



## Research article

## Analysis of students' anger during riding electric bicycles on campus

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## ABSTRACT

This paper presents a study of the causes of anger of students who ride electric bicycles on a university campus. A questionnaire survey of 370 students in university was conducted using a electric bicycle rider anger scale. Structural equation model is used to analyze the interaction between pedestrians, traffic management, other riders and environment and riders themselves. The results show that the overall level of students' riding anger on the campus was not high, and the interaction with the surrounding environment mainly reflected the riding anger of college students. The interaction of students' anger with campus traffic management requirements was relatively low. Based on the study results, several campus traffic management and safety education recommendations are made.

## 1. Introduction

Since the 21st century, electric bicycles in China have gradually become popular (Bigazzi and Wong, 2020; Fishman and Cherry, 2016). Electric bicycles have gradually become an important commuting tool for urban residents in developing countries such as China, Vietnam and Thailand, and the number of them continues to grow (Ma et al., 2019). Electric bicycles have faster speed, a more comprehensive application range, and better overall performance than traditional bikes (Fyhri and Sundfjord, 2020; Fishman and Cherry, 2016), and has become the best choice for some residents in large and medium-sized cities in China. With the sustained and rapid development of China's economy, the process of urbanization has accelerated, and the electric bicycle rapidly occupied the nonmotor vehicle market because of its unique advantages. Unlike North America and Europe, electric bicycles are the main mode of transportation in many large cities in China, mainly for commuting, not just for leisure. According to the statistics of the Chinese cycling association, China has nearly 300 million electric bicycles, ranking first in the world.

Like traditional bicycles and pedestrians, electric bicycles also belong to the category of vulnerable groups on the road. Compared with traditional bicycle cyclists, electric bicycle cyclists are more likely to have traffic accidents (Yang et al., 2015; Schepers et al., 2014). Numerous studies showed that the behavior of electric bicycle users is important in most traffic accidents (Ma et al., 2019). Many traffic accidents are due to the interaction between road users. The interaction between people and

the surrounding environment is particularly important. Such interaction often causes anger among road users, endangering road safety (Thomas et al., 2013). Driving in an angry situation almost doubles the likelihood of an accident (Deffenbacher et al., 2002).

The research on road user anger was originally on car driving. Driving anger studies have focused on car drivers and later were extended to non-motorists and evolved to riding anger. The definition of angry driving (When driving, they show higher frequency and greater intensity of angry behavior) was first proposed by Deffenbacher et al. (1994). Driving anger is often measured by DAS questionnaire. Anger is usually determined by the driver's character (Stephens and Groeger, 2009). Deffenbacher and et al. (2001) further proposed that driving anger can be manifested in four forms: self-regulation, verbal aggression, physical aggression, and vehicle aggression. Anger would increase the probability of risky driving and thus make dangerous driving behaviors (Ge et al., 2015). A variety of situations can arouse the anger of road users, such as their movement is hindered, other road users put them in danger, or they feel threatened by other people's hostility or impoliteness (Lajunen and Parker, 2001). There are a series of studies on driving anger in the world, such as Malaysia (Sullman et al., 2014), Turkey (Yasak and Esiyok, 2009), and India (Sagar et al., 2013). Scholars in Spain (Sullman et al., 2007), Japan (McLinton and Dollard, 2010), and other countries have developed driving anger scales suitable for their own countries and applied the scale to driver anger research. The current studies have found that the mechanism of driving anger is very complex, and the influencing factors of driving anger mainly focus on demographic characteristics,

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psychological factors, physiological factors, environmental factors, and genetic factors (Akbari et al., 2019; Møller and Haustein, 2017; Matović et al., 2020).

Although the research on driver anger has been enriched in the past few decades, there is very little research on the anger of non-motor vehicles, especially electric bicycles. For cyclists, Oehl et al. (2019) initially explored the interactive relationship between cycling anger and road users in Germany for cyclists. They published a cycling anger scale (CAS) covering 12 indicators, where the four main aspects include police interaction, cycling interaction, vehicle interaction, and pedestrian interaction. Anger mood usually presents a negative state. Aggressive cycling behavior and fines can induce angry emotions (Møller and Haustein, 2017). A cycling study in Australia verified that angry emotions can seriously affect the cycling behavior of cyclists, leading to dangerous behaviors (O'Hern et al., 2019). Pan et al. (2020) conducted an in-depth study on the influencing factors of bicycle anger in Shanghai. They found that vehicle behavior had the most significant impact on bicycle riders' rage. The tendency of cyclists to anger when interacting with the riding environment is closely related to the interactions between other road users (Oehl et al., 2016). Interaction with a driver is the most irritating situation encountered while riding a bicycle (Huemer et al., 2018). The findings from these studies show that propensities for anger and aggression in cyclists are like that of drivers, that is, the appearance of anger has an adverse effect on both car drivers and bicycle cyclists. Thereby a similar connection may exist for electric bicycle riders. In most cases, it will interact with other road users. The more opportunities for interaction, the easier it is to generate anger, especially when interacting with pedestrians and the surrounding environment.

In summary, a large number of studies have been conducted on the anger of car drivers and cyclists in the world, but there is little research on the anger of electric bicycle riders, especially in a campus area where electric bicycles are the main commuters. Since the new century, the rise of college enrollment rate has made the number of teachers and students in colleges and universities continually increase. When the campus constantly enriches and perfects its education environment, it also results in some problems such as overlong traffic routes among functional areas in campus, travel inconvenience and so on (Shu and Wu, 2018). The introduction of electric bicycles on campus was expected to ease campus travel problems. The number of electric bicycles is rapidly increasing in colleges and universities. Despite the obvious advantages, the rapid growth of electric bicycles has also brought a series of safety issues. Therefore, the research on electric bicycle riding in Colleges and universities can better solve the problem of campus traffic safety.

This research designs an electric bicycle anger scale with campus characteristics combined with the travel characteristics of campus electric bicycle and the environment, based on the campus traffic environment and the cycling anger scale (CAS). A structural equation model was established to explore the root causes of college students' anger on campus riding based on questionnaire analysis. Finally, based on the existing problems of electric bicycle in Campus, several recommendations related to safety education measures are proposed.

## 2. Method

### 2.1. Structural equation model

The structural equation model is a statistical method to analyze the relationship between variables based on the covariance matrix of variables. It is an essential tool for multivariate data analysis (Martynova et al., 2018). It mainly includes measurement model and structural model. Among them, the measurement and structural models are expressed by the function of linear regression (Bollen, 2014). The measurement model is mainly suitable for studying the relationship between observed and latent variables. It uses dominant variables to express non-dominant variables and make them explicit; The structural model

mainly uses latent variables (hidden variables). According to causality, it is divided into external latent variables and internal latent variables.

According to the questionnaire design in the electric bicycle rider anger scale, the measurement sub-models of this study include pedestrian interaction, traffic management interaction, rider interaction and environmental interaction. A more detailed description is given below. Because of this, the following interactions are assumed to be correlated:

**Hypothesis 1.** Pedestrian and rider interactions.

**Hypothesis 2.** Pedestrian and environmental interactions.

**Hypothesis 3.** Traffic management and rider interactions.

**Hypothesis 4.** Traffic management and environmental interactions.

**Hypothesis 5.** Rider and environmental interactions.

**Hypothesis 6.** Traffic management and Pedestrian interactions.

### 2.2. Participants and procedure

This research aims to the influencing factors of angry riding behavior of campus electric bicycles. The questionnaire was posted online through Sojump – a popular online survey tool in China. A total of 370 questionnaires were sent out to electric bicycle riders in Fuzhou University. After the invalid and problematic questionnaires were eliminated, 333 valid questionnaires were finally collected, with an effective rate of 90%. When the sample number is not less than 10 times the measurement variables, the structural equation model is credible (Bentler and Chou, 1987). The sample included 234 male students (70.27%) and 99 female students (29.73%). The mean age of the sample was 19.91 years (SD = 1.84, age-range = 17–29), covering students at all stages of life on campus. The study was approved by the ethics committee of the University. In order to stimulate participation, each participant will receive a small gift after completing the questionnaire.

### 2.3. Measures

Based on the cycling anger scale (CAS) by Oehl et al. (2019), an electric bicycle riding anger scale was made. Since the objects of investigation are students in this study, the parts that are not appropriate for campus traffic, such as interaction with cars, were deleted. In addition, a preliminary survey was conducted to understand the students' views on the riding environment of electric bicycles to design a targeted questionnaire. The questionnaire in this study consists of four parts (pedestrian interaction, traffic management interaction, rider interaction, and environment interaction), and the specific statistical data are shown in Table 1. The scale uses a 5-point scale (1 "not angry at all" to 5 "very angry"). This questionnaire has good reliability and validity (Table 2).

### 2.4. Data analysis

After soliciting the informed consent of school leaders and students, this study adopts the principle of stratified sampling and takes the grade as a unit. The obtained questionnaire data were processed by SPSS25.0 and AMOS22.0 software. First, the reliability and validity of the questionnaire were verified. Then, the path analysis of pedestrian interaction, traffic management interaction, rider interaction, and environment interaction were conducted by using a structural equation model. Finally, modification index (MI) and critical ratio (CR) were modified to ensure the validity of the model. The model fit was assessed by the standard chi-square fit statistic and the comparative fit index (CFI; Bentler and Dudgeon, 1996), the Tucker-Lewis Index (TLI; Tucker and Lewis, 1973), and the root-mean-square error of approximation (RMSEA; Browne and Cudeck, 1993). A CFI greater than 0.90 and an RMSEA less than 0.08 indicate a good model fit (Hu and Bentler, 1999). Because  $\chi^2$  statistic is very sensitive to sample size, we use ( $\chi^2/DF$ ) to evaluate model fitting. If

**Table 1.** Questionnaire dimensions and descriptive statistics<sup>a</sup>.

Latent and Measured Variables	Mean	SD
<b>Pedestrian Interaction (PI)</b>		
A1: Pedestrians stop in front of you and linger a long time	2.48	0.91
A2: Pedestrians suddenly barge in front of you	2.99	0.90
A3: Pedestrians occupy electric bicycle lanes	2.65	0.88
A4: Pedestrians make harsh noises next to you	2.51	0.98
<b>Rider Interaction (RI)</b>		
B1: Students riding electric bicycles pass you quickly from behind	2.15	0.89
B2: Students riding electric bicycles cut you in, forcing you to slow down or stop	3.06	0.98
B3: Students on electric bicycles honked furiously behind you	3.31	1.01
B4: The electric bicycles ahead is too slow for you to pass quickly	2.71	0.90
<b>Traffic Management Interaction (TMI)</b>		
C1: Try to run the yellow light and stopped by the security guard	2.22	0.85
C2: Stuck by the security guard and asked for a campus passcode	2.34	0.99
C3: Stopped by a security guard from entering the campus for riding a potentially illegal electric bicycle	2.44	0.93
C4: Wait too long at a red light at an intersection	2.43	0.96
C5: Try to get to the destination quickly while the traffic is very heavy	2.60	0.99
<b>Environment Interaction (EI)</b>		
D1: See the uncivilized phenomenon around	3.15	0.99
D2: Some unclean things fell on the electric bicycle	3.37	1.01
D3: The electric bicycle violently bumps as it passes through the potholes	2.45	1.04
D4: Severe weather, such as heavy rain or extreme heat	2.76	1.00
D5: During the cycling process, the surrounding environment is very noisy	2.56	0.98

<sup>a</sup> SD = standard deviations.

**Table 2.** Reliability and validity analysis of latent variables.

Index Type and Index Name	Interaction			
	PI	RI	TMI	EI
<b>Reliability indices</b>				
Cronbach's alpha	0.826	0.747	0.846	0.836
Standards-based Cronbach's alpha	0.829	0.747	0.848	0.836
<b>Validity index</b>				
KMO	0.792	0.672	0.813	0.832
<b>Bartlett spherical inspection</b>				
Approximate chi-square	494.670	324.069	710.032	648.638
df	6	6	10	10
Sig.	0	0	0	0

$\chi^2/DF$  is less than 3, it means that the model is acceptable (Byrne, 2009; Jiang et al., 2019).

### 3. Results

#### 3.1. Descriptive statistics and analysis

According to the scoring statistics of the scale in this study, the average score of the four latent variables in the scale is environmental interaction (2.86), rider interaction (2.81), pedestrian interaction (2.66), and traffic management interaction (2.41) in descending order. According to the data, riders are most likely to experience anger when they interact with their surroundings. At the same time, interacting with regulatory conditions such as traffic management produced the lowest levels of anger.

We used independent sample t test to analyze the relationship between demographic characteristics and cycling anger. It was found that the difference in response to riding anger during gender, education and

riding frequency were statistically significant and showed a statistically significant difference between the good and adverse outcome (Table 3). Although different sociodemographic characteristics show different scores, male are more likely to riding anger than female and undergraduates than postgraduates, and people with less riding frequency are more prone to anger. However, in general, the overall riding anger state is still relatively low.

#### 3.2. Model construction and verification

First, AMOS22.0 software was used to construct the structural equation model for all the actual measured data and verified. Including pedestrian interaction, traffic management interaction, rider interaction, and environment interaction as latent variables, a total of 18 measurement items were used. The relationship among latent variables was assumed, and an initial model was established. The results show that the fitting indexes of this model are:  $\chi^2/DF = 3.735$ , CFI = 0.875, GFI = 0.857, AGFI = 0.810, RMSEA = 0.091. All the indicators are poor, indicating that the model fitting degree needs to be adjusted again.

In modification indexes, we found that the M.I. of several other pairs such as e5-e18 is relatively large, so we corrected it. And because hypothesis 6 doesn't reach significant level, we refuse to accept it. A more suitable model is obtained by correcting the initial model with correction index (MI), critical ratio (CR) and path adjustment. Refer to Figure 1 for the Cause model of anger of electric bicycle riders model. The results show that the fitting indexes of the model are as follows:  $\chi^2/DF = 2.257$ , CFI = 0.954, GFI = 0.932, AGFI = 0.902, and RMSEA = 0.062. The path coefficient between all variables is significant at the level of 0.05. In addition, the basic relevancy analysis indicates that the error variances from e1 to e18 were positive. The CR values of all error variances ranged from 10.782 - 17.388, and all of them reached a significant level of 0.001 or above. The standard error of the parameter is between 0.06 and 0.13, which is not large. The factor load between the potential variable and its measuring pointer is between 0.60 and 0.85, which meets the criteria requiring a value greater than 0.50 and less than 0.95. As far as the above analysis is concerned, the inspection results meet the requirements. Satisfactory basic fitness also indicates good model quality (Table 4).

#### 3.3. Model interpretation

##### 3.3.1. Relationship among latent variables

Pedestrian interaction, traffic management interaction, rider interaction, and environmental interaction are correlated (Figure 1). The potential variables of pedestrian interaction, rider interaction, traffic management interaction, and environmental interaction were all positive, and the path coefficients were 0.20, 0.68, and 0.55, respectively. Compared with the change in pedestrian interaction or traffic management interaction, the rider interaction is more sensitive to environmental interaction. Rider interaction (the anger generated by the interaction between riders) is more likely to become stronger or weaker with the

**Table 3.** Results of independent-sample T test of demographic features.

Variables	N	%	Overall average score	t
<b>Gender</b>				
Male	234	70.27	2.73 ± 0.56	2.805**
Female	99	29.73	2.54 ± 0.58	
<b>Education</b>				
Undergraduate	216	64.86	2.80 ± 0.54	5.739***
Postgraduate	117	35.14	2.44 ± 0.56	
<b>Riding frequency</b>				
Once a week and less	77	23.12	2.88 ± 0.72	3.699***
Several times a week and more	256	76.88	2.61 ± 0.51	

Note. \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001.

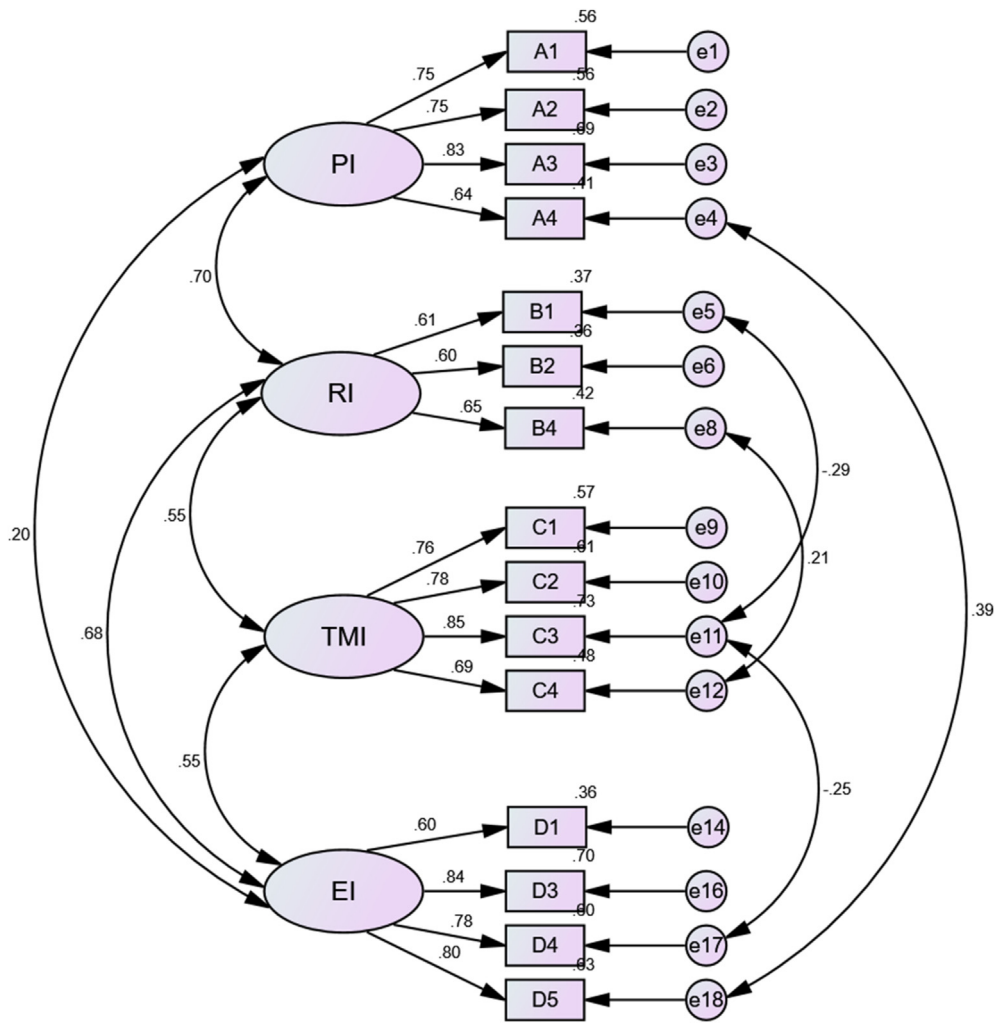


Figure 1. The cause model of anger of electric bicycle riders model.

Table 4. Assessment of model fit.

Index name	$\chi^2/DF$	CFI	GFI	AGFI	RMSEA	TLI
Initial model	3.732	0.871	0.858	0.813	0.092	0.849
Final model	2.257	0.954	0.932	0.902	0.062	0.942
Standard requirement	<3.0	>0.9	>0.9	>0.9	<0.08	>0.9

change of environmental interaction. The interaction between latent variables of pedestrian interaction, traffic management interaction, and rider interaction were all positive, and the path coefficients were 0.70 and 0.55, respectively. These values indicate that rider interaction is more vulnerable to pedestrian interaction. In other words, the anger generated by the interaction between riders and pedestrians tends to increase as this interaction changes. Note that the induction of anger among the electric bicycle riders results from the joint action of multiple factors, and the potential variables are mutually promoting and acting together.

3.3.2. Relationship between latent variables and observed variables

Pedestrian interaction, traffic management interaction, rider interaction, and environment interaction all have a specific correlation with their corresponding observed variables. Thus, the observed variables will have different degrees of influence on their corresponding latent

variables. Pedestrian interaction, cyclist interaction, traffic management interaction, and environment interaction positively affect their observed variables, where pedestrian occupancy of electric bicycle path has the largest path coefficient for pedestrian interaction with a value of 0.83. Compared with other observed variables, it is more likely to make riders angry.

The path coefficient of "stopped by a security guard from entering the campus for riding a potentially illegal electric bicycle" was the largest, at 0.85. This factor was more likely to make riders angry than other observed variables. In rider interaction, the path coefficients of each observed variable were close to each other, which were 0.61, 0.60, and 0.65, respectively, indicating that the sensitivity of each observed variable to rider interaction was close. In terms of environmental interaction, the path coefficient of "the electric bicycle violently bumps as it passes through the potholes" is the largest, which is 0.84. This result indicates that this factor has the greatest impact on environmental interaction and is more likely to cause riders to have angry emotions.

3.3.3. Residual analysis

In this model, e4 and e17, e5 and e11, e8 and e12, and e11 and e17 all have a significant correlation. The main reason may be that rider interaction, and pedestrian interaction are all road users. At the same time, the questionnaire description of the measurement indicators in the model is similar, and the traffic management interaction also serves the road users, so the residuals of all variables are correlated.

## 4. Discussion

This study aims to investigate the anger of Chinese campus electric bicycle riders, and to understand whether their tendency to become angry in the electric bicycle environment is related to their surrounding interactions.

We found that pedestrian interaction, traffic management interaction, rider interaction, and environmental interaction contribute to the generation of anger among electric bicycle riders. Moreover, these factors can promote each other to induce the rider's anger. The results indicate that electric bicycle riders are more likely to experience anger under circumstances where their progress get interrupted or they feel threatened by other road users, resembling the conclusion drawn by a series of studies on driving anger (e.g., Deffenbacher et al., 2016). Unstable riding mood affects riders' riding performance. It also hinders the normal play of the rider's technology. In other words, anger not only affects their risk perception and information processing ability, but also has a negative impact on other road users (Funkenstein et al., 1954). Because the riding process of drivers on the road is the process of human vehicle road interaction, environmental factors affect the rider's mood and behavior. When in a specific environment, the pressure given by environmental factors will affect the rider's emotion and behavior regulation and control ability. Therefore, it is easy to generate riding anger and aggressive riding when the rider is in a specific environment (Stephens and Groeger, 2009). Moreover, the driver will be angry because of the increased driving pressure caused by the environment, which has similar results for electric bicycle riders.

This study also shows that environmental interaction has the most significant impact on riders' anger. Many studies have shown that the environment can influence changes in anger. For example, Lei (2014) found that bad weather would increase the level of driving anger, which is more obvious in electric bicycle riders. However, environmental factors often stem from their effect on a rider's mood or stress levels and generally do not directly respond. Riders' infractions or aggressive riding behaviors also generate anger, which is consistent with the research of Hezaveh et al. (2018). People sometimes show this anger when interacting with other road users (Stephens et al., 2019). This theory can be applied to campus traffic congestion and poor road conditions. Waiting too long at a red light also increases the level of angry riding among riders. Adventure riding and aggressive riding are significantly related to riding anger (Zheng et al., 2020). Wichens and et al. (2013) found that slow driving, hostile gestures, and other car behaviors would arouse drivers' anger, which is also applicable to the current research regarding on-campus electric bicycles. In the pedestrian interaction, the level of anger was not high, indicating that the rider was more moderate in the interaction with the pedestrian. Given that riders are respectful and courteous to pedestrians, there is not much friction.

Importantly, although angry riding is very dangerous, the phenomenon of angry riding among college students is not obvious, and most students can effectively control their emotions. This may be related to the success of quality-oriented education in colleges and universities. It also confirms the finding by Yasak and Esiyok (2009) that the higher the education level, the lower the driving anger level. However, the rage will still negatively impact campus traffic safety, so it is still necessary to strengthen the psychological education of students.

### 4.1. Policy recommendations

Preventing the emergence of angry cycling on campus and improving the safety of electric bicycles are an important part of ensuring the safety of college students' daily travel. Therefore, strengthening campus safety education and management of students is needed. Based on the results of this study and given the hazards of rage riding, the following recommendations are made:

First, Optimize campus road traffic planning. In this study, we confirmed that the riding environment may trigger anger. Hence, in the

long term, the layout of campus planning should be optimized. The necessary parking areas for electric vehicles and bicycles should be designated so that all kinds of non-motor vehicles can conveniently park nearby. It is also necessary to set up an electric-vehicle charging area nearby for the students' convenience. The road space should be separated from the space designated for pedestrians. At the same time, the non-motorized lane can be painted in color to highlight its uniqueness so that other road users can stay away from the non-motorized lane psychologically and reduce pedestrian interactions.

Second, strengthen campus traffic management. Our survey found that inappropriate management measures on campus often lead to anger when students ride electric bicycles. It is necessary to take reasonable traffic management measures on campus. For example, a fence should be set up on the main roads where more people are on campus to prohibit motor vehicles from passing during rush hours and quitting time to reduce the intensive contact between motor vehicles, electric vehicles, and pedestrians.

Third, strengthen training and practice by various means. An important reason why angry riding on campus is not serious is the good safety education in Colleges. It is very necessary to continue to carry out similar educational activities, including entrance education, traffic safety courses, education film on traffic safety warnings, reporting system for campus traffic accidents, theme education activities, "traffic safety day" publicity, and a visit to education workshop. In addition, traffic safety training should be regularly conducted to strengthen traffic safety education and students' psychological education. Students' traffic safety consciousness and mental health should be improved from two aspects (daily life and class) to cultivate students' traffic safety consciousness and improve their emotional control (Zhang, 2021).

In brief, the key to really reduce angry riding is the rule of law and personal constraints. We recommend strengthening law enforcement and education while improving the electric bicycle infrastructure as a potential means of addressing such behaviour. Through reasonable campus road planning, strengthening campus traffic management, and safety education and practice, reducing the unreasonable interaction between e-bike riders and the environment is an important measure to effectively avoid the phenomenon of angry riding on campus.

### 4.2. Limitations and future research

This study has some limitations. First, although stratified sampling was adopted in the study and the grades were representative to a certain extent, there are still some limitations in the sampling. That is, it fails to include students of all majors, which may affect the research results. In addition, The results and models are based on self-reporting, which lacks objectivity. Social expectation is a central problem in the study of self-reported data (Fischer and Fick, 1993). Maybe not everyone will honestly report this type of dangerous behavior. The self-reported and the external-rated behavior greatly differ (Useche et al., 2021). Therefore, we can explore whether the self-perception of riding electric bicycles will be different from that of other users in the future.

## 5. Conclusion

In this study, the factors affecting the anger of electric bicycle riders on campus were analyzed using a questionnaire survey and the structural equation model. Appropriate countermeasures for campus traffic safety were recommended. From a theoretical perspective, this study explores the impact of pedestrian interaction on riders' anger, including pedestrian, rider, traffic management, and environmental interactions. These interactions have a specific practical significance for campus traffic safety and students' mental health education. Based on the preceding four aspects, the results showed that a comfortable, safe, and fast traffic environment could be created on campus. This plays a viable role in improving the traffic safety of the entire campus and even provides a

theoretical reference for building a good campus image. Based on this study, the following conclusions can be drawn:

1. The anger level of campus electric bicycle riders is relatively low because of the continuous promotion of quality-oriented education in universities and improving students' psychological coping level to emergencies.
2. The anger of electric bicycle riders on campus is mainly caused by pedestrian interaction, rider interaction, traffic management interaction, and environmental interaction, where environmental factors are more likely to irritate riders.
3. Since the safety education of university students, especially traffic safety education, is of great significance and far-reaching influence, it is necessary to strengthen further the management and education of traffic safety on campus in a careful, long-term, and practical way.

## Declarations

### Author contribution statement

Changbin Xu: Conceived and designed the experiments; Performed the experiments; Wrote the paper.

Linwei Wang: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Said M. Easa: Analyzed and interpreted the data; Wrote the paper.

Yanqun Yang: Contributed reagents, materials, analysis tools or data; Analyzed and interpreted the data; Wrote the paper.

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### Data availability statement

Data included in article/supp. material/referenced in article.

### Declaration of interests statement

The authors declare no conflict of interest.

### Additional information

No additional information is available for this paper.

## References

- Akbari, M., Kamran, B.L., Heydari, S.T., Motevalian, S.A., Tabrizi, R., Asadi-Shekari, Z., Sullman, M.J., 2019. Meta-analysis of the correlation between personality characteristics and risky driving behaviors. *J. Injury Viol. Res.* 11 (2), 107.
- Bollen, K.A., 2014. *Structural Equations with Latent Variables*. Wiley.
- Byrne, B.M., 2009. *Structural Equation Modeling with AMOS: Basic Concepts, Applications, and Programming*, second ed. Taylor & Francis.
- Browne, M.W., Cudeck, R., 1993. Alternative ways of assessing model fit. In: Bollen, K.A., Long, J.S. (Eds.), *Testing Structural Equation Models*. Sage, Beverly Hills, CA, pp. 136–162.
- Bentler, P.M., Chou, C.P., 1987. Practical issues in structural modeling. *Socio. Methods Res.* 16 (1), 78–117.
- Bentler, P.M., Dudgeon, P., 1996. Covariance structure analysis: statistical practice, theory, directions. *Annu. Rev. Psychol.* 47, 563–592.
- Bigazzi, A., Wong, K., 2020. Electric bicycle mode substitution for driving, public transit, conventional cycling, and walking. *Transport. Res. Transport Environ.* 85, 102412.
- Deffenbacher, J.L., Lynch, R.S., Oetting, E.R., Swaim, R.C., 2002. The driving anger expression inventory: a measure of how people express their anger on the road. *Behav. Res. Ther.* 40 (6), 717–737.
- Deffenbacher, J.L., Lynch, R.S., Oetting, E.R., Yingling, D.A., 2001. Driving anger: correlates and a test of state-trait theory. *Pers. Individ. Differ.* 31 (8), 1321–1331.
- Deffenbacher, J.L., Oetting, E.R., Lynch, R.S., 1994. Development of a driving anger scale. *Psychol. Rep.* 74 (1), 83–91.
- Deffenbacher, J.L., Stephens, A.N., Sullman, M.J.M., 2016. Driving anger as a psychological construct: twenty years of research using the Driving Anger Scale. *Transport. Res. Part F: Traffic Behavior and Psychology* 42, 236–247.
- Fishman, E., Cherry, C., 2016. E-bikes in the mainstream: reviewing a decade of research. *Transport Rev.* 36 (1), 72–91.
- Fischer, D., Fick, C., 1993. Measuring social desirability: short forms of the Marlowe-Crowne social desirability scale. *Educ. Psychol. Meas.* 53 (2), 417–423.
- Funkenstein, D.H., King, S.H., Drolette, M., 1954. The direction of anger during a laboratory stress-inducing situation. *Psychosom. Med.* 16 (5), 404–413.
- Fyhri, A., Sundfør, H.B., 2020. Do people who buy e-bikes cycle more? *Transport. Res. Transport Environ.* 86, 102422.
- Ge, Y., Qu, W., Zhang, Q., Zhao, W., Zhang, K., 2015. Psychometric adaptation of the driving anger expression inventory in a Chinese sample. *Transport. Res. F Traffic Psychol. Behav.* 33, 75–86.
- Hu & Bentler, 1999. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct. Equ. Model.* 6 (1), 1–55.
- Huemer, A.K., Oehl, M., Brandenburg, S., 2018. Influences on anger in German urban cyclists. *Transport. Res. F Traffic Psychol. Behav.* 58, 969–979.
- Hezaveh, A.M., Zavareh, M.F., Cherry, C.R., Nordfjærn, T., 2018. Errors and violations in relation to bicyclists' crash risks: development of the bicycle rider behavior questionnaire (BRBQ). *J. Transport Health* 8, 289–298.
- Jiang, K., Yang, Z., Feng, Z., Yu, Z., Huang, Z., 2019. Mobile phone use while cycling: a study based on the theory of planned behavior. *Transport. Res. F Traffic Psychol. Behav.* 64, 388–400.
- Lei, H., 2014. *Analysis and Modeling of Driving Behavior under Anger (Doctor Thesis)*, 2014. Wuhan University of Technology, Wuhan, Hubei, China.
- Lajunen, T., Parker, D., 2001. Are aggressive people aggressive drivers? A study of the relationship between self-reported general aggressiveness, driver anger and aggressive driving. *Accid. Anal. Prev.* 33, 243–255.
- Ma, C., Yang, D., Zhou, J., Feng, Z., Yuan, Q., 2019. Risk riding behaviors of urban e-bikes: a literature review. *Int. J. Environ. Res. Publ. Health* 16 (13), 2308.
- McLinton, S.S., Dollard, M.F., 2010. Work stress and driving anger in Japan. *Accid. Anal. Prev.* 42 (1), 174–181.
- Møller, M., Haustein, S., 2017. Anger expression among Danish cyclists and drivers: a comparison based on mode specific anger expression inventories. *Accid. Anal. Prev.* 108, 354–360.
- Matović, B., Jovanović, D., Pljakić, M., Stanojević, P., 2020. Driving anger and factors related to aggressive driving among Serbian drivers. *Traffic Inj. Prev.* 21 (5), 319–323.
- Martynova, E., West, S.G., Liu, Y., 2018. Review of principles and practice of structural equation modeling. *Struct. Equ. Model.: A Multidiscip. J.* 25 (2), 325–329.
- Oehl, M., Brandenburg, S., Huemer, A.K., 2019. Cyclists' anger experiences in traffic: the cycling anger scale. *Transport. Res. F Traffic Psychol. Behav.* 62, 564–574.
- Oehl, M., Emmermann, B., Brandenburg, S., Huemer, A.K., 2016. Cycling anger: regular cyclists vs. Professional bicycle messengers. In: Paper Presented at the International Cycling Safety Conference 2016 Bologna.
- O'Hern, S., Stephens, A.N., Young, K.L., Koppel, S., 2019. What makes cyclists angry? The relationships between trait anger, interest in cycling and self-reported comfort levels. *Transport. Res. F Traffic Psychol. Behav.* 62, 672–680.
- Pan, X., Gan, H., Yin, P., Che, L., 2020. Study on the influencing factors of bicycle anger. *Logist. Sci-Tech.* 43 (12), 67–71.
- Schepers, J.P., Fishman, E., Den Hertog, P., Wolt, K.K., Schwab, A.L., 2014. The safety of electrically assisted bicycles compared to classic bicycles. *Accid. Anal. Prev.* 73, 174–180.
- Sagar, R., Mehta, M., Chugh, G., 2013. Road rage: an exploratory study on aggressive driving experience on Indian roads. *Int. J. Soc. Psychiatr.* 59 (4), 407–412.
- Shu, Z., Wu, X., 2018. The route planning on campus bus in H university. *Am. J. Ind. Bus. Manag.* 8 (3), 473–486.
- Stephens, A.N., Groeger, J.A., 2009. Situational specificity of trait influences on drivers' evaluations and driving behaviour. *Transport. Res. F Traffic Psychol. Behav.* 12 (1), 29–39.
- Sullman, M.J., Gras, M.E., Cunill, M., Planes, M., Font-Mayolas, S., 2007. Driving anger in Spain. *Pers. Individ. Differ.* 42 (4), 701–713.
- Stephens, A.N., O'Hern, S., Trawley, S., Young, K.L., Koppel, S., 2019. Self-reported aggression amongst active cyclists. *Accid. Anal. Prev.* 128, 46–52.
- Sullman, M.J., Stephens, A.N., Yong, M., 2014. Driving anger in Malaysia. *Accid. Anal. Prev.* 71, 1–9.
- Tucker, L.R., Lewis, C., 1973. A reliability coefficient for maximum likelihood factor analysis. *Psychometrika* 38, 1–10.
- Thomas, P., Morris, A., Talbot, R., Fagerlind, H., 2013. Identifying the causes of road crashes in Europe. *Ann. Adv. Auto. Med.* 57, 13.
- Useche, S.A., Gene-Morales, J., Siebert, F.W., Alonso, F., Montoro, L., 2021. Not as safe as I believed": differences in perceived and self-reported cycling behavior between riders and non-riders. *Sustainability* 13 (4), 1614.
- Yasak, Y., Esiyok, B., 2009. Anger amongst Turkish drivers: driving Anger Scale and its adapted, long and short version. *Saf. Sci.* 47 (1), 138–144.
- Yang, X., Huan, M., Abdel-Aty, M., Peng, Y., Gao, Z., 2015. A hazard-based duration model for analyzing crossing behavior of cyclists and electric bike riders at signalized intersections. *Accid. Anal. Prev.* 74, 33–41.
- Zhang, Y., 2021. Reduce the occurrence of "road rage" and ensure the safety of self-driving travel passengers. In: *E3S Web of Conferences*, 251. EDP Sciences, p. 3074.
- Zheng, Y., Ma, Y., Cheng, J., 2020. Cycling anger in China: the relationship with gender roles, cycling-related experience, risky and aggressive riding. *Transport. Res. F Traffic Psychol. Behav.* 68, 52–66.