

“Likes” and “Dislikes” on the Road: A Social Feedback System for Improving Driving Behavior

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ABSTRACT

Driving is a social activity, and therefore driving is not only a matter of skills but also of emotion. Numerous studies show that aggressive driving makes a significant contribution to traffic accident involvement. In previous research, a concept based on Driver to Driver communication employing location-based services was proposed that enables road users to express their disapproval and appreciation of others' driving behavior. In the current study, a complete prototype based on this concept, which enables participants to send and receive feedback while driving and review their behavior afterwards, was developed. The acceptance and influence of driving behaviour of this concept were investigated in a driving simulator. It was found that the system positively influenced people's driving behavior and was accepted by most participants.

Author Keywords

Connected car; Driver-to-driver communication; Social computing.

ACM Classification Keywords

H.4.m [Information Systems Applications]: Miscellaneous; H.5.2 [Information Systems Applications]: User Interfaces-user-centered design

INTRODUCTION

Drivers need to coordinate with each other to share the infrastructure [1]. But when one sits in the “iron cage”, there are only few channels to deliver information on the road. Moreover, the design of cars depersonalizes other drivers [2]. These facts have been shown to contribute to aggressive, selfish and anti-social driving behavior [3]. The advent of everywhere available connectivity and the broad penetration of social network services provide opportunities for changing this situation [4]. The relationship between drivers

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on the road may gain more transparency, enabling social information to pass through the steel shell of the cars and creating opportunities to reduce anonymity and strengthen empathy.

Previously, a system based on Driver to Driver communication employing location-based services was proposed, which enabled users to express appreciation and disapproval towards nearby drivers about their polite and impolite driving behavior by gestures [5] and to receive others' evaluation through audio and visual feedback as well [6]. In the current study, a complete prototype based on this concept, which enables participants to send and receive feedback while driving, and an interactive website that enables participants to review the situations in which they received and sent feedback, were integrated to investigate the acceptance of this system and whether it exerted positive influence on social driving behavior.

Aggressive driving

Aggressive driving may be defined as [7] any driving behavior that intentionally endangers others psychologically, physically, or both. Evidence both from the literature and news headlines suggests that aggression occurs among motorists on a regular basis [8]. A survey by the Automobile Association Britain shows that 90% of respondents reported that they had been involved in a ‘road rage’ incident in the previous year [9]. In a recent diary study, Underwood et al. [10] found a link between anger and subsequent near accidents. It was also reported by Parker et al that, over and above other variables, intentional aggressive driving behavior makes a significant contribution to involvement in traffic accidents [11].

Causal model of aggressive driving

Understanding the causes of aggressive driving is essential for effective intervention. Therefore, a variety of explanatory models of aggressive driving have been proposed [12, 13]. However, insufficient attention is paid in each of these models to the distinction between the interpretation of “triggering events” and the response to those events. In the report of drugs and crime prevention committee of the state of Victoria, Australia [8], a more complete model was proposed (Fig.1). In this model, all aggressive driving behavior starts from the “Trigger”, such as being stuck behind a slow driver. Acts of violence are precipitated by the “triggering event”, but more important is the interpretation

of the triggers. Four kinds of factors, which are person-related, situational, car-related and cultural factors, influence not only on the interpretation of the “Trigger” but also people’s response to the “Trigger”. At last, the outcome (commit aggressive behavior or not) is decided by all the factors.

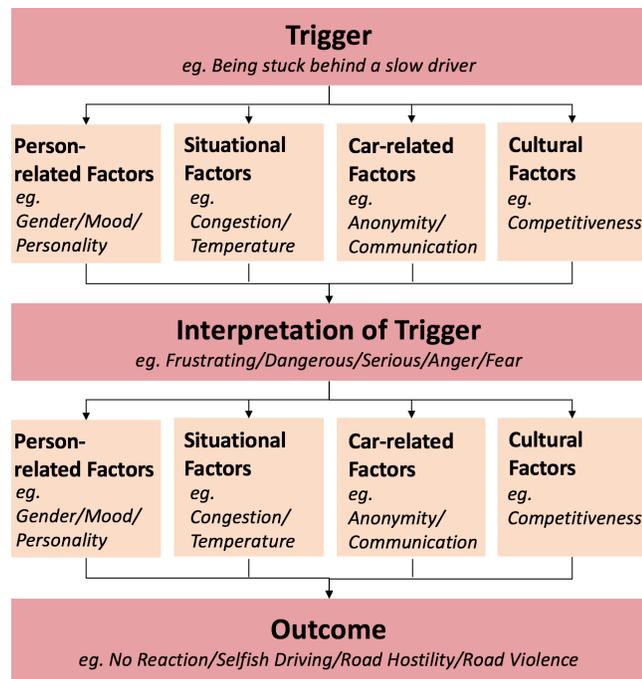


Figure 1. Causal model suggested by the report of drugs and crime prevention committee of the state of Victoria, Australia.

Car-related Factors of aggressive driving

Some of the factors influencing aggressive driving are Car-related factors. Two aspects of the car itself that play a part in causing the phenomenon of aggressive driving are mostly mentioned in previous research [14, 15, 16]: communication difficulties and anonymity on the road.

Communication difficulties

Aggressive behavior may occur because of the difficulties road users have in unambiguously communicating with each other [8]. Firstly, the physical distance between road users makes it difficult to obtain full information about an action. Secondly, problems may arise because of the difficulty drivers have in communicating their anger or frustration to other road users’ behavior. The message as communicated through a gesture, the horn or flashing headlights, may not be seen or heard by the intended recipient or even be misunderstood. The difficulty in conveying disapproval and expressing their emotion can make drivers believe that the only way to get their message across is by acting violently. Thirdly, the isolating nature of cars can also make it difficult to apologise for errors made while driving.

Anonymity

The vehicle design (metal frames, tinted windows) provides a feeling of anonymity [8]. From the perspective of

perpetrators, the anonymity offered by the structure of cars, as well the ease with which drivers can usually escape from the scene of violence, has been widely cited as one of the main factors influencing the decision to act violently on the road [18, 19]. The physical structure of vehicles induces a tendency to depersonalize other drivers. For example, instead of thinking of another driver as a mother of young children on her way to visit her dying father in hospital, they may simply be thought of as a “blue Fiesta” being driven by a total waster [15].

RELATED WORK

Mitigating aggressive driving by connectivity between vehicles

Many attempts were made for addressing the problem of aggressive driving from the perspective of car-related factors, as it is more feasible for technical solutions comparing with other factors.

There were several attempts to enhance social communication by conveying messages physically. In 1990, a Belgian insurance company aimed at reducing road aggression by giving their members two plastic hands – a red “I’m sorry” hand and a green “go ahead” hand – to be used when a driving error was made [8]. At the 2001 Tokyo Motor Show [21], Toyota displayed a car capable of warning other drivers of the driver’s mood by the color of LED lights on the bonnet. The light display was intended to warn people how to react to approaching vehicles. However, using a physical communication method limits both the quality and quantity of information.

With everywhere available connectivity and the broad penetration of social network services, the communication between drivers on the road may change fundamentally. Firstly, quality and quantity of information could be transferred without any limitation, which may reduce the misunderstanding. Secondly, information could be delivered to a specific driver, without distracting drivers who are not concerned. Finally, staying anonymous becomes difficult, the behavior of road users would be traced by sensors, evaluated by systems and stored in the cloud.

This trend has drawn attention by both the industry and academia. For example, Lexus unveiled the concept car LF-FC at the 2015 Tokyo Motor Show [17], which enables the driver to send a pre-set message such as “After you” to nearby drivers by gesture. Schroeter et al explored the possibility of reducing driver aggression by humanizing cars and representing other drivers’ eye gaze and head pose through overlaid human-like avatars [3]. The experiment in a driving simulator showed that their approach has the potential to improve social interactions between drivers, allowing clearer collective decision making between road users and reducing the incidence of antisocial behavior in the road environment. Although some attempts for reducing aggressive driving by the latest V2V technology were proposed, so far, there is no systematic solution and related

validation to address this problem under a theoretic framework.

Concept and rationale

According to the intervention strategies to counter aggressive driving mentioned above, in this paper, a social feedback system for improving driving behavior by enhancing communication between drivers is suggested and an experiment was conducted, for the purpose of exploring the possibility of solutions based on new technologies. The system was based on the concept of “Liking other drivers’ behavior” which emerged from interviews with 22 people [22]. The concept suggested “You can give other drivers around you a “Like” or a “Dislike” according to their driving behavior”.

This concept enlarges the communication channel between drivers. “Dislike” could be used to express disapproval and the sender knows that it would be received by the perpetrators as a reprimand, which may prevent further acts of violence. “Like” could be used to express the appreciation of good driving behavior, which may cultivate polite driving habits.

Beside real time feedback on the road, afterwards feedback might also effective. Birsen et al proposed a system for reducing driving distraction, which not only provided real time feedback, but also retrospective feedback presented at the end of a trip [23]. Their result showed that combined feedback (real time and retrospective) is more effective than only real time feedback. Shannon et al also suggested an afterward feedback system, which coached drivers on their performance and encouraged social conformism by comparing their performance to peers [24]. They argued that real time feedback is more obtrusive and afterwards feedback is more acceptable. As a result, afterwards feedback was also adopted by this system.

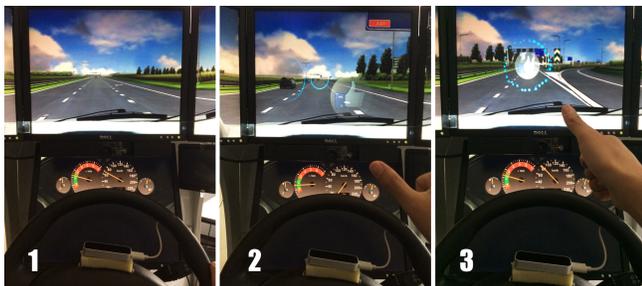


Figure 2. Procedure of “Liking”. Step 1: Normal driving status; Step 2: Stick out the thumb; Step 3: Point at the target and straighten the arm.

DESIGN AND HYPOTHESES

Design

A prototype based on this concept, which enables participants to send and receive feedback while driving and to review the feedback afterwards, was designed, developed and integrated in a driving simulator, for the purpose of investigating the acceptance of this system and whether it exerted positive influence on social driving behavior.

Sending Feedback

A gesture-based interaction system for this concept had been evaluated through a user test deploying a prototype integrated in a driving simulator [5]. The user test results demonstrated that people held a positive attitude towards the gesture-based interaction. The flow of the “Like” operation can be divided into three steps (Fig.2):

- Step 1: The driver is in the normal driving status and the system is standby.
- Step 2: The driver wants to give another person’s driving behavior a “Like”. He releases one hand from the steering wheel, sticks out the thumb to give the target car a “Like”.
- Step 3: The driver points at the target car with his thumb and straightens his arm to confirm the “Like” operation.

Receiving Feedback



Figure 3. Two states of the interface of receiving real time feedback. 1. When no evaluation is received, the interface shows how many “Like/Dislike” the participant already received. 2. When the participant receives a “Like/Dislike”, the corresponding icon enlarges and fills the screen.

Later, an 8” screen in front of the steering wheel was set up on the driving simulator which enabled the user to receive others’ feedback in real time. The interface has two states (Fig.3):

- State 1: The interface shows the amount of “Likes” and “Dislikes” received.
- State 2: When the driver receives a new “Like” or “Dislike”, the corresponding icon enlarges and the screen is filled with the corresponding background color, which provides peripheral information, along with audio feedback.

Reviewing Afterwards

In in-depth interviews about this system participants suggested to add the opportunity to review the feedback after the ride. As a result, in this study, an interactive website, which enabled participants to review the scenarios in which they received and sent “Likes/Dislikes” feedback was implemented.

The 3D interactive map was programmed in javascript with the library “Threejs” (<http://threejs.org>). It enabled participants to observe the map by zooming in/out, rotating

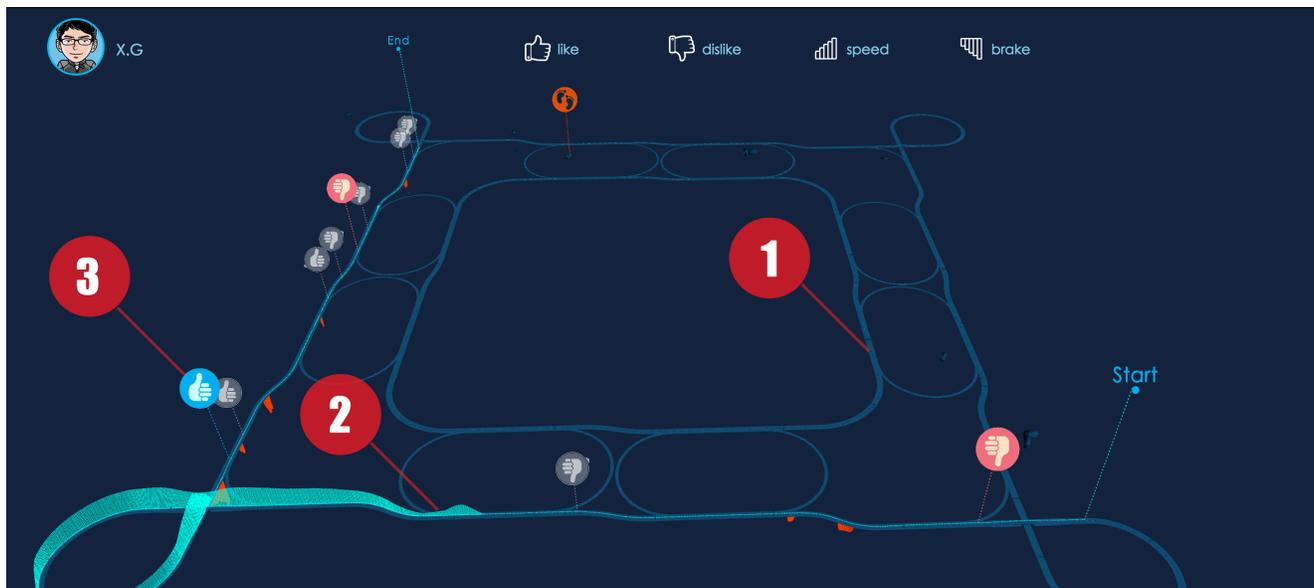


Figure 4. layers of information on the map: 1.Model layer, 2.Driving data layer, 3.Feedback layer and 4.Video Layer

and locking their perspective on a specific target. Three layers of information were presented on the map (Fig.4):

1. Model layer: 3D model of the driving scenario (imported from the driving simulator), including roads, lanes, signs, important buildings etc.
2. Driving data layer: Track of driving, start point, end point, points of speeding and hard braking.
3. Feedback layer: Points where they received and sent "Like/Dislike".



Figure 5. Video layer: participants could click "Like/Dislike" icon to move the perspective center to this point. Then click the video icon review the video record.

A fourth layer was added, enabling Participants to "lock on" one of the "Likes/Dislikes" icon to review a video record of the situation (Fig.5).

Hypotheses

We tested 3 hypotheses:

- H1: The system has a positive influence on driving behavior. It is predicted that the participants' driving behavior improves according to observed driving performance (Likes/Dislikes received) and subjective data of driving performance.

- H2: Afterwards reviewing exerts influence on driver's later driving behavior. It is predicted that driving behavior is different between drivers with afterwards feedback and drivers without afterwards feedback.
- H3: People hold a positive attitude towards this concept.

EXPERIMENT

Equipment

The GreenDino's driving simulator system included a steering wheel, seat, pedals, gears and three 42" screens. When the participants were driving in the simulator, the driving image was also displayed on the screen of a laptop in another room, enabling observers acting as other drivers" to observe the driving behavior and giving evaluative feedback on participants' driving behavior. If the observers clicked the "Like" or "Dislike" icon on their screen, the corresponding icon was shown on an 8" screen in front of the participant, informing him through visual and sound feedback. For capturing "Like/Dislike" the participant sent, a LeapMotion sensor was set up in front of the steering wheel, which recognized the thumbs up/down gestures of participants and provided corresponding audio feedback (Fig.6).

Scenario

A highway scenario that included curves, viaducts, entrance ramps and exit ramps, along with high density of traffic was created for testing. The total duration of the scenario was 8 minutes. Seven of the other vehicles in the scenario were programmed to behave impolitely in three ways: Two drivers drove very slowly on the overtaking lane, three changed lane suddenly and two drivers merged in from ramps aggressively.

Participants

A between groups test involving 30 participants was conducted. The participants were divided into three groups. In order to get equal groups we balanced: driving experience,

age and gender. Each group contained five male and five female participants. The average age of the first group was 26.6 (SD 3.4), the second group 25.6 (SD 2.9) and third group 27.1(SD 2.7). They had quite equal driving experience, measured in the amount of years that the participants had a driver's license: the first group was 6.7 (SD 3.4), the second group 6.8 (SD 3.2) and the third group 6.6(SD 3.3). We recruited young people (18-35) as they are familiar with the concept of "Like" and "Dislike" from social media such as Facebook. Also they were familiar with "new technologies" that allow connectedness between drivers.



Figure 6. Driving simulator which integrating LeapMotion for participants to send feedback and an 8" screen to receive feedback.

Observers and criteria of evaluation

Two observers, who were not related to this research topic, acted as "other road drivers" evaluating the participants' behavior from a monitor. The observers were not aware of which condition the participants were allocated to. Observers gave "Like" and "Dislike" in a separate room without seeing participants' face. The standard of negative and positive evaluation was created based on "20 most annoying driving behaviors" in the survey conducted by the Consumer Reports National Research Center in January 2012 [26]. The observers applied the following rules:

For giving "Dislike":

- Tailgating
- Cutting off other cars
- Speeding and swerving in and out of traffic
- Not letting others merge into a lane
- Not using turn signals
- Driving slowly in the passing lane
- Overtaking from right side (which is prohibited in the country where this research was conducted)

For giving "Like":

- Giving space to others merging into highway by changing to overtaking lane
- Reducing speed gently
- Letting fast car overtake
- Keeping distance to front vehicle when they reduce speed

Besides the observers' judgments, an objective assessment of the driving performance was conducted. To this end, GreenDino's driving simulator generated 41 kinds of basic driving quality scores by analyzing the driving behavior (sampled at a frequency of 10 Hz) driving behavior [20]. Five scores were chosen for evaluating the driving performance (further explained under Results).

Procedure

The participants of group 1 had two driving sessions and were provided with complete feedback (both real time feedback and afterwards feedback). Group 2 had two similar driving sessions with only real time feedback. The participants of group 3 also had two similar driving session but without sending, receiving and reviewing feedback at all. The driving performance results in the second session of group 1, group 2 and group 3 were compared to verify the hypotheses (Fig 7).

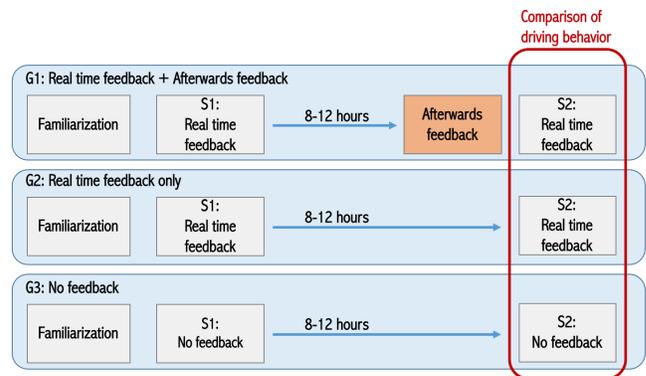


Figure 7. Procedure of testing between 3 groups.

For the first session, each participant was invited to drive in the simulator in a free driving mode for 30 minutes with the purpose of getting familiar to the driving simulator. Then she/he was introduced to the concept of the driving behavior feedback system. Furthermore they were asked to practice sending evaluation to other cars by posting thumbs up and thumbs down in front of the LeapMotion.

Then the participants were asked to assume themselves driving under this condition: *You are driving to meet a client in an unfamiliar city. It's a little late. Unfortunately, you encounter heavy traffic on the highway, so drive as fast as you can until reaching the church, which is the destination of the journey. You can send "Like/Dislike" to others and may receive others' "Like/Dislike" as well.* After that, each participant drove on the simulator for 8 minutes.

There was an 8-12 hour interval between session 1 and session 2, allowing drivers in group 1 to log in to the website to review their driving performance after the journey and start driving again.

For the second session, all participants were asked to drive in the same scenario again. Before the second session participants in group 1 were asked to review their last driving by log to the website to see their performance and watching

the video clips (Fig.8). The experimenter sat together with them and helped to explain the reasons for each “Like/Dislike” they got. There was no reviewing session for group 2.

RESULTS

Objective driving performance was measured in two ways: 1) Numbers of “Likes” and “Dislikes” received and 2) Driving quality as measured by the simulator.

Numbers of “Likes” and “Dislikes” received

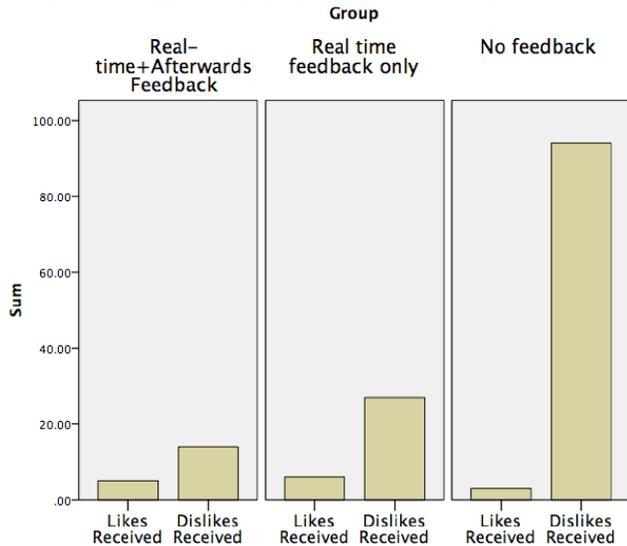


Figure 9. Histogram of “Dislikes” participants received (summed across participants).

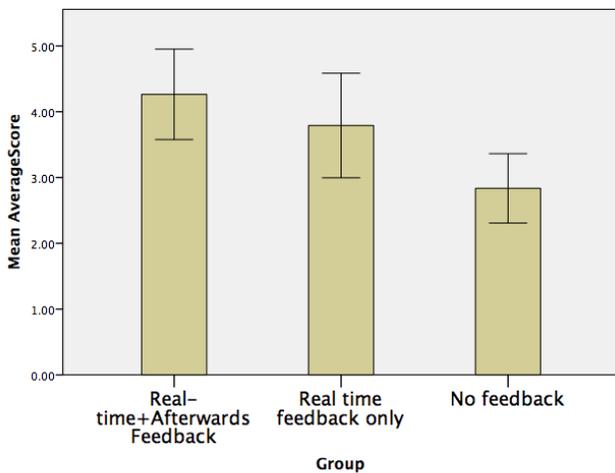


Figure 10. Mean of average score of driving performance.

The number of “Likes” and “Dislikes” received in three conditions are shown in Fig 9. For group 1 (with real-time and afterwards feedback), 5 “Likes” (Mean per participant = 0.50, SD = 0.52) and 14 “Dislikes” (Mean = 1.40, SD = 1.17) were received in total; For group 2 (with real time feedback only), 6 “Likes” (Mean = 0.60, SD = 0.69) and 27 “Dislikes” (Mean = 2.70, SD = 2.40) in total; For group 3 (no feedback), 3 “Likes” (Mean = 0.30, SD = 0.48) and 94 “Dislikes” (Mean = 9.40, SD = 7.37) in total. Because of the low number of

Likes, no statistical test was conducted. As the “Dislikes” were not normally distributed, a Kruskal-Wallis test was conducted. Results showed that there was a significant difference ($p = 0.001$) in “Dislikes” received between the 3 groups. Post-hoc tests were conducted applying Mann-Whitney U tests, adjusting the significance level applying Bonferroni correction. Results showed that there was a significant difference in “Dislikes” received between group 1 and group 3 ($p < 0.001$, $r = 0.524$) and group 2 and group 3 ($p = 0.005$, $r = 0.245$) but no significant difference between group 1 and group 2: participants in group 1 and group 2 received fewer Dislikes than participants in group 3.

Driving quality

A general score was calculated by averaging five kinds of driving quality scores generated by the driving simulator. As these scores were related to safe driving performance and the criteria of “20 most annoying driving behaviors”, and were selected for objective evaluation of social driving performance. They are: Keeping safe speed, which measures speeding behavior (above 10% of speed limitation); Position inside lane, which measures incorrectly using the road; Smooth braking, which measures tailgating and driving too fast; Smooth steering, which measures aggressive cutting in, swerving in and out of traffic; And keeping distance to other cars, which measures tailgating and aggressive cutting in. Each value ranges from 0 to 10 and a higher value indicates better performance. ANOVA was conducted to compare the objective social driving performance among 3 groups. Results showed that there was a significant difference in the average driving performance score, $F(2,27) = 6.684$, $p = 0.004$. Post Hoc comparisons showed that there was a significant difference between group 1 and group 3 ($p = 0.001$, $r = 0.641$) and group 2 and group 3 ($p = 0.452$, $r = 0.452$), but there was no significant difference between group 1 and group 2 ($p = 0.274$). The results indicate that this system significantly influenced driving behavior, no matter there was only real time feedback or real time feedback combined with afterwards feedback. Adding the afterward feedback on real time feedback did not significantly influence the driving behaviour. From the perspective of each item of social driving performance separately, Keeping safe speed ($p = 0.11$, $r = 0.535$) and Position in lane ($p = 0.13$, $r = 0.525$) was significantly different between group 1 and group 3. There was no significant difference of other items.

Correlations between observed performance, objective performance and sent “Like/Dislike”

Spearman’s rho correlation was calculated between observed performance and received “Dislikes”. There was a significant negative correlation ($\rho = -0.531$, $p = 0.003$) between the number of “Dislikes” participants received and the average driving performance generated by the simulator, which confirmed the consistency between the observations and the performance data: The worse they drove, the more dislikes they received. Because of the small number of Likes, no correlation was calculated between received “Likes” and driving performance.

Semi-structured Interviews

In order to get further feedback about this system, semi-structured interviews were conducted after the second driving session. We used affinity diagramming to process the raw data. Remarks concerned the following topics:

- Overall concept
- Real time feedback
- Afterwards feedback
- Distraction

Below we discuss the main findings per topic:

Overall Concept

In general, participants appreciated the communication between the cars, but argued that the focus should be more on communication and suggestion, (e.g. telling others that I am in hurry or apologizing) rather than judging someone's behavior. As one participant argued: *"Like and Dislike is very binary, I would like to be able to communicate more expressively to others."* Four participants mentioned that they wanted to use "Like" for an apology to other cars when they made mistakes.

Real Time Feedback

All the participants thought that sending "Dislike" attenuated their anger. *"I feel released after sending a 'Dislike'",* a participant said. While analyzing the amount of "Like/Dislike" that the participants gave, it appeared that they are more inclined to give 'Dislikes'. One reason for this could be that the driving situation may have resulted in more "Dislikes". As a participant said: *"There are very few reasons to give a like on the highway"*.

Most participants (18 of 20) said it was not comfortable to receive "Dislikes", although none of them felt anger about received "Dislikes". *"I know it was my fault."* one said. Regarding giving and receiving real time feedback the majority of participants said they missed the ability to be more expressive. Also from the comments about giving "Dislikes", participants would like to give more constructive feedback like: *"Look in your back mirror"* or *"Next time pay more attention"*. A more expressive feedback to give and receive would be a good addition to the system in order to have more freedom in how to communicate. Some participants mentioned occasions when they took the feedback into account: *"I slowed down when other cars would be around"* and *"I realize that I bother people"*.

Afterwards Feedback

In general, most participants in group 1 (7 of 10) were interested in the moments they received feedback. The videos were appreciated in order to get back to the context in which they had received feedback, especially when it was combined with data visualization of speeding and braking.

One participant preferred the afterwards feedback: *"It allows me to take a step back from the emotions and feelings I had while driving and allows me to look objectively to my own driving"*, while others argued: *"I do not see any reason to*

look back at the offline feedback as I know what I did wrong" and: *"direct feedback is much more useful as I know at that moment I directly can learn from it, and otherwise will have forgotten what it was about"*. Two participants suggested providing an average number of "Likes/Dislikes" that people received on this road for reflection. Another interesting comment was that some participants would like to share their "Likes" on social network.

Distraction

Generally, the usability of the real time feedback system was considered acceptable. Most participants (16 of 20) said that the interaction of giving feedback did not distract them from driving. But three participants argued that it was hard to hold the steering wheel by one hand when sending a "Like/Dislike", especially in curves. As regards receiving feedback, all participants said the message was clear especially with audio feedback: *"Audio feedback is great, I don't need to lower down my head to look at the screen"*. However, distraction came from the psychological "impact" when they received "Dislikes". Six of twenty mentioned that when they got negative feedback, they felt nervous. *"If negative feedback, give afterwards"* a participant said.

DISCUSSION AND CONCLUSION

In this study, we investigated how drivers feel about receiving feedback on their driving behavior from other drivers. The following hypotheses were examined:

- H1. The presence of this system has a positive influence on driving behavior. The results supported H1. Participants with feedback drove more socially than the participants without any feedback according to both observed behavior and objective driving performance.
- H2. Afterwards reviewing exerts influence on driver's following behavior. There was no sufficient evidence to support H2. Afterwards feedback was not more effective than real-time feedback only.
- H3. People hold a positive attitude towards this concept. Results of the semi-structured interviews supported H3, although some participants had doubts about the function of judging others' behavior.

Generally, the system positively influenced people's driving behavior. It enlarged the communication bandwidth between drivers by providing binary feedback. "Dislike" attenuated the anger of senders and reminded the receivers that they bothered others. "Like" provided positive feedback for receivers for cultivating polite driving behavior. However, enhancing social communication only by judgment information seemed insufficient. There should be some expressive way of communication, such as apology. Furthermore, contextual information could also be included, such as showing "I am in a hurry", in order to explain or justify offensive behavior.

Afterwards feedback enabled drivers to review their "Likes/Dislikes" for improvement on their driving behavior. However, it seemed that people lacked motivation to do that.

A peer pressure such as showing average “Dislikes” people received on this road was suggested. Finally, this study generates helpful insight for intervening aggressive driving behavior from car-related factors perspective.

The current system did not address reducing anonymity and creating empathy among drivers. Although privacy is an issue in the context of driving [22], there is some space of “social transparency [25]” such as showing that the front driver is an elderly person or even a “Stars War” fan. This could also influence people’s attitude toward others. This will be taken up in future research.

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