Design of Vehicle-to-Vehicle Communication System for Chinese and German Drivers

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Abstract. Vehicle-to-Vehicle communication system is a designed to deal with the growing car accidents during the recent years. It allows drivers to communicate with each other visually and aurally. This study investigates the relationships between the communication styles of Vehicle-to-Vehicle system and drivers' driving behaviors in Chinese and German cultures. Results showed that all three styles (text, voice and emoticon) have significant effect on Chinese drivers, but only emoticon has effect on German drivers. And Chinese drivers like voice most while German drivers like emoticon most. Cultural differences, privacy issues and driving experience are discussed to explain the results.

Keywords: Communication styles · Emotion · Attitude · Cultural difference

1 Introduction

Roads become congested and accidents have steadily risen during the recent years. Research has shown that driving risks arise from the drivers themselves, the surroundings and technical issues regarding their vehicles. Offensive driving behavior from other drivers may induce negative driving emotion, influence driving behaviors and decrease driving performance. Therefore the communication between drivers has drawn a lot of attention.

New technologies constantly arise to cope with those problems. One example is Vehicle-to-Vehicle communication system (also abbreviated as V2V system), which allows drivers to know the exact position and speed of surrounding vehicles and aims to assist drivers by transmitting information between vehicles.

There are different communication styles between drivers. Studies show that different styles may cause different effects on receivers' emotion and attitude, and influence drivers' driving behaviors. Therefore, this paper aims to investigate the relationship between the communication styles of V2V system and driving behaviors in different cultures.

P.L.P. Rau (Ed.): CCD 2015, Part II, LNCS 9181, pp. 121–128, 2015.
DOI: 10.1007/978-3-319-20934-0_12

2 Literature Review

2.1 Driving Behavior Model

Most of driving behavior models are deduced from TPB model [1], which has long been used to explain the reason of some aggressive driving behavior like over-speeding and drunk driving [2, 3]. This model shows that attitude contributes to certain behavior. This is also proved in a study that a high-risk perception lead to a high risk-driving attitude, which is closely related to higher tendency of risky driving [4]. Therefore attitude is a significant predictor for potential driving behavior.

Some studies scientifically proven there is a connection between emotions and driving skills or performance. Anger leads to decreased subjective safety level and degraded driving performance; while happiness leads to degraded driving skills [5]. And driving anger is a very important emotion for drivers, since it leads to stronger acceleration and higher speed [6], and reduces risk perception [7]. Furthermore, one study showed there is no significant difference between traffic-related and traffic-unrelated emotions [4].

In conclusion, driving attitude and emotion can be changed by short sudden stimulus and can be regarded as two main predictors for driving behavior.

2.2 Effects of Communication Styles

There are three common communication styles. The first one is visual stimulus including text, images and video. It is a traditional communication style used in vehicle systems to transmit messages, like the navigation system, the instrument panel, and the in-vehicle control systems. Many psychological studies have proved that text and image can induce the receiver's emotions. Studies regarding vehicles also proved this. It is indicated the process of text in and output may cause the drivers' distraction [8], and negative distractions reduced lateral control and slowed driving speed [9]. Besides, some studies also focus on the relation of images and visual stimulation to driving performance. A direct effect was measured by Tricka et al. [10]. Their study discovered a decrease in driving performance for negative and an increase of driving performance for positive images. So visual stimulus is a useful way to influence driving behaviors. And visual stimulus can be separated into different levels, since images transmit richer information than text.

Another communication style is audial stimulus, including sound, voice and telephone. For example, the new navigation system, taxi broadcasting station, and some cars can play music automatically to correspond to the drivers' emotion. Studies showed that happy music had the strongest effect on the driver that their mean speed decreased and their lateral control deteriorated; while sad music makes them drive slower and keep their vehicle in its lane [11]. But another study in Spain showed a contrast result that a (not emotional) beep reduced the frequency of accidents in the upcoming risky situation, while the emotional cues did not [12]. This means that not all emotional stimulus have an effect on driving behaviors.

The third communication style is haptic stimulus, including vibration, temperature, and so on. For example, some new cars can adapt the in-car temperature according to drivers' emotion to help drivers calm. Some cars used shaking chairs to awaken drivers so that it can prevent drivers from sleeping on the road. But few studies have shown the connection between haptic stimulus and driving behavior.

In conclusion, there are different communication styles: visual stimulus, audial stimulus and haptic stimulus. And studies have shown connections between driving behaviors and visual or audial stimulus.

2.3 Cultural Difference in Driving Behavior

Cultures can be generally divided into high-context cultures and low-context cultures. Studies have shown that human decisions and behaviors can be influenced by different cultures [13]. This conclusion can be also used in the vehicle domain. Studies showed significant cultural differences in driver self-assessment among U.S., Spanish, and West German drivers, for example, U.S. drivers assessed themselves as safer than West German and Spanish subjects [14]. A similar study was conducted again in China. The results indicated that Chinese drivers and German drivers have a different perception of driving anger that Chinese drivers showed lower angry level than German drivers. Besides, Chinese drivers will get higher angry level as their age grows, while German drivers are in the contrast [15].

Therefore, culture is a significant variable contributing to driving behavior. But these results are concluded by questionnaire using different scenarios. In our study we will only take one scenario (offensive driving) into consideration to compare the difference between Chinese and German drivers.

3 Research Framework and Methodology

3.1 Research Framework

Studies have proven a connection between of driving behavior and V2V system, but few studies emphasized the differences between different communication styles through the emotion and attitude. Besides, although some studies have been focusing on the cultural difference in driving behavior, none could emphasize the interaction effect between the cultures and communication styles. Therefore, this study assumes an effect of V2V system and explores the effect of different communication styles on the drivers' emotion and attitude in different cultures. This study will be conducted in order to answer the following research question:

What effects do the different communication styles have on driving behaviors through emotion and attitude in Chinese and German cultures?

The independent variables are communication styles with 4 levels (text, voice, emoticon and no communication) and cultures with 2 levels (German and Chinese).

3.2 Task and Participants

Participants were required to watch scenarios with 4 different levels of communication styles shown in slides with pictures and text descriptions in a Latin-Square sequence design. All scenarios were given time pressure, and the other driver's behavior was designed as aggressive and against law to enhance the emotion inducted by the scenarios.

Twenty-four participants were invited to take part in the experiment: 12 Chinese and 12 German participants. Only experienced male drivers (with more than 2 years driving experience) were accepted, since novel drivers and female drivers will have more emotions (for example, fear and anxiety) than experienced male drivers. All participants are all graduate students in Department of Mechanical Engineering, Tsinghua University. The information of participants is shown in Table 1.

Table 1. Information of participants

Items	Chinese	German
Age (years old)	Mean 24.17, SD 1.19	Mean 24.25, SD 0.97
Driving Experience (years)	Mean 2.71, SD 1.83	Mean 5.92, SD 2.02

Participants filled in a questionnaire about their personal information and driving experience before the experiment. And during the experiment after watching each scenario, they were required to answer a questionnaire about their emotions and attitudes. After all scenarios, they would receive a short interview about their feelings and preference about different communication styles.

4 Results and Analysis

The two parameters measured in this experiment are emotion and attitude of the driver after receiving different styles of V2V system. Data about emotions and attitudes of the drivers are collected by questionnaire and analyzed by repeated measure ANOVA.

Table 2. Comparison of emotion level towards different styles

Styles	Cultures	Negative emotion	Positive emotion
No communication	Chinese	Mean 5.57, SD 0.89	Mean 2.08, SD 0.84
	German	Mean 4.38, SD 2.24	Mean 1.75, SD 0.79
Text	Chinese	Mean 4.17, SD 1.49	Mean 2.92, SD 1.10
	German	Mean 3.80, SD 0.97	Mean 2.22, SD 1.12
Voice	Chinese	Mean 3.60, SD 1.17	Mean 3.50, SD 1.31
	German	Mean 3.77, SD 1.19	Mean 2.06, SD 0.85
Emoticon	Chinese	Mean 4.45, SD 1.26	Mean 2.56, SD 1.38
	German	Mean 4.03, SD 1.31	Mean 2.47, SD 1.20

4.1 Emotion

Table 2 shows the comparison of the emotion level towards different styles between Chinese and German participants.

Negative Emotion. There is marginal significant interaction effect between communication styles and cultures. When offended by other drivers without communication, Chinese drivers would feel angrier than German drivers ($F = 7.21$, $p = 0.014$). But there is no significant difference between Chinese and German drivers in other conditions.

For Chinese drivers, they ranked higher angry level in the scenario without communication than text ($p = 0.000$), voice ($p = 0.000$) and emoticon ($p = 0.006$), meaning that all three styles have a significant effect on decreasing Chinese drivers' negative emotion.

For German drivers, results showed that the effect of communication styles on German drivers' negative emotion is not significant ($F = 1.43$, $p = 0.243$).

Positive Emotion. There is significant interaction effect between communication styles and cultures. ($DF = 20.00$, $p = 0.006$). When receiving a voice communication after being offended by other drivers, Chinese drivers would feel more happy and relaxed than German drivers ($F = 10.21$, $p = 0.004$). But there is no significant difference between Chinese and German drivers in other conditions.

For Chinese drivers, they ranked significantly lower positive emotion level in the scenario without communication than text ($p = 0.000$) and voice ($p = 0.000$), meaning that text and voice have a significant effect on increasing Chinese drivers' positive emotion.

For German drivers, results showed that that the effect of communication styles on German drivers' positive emotion is not significant ($F = 2.22$, $p = 0.094$).

4.2 Attitude

Table 3 shows the comparison of the attitude level towards different styles between Chinese and German participants.

Table 3. Comparison of attitude level towards different styles

Styles	Cultures	Negative attitude	Positive attitude
No communication	Chinese	Mean 5.96, SD 0.96	Mean 2.38, SD 1.11
	German	Mean 5.83, SD 1.60	Mean 2.42, SD 1.28
Text	Chinese	Mean 4.38, SD 0.93	Mean 4.29, SD 1.27
	German	Mean 5.38, SD 1.35	Mean 3.13, SD 1.32
Voice	Chinese	Mean 4.42, SD 1.16	Mean 4.63, SD 1.33
	German	Mean 5.46, SD 1.30	Mean 3.25, SD 1.08
Emoticon	Chinese	Mean 5.25, SD 0.92	Mean 3.50, SD 1.17
	German	Mean 5.21, SD 1.50	Mean 3.54, SD 1.41

Negative Attitude. There is significant interaction effect between communication styles and cultures. (DF = 20.00, p = 0.008). When receiving a text communication after being offended by other drivers, Chinese drivers would feel think the other driver less offensive and impolite than German drivers (F = 4.46, p = 0.046). But there is no significant difference between Chinese and German drivers in other conditions.

For Chinese drivers, they ranked significantly higher negative attitude level in the scenario without communication than text (p = 0.000) and voice (p = 0.001), meaning that text and voice can decrease Chinese drivers' negative attitude.

For German drivers, results showed that the effect of communication styles on German drivers' negative attitude is not significant (F = 1.80, p = 0.156).

Positive Attitude. There is significant interaction effect between communication styles and cultures. (F = 4.069, p = 0.010). When offended by other drivers, Chinese drivers are more willing to understand and forgive the other driver than German drivers with a text (F = 4.88, p = 0.038) or voice communication (F = 7.72, p = 0.011). But there is no significant difference between Chinese and German drivers in other conditions.

For Chinese drivers, they ranked significantly lower positive attitude level in the scenario without communication than text (p = 0.000), voice (p = 0.001) and emoticon (p = 0.003), meaning that all three styles have a significant effect on increasing Chinese drivers' positive attitude.

For German drivers, they ranked significantly lower positive attitude level in the scenario without communication than emoticon (p = 0.003), meaning that the emoticon can increase German drivers' positive attitude.

5 Discussion

From the result part, we can conclude that all three styles (especially text and voice) can influence Chinese drivers' driving behavior while only emoticon can influence German drivers' driving behavior. Besides, interviews after the experiment showed that Chinese drivers like voice most and German drivers like emoticon most.

One reason is that Chinese are always described as high-context culture and think in holistic way [16]. Therefore they would focus more on the relationship between objects and emphasize the existence of change. They try to collect as much information as possible to get a better control of the surrounding and understand the context. This is consistent with their reaction for V2V system. In our experiment, Chinese participants believed that they could obtain more information to control driving situation through V2V system. And voice can transmit more information than text using tone and rhythm, which help Chinese drivers understand the motivation of the sender. As a result, Chinese drivers think the V2V system helpful and they like the voice best. On the other hand, German are always described as low content culture. They think in analytic way. In our experiment, German drivers like emoticon most because emoticon could be regarded as more direct and clear compared to voice and text. Besides, some German participants mentioned that they could control the car and their behavior by themselves so the V2V system was unnecessary and useless.

Moreover, privacy issue was also considered in this study. Some German participants mentioned that communications from the other driver violated their privacy. It was not comfortable to receive others' information in their own driving space; while other research indicated that Chinese are usually not as sensitive as western culture in privacy issue. This lead to a low acceptance of V2V system by German drivers.

Also, bias of emotion caused by different interpretation of emoticon was another reason. Both German and Chinese participants mentioned that if emoticon only showed sad face without context could be explained in either sorry or ridicule. Emoticon design issue can be discussed more in the future.

And the difference between two groups could also influenced by driving experience. In this study, German participants had more driving experience and were more skilled than Chinese participants. There were no Chinese participant had long-distance driving experience, but eight participants from Germany did. It is rational that skilled drivers do not need help while driving so that they may have lower aspiration to receive additional information and use V2V system than novel drivers.

6 Conclusions

This study made an investigation of the effect of communication styles on driving behavior in different cultures. Repeated measure ANOVA analysis was conducted to understand different effects on driving behaviors of cultures and communication styles measured by emotion and attitude. Results showed that all three styles (text, voice and emoticon) have a significant effect on Chinese drivers, but rarely have effect on German drivers. According to the interviews, we find Chinese drivers like voice most and German drivers like emoticon most. This can be explained by high/low context culture and holistic/analytic thinking. Besides, the acceptance of V2V system and privacy issues are also discussed in our study.

There are still some limitations in our study, so future research can be done with empirical studies to validate the findings in the survey or with field observation to acquire real data to study the effect of communications on driver behaviors.

Acknowledgements. This study was funded by a Natural Science Foundation China grant 71188001 and State Key Lab Automobile Safety and Energy.

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