Effect of gender and personality characteristics on the speed tendency based on advanced driving assistance system (ADAS) evaluation

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Abstract

Purpose – This study aims to explore the relationship between speed behavior of participants and driving styles on interchange ramps. A spiral interchange in Chongqing was selected as an experimental road to carry out field driving experiment.

Design/methodology/approach – The continuous operating speed during experiment was selected by Mobile Eye, and the driving style was selected via two inventories.

Findings – Different driving behaviors showed great differences in age, driving mileage and driving experience. During driving process, male pursued driving stimulation more, whereas female pursued driving steadiness more. Therefore, driving characteristics of male were more disadvantageous to driving safety than that of female. Except for the large speed difference at the entrance and exit of the ramps, the differences at other positions were small. And the operating speed of male was slightly higher than that of female. The difference between different genders at the ascending end position achieved 4–5 kph, and the difference at other feature points were mostly 1–2 kph. During driving process, risky participants were more likely to pursue driving stimulation, and the poor speed control behavior was reflected in wide range of desired operating speed. Based on the results of analyzing at feature points, melancholy and sanguine participants more tended to take a high operating speed, and the poor speed control behavior was reflected in the most widely desired speed range. The speed control behavior of mixed participants was more cautious.

Originality/value – Advanced driving assistance system combined with two inventories was used to explore difference of speed behavior.

Keywords Driving style, Interchange, MDSI-C, Speed behavior, TTI

Paper type Research paper

Introduction

Driving behavior had always been the focus of research in the field of traffic safety, and different subjects had different perspectives on driving behavior.

Scholars who focused on traffic psychology tended to use different scales to analyze the correlation among the participant's sociodemographic factor, personality, self-reported information and the scale factor, as well as to investigate the relationship between the driving style and the scale factors. Taubman-Ben-Ari and Yehiel (2012); Taubman-Ben-Ari and Skvirsky (2016); and Taubman-Ben-Ari *et al.* (2004) used NEO-five factor inventory (NEO-FFI) and multidimensional driving style inventory (MDSI) to discuss the correlation between participants with different personality characteristics (such as different genders, different ages, different educational levels, different working status) and driving behavior. Based on the information selected by brief sensation seeking scale, Zimbardo time perspective inventory and NEO-FFI, Linkov *et al.* (2019) combined the operating data of participant on the driving simulator with fixed scene to analyze the relationship between operating speed and responsibility. Bernstein and Calamia (2019) combined the participant's self-reported driving behavior with information selected via different scales and used exploratory factor analysis to reveal the correlation between factors. W. Chu *et al.* (2019) revealed the relationship among external affective demand, functionality, internal requirement and driving style. Steinbakk *et al.* (2019) used UPPS-impulsivity scale to discuss the relationship between speed choice behavior and personality traits of different drivers in the work area.

To illustrate the relationship between traffic safety and driving behavior, scholars were more inclined to investigate the various operating data (operating speed, lateral acceleration, pedal force, etc). with theoretical models, driving simulator and field driving experiment to discuss the relationship among the various operating data. Chevalier *et al.* (2016) investigated the ability of elderly drivers with cognitive decline to control their

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speed during driving process and revealed the impact of cognitive decline on the speed of older drivers (). Based on driving motivation, turn signal usage, duration, urgency and impact, Wang *et al.* (2019a) established multilevel mixed-effects linear models to deal with unsafe lane-change phenomenon. Combined with physiological index and braking requirement of driver, Musicant *et al.* (2019) revealed the relationship between driver's heart rate and deceleration intensity during driving. Zhang *et al.* (2019) discussed the relationship between driving space, a kind of vehicle operating space originated from driver space during driving process, and driving emotion, and revealed the influence of vehicle emotion on distance from surrounding vehicles during driving. Based on the field driving experiment, Eboli *et al.* (2017) divided the participant into safe, unsafe and safe but potentially dangerous according to the average speed, 50th percentile operating speed and 85th percentile operating speed. Chen *et al.* (2019) established a graphical approach to reveal driver longitudinal acceleration behavior with different personalities. Wang *et al.* (2019b) used the Gray relation entropy analysis method to analyze the physiological and psychological factors of driving process and revealed the sequence of influencing factors of driving tendency .

In the prior research, in brief, there were few studies combining the field driving experiment and scale. Some of research studies were based on the section velocity and lacked relevant test of continuous operating speed and driving style tested by scale. The objective of this paper was to discuss the difference in speed behavior between different types of participant during driving and the speed behavior characteristics of various types, and the relationship between individual characteristic and operating speed were explored. Different types of participant were classified by the MDSI and temperament-type inventory (TTI) scales.

Methods

The interchange ramp in Nanan District of Chongqing City, China, was selected as the experimental road, and 30 participants with different individual characteristics were selected from the DiDi (a transportation network company). According to usual driving mode, each participant should drive on two selected ramps until the end of mission. The relationship between operating speed and driving behavior in ramp was analyzed via collecting operating speed during driving.

Before started the driving experiment, the detailed driving route should inform to participant. To restore the driving behavior of each participant during the driving process to the greatest extent, experimenters would not guide the driver during the experiment, and the participant would control the vehicle completely according to his usual driving style. Every participant needed to complete two designated questionnaires to distinguish the driving style. To prevent the result of random answer from affecting the style judgment, each questionnaire should be completed under the guidance and supervision of experimenters. After completing the questionnaire, participant listened to the instruction of the experimenter to start the driving task. Each participant's driving task is 2–4 rounds, and each round was required traveling the designated test ramp at least once (completing a travel from start position to end position as a round).

Experimental road and vehicle

Experimental equipment included Mobile Eye and two driving recorders. Mobile Eye was an important part of advanced driving assistance system. Its functions included collision warning, lane departure warning, vehicle speed recording, etc. The way of Mobile Eye collected speed data by connecting the data port of the instrument to the controller area network of the vehicle to obtain the vehicle operating speed transmitted by the on-board ECU in real-time with the acquisition frequency of about 10 Hz, and the speed data of Mobile eye was consistent with that of the instrument panel.

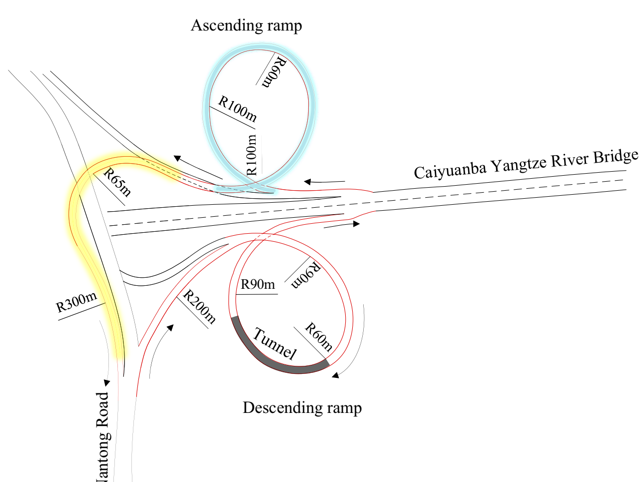
Mobile Eye was used to record the continuous operating speed during the experiment. All external environments during the experiment were collected by the front and rear driving recorders. As the field driving experiment was affected by many uncontrollable factors (congestion, car accidents, etc.), so the result affected by uncontrollable factors would be eliminated during the data processing process to increase data reliability. Hyundai Santa Fe was selected as experimental vehicle.

According to Figure 1, Sujiaba interchange was located in Nanan District of Chongqing, which connected the Caiyuanba Yangtze River Bridge and other major roads. Two ramps on Sujiaba interchange were selected as experimental road, including an ascending ramp and a descending ramp, shown in Figure 1. Ascending ramp was composed of an oval curve (blue area in Figure 1) and a S-shaped curve (green area in Figure 1), and descending ramp consisted of an oval curve. Both of ramps connected Caiyuanba Yangtze River Bridge and Nantong Road.

Multidimensional driving style inventory and temperament-type inventory

Orit Taubman-Ben-Ari *et al.* designed and validated MDSI in 2004, and it was one of the most widely used driving style scales in 20 years. On the basis of the MDSI, Sun *et al.* (2014) adapted the scale and verified its reliability and validity and compiled MDSI-C which was more suitable for China's

Figure 1 Sujiaba interchange



national conditions. This paper used MDSI-C to collect the driving style of participants.

According to TTI, compiled by Zhang and Chen (1985) in 1985, participants were divided into four different temperament types (choleric, sanguine, melancholy, phlegmatic participants) and several mixed temperaments. Liu *et al.* (2006) defined the characteristics of four temperament types in driving style.

This experiment used above-mentioned scales to divide participants into several descriptions and explored speed trend and behavior characteristics of every description. The trend and characteristics of every description were deeply combined with driving video to analyze and summarize behavior characteristics of driving style.

Participant

Taking into account the driving safety during the experiment, participants were required to have certain driving experience to avoid accidents and casualties during the experiment. According to all the samples provided by DiDi, 30 drivers were selected as participants, and they were asked to finish the MDSI-C and TTI. Based on the results of the scale, participants were classified according to demographic characteristics and driving styles. As a result, the demographic characteristics were mainly based on genders, and the driving style of the participant was mainly based on the results of MDSI-C and TTI.

Result

Analysis of driving styles according to gender

According to gender and personal information, the data selected by the MDSI-C and the TTI were listed by the relationship among different factors, gender and self-reported information, as shown in Tables 1–3.

Means and SDs of factors based on MDSI-C and TTI were listed in Tables 1 and 2, which showed the difference between male and female participants under different factors. The factors with higher score were dissociative, angry and risky, and the driving behaviors related to the three factors were anxious, angry and risky. According to the analysis of driving videos, the dissociative factor during driving was mainly caused by communication with other person, indicating that participant expected to "communicate + driving" model instead of focusing only on driving. The angry factor was mainly caused by improper driving (e.g. jump a queue, frequent lane change, etc). of other vehicles and other vulnerable traffic participants (pedestrians, motorcycles, etc). sudden broken in, and participants mainly manifested by cursing, whistling and impatience. The main reasons for risk factor were high operating speed during driving (in most cases, it is higher than the speed limit) and participant's overconfidence.

The results of means and SDs of driving style measured by the MDSI-C and self-reported information (age, driving mileage and driving experience) were shown in Table 3. As a result, the mean age of anxious participant was the highest, and the mean age of risk participant was the lowest, and the mean driving mileage was also the highest anxious participant, the lowest risk participant, and anxious participant were often characterized by short driving mileage (<100,000 kilometers) and long driving mileage (>500,000 kilometers). Similarly, anxious participant also showed polarization in mean driving experience.

The means and SDs of four temperament types based on TTI were listed in Table 2. Choleric, sanguine, phlegmatic scores of males were more discrete than those of females, and choleric, sanguine, melancholy mean scores of males were higher than that of females. Based on Tables 1 2 and driving video, female was more inclined to focus on driving (driving stability was higher),

Table 1 MDSI-C Factors according to gender

Factors	Dissociative		Anxious		Angry		High-velocity		Risky	
Gender	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Male(n = 21)	2.74	0.84	1.68	0.68	3.06	1.19	1.59	0.94	3.49	1.09
Female(n = 9)	2.73	0.91	1.67	0.77	2.58	0.72	1.26	0.4	3.07	0.74

Table 2 TTI Factors according to gender

Factors	Choleric				Sanguine				Melancholy				Phlegmatic			
Gender	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD
Male(n = 21)	16	−8	3.67	5.45	21	−5	5.90	5.87	19	−10	3	7.13	15	−2	4.81	4.33
Female(n = 9)	6	−4	0.89	3.38	12	−5	4.44	4.95	12	−11	0.78	7.52	11	3	6.33	2.40

Table 3 MDSI-C Driving style according to self-reported information

	Age (years)		Driving mileage (10^5 km)		Driving experience (years)	
	Mean	SD	Mean	SD	Mean	SD
Risky	32.86	6.85	14.29	10.66	8.24	4.51
Anxious	40.50	7.70	32.50	23.05	11.75	7.22
Angry	34.60	5.54	20.00	5.48	12.40	4.45

male was characterized by irritability, impatience and preference for conversation, which was not conducive to safety.
The 15th and 85th percentile speed were selected as feature percentile speed, and the feature percentile speed curves of the descending and ascending ramps were showed in Figure 2. Male and female were indicated by a solid black line and a black dotted line, respectively. The green area represented the operating speed male > female, and the orange area represented female > male. The column represented the difference between the speed difference according to gender and the minimum operating speed (green: male > female, orange: female > male).

Figure 2(a) and (b) was the 15th operating speed for different genders in the descending and ascending ramps. In Figure 2(a), operating speed of male was generally higher than that of female, and the differences were within 10% (generally at 2–3kph), and the differences of the entrance and exit were 16% and 17%, respectively. In Figure 2(b), due to the good road alignment and line of sight at the entrance, operating speed of female was higher than male between 40 and 160 m, and the differences were lower than 10% (1–4kph). At 180–960m, male ran faster than female, and the differences were within 10% (generally at 1–4kph). 980–1100m, the section closed to the exit, female operating speed higher than male, and the differences were 14% (5kph).

Figure 2(c) and (d) were the 85th operating speed for different genders in the descending and ascending ramps. In Figure 2(c), the difference was 28% (7kph) when entering the ramp, which was the largest difference in entire ramp. The differences between 160 and 740 m were maintained in a small region (generally at 1kph, the max was 2kph). Close to the exit (760–840m), the differences were gradually increased (5%–7%, 3–4kph). In Figure 2(d), the differences were relatively stable and had been maintained at 1–3kph. At exit, the maximum difference reached 19% (7kph).

In the previous research, the research on the operating speed focused on the difference of operating speed of feature points (DSP, DEP, ASP and AEP) and analyzed the operating speed characteristics under different feature positions (Fu and Xu, 2019). The author extracted the feature positions and distinguished them according to the feature percentile positions (15th, 50th and 85th) as the previous research, and the 85th percentile value was selected to analyze difference between genders. The results were summarized in Table 4.

DPS, DEP, ASP and AEP represented decelerating start position, decelerating end position, accelerating start position and accelerating end position, respectively. Owning to ascending ramp that had two different accelerating and decelerating processes, the ramp was divided into two sections according to the different accelerating and decelerating processes.

The feature positions of the descending ramp were 380 m, 520 m and 820 m, respectively. In Figure 2(a), the difference at 380 m was 5% (2 kph), 2% (1 kph) at 820 m and basically same at 520 m. In Figure 2(c), the difference at 380 m was 2% (1 kph), the same at 520 m and 7% (5 kph) at 820 m.

The feature points of AR1 were 300, 480 and 740m, and that of AR2 were 760, 920 and 1020 m. In Figure 2(b), the difference at 300 m was 6% (3 kph), 5% (2kph) at 480 m, 4% (2 kph) at 740 m, 3% (2 kph) at 760 m, 4% (2 kph) at 920 m and 9% (4 kph) at 1020 m. In Figure 2(d), the difference at 300 m was basically same, 5% (2 kph) at 480 m, 1% (1 kph) at 740 m, 2% (1 kph) at 760 m, 5% (2 kph) at 920 m and 3% (2 kph) at 1020 m.

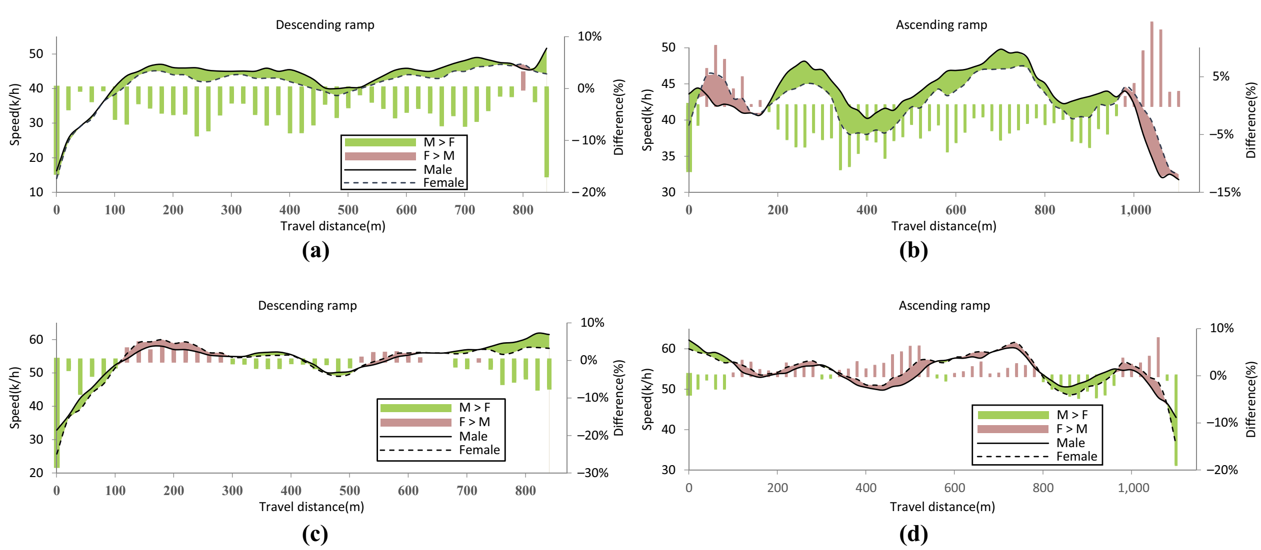
In summary, the difference between different genders was larger (4–5 kph) at the AEP, while difference of other feature positions centralized in 1–2 kph, and the maximum was not more than 3 kph.

Analysis of speed behavior according to multidimensional driving style inventory-C and temperament-type inventory

Analysis of speed behavior according to multidimensional driving style inventory-C

According to the driving styles selected by MDSI-C, the participants were classified according to the driving styles, and

Figure 2 Speed behavior of participants according to gender



Notes: a and b represented difference of 15th percentile speed, c and d represented difference of 85th percentile speed

Table 4 Feature points of 15th, 50th, 85th percentile distance

	(R)DSP (m)			(Y)DEP/ASP (m)			(B)AEP (m)		
	AR 1	AR 2	DR	AR 1	AR 2	DR	AR 1	AR 2	DR
(B)15th	0	680	180	360	820	420	600	940	600
(O)50th	60	720	200	420	860	480	720	980	680
(G)85th	300	760	380	480	920	520	740	1020	820

Note: AR1 – oval curve (first curve) of ascending ramp, AR2 – S-shaped curve (second curve) of ascending ramp, DR – descending ramp

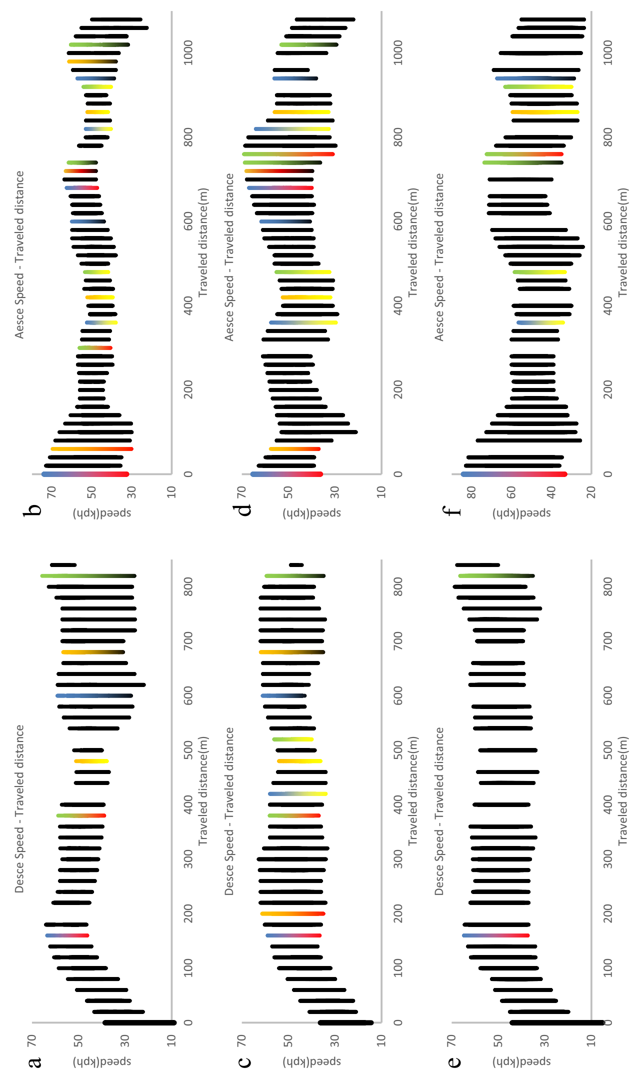
the operating speed distribution figures of each style on the descending and ascending ramps were obtained, as shown in Figure 3. The 15th, 50th and 85th percentile positions in Table 4 were marked with different colors (Blue-15th, Orange-50th, Green-85th, Red-DSP, Yellow-DEP/ASP, Black-AEP), as shown in Figure 3 (e.g. Blue and Red-15th DSP, Orange and Black-50th AEP). Among Figure 3, the figures on left side were the descending ramp (a, c, e), and the figures on right side were the ascending ramp (b, d, f).

In Figure 3(a), the operating speed was increased from 0 m to 180 m when entering the ramp, the difference at the entrance reached 30kph, and the differences were remained at 17–21kph. At 200–500m, the operating speed showed a downward trend, and the differences were maintained at 12-20kph. At 300–400m, the change of operating speed was relatively stable (difference: 16–20kph, the minimum speed difference and the maximum speed difference were not more than 2kph). After 520 m, the maximum operating speed was gradually increased and the minimum operating speed was gradually decreased, and the differences were increased (difference: 12–40kph). In Figure 3(b), the operating speed from 0 m to 200 m was decreased, and the differences were gradually decreasing (difference: 41-12kph). From 200 m to 920 m, the differences of most sections (200–500m and 740 –920m) were maintained in a small interval (10–15kph), the maximum and minimum speeds were distributed in 52–64kph and 38–44kph, respectively. From 940 m, the operating speed was decreased, and the difference started to increase gradually (difference: 19–33kph).

In Figure 3(c), the speed from the entrance to 220 m was gradually increased, the maximum speed of 300–440m was gradually decreased and the minimum speed was gradually increased. The maximum and minimum speeds of 480–640m were gradually increased, and the maximum and minimum speeds of 740–800m were gradually decreased. The differences were relatively small at 0–140 m and 460–640m, and the differences at 180–320m and 660–780m were larger, while the maximum difference was lower than 29kph. In Figure 3(d), the maximum and minimum speeds of 0–100m and 120–280m had a same trend. After a period of decline (300–380m), the speed started to increase gradually from 480–740m, the minimum speed remained unchanged, the maximum speed was gradually increased, the maximum speed of 760–860m was decreased, and the minimum speed was showed without change. At 880–1100m, the speed was gradually reduced after a small increased. The speed differences were larger at 100–140m and 760–800m, and the difference from 520 to 760 m was gradually increased, and the remaining differences were around 20kph.

In Figure 3(e), the speed was gradually increased from 0 m to 160 m, the maximum and minimum speeds of 180–640m were relatively stable, and the differences were also maintained at 23–27kph. From 740 m, the difference and operating speed were increased. In Figure 3(f), the maximum speed of 0–160m showed a downward trend, and the minimum speed decreased first and then increased, and the difference at the entrance

Figure 3 Speed behavior of participants according to MDSI-C factors



Notes: a and b represented angry participants, c and d represented anxious participants, e and f represented risky participants reached 50kph. The maximum speed of 500–700m was decreased, and the minimum speed was the first to decrease and then increase. The maximum and minimum speeds of 740–860m were the same as the decreased trend. The maximum and minimum speeds of 880–960m were the same as the increased trend, and then declined.

In summary, in the descending ramp, there was a large speed difference at the entrance between the angry and risky participants, and the differences of risky participants were greater. maximum speed when entering the ramp: Risky > Angry > Anxious, the operating speed after the accelerating process of entering the ramp: Risky = Angry > Anxious. There was a significant decelerating trend for angry participants, and the anxious and risky participants were more stable. When driving out of the ramp, there was a speed-up phenomenon for both angry and risky participants, and anxiety participants tended to move at a constant speed or slow down.

In the ascending ramp, there was a large speed difference at the entrance of the angry and risky participants, and the difference of the risky participants were greater. The maximum speed at the entrance: Risky > Angry > Anxious. The range of speed fluctuation during driving: Risky > Anxious > Angry. The risky and anxious participants had a significant speed-up phenomenon at 460–760m, and the angry participants only decreased with the other two types of participants after a small increased in speed. When out of ramp, risky and angry participants tended to speed up first and then slow down, while Anxious participants tended to slow down until leave the ramp.

Based on Table 4 and Figure 3, the maximum and minimum operating speeds and the speed difference of participants at different feature points were summarized and listed in Table 5. The speed differences at the feature points were compared among different participants, and the difference of expected speed among different types of participants at the same position and the relationship between expected speed and performance were discussed.

According to Table 5, in descending ramp, the maximum speed at the DSP: Risky > Angry > Anxious, and the speed difference: Risky > Anxious > Angry. Maximum speed at the DEP: Risky > Anxious > Angry, and the speed difference: Risky > Anxious > Angry (15th percentile: Anxious > Risky > Angry). Speed difference at AEP: Angry > Risky > Anxious.

In the first curve of ascending ramp, the maximum speed of DSP: Risky > Anxious > Angry (85th percentile: Anxious > Risky > Angry), speed difference: Risky > Angry > Anxious. The maximum speed of DEP: Risky > Anxious > Angry, speed difference: Risky > Angry > Anxious. The maximum speed of AEP: Risky > Anxious > Angry, speed difference: Risky > Anxious > Angry. In the second curve of ascending ramp, the maximum speed of DSP: Risky > Angry > Anxious, speed difference: Risky > Anxious > Angry. The maximum speed of DEP: Risky > Anxious > Angry, speed difference: Risky > Anxious > Angry. The maximum speed of AEP: Risky > Angry > Anxious, speed difference: Risky > Angry = Anxious.

According to the above analysis, the risky participants had the maximum operating speed at the feature points than the other two types of participants, and the angry driver had the lowest. Similarly, the speed differences, that was the desired speed interval, of risky participants were higher than the other two types of participants.

Analysis of speed behavior according to temperament-type inventory

Based on the driving factors were selected by the TTI, the participants were divided into 7 categories, and the distribution of the operating speed of each type of participants in the descending and ascending ramps were investigated, as shown in Figure 4.

In Figure 4(a), the operating speed was increased from 0 m (max: 28 kph, min: 11 kph) to 180 m (max: 61 kph, min: 46 kph) when entering the ramp, 200–500m was slowly decreased, and 520–820m was slowly increased. The speed differences between 0 and 440 m were maintained at 14–19kph, the speed differences between 460 and 700 m were maintained at 6-10kph, and the speed differences between 720 and 820 m were gradually increased to 22kph.

In Figure 4(b), as the maximum speed gradually decreased and the minimum speed didn't change, the difference of 0–200m was continuously decreasing (44kph to 15 kph), and the speed of 200 m-820m was the process of two first rising and then falling, respectively. It had also grown from small to large then to small. When driving away from the ramp, operating speed was also the trend of rising first and then falling.

Table 5 Speed of feature points according to MDSI-C driving styles

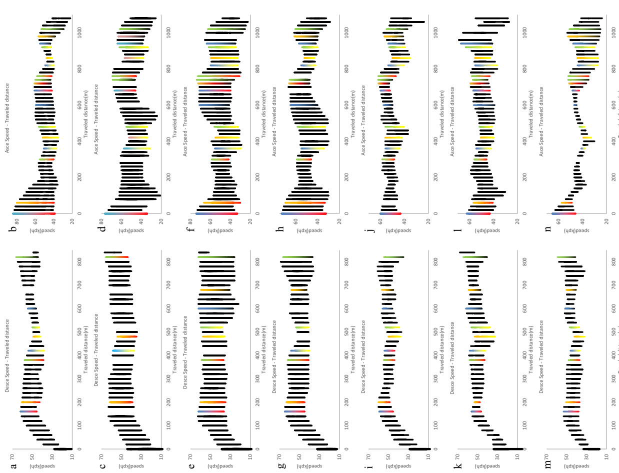
		Speed of DR (kph)									Speed of AR 1 (kph)									Speed of AR 2 (kph)								
		Angry			Anxious			Risky			Angry			Anxious			Risky			Angry			Anxious			Risky		
		Max	Min	Dis	Max	Min	Dis	Max	Min	Dis	Max	Min	Dis	Max	Min	Dis	Max	Min	Dis	Max	Min	Dis	Max	Min	Dis	Max	Min	Dis
DSP	15th	64	46	17	59	37	22	65	37	27	74	33	41	65	36	29	84	33	51	63	47	15	67	40	27	71	43	28
	50th	63	46	17	61	35	26	63	37	26	70	30	39	58	37	21	80	27	53	63	48	15	68	40	28	72	37	35
	85th	59	39	20	58	37	21	62	37	25	56	41	15	61	35	26	60	39	21	60	47	12	69	31	38	72	35	37
DEP	15th	54	38	16	58	34	24	58	37	22	52	38	14	57	30	28	56	34	22	53	40	16	64	33	31	60	27	32
/ASP	50th	51	38	13	54	36	18	57	32	25	52	40	13	52	32	20	56	30	26	52	42	15	56	33	23	59	27	32
	85th	52	38	14	56	40	16	59	33	26	53	42	12	55	32	23	58	33	25	54	40	14	56	34	21	63	30	33
AEP	15th	59	27	32	61	43	18	62	38	24	60	44	16	62	41	21	71	38	33	57	39	18	56	38	18	67	29	39
	50th	57	31	26	62	35	27	59	40	19	63	48	15	48	40	28	72	37	35	41	38	18	57	39	18	68	26	43
	85th	66	26	40	59	35	24	66	35	31	62	48	14	69	36	32	74	35	39	60	32	24	53	29	24	62	25	37

In Figure 4(c), the speed of 0–160m was increased. After a small decrease of 180 m-480m, the speed was gradually increased away from the ramp, the maximum and minimum speed differences were respectively at the entrance and exit, and the speed differences of the remaining positions were maintained at 20kph. In Figure 4(d), the maximum and minimum operating speeds of 0–180m were decreasing. After a stable operation for a certain distance, the maximum and minimum operating speeds of 300–760m were the same as the first rising and then decreasing, and the trend of 780–1100m was the same as the decrease-increase- decrease trend. The speed difference reached a maximum (42 kph) at entrance, the 0 m-140m speed differences were maintained at a high level (>30kph), and the remaining positions were remained at 20–25kph.

In Figure 4(e), the running speed of 0 m-140m was increased, and the speed of 160–520m was maintained in a small range (max: 58–62kph, min: 34–38kph). From 540 m, the speed difference showed a different trend, and the differences (> 30kph) increased significantly. In Figure 4(f), the speed differences at the entrance (0–80m) and the middle section of the ramp to the driving ramp (560–1080m) were maintained at 30 kph. The operating speed trend was the same as that of the Sanguine participants, and there was a significant drop-up-drop phenomenon.

In Figure 4(g), the speed of 0–180m showed an upward trend, the maximum speed of 200 m-480m decreased, the minimum speed was maintained at 40kph, the speed differences decreased gradually, the speed of 500–800m showed an upward trend, and the speed difference began to increase gradually at 680 m. In Figure 4(h), 0–140m, 480–600m, 1020–1060m speed differences of three sections >25kph, speed differences of 180–320m and 800–920m <15kph. The maximum and minimum operating speeds had a same trend from 200 m to 1060 m.

Figure 4 Speed behavior of participants according to TTI factors



Notes: a and b represented choleric participants, c and d represented sanguine participants, e and f represented melancholy participants, g and h represented phlegmatic participants, i and j represented sanguine-melancholy participants, k and l represented choleric-phlegmatic participants, m and n represented melancholy-phlegmatic participant

Figure 4(i), (k) and (m) were the speed trends of the descending ramp of three mixed participants (sanguine-melancholy, choleric-phlegmatic and melancholy-phlegmatic). 0–180m of mixed participants were on the same trend, and the driving speeds of the two types of sanguine-melancholy and melancholy-phlegmatic participants were the same. The choleric-phlegmatic participants had large speed differences between 360 m and 600 m. The speed differences between the sanguine-melancholy and melancholy-phlegmatic participants were larger when driving away from the ramp. Operating speeds of Sanguine-melancholy participants were declined as it leaved the ramp, and the other two type participants were on the rise.

Figure 4(j), (l) and (n) was the operating speed trends of three mixed participants (sanguine-melancholy, choleric-phlegmatic and melancholy–phlegmatic, respectively). The mixed participants entrance ran at a significantly lower speed than the other four types of participants. The choleric-phlegmatic and melancholy-phlegmatic participants with large differences in speed were at the exit. The speed differences of sanguine-melancholy participants were generally stable and did not have much fluctuation.

According to the data in Table 4 and Figure 4, the maximum and minimum speeds and speed difference of different types at different feature points were summarized in Table 6.

According to Table 6, in the descending ramp, maximum speed at DSP: phlegmatic > sanguine > melancholy > … > melancholy-phlegmatic, speed difference: melancholy > sanguine > phlegmatic > … > choleric-phlegmatic. Maximum speed at DEP: melancholy > sanguine > choleric-phlegmatic > … > melancholy-phlegmatic, speed difference: melancholy > sanguine > choleric-phlegmatic > … > melancholy-phlegmatic. Maximum speed at AEP: sanguine > choleric-phlegmatic > melancholy > … > melancholy-phlegmatic, speed difference: melancholy > sanguine > phlegmatic > … > melancholy-phlegmatic.

In the first curve of ascending ramp, maximum speed at DSP: choleric > sanguine > phlegmatic > … > melancholy- phlegmatic, speed difference: sanguine > choleric> melancholy > … > melancholy-phlegmatic. Maximum speed at DEP: sanguine = melancholy = phlegmatic > … > melancholy-phlegmatic, speed difference: melancholy > phlegmatic > sanguine > … > melancholy-phlegmatic. Maximum speed at AEP: melancholy > sanguine > phlegmatic > … > melancholy-phlegmatic, speed difference: melancholy > sanguine > phlegmatic > … > sanguine-melancholy.

In the second curve of ascending ramp, maximum speed at DSP: melancholy > sanguine > phlegmatic > … > melancholy-phlegmatic, speed difference: melancholy > sanguine > phlegmatic > … > sanguine-melancholy.

In summary, the melancholy and sanguine participants were the two fastest types for speed, followed by the phlegmatic participants and the choleric-phlegmatic participants, and the last were the melancholy-phlegmatic participants. The biggest differences were also the melancholy participants and the sanguine participants, followed by the phlegmatic participants, the smallest being the melancholy-phlegmatic participants.

Discussion

This paper classified the participants according to the data selected by MDSI-C and TTI. Meanwhile, the speed behavior

Table 6 Speed of feature points according to TTI factors

			Speed of DSP (kph)			Speed of DEP/ASP (kph)			Speed of AEP (kph)		
			15th	50th	85th	15th	50th	85th	15th	50th	85th
DR	Choleric	Max	62	60	58	54	49	50	54	58	66
		Min	46	43	39	38	42	43	46	50	44
		Dis	16	18	19	16	7	7	8	8	22
	Sanguine	Max	62	62	59	58	54	56	61	62	66
		Min	38	39	38	37	35	33	39	40	43
		Dis	24	23	21	21	19	23	22	22	23
	Melancholy	Max	62	60	59	56	57	59	62	59	62
		Min	37	35	37	34	36	38	27	31	26
		Dis	25	25	22	22	21	21	34	28	36
	Phlegmatic	Max	65	63	62	58	51	53	59	58	66
		Min	45	45	41	40	41	41	42	43	37
		Dis	20	18	21	18	10	12	17	15	29
	Sanguine-Melancholy	Max	59	60	55	54	50	53	56	57	55
		Min	45	49	44	44	38	39	46	45	35
		Dis	14	11	11	10	12	14	10	11	20
	Choleric-Phlegmatic	Max	56	53	58	58	53	56	61	59	64
		Min	47	48	43	42	33	37	46	47	41
		Dis	9	5	15	16	20	19	16	12	24
	Melancholy-Phlegmatic	Max	53	51	48	46	42	47	51	50	59
		Min	38	37	37	37	32	37	42	41	41
		Dis	15	14	11	9	10	9	9	9	18
AR 1	Choleric	Max	84	80	55	51	52	56	59	61	60
		Min	39	40	40	37	35	39	41	43	44
		Dis	45	40	15	13	17	17	19	18	16
	Sanguine	Max	76	68	61	57	52	55	62	68	69
		Min	34	27	35	31	34	34	38	47	46
		Dis	42	41	26	26	18	21	24	21	22
	Melancholy	Max	74	66	59	55	55	56	71	72	74
		Min	33	30	42	30	32	32	41	40	36
		Dis	41	36	17	26	23	24	30	33	37
	Phlegmatic	Max	73	70	59	55	56	58	65	66	66
		Min	33	33	46	34	30	33	40	48	47
		Dis	40	36	13	21	25	25	25	19	18
	Sanguine-Melancholy	Max	60	58	59	56	56	56	58	62	62
		Min	44	48	48	44	42	40	50	53	50
		Dis	16	10	10	12	14	16	8	9	12
	Choleric-Phlegmatic	Max	62	57	56	54	51	52	56	59	57
		Min	43	41	46	42	40	41	39	44	45
		Dis	19	16	10	12	11	11	17	15	12
	Melancholy-Phlegmatic	Max	65	57	44	41	39	43	47	51	52
		Min	46	49	43	38	33	38	45	37	35
		Dis	19	8	1	3	7	4	2	14	17
AR 2	Choleric	Max	61	61	58	49	48	53	55	57	54
		Min	42	43	43	40	42	43	44	39	29
		Dis	19	18	16	9	6	10	11	18	24
	Sanguine	Max	67	68	69	64	57	62	64	63	61
		Min	46	47	45	38	38	34	39	37	32
		Dis	21	21	24	26	19	28	25	26	30
	Melancholy	Max	71	72	72	60	59	62	64	66	62
		Min	40	40	31	33	33	34	35	30	25
		Dis	31	33	42	27	27	27	29	35	37
	Phlegmatic	Max	65	66	64	55	52	54	57	61	60
		Min	46	48	47	42	43	40	42	40	36
		Dis	19	19	17	13	9	14	16	21	25

(***continued***)

Table 6

		Speed of DSP (kph)			Speed of DEP/ASP (kph)			Speed of AEP (kph)		
		15th	50th	85th	15th	50th	85th	15th	50th	85th
Sanguine-Melancholy	Max	60	62	62	54	50	53	54	57	55
	Min	52	53	47	40	35	40	40	41	38
	Dis	8	9	14	13	15	13	14	16	17
Choleric-Phlegmatic	Max	57	59	58	55	55	63	67	68	56
	Min	43	44	43	37	43	42	41	38	36
	Dis	14	15	15	18	13	21	26	30	20
Melancholy-Phlegmatic	Max	48	51	52	44	44	46	48	52	51
	Min	43	37	35	27	27	30	29	26	25
	Dis	6	14	17	17	17	16	19	26	26

characteristics of different types of participants during driving process and the difference between characteristics and descriptions of participants in operating speed were discussed. In the past research, some conclusions of MDSI-based research studies pointed out that male reckless and angry driving style was more obvious and prominent than female. Therefore, female was more anxious and cautious during driving (Taubman-Ben-Ari and Yehiel, 2012; Taubman-Ben-Ari and Skvirsky, 2016; Taubman-Ben-Ari *et al.*, 2004). Based on the results of participants with different characteristics in China, male was more irritated during driving and more stimulating by high speed. On the contrary, female tended to be more stable in driving. The risky driving behavior that pursued driving pleasure mainly existed in participants with young age, low driving mileage and low driving experience. Angry driving behavior mainly existed in middle-aged participants with considerable driving experience. According to the analysis results, female on some sections drove faster than the male, but it was generally believed that in most cases, the speed of male was higher than that of female.

Based on the operating speed of different types of participants and the characteristics of each type, it was found that there were some differences between the type characteristics of participants and the speed behavior. In the ascending ramp, anxious participants tended to slow down from the ramp, and risky and angry participants tended to speed up and then slow down when they leaved the ramp. However, the driving aggression of angry participants were not manifested in speed behavior, but only in physical behavior (cursing, whistling and impatient).

According to Liu *et al.* (2006), the definition of different types was founded that choleric participants were not prominent in operating speed. Sanguine participants and melancholy participants were more inclined to pursue high speed, and there were certain differences with the definition. The reason may be that the professional driver would weaken the influence of personality on driving behavior during driving to ensure safety.

Conclusion

On the designated interchange, from the perspective of driving safety, the field driving experiment was held to discuss the operating speed of different participants and analyze the difference among different participants speed and the different characters in driving with the parameters such as typical percentile speed and distance. The continuous operating speed during driving was selected by Mobile Eye, and the driving style was selected by the MDSI-C and TTI. The main findings were as follows:

- Older participants were more likely to be Anxious, and driving anxiety was more polarized in driving age and driving mileage. The Risky driving behavior was characterized by low age, low mileage and low experience. The Angry driving behavior was characterized by middle-aged drivers with certain driving experience.
- During driving, male was more motivated to drive, and female was more likely to pursue driving stability. Moreover, male traits of driving (prone to anger, irritability, tended to have conversation, etc). were more detrimental to driving safety than female.
- In descending and ascending ramps, except for the large speed differences at the entrance and exit of ramps, the differences at other positions were small. In addition, the operating speed of male was slightly higher than female.
- The differences between different genders at the ascending terminal were 4-5 kph, and the difference of other feature points were mostly 1–2 kph.
- The Risky participants had higher requirements for speed than the other two types, Anxious participants tended to shift speed and had poor speed control. However, the aggressiveness of the Angry driver was not reflected in the speed.
- Melancholy and sanguine participants were more inclined to operate at higher speed, and the poor speed control was reflected in the most widely desired speed range. Mixed participant speed control was more cautious.

References

Bernstein, J.P.K. and Calamia, M. (2019), "Dimensions of driving-related emotions and behaviors: an exploratory factor analysis of common self-report measures", *Accident Analysis & Prevention*, Vol. 124, pp. 85-91.

Chen, C., Zhao, X., Zhang, Y., *et al.* (2019), "A graphical modeling method for individual driving behavior and its application in driving safety analysis using GPS data", *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 63, pp. 118-134.

Chevalier, A., Coxon, K., Rogers, K., *et al.* (2016), "A longitudinal investigation of the predictors of older drivers' speeding behavior", *Accident Analysis & Prevention*, Vol. 93, pp. 41-47.

Chu, W., Wu, C., Atombo, C., *et al.* (2019), "Traffic climate, driver behaviour, and accidents involvement in China", *Accident Analysis & Prevention*, Vol. 122, pp. 119-126.

Eboli, L., Guido, G., Mazzulla, G., *et al.* (2017), "Investigating car users' driving behaviour through speed analysis", *Promet - Traffic&Transportation*, Vol. 29 No. 2, pp. 193-202.

Fu, J. and Xu, J. (2019), "Analysis on the speed behavior of the helix bridge based on naturalistic driving patterns", In: *19th COTA International Conference of Transportation Professionals. Nanjing: CICTP*, pp. 3604-3615.

Linkov, V., Zaoral, A., Řezáč, P., *et al.* (2019), "Personality and professional drivers' driving behavior", *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 60, pp. 105-110.

Liu, J., Tian, T., Rong, J., *et al.* (2006), "Initial research on relationship between drivers' temperament and travel speed", *Journal of Beijing University of Technology*, Vol. 32, pp. 27-32.

Musicant, O., Laufer, I. and Botzer, A. (2019), "Changes in physiological indices and deceleration behaviour as functions of braking demands and driver's physiological cluster", *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 62, pp. 406-415.

Steinbakk, R.T., Ulleberg, P., Sagberg, F., *et al.* (2019), "Speed preferences in work zones: the combined effect of visible roadwork activity, personality traits, attitudes, risk perception and driving style", *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 62, pp. 390-405.

Sun, L., Yang, C. and Chang, R. (2014), "Revision and preliminary application of multidimensional", *Chinese Journal of Ergonomics*, Vol. 20, pp. 6-9.

Taubman-Ben-Ari, O. and Yehiel, D. (2012), "Driving styles and their associations with personality and motivation", *Accident Analysis & Prevention*, Vol. 45 No. 3, pp. 416-422.

Taubman-Ben-Ari, O. and Skvirsky, V. (2016), "The multidimensional driving style inventory a decade later: review of the literature and re-evaluation of the scale", *Accident Analysis & Prevention*, Vol. 93, pp. 179-188.

Taubman-Ben-Ari, O., Mikulincer, M. and Gillath, O. (2004), "The multidimensional driving style inventory–scale construct and validation", *Accident Analysis & Prevention*, Vol. 36 No. 3, pp. 323-332.

Wang, X., Liu, Y., Wang, J., *et al.* (2019a), "Study on influencing factors selection of driver's propensity", *Transportation Research Part D: Transport and Environment*, Vol. 66, pp. 35-48.

Wang, X., Yang, M. and Hurwitz, D. (2019b), "Analysis of cut-in behavior based on naturalistic driving data", *Accident Analysis & Prevention*, Vol. 124, pp. 127-137.

Zhang, T. and Chen, H. (1985), "Report on the preparation of temperament scale and its preliminary application", *Journal of Shanxi University (Philosophy and Social Science Edition)*, Vol. 1 No. 4, pp. 73-77.

Zhang, Q., Ge, Y., Qu, W., *et al.* (2019), "Effects of anger and collision history on driver space preference", *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 63, pp. 108-117.

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