speeding (defined as exceeding the posted speed limit, racing or driving too fast for conditions) is one of the most prevalent contributing factors in traffic crashes. In 2009, speeding contributed to 31% of all fatal crashes in the United States, which resulted in the loss of 10,591 lives (National Highway Traffic Safety Administration, 2009). In addition to these speeding-related accidents, head-on collisions (due to an unsafe central-line crossing or lane changing) and accidents involving pedestrians were identified as another two major types of fatal traffic crashes, and each account for around 11% of all fatal crashes in the United States (Nhtsa, 2009). Many strategies and systems have been proposed to prevent a driver from violating traffic laws and help him/her form safe driving habits; the feedback system is one of these strategies.

In a driving context, feedback is the information about the driver's, vehicle's, and environment's state that is available to the driver. The driver can receive real-time or concurrent feedback at the moment an event occurs. Such feedback has the potential to raise a driver's awareness of his immediate driving performance and environmental changes. Also, concurrent feedback improves a person's driving safety by modulating his/her distracting activities (e.g., interacting with a global position system, GPS) (Horrey and Wickens, 2006). The literature has reported on the effects of concurrent feedback on driving performance and one's engagement with distractions (Brookhuis and De Waard, 1999; Levick

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and Swanson, 2005; Donmez et al., 2007; Mcgehee et al., 2007; Donmez et al., 2008; Toledo et al., 2008; Van Nes et al., 2008). For example, intelligent speed adapter/assistance (ISA) is a concurrent feedback system that informs a driver about the speed limit when he/she drives above it. ISA systems have proven to be effective at improving speed management in various countries.

A driver can also receive retrospective or post hoc feedback after an event occurs. For example, information on the frequency of running red lights can be presented after a trip is completed. Retrospective feedback has several strengths compared with concurrent feedback. The first and the most obvious advantage is that retrospective feedback does not interfere with immediate driving performance. Second, retrospective feedback helps a driver understand how safe his/her driving is by refreshing his/her memory of the last trip. Accordingly, the driver is made aware of certain situations where incidents may occur, and may eventually change their long-term driving behavior (Donmez et al., 2008). Third, retrospective feedback that displays a report after a trip can convey detailed information about prior incidents without time or resource constraints. In this way, a driver can better assess and modulate his/her overall driving behaviors according to the feedback. In fact, only one existing study on retrospective feedback systematically reports its influence on driving performance. Donmez et al. (2008) examined the effects of retrospective and combined (i.e., both concurrent and retrospective) feedback on driving performance and distraction engagement. These authors were interested in a safety-critical scenario in which participants followed a leading vehicle that braked periodically; here, a change in behavior is needed to decrease the chance of an imminent collision. Retrospective feedback about the number of incidents that occurred (e.g., the time to collision with the leading vehicle and the number of lane deviations), along with the driver's distraction level and the incident's severity level, was provided to a driver at the end of each trip. Interestingly, both feedback conditions resulted in a faster response to lead-vehicle braking events, with combined feedback resulting in longer glances to the road.

Although Donmez et al. (2008) explored the effects of retrospective feedback on driving performance, to our knowledge, no experimental study has been conducted to assess how retrospective feedback affects a person's driving performance in a more general scenario. Specifically, the previous study of retrospective feedback attempts to enhance a driver's behaviors in an emergency (such as an imminent, rear-end collision). In reality, these collisions (or safety-critical scenarios) occur rarely compared with general moving violations (i.e., speeding or central-line crossing). Thus, a driver is expected to benefit more from a new retrospective feedback that reports global measures of human factors that have been identified as significant factors in fatal traffic crashes (e.g., speeding, crossing the central line to changing lanes, running a red light). However, it might be more difficult for a driver to accept retrospective feedback in a general scenario where the moving violation may not lead to a collision than it would be in a safety-critical scenario. For example, the NHTSA conducted a survey in 2002 and found that 80% of all drivers had exceeded the posted speed limit during the month before the survey was taken (Royal, 2003). Because speeding is common (or even universal) and may not result in an accident, the potential value of retrospective feedback for modulating a driver's unsafe driving behaviors in non-critical driving situations needs further investigation.

According to social psychology's triangle model of responsibility, giving a driver feedback on his/her driving performance is considered an attempt to strengthen the sense of responsibility that connects the rules and goals for performance to the actions and consequences of the performance (Schlenker et al., 1994). The triangle model of responsibility is a major social psychological theory, and it offers a coherent framework for understanding the determinants and effects of responsibility (Britt, 1999). The model consists of three elements: identity (i.e., a person's characteristics, roles and qualities), prescription (i.e., the rules or goals for performance) and event (i.e., the actions and consequences of performance). Responsibility is the psychological adhesive that joins the three elements and provides a basis for judgment and sanctioning (Schlenker et al., 1994). According to this model, existing feedback enhances the rule-action linkage. Probably, providing a driver with feedback about his/her performance on the last trip informs him/her a clear and salient set of rules that should be applied to his/her actions (e.g., longer fixations on the road). However, existing feedback systems do not consider identity and its two connections, the identity-rule link and the identity-action link, which decreases the overall strength of connections and responsibility. In contrast, this study presents a new retrospective feedback system that takes a driver's identity (and therefore the whole triangle model of responsibility) into consideration. We reasoned that mention of a driver's identity in the feedback would raise a driver's awareness of the responsibility, which will eventually regulate his/her unsafe driving behaviors, such as speeding.

From a psychological perspective, identity refers to a person's sense of who or what he/she is. Identity consists of several dimensions, with name being one of the major dimensions. In general, names serve as a symbolic representation of the person we present to others. Snyder and Fromkin (1980) proposed that names were "uniqueness attributes" through which individuals can differentiate themselves from other people. The relationship of the name to an individual's sense of personal identity has been explored by a variety of psychologists and sociologists (Kuhn and Mcpartland, 1954; Gordon, 1968; Montemayor and Eisen, 1977). Additionally, previous studies suggest that people are especially attentive to events that are emotional significant to them because of the salience of names in one's spontaneous self-concept. For example, people can hear someone mention their name in the midst of a noisy cocktail party and while they are sleeping (Moray, 1959; Allport and Willard, 1961). This phenomenon reflects the attention-eliciting value of names and indicates that an individual's name has a higher priority than other information that he/she attends to (Deutsch and Deutsch, 1963; Wood and Cowan, 1995; Kawahara and Yamada, 2004). Therefore, we assumed that mention of a driver's name at the beginning of retrospective feedback would attract his/her attention to such feedback with considerable power.

Other dimensions in addition to a person's name (such as one's gender or occupation) have also been shown in the literature to have an association with one's identity, self or attention (e.g., Brewer and Gardner, 2004). Compared to these categories, a person's name is the most salient and characteristic category (Howarth and Ellis, 1961); however, all of the aforementioned categories inevitably involve personal privacy. Therefore, we had to consider how to protect driver privacy when designing our current feedback system. Recently, public opinion polls find that a majority of people are concerned about threats to their personal privacy (Phelps et al., 2000). If we were to present too much a driver's private information to at once, he/she may feel uncomfortable and eventually refuse to use the system. Thus, the current study only presented a driver's name when conveying feedback information to him/her.

Although separate lines of research exist on both retrospective feedback and names, it is not clear whether a new retrospective feedback system that adds a driver's full name at the beginning of the trip report will be better than current systems. Therefore, the purposes of this study are to compare and assess the effects of both types of retrospective feedback systems (i.e., with vs. without driver names, hereafter referred to as "driver identity") on safety-related driving behavior variables in a simulated driving task.