The Effects of Driver Identity on Driving Safety Using a Retrospective Feedback System

Guozhen Zhao Changxu Wu*

State University of New York at Buffalo

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.

Keyword: Driver identity; Retrospective feedback; Name; Driving safety; Speeding; Momentum of potential collision

* Corresponding Author. Email: changxu.wu@gmail.com

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 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 and colleagues (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.

2. Methods

2.1. Participants

We studied 30 native English speakers (13 males and 17 females), whose average age was 29.1 years (range = 22-44, SD = 7.9), in a driving simulator. Participants were screened to ensure that they had good visual acuity and hearing. Additionally, all participants were right-handed, had valid US driver licenses and had driven within the last six months.

2.2. Experimental design and feedback system

We used a mixed factorial design with feedback type as a between-subject variable: no feedback (control group, 10 subjects), feedback without driver identity (10 subjects) and feedback with driver identity (10 subjects). Each participant completed 3 consecutive drives: drive 1 (without feedback), drive 2 (after one instance of feedback) and drive 3 (after a second instance of feedback). As a result, drive serves as a within-subject variable.

The driving scenario was a 9-mile, two-lane (in each direction) local environment. Four types of driving events were included: a pedestrian crossing the road, an intersection with traffic lights, a speed limit and a vehicle. First, we designed two types of pedestrians to cross the road: a target and a non-target. Initially, pedestrians were displayed 2 feet from either the left or right roadway edge line. When the driver was within 200 feet of the pedestrian (target), it began to cross the road at a constant speed of 2 feet per second. To reduce learning effects, stationary pedestrians (non-targets) were also displayed with an exact ratio of 1:3 (target: non-target). Second, two types of intersections with traffic lights were included: target and non-target. Target traffic lights turned from green to yellow when the driver was within 200 feet of the intersection. The light then stayed yellow for a total of 3 seconds before turning red. Non-target traffic lights remained green and occurred 3 times as often as target traffic lights. Third, speed limit signs with different speed limits (range = 20-60 mph) were displayed 1000 feet in front of the driver.

Participants were instructed to adjust their speed and follow the speed limit throughout the task. Finally, an approaching vehicle in the other lane appeared 1000 feet from the driver every 1000 feet he/she travelled. There were approximately 15 approaching vehicles, which always followed the speed limit, during each 3-mile section.

Additionally, there was an intersection with a traffic light at miles 3 and 6. When participants were within 200 feet of these 2 intersections, the traffic light turned red for 1 min. After a participant's vehicle was fully stopped, the feedback system displayed his/her driving performance during the previous section[1]. In this way, the session was segmented into three separate drives, and the three types of driving events were evenly and randomly distributed throughout each drive without overlap.

Drivers in the control group stopped at these two 1-min-long red lights but did not receive any feedback. In contrast, drivers in the other two groups received a trip report while they were waiting for the red light to change. If there were no accidents or incidents in the previous section, drivers received positive feedback (see Fig. 1a), which was designed to increase their acceptance of the trip report (Brandenburg and Mirka 2005, Donmez *et al.* 2008). If both accidents and incidents occurred in the previous section, accidents (such as the frequency of hitting a pedestrian or colliding with a vehicle) were displayed first (see Fig. 1b). Next, a few major incidents such as speeding (frequency and duration), crossing the central line (frequency and duration), driving too close to a simulated pedestrian (frequency only) and running a red light (frequency only) were presented if they occurred, and this report was followed by detailed information about each incident type, which was illustrated using figures or video animation[2] (see Fig. 1c-1f). Drivers could also receive positive feedback if they had better driving behaviors in the current drive than in the last one: "According to your driving performance in the previous section, your driving behavior has improved but is still relatively unsafe compared with other drivers. Please drive carefully for your own safety and other people's safety. Thank you".

[1] All participants stopped in front of these two intersections in the experiment.
[2] The red-light violation feedback was presented via a video clip that animated the act of passing through the traffic light as it turns from yellow to red.

Fig. 1. Samples of the trip report (a. Positive feedback for no accidents or incidents; b. Information on accidents; c. Information on major incidents; d. Information on the frequency of driving too close to a pedestrian; e. Information on central-line crossing frequency; f. Information on speeding duration)

In addition to the features mentioned above, the feedback system with driver identity displayed a driver's name at the beginning of the trip report (see Fig. 1a for a case in which there are no accidents or incidents in the previous sections, Fig. 1b for a case in which there are accidents and Fig. 1c for a case in which there are incidents). A driver's name did not appear when displaying the detailed information about each type of incident. All names were pre-recorded by an experimenter before the formal driving task, and all feedback information was given in both the visual and auditory modalities.

2.3. Apparatus

The driving task was completed using a STISIM® driving simulator (STISIMDRIVE M100K). The STISIM simulator was installed on a Dell Workstation (Precision 490, Dual Core Intel Xeon Processor 5130 2 GHz) with a 256 MB PCIe×16 NVIDIA graphic card, Sound Blaster® X-Fi™ system, and Dell A225 Stereo System. The driving scenario was presented on a 27-inch LCD with 1920×1200 pixel resolution. The driving simulator also included a Logitech Momo® steering wheel with force feedback, a gas pedal and a brake pedal.

The trip report was displayed on a 12.1 inch ELO screen, which was located 50 cm from the participants' right hand and 91 cm from their eyes. The visual angle of the touch screen was 13.1 degrees and controlled by a Dell PC (OPTIPLEX 745), which was connected to the driving simulator via a Labjack® system.

2.4. Experimental procedure

Upon arrival, we asked participants to sign a consent document and fill out a set of self-report measures before engaging in the driving task. These questions were designed to capture information about each participant's demographic characteristics (e.g., age and gender) and driving history (e.g., their estimated annual driving mileage and the year their first US driver license was issued to them).

Participants then completed five consecutive practice blocks of the driving task to familiarize themselves with the driving simulator and the different road events. Each practice block lasted for 15-20 min. This relatively long period of practice (1.5-2 hours in total) was expected to control confounding learning effects on driving behaviors.

2.5. Measurement

Several major behavioral measures from the driving simulator were examined and can be grouped into two categories: accident or incident. In terms of accidents, two types could have occurred in the simulated driving environment. First, a pedestrian-related accident was when a driver did not respond quickly enough and therefore hit a simulated pedestrian who was crossing the road. Second, a vehicle-related accident was any collision with a vehicle on the road. Incidents were defined as a traffic violation with relatively minor importance or severity compared with an accident. Incidents measured the frequency of running red lights, speeding and central-line crossing (for speeding and central-line crossing, the magnitude and duration were also measured).

Frequency of running a red light. This measure reflects the number of times a driver crossed the stop line for a traffic light while the traffic light was red.

Frequency of speeding. This measure indicates the number of times a vehicle's speed exceeded the posted speed limit.

Duration of speeding. This measure provides the amount of time (in seconds) that a driver spent above the posted speed limit.

Magnitude of speeding. This measure reports the speed deviations (in miles per hour) from the speed limit.

Momentum of potential collision. This measure indicates the severity of a potential collision (in kN per second) due to a speeding violation.

Frequency of central-line crossing. This measure reflects the number of times the wheels of the driver's vehicle made contact with the other side of the roadway.

Duration of central-line crossing. This measure captures the amount of time that the wheels of the driver's vehicle made contact with the other side of the roadway.

Magnitude of central-line crossing. This measure indicates the lateral distance away from the roadway dividing line that the wheels of the driver's vehicle deviated onto the other side of the roadway.

Frequency of driving too close to a pedestrian. This measure reflects the number of times a vehicle drove too close to a simulated pedestrian. This incident's threshold was estimated from the median distance between our drivers' vehicles and a pedestrian in both the lateral and longitudinal directions, which was recorded in a previous driving study (Zhao *et al.* 2010). We used a lateral distance of 8.3 feet and a longitudinal distance of 5.2 feet in this study.

2.6. Data analysis

Analysis of variance (ANOVA) was used to examine group differences in demographic factors (i.e., age and education level) and driving history (i.e., the year a US driver's license was obtained). A chi-square analysis was used for categorical variables (i.e., gender and annual mileage). We then conducted a multivariate analysis of covariance (MANCOVA) with the driving behavior variables serving as dependent variables. Significant findings were followed-up with a Tukey's test to compare differences in feedback from the first to last drive.

3. Results

3.1. Descriptive analysis

One-way ANOVAs were conducted to compare group differences on demographic variables and driving history (see Table 1). There were significant differences among the three feedback groups for age ($F(2, 27) = 6.44$, $p = .005$), annual mileage (Pearson $\chi^2(8) = 21.75$, $p = .005$), and the year their license was first obtained ($F(2, 27) = 5.26$, $p = .012$). No significant group difference was found for gender or education level.

Descriptive statistics (sample means and standard deviations) were provided to describe the main features of the sample for each measurement (see Appendix I). Descriptive statistics of the number of speeding and deviations from the speed limit were shown to give a sense of the frequency and magnitude of speeding under different speed limit conditions (see Appendix II).

Table1. The means and standard deviations for demographic and driving history variables

	No feedback (n=10)	Feedback with driver identity (n=10)	Feedback without driver identity (n=10)
Demographic Factors			
Age (years) [a]	33 (8.2)	31.5 (8.2)	22.9 (1.1)
Gender (% Male)	50	40	40
Education (years)	15 (2.0)	14.2 (2.1)	16.1 (0.3)
Driving History			
Years licensed (years) [a]	17 (7.0)	11.1 (8.7)	6.8 (2.0)
Annual mileage (miles) [a]	4 (0.6)	2.7 (1.6)	2.6 (0.8)

"Year licensed" refers to the number of years since a driver obtained his/her first valid US driver license; "Annual mileage" is a self-reported measure on a scale of 5 categories (e.g., less than 5,000 miles, 5,000 to 7,500 mile, etc).

[a] A significant difference among three feedback groups (*p*'s < .05).

3.2. MANCOVA

MANCOVA was performed with feedback type as a between-subjects factor and drive as a within-subject factor. Ten driving behavioral variables served as dependent variables: frequency, duration and magnitude of speeding; frequency, duration and magnitude of central-line crossing; frequency of running a red light; frequency of driving too close to a pedestrian; frequency of hitting a simulated pedestrian; and frequency of hitting a simulated pedestrian. No drivers collided with an approaching vehicle on the road during the formal test; therefore, frequency of colliding with a vehicle was not entered as a dependent variable. In addition, age, annual mileage and the year a subject obtained his/her first license were significantly different among the three feedback groups; therefore, we entered these three factors into the MANCOVA as covariates to control their potential effects on driving variables. In the overall MANCOVA, the interaction of feedback type × drive was significant (Wilks' λ = .49, p = .009), as was the main effects of feedback type (Wilks' λ = .39, p < .0001) and drive (Wilks' λ = .51, p < .0001).

3.2.1 Frequency of central-line crossing

A significant feedback type × drive interaction was revealed for the frequency of central-line crossing (see Fig. 2) ($F(4, 78) = 2.85$, p = .029). Pair-wise comparisons showed that drivers using the feedback system with driver identity were the least likely to cross the central line compared to those who used the other two feedback systems on drives 2 and 3 (see Table 2). We found no significant difference in the frequency of central-line crossing among the three systems when there was no feedback on drive 1. Moreover, feedback type had a significant main effect on the frequency of central-line crossing ($F(2, 78) = 14.25$, $p < .0001$). However, the main effect of drive was not significant for this measurement.

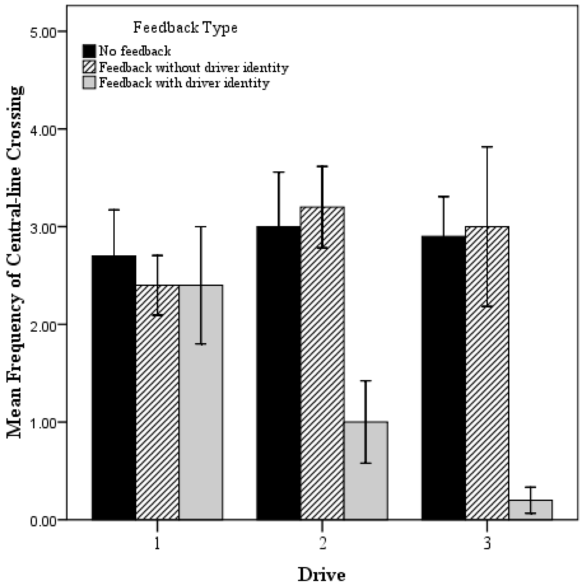

Fig. 2. Frequency of central-line crossing, which showed a significant interaction between feedback type and drive (error bars indicate ±1 standard error)

Table 2. Pair-wise comparisons for the frequency of central-line crossing

Pair-wise comparison	*p*-value	i-j (95% CI)
Drive 1 (no feedback)	*NS*	
Drive 2 (after 1st feedback)		
No feedback vs. Feedback without driver identity	*NS*	
No feedback (i) vs. Feedback with driver identity (j)	$p = .028$	2.0 (.19, 3.81)
Feedback without (i) vs. Feedback with driver identity (j)	$p = .003$	2.7 (.89, 4.51)
Drive 3 (after 2nd feedback)		
No feedback vs. Feedback without driver identity	*NS*	
No feedback (i) vs. Feedback with driver identity (j)	$p = .004$	2.7 (.83, 4.57)
Feedback without (i) vs. Feedback with driver identity (j)	$p = .003$	2.8 (.93, 4.67)
Between drive 1 and drive 3		
No feedback vs. Feedback without driver identity	*NS*	
No feedback (i) vs. Feedback with driver identity (j)	$p = .001$	1.67 (.64, 2.7)
Feedback without (i) vs. Feedback with driver identity (j)	$p < .0001$	1.83 (.8, 2.86)

3.2.2 Duration of central-line crossing

The main effect of feedback type was significant for the duration of central-line crossing ($F(2, 78) = 3.57$, $p = .033$) (see Fig. 3). Further analysis indicated that drivers benefited from the feedback system with driver identity, which led to the shortest time period of central-line crossing compared to those who used the feedback system without driver identity (95% CI: -4.73 (-7.51, -1.94), $p < .0001$) and the system without feedback (95% CI: -4.92 (-7.7, -2.14), $p < .0001$). There was no significant difference between the feedback system without driver identity and no feedback system. The main effect of drive and the feedback type × drive interaction were not significant for this measure.

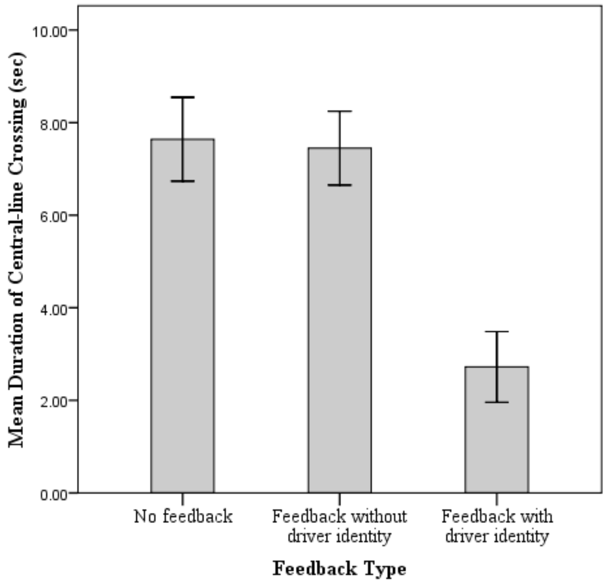

Fig. 3. A comparison of the duration of central-line crossing for the three feedback systems (error bars indicate ±1 standard error)

3.2.3 Magnitude of central-line crossing

There was a significant feedback type × drive interaction for the magnitude of central-line crossing (see Fig. 4) ($F(4, 78) = 3.66$, $p = .009$). Pair-wise comparison showed that drivers using the feedback with driver identity made the smallest lateral deviations from the roadway dividing lines compared to those who used the other two systems on drive 2. No significant difference was found in the magnitude of central-line crossing among the three systems on drive 1 or 3 (see Table 3). Moreover, we found a significant main effect of feedback type for the magnitude of central-line crossing (F(2,

78) = 4.18, p = .019). However, the main effect of drive was not significant for this measurement.

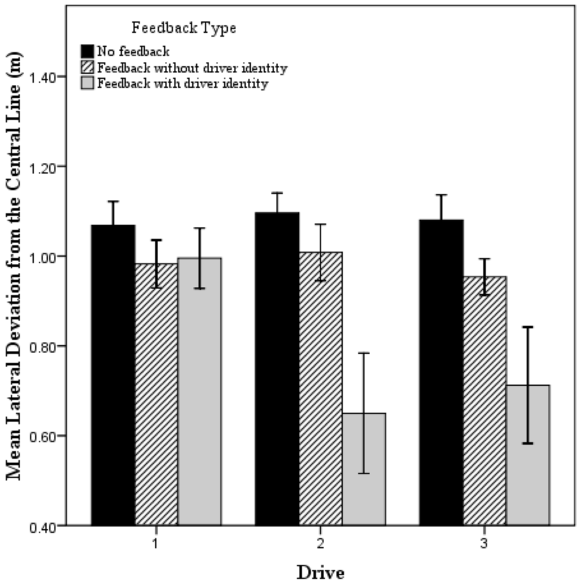

Fig. 4. The magnitude of central-line crossing, which showed a significant interaction between feedback type and drive (error bars indicate ±1 standard error)

Table 3. Pair-wise comparisons for the magnitude of central-line crossing

Pair-wise comparison	*p*-value	i-j (95% CI)
Drive 1 (no feedback)	*NS*	
Drive 2 (after 1st feedback)		
No feedback vs. Feedback without driver identity	*NS*	
No feedback (i) vs. Feedback with driver identity (j)	p = .004	.45 (.13, .76)
Feedback without (i) vs. Feedback with driver identity (j)	p = .022	.36 (.05, .67)
Drive 3 (after 2nd feedback)		
No feedback vs. Feedback without driver identity	*NS*	
No feedback (i) vs. Feedback with driver identity (j)	p = .013	.37 (.07, .67)
Feedback without (i) vs. Feedback with driver identity (j)	*NS*	
Between drive 1 and drive 3		
No feedback vs. Feedback without driver identity	*NS*	
No feedback (i) vs. Feedback with driver identity (j)	p < .0001	.3 (.14, .45)
Feedback without (i) vs. Feedback with driver identity (j)	p = .011	.2 (.04, .35)

3.2.4 Frequency of speeding

The main effect of feedback type was significant for the frequency of speeding (see Fig. 5) (F(2, 78) = 8.93, p < .0001). Pair-wise comparisons indicated that drivers from both the feedback system with driver identity (95% CI: -3.1 (-4.7, -1.5), $p < .0001$) and the system without driver identity (95% CI: -1.6 (-3.2, -.01), $p = .049$) exceeded the speed limit less often compared to those in the control group. There was no significant difference for the frequency of speeding between the two feedback systems. Moreover, the main effect of drive and the interaction effect of feedback type × drive for the frequency of speeding were not significant.

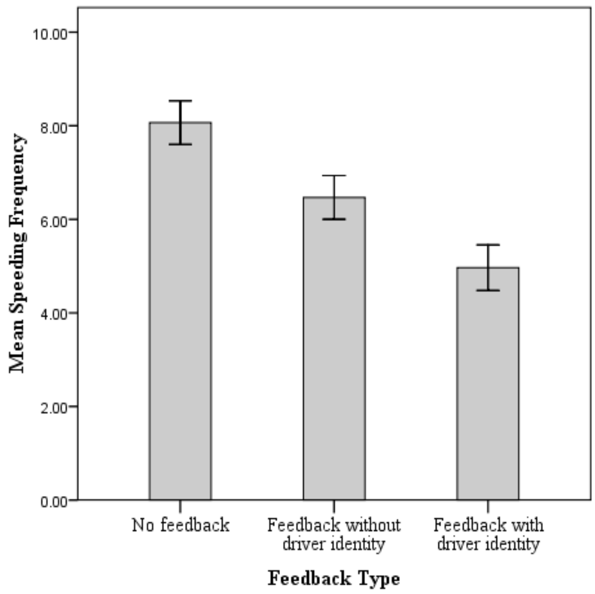

Fig. 5. A comparison of the frequency of speeding for the three feedback systems (error bars indicate ±1 standard error)

3.2.5 Duration of speeding

We found a significant feedback type × drive interaction effect for the duration of speeding (see Fig. 6) ($F(4, 78) = 3.16$, $p = .018$). Pair-wise comparisons revealed that drivers using the feedback system with driver identity had shorter speeding durations compared with drivers who used the other two systems on drive 3 (see Table 4). There was no significant difference for the duration of speeding among the three systems on drive 1 or 2. Further, there was a significant main effect of feedback type for the duration of speeding ($F(2, 78) = 4.1$, $p = .02$). However, the main effect of drive was not significant for this measure.

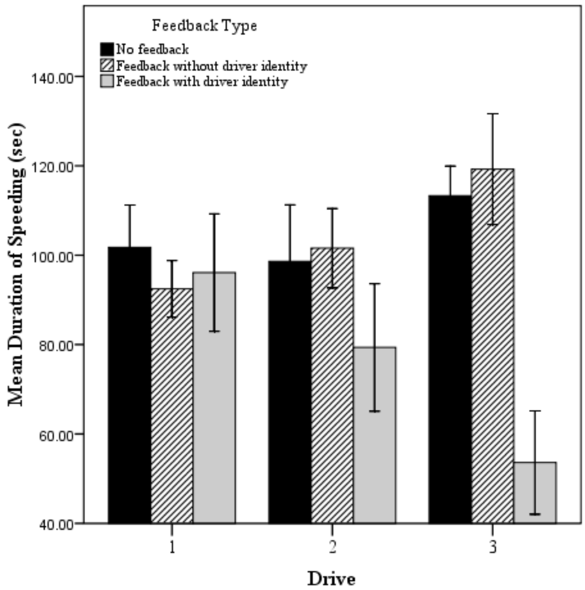

Fig. 6. Duration of speeding, which showed a significant interaction between feedback type and drive (error bars indicate ±1 standard error)

Table 4. Pair-wise comparisons for the duration of speeding

Pair-wise comparison	p-value	i-j (95% CI)
Drive 1 (no feedback section)	*NS*	
Drive 2 (after 1st feedback section)	*NS*	
Drive 3 (after 2nd feedback section)		
No feedback vs. Feedback without driver identity	*NS*	
No feedback (i) vs. Feedback with driver identity (j)	*p* = .001	59. 7 (22.86, 96.54)
Feedback without (i) vs. Feedback with driver identity (j)	*p* < .0001	65.64 (28.8, 102.48)
Between drive 1 and drive 3		
No feedback vs. Feedback without driver identity	*NS*	
No feedback (i) vs. Feedback with driver identity (j)	*p* = .008	28. 21 (6.24, 50.18)
Feedback without (i) vs. Feedback with driver identity (j)	*p* = .009	28.08 (6.11, 50.04)

3.2.6 Magnitude of speeding

The main effect of feedback type was significant for the magnitude of speeding (see Fig. 7) ($F(2, 78) = 9.69$, $p < .0001$). Pair-wise comparisons showed that drivers using the feedback with driver identity had the shortest speed deviations from the speed limit compared to those in the control group (95% CI: -2.12 (-4.06, -.18), $p = .029$) and those using the feedback without driver identity (95% CI: -2.26 (-4.2, -.32), $p = .018$). There was no significant difference in the magnitude of speeding between the control group and the group that received feedback without driver identity. Moreover, the main effect of drive and the interaction effect of feedback type × drive were not significant for the magnitude of speeding.

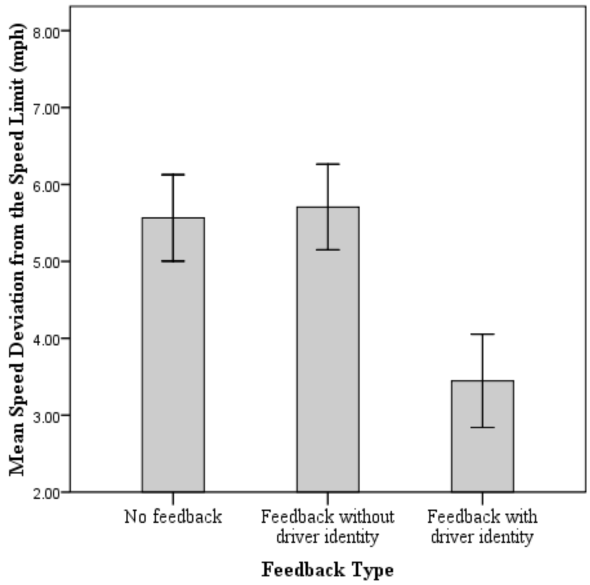

Fig. 7. A comparison of the magnitude of speeding for the three feedback systems (error bars indicate ±1 standard error)

The severity of a potential collision due to speeding was examined by taking the ratio of the deviation from speed limit and the posted speed limit. A set of mathematical equations were then developed to calculate the effect of speeding on collision severity, followed by an analysis on a new index - momentum of potential collision (see Appendix III).

3.2.7 Frequency of running a red light

There was a significant main effect of drive on the frequency of running a red light ($F(2, 78) = 10.42$, $p < .0001$). Pair-wise comparisons indicated that people ran the fewest red lights on drive 3 compared to drive 1 (95% CI: -1.43 (-2.23, -.64), $p < .0001$) and drive 2 (95% CI: -1.07 (-1.86, -.27), $p = .005$). No significant difference for this measure was found between drive 1 and drive 2. The main effect of feedback type and the interaction effect of feedback type × drive were also not significant.

3.2.8 Frequency of driving too close to a pedestrian

The main effect of feedback type was significant for the frequency of driving too close to a pedestrian (see Fig. 8) (F(2, 78) = 4.29, p = .017). However, pair-wise comparisons did not indicate any significant differences among the three feedback systems. Moreover, the main effect of drive and the interaction effect of feedback type × drive were not significant.

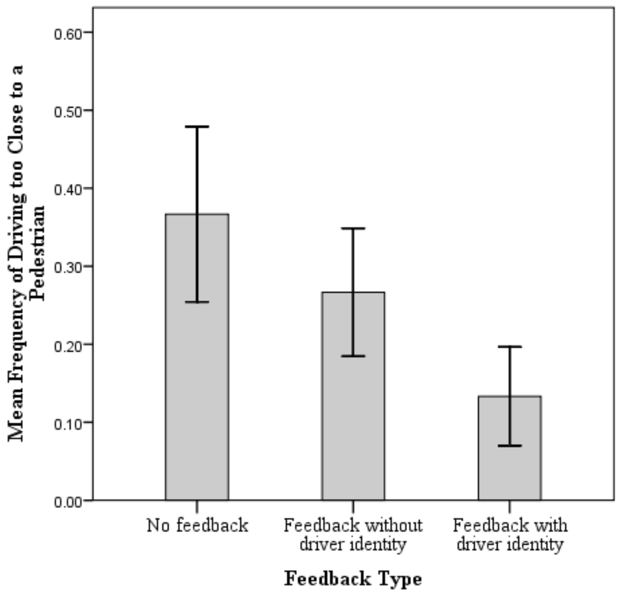

Fig. 8. A comparison of the frequency of driving too close to a pedestrian for the three feedback systems (error bars indicate ±1 standard error)

Finally, there was no significant interaction effect or main effects for feedback type or drive on the frequency of hitting a simulated pedestrian.

4. Discussion

The aim of this study was to assess the effects of a new retrospective feedback system that uses driver identity on driving variables during the performance of a simulated driving task. Feedback type served as a between-subject variable with three conditions: no feedback (the control group), feedback without driver identity, and feedback with driver identity. The feedback with driver identity displayed a driver's name, which was pre-recorded by an experimenter, in both the visual and auditory modalities at the beginning of the trip report. Several aspects of participants' driving behavior were collected. This study found that drivers gained a great benefit from the feedback system that used driver identity. Specifically, drivers using this system had the shortest time period and magnitude of central-line crossing and speeding, and they were the least likely to cross the central line, exceed the speed limit or run a red light than those who used the feedback system without driver identity and those who used the system without feedback between drive 1 and drive 3.

Although age, annual mileage and the number of years since a driver obtained his/her first valid driver license were significantly different in the three feedback groups, these three factors were all entered into the MANCOVA as covariates to control their potential effects on driving variables (Zhao *et al.* 2010). In our experimental design, drivers in each group went through the same driving condition, and all road events were evenly and randomly distributed throughout each drive without overlapping. Consequently, we believe that the different effects of two feedback systems on a driver's behaviors are a result of the design of this new retrospective feedback system, in which a driver's identity is embedded, rather than the influences of other group differences.

According to the current findings, retrospective feedback that mentions a driver's name benefits driving performance. This phenomenon might be explained by the triangle model of responsibility and the attention-eliciting value of names. The triangle model of responsibility suggests that responsibility is the psychological adhesive that joins the three elements: identity (i.e., a person's name), prescription (i.e., the rules or goals for performance) and event (i.e., the actions and consequences of performance) (Schlenker *et al.* 1994). Previous retrospective feedback without driver identity only enhances the rule-action linkage by informing a driver a set of rules that should be applied to his/her actions. In contrast, mention of a driver's name in the retrospective feedback attempts to enhance three linkages together to increase the overall strength of connections and responsibility. Specifically, when a driver's identity is mentioned in the feedback, the identity-rule linkage becomes strong because he/she cannot distance himself/herself from responsibility by arguing that the rules do not apply to him/her. Also, the identity-event linkage becomes strong because the driver has personal control over the event, such as intentionally bringing about a particular consequence of action. In short, mention of a driver's name in the feedback (and therefore the whole triangle model of responsibility) strengthens the sense of responsibility for his/her own safety and other people's safety. Additionally, when a driver's name is mentioned, he/she is more likely to attend to the feedback with considerable power and recognize that the report reflects his/her own (rather than someone else's) driving performance (McGuire *et al.* 1979, Wood and Cowan 1995, Kawahara and Yamada 2004).

Compared to the feedback system that uses driver identity, existing feedback systems without driver identity do not seem to have as great a value for reducing unsafe driving behaviors (such as speeding or crossing the central line) as one might expect. According to the current findings, there are no significant differences between a feedback system without driver identity and no feedback system for all measures except the frequency of speeding. In contrast, Donmez et al. (2008) examined the effects of retrospective feedback (without driver identity) on driving behaviors. They found that a driver benefited from feedback as they responded faster to leading vehicle braking events and looked at the road longer. The reason may result in part from the different driving scenarios. Donmez and colleagues (2008) conducted an experiment where all participants were asked to follow a leading vehicle that braked periodically. These authors were therefore focused on a safety-critical scenario where a change in behavior was needed to avoid an imminent collision. This safety-critical scenario increases the power of feedback for attracting a driver's attention and his/her acceptance of feedback. However, the present study uses a more general driving scenario in which violating a traffic law may not cause a collision. In this case, a driver may be used to some risky behaviors and does not attend to feedback (e.g., a person sticks to driving 5 mph over the speed limit and believes that he/she will not get a speeding ticket), which eventually decreases the effectiveness of the retrospective feedback and results in no difference between the driving performance of the group with traditional feedback (without driver identity) and the control group.

In this study, only the driving behavior of running a red light improved from the first to last drive as indicated by a significant main effect of drive. Drivers, on average, ran fewer red lights in drive 3 compared to drive 1 and 2 across the three feedback systems. This pattern indicates that previous retrospective feedback without driver identity (developed by Donmez and colleagues) had a benefit on the red light violation in drive 3. One possible reason for this is that red light violations are more likely to be caught and given a greater penalty in reality. In contrast, speeding violations are quite common, and a driver may not receive a speeding ticket when exceeding the speed limit by a small magnitude. Therefore, a driver may pay more attention to running a red light, which increases the effectiveness of the feedback without driver identity.

In practice, this new retrospective feedback with driver identity enhances driving performance under a general driving scenario. Although it seems more difficult for a driver to accept feedback in such a general scenario, mentioning a driver’s identity (i.e., name) in the feedback has proven to be a promising approach for improving retrospective feedback design. This method could also be applied when designing other feedback systems (e.g., concurrent and combined feedback systems) or an in-vehicle intelligent system (IVIS). Specifically, as mechanical sensors, GPS, video and other technologies become available in vehicles, the current retrospective feedback is easy to implement in the real world. These in-vehicle sensors and technologies are able to measure dynamic vehicle variables (such as speed and lance position) and environmental variables (such as the current posted speed limit). Then a global measure of performance (such as speeding) is recorded over time and displayed at the end of a trip. In addition, this new retrospective feedback can be made mandatory for a driver with a relatively poor driving history.

It is important to note that, in addition to a person’s name, other personal dimensions (such as one’s gender or occupation) are suggested to have a close connection to one’s identity, self or attention (Brewer and Gardner 2004). However, this study added only one’s name to the new retrospective feedback system due to its unique and the most salient attribute (Howarth and Ellis 1961). In fact, all aforementioned categories related to identity inevitably touch upon personal privacy. It is not valuable to add all self-relevant information to increase the effectiveness of a feedback system by sacrificing a person's personal privacy. This new feedback system provided both visual and auditory information. If a driver selects the visual feedback information, it can be seen by only them, which protects their privacy. If there are no passengers in the car, then privacy is not an issue; moreover, when there are passengers in the car, they usually know a driver's name already (the exceptions being taxi or public transportation drivers). Further, when there are passengers in the car, a driver may drive more safely, as dictated by social norm theory (Parker *et al.* 1995).

Additionally, we conducted another small experiment in which we defined a speeding violation as the exceedances of the posted speed limit by 5 mph. We found that the retrospective feedback with driver identity was still working even if we defined a speeding violation as the exceedances of the posted speed limit by a larger magnitude. Also, the feedback system did not cause drivers to monitor the speedometer more frequently than they are used to in reality (see Appendix IV).

This study has limitations that need to be addressed in future work. For example, the effects of the current feedback system with driver identity on modulating a driver's long-term driving behaviors and enhancing driving safety was not examined in the current experimental setting, as we note above. A real road testing using such a feedback system may be needed. In addition, the current study artificially designed two 1-min traffic lights so that a driver had to stop and wait, which gave time for the feedback information of the last trip to be displayed. In reality, it is impossible to always convey the feedback information at the end of a trip because the length of a trip is unknown, and a driver may forget what occurred in the last trip. Therefore, when and where to provide a driver with such feedback information, as well as the length of each trip report, needs further investigation.

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References

Allport, G.W., Willard, G., 1961. Pattern and growth in personality Holt, Rinehart and Winston New York.

Brandenburg, D.L., Mirka, G.A., 2005. Assessing the effects of positive feedback and reinforcement in the introduction phase of an ergonomic intervention. Human Factors: The Journal of the Human Factors and Ergonomics Society 47 (3), 526.

Brewer, M.B., Gardner, W., 2004. Who is this" We"? Levels of collective identity and self representations. In: Hatch, M.J., Schultz, M. eds. Organizational identity: A reader. Oxford University Press Inc, New York.

Britt, T.W., 1999. Engaging the self in the field: Testing the triangle model of responsibility. Personality and Social Psychology Bulletin 25 (6), 698.

Brookhuis, K., De Waard, D., 1999. Limiting speed, towards an intelligent speed adapter (isa). Transportation Research Part F: Traffic Psychology and Behaviour 2 (2), 81-90.

Deutsch, J.A., Deutsch, D., 1963. Attention: Some theoretical considerations. Psychological review 70 (1), 80-90.

Donmez, B., Boyle, L.N., Lee, J.D., 2007. Safety implications of providing real-time feedback to distracted drivers. Accident Analysis and Prevention 39 (3), 581-590.

Donmez, B., Boyle, L.N., Lee, J.D., 2008. Mitigating driver distraction with retrospective and concurrent feedback. Accident Analysis and Prevention 40 (2), 776-786.

Gordon, C., 1968. Self conceptions: Configurations of content. In: Gordon, C., Gergen, K. eds. The self in social interaction: I. Classic and contemporary perspectives. Wiley, New York, pp. 115-136.

Horrey, W.J., Wickens, C.D., 2006. Examining the impact of cell phone conversations on driving using meta-analytic techniques. Human Factors: The Journal of the Human Factors and Ergonomics Society 48 (1), 196.

Howarth, C.I., Ellis, K., 1961. The relative intelligibility threshold for one's own name compared with other names. The Quarterly Journal of Experimental Psychology 13 (4), 236-239.

Kawahara, J., Yamada, Y., 2004. Does one s name attract visual attention? Visual Cognition 11 (8), 997-1017.

Kuhn, M.H., Mcpartland, T.S., 1954. An empirical investigation of self-attitudes. American Sociological Review, 68-76.

Levick, N.R., Swanson, J., Year. An optimal solution for enhancing ambulance safety: Implementing a driver performance feedback and monitoring device in ground emergency medical service vehicles, pp. 35-50.

Mcgehee, D.V., Raby, M., Carney, C., Lee, J.D., Reyes, M.L., 2007. Extending parental mentoring using an event-triggered video intervention in rural teen drivers. Journal of Safety Research 38 (2), 215-227.

Mcguire, W.J., Mcguire, C.V., Winton, W., 1979. Effects of household sex composition on the salience of one's gender in the spontaneous self-concept* 1. Journal of Experimental Social Psychology 15 (1), 77-90.

Montemayor, R., Eisen, M., 1977. The development of self-conceptions from childhood to adolescence. Developmental Psychology 13 (4), 314-319.

Moray, N., 1959. Attention in dichotic listening: Affective cues and the influence of instructions. The Quarterly Journal of Experimental Psychology 11 (1), 56-60.

National Highway Traffic Safety Administration, 2009. Traffic safety facts: Overview. Department of Transportation DOT HS 810 993.

Nhtsa, 2009. Traffic safety facts: Overview. Department of Transportation DOT HS 810 993.

Parker, D., Manstead, A.S.R., Stradling, S.G., 1995. Extending the theory of planned behaviour: The role of personal norm. British Journal of Social Psychology 34 (2), 127-138.

Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A.A., Jarawan, E., Mathers, C., 2004. World report on road traffic injury prevention World Health Organization Geneva.

Phelps, J., Nowak, G., Ferrell, E., 2000. Privacy concerns and consumer willingness to provide personal information. Journal of Public Policy & Marketing 19 (1), 27-41.

Rothengatter, T., 1991. Automatic policing and information systems for increasing traffic law compliance. Journal of applied behavior analysis 24 (1), 85.

Royal, D., 2003. National survey of speeding and unsafe driving attitudes and behaviors: 2002. Volume ii-findings report. National Highway Traffic Safety Administration (NHTSA), Washington DC.

Schlenker, B.R., Britt, T.W., Pennington, J., Murphy, R., Doherty, K., 1994. The triangle model of responsibility. Psychological review 101 (4), 632.

Snyder, C.R., Fromkin, H.L., 1980. Uniqueness: The human pursuit of difference Plenum Press New York.

Toledo, T., Musicant, O., Lotan, T., 2008. In-vehicle data recorders for monitoring and feedback on drivers' behavior. Transportation Research Part C: Emerging Technologies 16 (3), 320-331.

Van Nes, N., Houtenbos, M., Van Schagen, I., 2008. Improving speed behaviour: The potential of in-car speed assistance and speed limit credibility. Intelligent Transport Systems, IET 2 (4), 323-330.

Wood, N., Cowan, N., 1995. The cocktail party phenomenon revisited: How frequent are attention shifts to one's name in an irrelevant auditory channel? Journal of Experimental Psychology-Learning Memory and Cognition 21 (1), 255-260.

World Health Organization, 2009. Global status report on road safety: Time for action. In: Disability, D.O.V.I.P. ed. World Health Organization, Geneva, Switzerland.

Zhao, G., Wu, C., Houston, R.J., Creager, W., 2010. The effects of binge drinking and socio-economic status on sober driving behavior. Traffic Injury Prevention 11 (4), 342-352.

Appendix I. The Descriptive Statistics of Dependent Variables

Table 1. The means and standard deviations for dependent variables

	No feedback (control group, n=10)			Feedback without driver identity (n=10)			Feedback with driver identity (n=10)		
	Drive 1	Drive 2	Drive 3	Drive 1	Drive 2	Drive 3	Drive 1	Drive 2	Drive 3
Frequency of central-line crossing	2.7 (1.49)	3 (1.76)	2.9 (1.29)	2.4 (.97)	3.7 (1.77)	3 (2.58)	2.4 (1.9)	1 (1.33)	.2 (.42)
Duration of central-line crossing (s)	7.5 (5.85)	8.04 (5.15)	7.39 (4.31)	7.31 (3.7)	7.93 (3.21)	7.1 (5.72)	6.24 (5.32)	1.71 (2.45)	.22 (.54)
Magnitude of central-line crossing (m)	1.07 (.17)	1.1 (.14)	1.08 (.18)	.98 (.17)	1.01 (.2)	.95 (.13)	1 (.21)	.65 (.42)	.71 (.41)
Frequency of speeding	8.3 (1.34)	7.7 (2.67)	8.2 (3.29)	6.6 (1.65)	6.4 (3.24)	6.4 (2.8)	6.6 (1.78)	4.4 (2.67)	3.9 (2.85)
Duration of speeding (s)	101.76 (29.9)	98.62 (39.89)	113.31 (20.96)	92.48 (20)	101.56 (28.06)	119.25 (39.2)	96.11 (41.53)	79.36 (45.13)	53.61 (36.55)
Magnitude of speeding (mph)	5.66 (1.82)	5.51 (2.59)	5.52 (4.53)	5.78 (2.92)	5.77 (3.19)	5.56 (3.34)	6.35 (3.05)	1.97 (2.95)	2.02 (1.86)
Frequency of running a red light	2.3 (1.42)	2.3 (1.42)	1.7 (1.64)	2.5 (.53)	2.7 (1.34)	1 (1.49)	2.7 (1.34)	1.4 (.7)	.5 (.97)
Frequency of driving too close to a pedestrian	.4 (.57)	.4 (.6)	.3 (.42)	.2 (.21)	.3 (.43)	.3 (.38)	.2 (.32)	.2 (.22)	0 (0)

Appendix II. The Descriptive Statistics of Frequency and Magnitude of Speeding

Table 2. The means and standard deviations of the frequency and magnitude of speeding for each speed limit

	No feedback (control group, n=10)			Feedback without driver identity (n=10)			Feedback with driver identity (n=10)		
	Drive 1	Drive 2	Drive 3	Drive 1	Drive 2	Drive 3	Drive 1	Drive 2	Drive 3
Frequency of speeding									
20 mph	2.3 (1.77)	2.4 (1.26)	3 (1.89)	2.2 (1.23)	2.1 (.99)	2.3 (1.06)	1.9 (1.2)	1.7 (.95)	1.2 (.92)
30 mph	2.3 (1.34)	2.3 (1.77)	2.4 (1.35)	1.9 (.88)	1.8 (.79)	1.9 (.74)	1.6 (.7)	1.4 (1.17)	1.2 (.79)
40 mph	1.7 (.82)	1.2 (.92)	1.6 (1.17)	1.3 (.82)	1.2 (.92)	1.2 (.79)	2 (.82)	.8 (.79)	.8 (.63)
50 mph	1.1 (.57)	.9 (.74)	.7 (.67)	.7 (.67)	.7 (.67)	.6 (.52)	.6 (.52)	.3 (.48)	.4 (.52)
60 mph	.9 (.57)	.9 (.88)	.5 (.53)	.5 (.53)	.6 (.7)	.4 (.52)	.5 (.53)	.2 (.42)	.3 (.48)
Magnitude of speeding (mph)									
20 mph	9.63 (2.15)	8.83 (3.13)	9.09 (3.75)	9.98 (2.71)	8.96 (3.69)	9.13 (4.2)	9.71 (3.82)	2.76 (2.58)	3.03 (2.62)
30 mph	6.93 (2.52)	7.72 (3.18)	7.47 (3.14)	8.28 (2.09)	8.45 (4.33)	8.37 (3.92)	7.49 (2.7)	2.56 (2.46)	2.53 (2.14)
40 mph	6.28 (2.44)	5.34 (3.02)	5.59 (3.79)	5.72 (3.04)	5.77 (3.07)	5.27 (2.7)	6.95 (2.66)	3.01 (2.81)	2.26 (2.12)
50 mph	3.41 (1.52)	2.95 (3.78)	3.12 (4.73)	3.39 (3.82)	3.02 (2.69)	3.24 (3.82)	4.87 (3.66)	.89 (.87)	1.32 (1.6)
60 mph	2.04 (1.74)	2.71 (3.37)	2.36 (4.11)	1.52 (2.66)	2.64 (1.92)	1.8 (2.2)	2.73 (2.81)	.63 (.93)	.97 (1.19)

Appendix III. The Development of Momentum of Potential Collision

In physics, the severity of a collision is directly related to the momentum (p), which is the product of the mass (m) and an object's velocity (v) regardless of the collision position:

$$p = m \times v \tag{1}$$

Because the velocity is equal to the current speed limit plus the speed deviation (Δv) from the limit (v_{sl}), the momentum can be further developed in Equation 2:

$$p = m \times (\Delta v + v_{sl}) \tag{2}$$

If we take the ratio ($R = v/v_{sl}$) into account, the momentum is expressed by Equation 3:

$$p = m \times v_{sl} \times (R + 1) \tag{3}$$

According to Equation 3, collision severity cannot be determined by either v_{sl} or R independently. Therefore, we developed a new equation to describe the total potential severity of the crash (which we call the Momentum of Potential Collision) as a function of the magnitude of speeding (Δv_i), speed limit (v_{sli}) and frequency of speeding (f_i), and n was the number of speeding:

$$p_{total} = \sum_{i=1}^{n} m \times (\Delta v_i \times f_i + v_{sli}) \qquad (i = 1, 2, \ldots n) \tag{4}$$

We performed the analysis for this new measurement (assuming that the vehicle weight is 1200 kg). The main effect of feedback type on the magnitude of speeding was significant (see Fig. A1) ($F(2, 78) = 3.28$, $p = .046$). Pair-wise comparisons showed that feedback with driver identity led to the smallest momentum compared to no feedback (95% CI: -26.01 (-47.6, -4.43), $p = .014$) or feedback without driver identity (95% CI: -23.94 (-45.52, -2.35), $p = .026$). There was no significant difference in momentum between the control group and the group of feedback without driver identity. Neither the main effect of drive nor the interaction effect between feedback type and drive on momentum was significant.

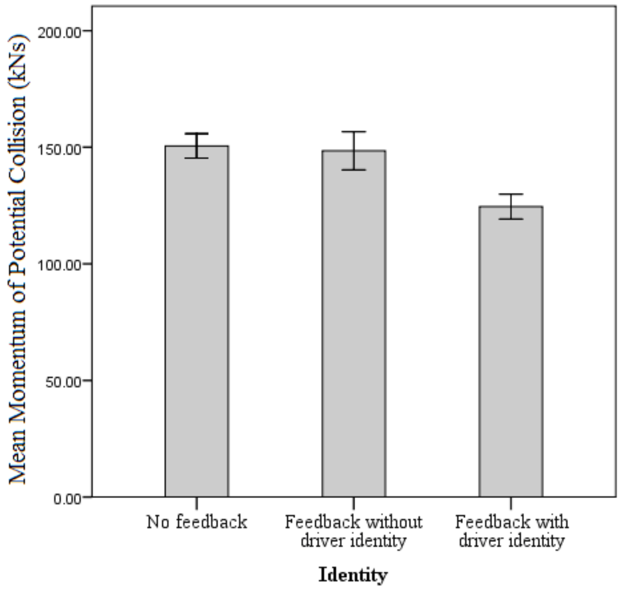

Fig. A1. Mean momentum for the three feedback systems (error bars indicate ±1 standard error)

Appendix IV. A New Experiment and Results

We conducted one more experiment (n=12; 6 male and 6 female) with the same experiment settings and driving tasks. Their average age was 28 years (range = 22-35, SD = 4.45). Six drivers were not provided feedback information (control group) while the other six drivers (feedback group) were provided feedback with driver identity given two types of speeding criteria: 1) The original speeding criteria (used the posted speed limit; see the main text) and; 2) The new speeding criteria (used the posted speed limit plus 5 mph). These two criteria's run order was counterbalanced.

Compared to the control group, drivers in the feedback group with the new speeding criteria improved their driving performance in terms of the frequency of speeding (Mann-Whitney Test $U = 2.0$, $Z = -2.58$, $p = .009$), duration of speeding ($U = 3.0$, $Z = -2.402$, $p = .015$), and magnitude of speeding ($U = 1.0$, $Z = -2.722$, $p = .004$) from the first to last drive. There were no significant differences between the feedback (with driver identity) that used the original speeding criteria and the feedback that used the new speeding criteria in the frequency of speeding ($U = 14.5$, $Z = -.561$, $p = .589$), duration of speeding ($U = 12.0$, $Z = -.961$, $p = .394$), and magnitude of speeding ($U = 17.0$, $Z = -.16$, $p = .937$). This indicated that the feedback system with driver identity was still working even if we defined a speeding violation as the exceedances of the posted speed limit by a larger magnitude.

Frequency and duration of eye fixation on the speedometer were also recorded and measured by an eye-movement recording system in this new experiment. No significant differences were revealed between the feedback with the original speeding criteria and the control group (no feedback) in terms of frequency of speedometer checking ($U = 15.0$, $Z = -.48$, $p = .699$) or duration of speedometer checking ($U = 16.5$, $Z = -.245$, $p = .818$). Similarly, there were no significant differences between the feedback with new speeding criteria and the control group in terms of frequency of speedometer checking ($U = 15.5$, $Z = -.401$, $p = .699$) or duration of speedometer checking ($U = 11.5$, $Z = -1.063$, $p = .31$). These results suggested that drivers using the retrospective feedback did not check the speedometer more frequently than those who did not use the feedback system. In other words, the feedback system does not distract drivers in checking the speedometer.