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# Analyzing the cycling behaviors of Chinese adolescents through structural equation models

Jianrong Liu, Xinyu Chen, Mingyang Pei [*]

*Department of Civil and Transportation Engineering, South China University of Technology, Guangzhou, 510641, China*

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ABSTRACT

*Introduction:* Obesity prevalence is rising among adolescents in China, increasing the incidence of several health problems in this population. In this context, adolescents could improve their health by engaging in regular physical activity, such as cycling, whether commuting to school or during leisure time.

*Methods:* Through structural equation modeling, this article investigated the constructs that may impact the cycling activities of adolescents. A total of 424 students were interviewed, with 413 completing the questionnaires. Cycling behaviors were studied using the theory of planned behavior (TPB), the prototype willingness model (PWM), and the integrative model (a model that combines the TPB, the PWM, and the construct descriptive norm). The explanatory powers of these models were compared.

*Results:* Adolescents' cycling behaviors were influenced by several psychological factors, either directly or indirectly. Attitudes and descriptive norms had a significant effect on intention and willingness, whereas subjective norms acted only on intention. Perceived behavioral control had no significant effect on behavioral intentions or cycling behaviors. Prototype similarity significantly affected willingness.

*Conclusions:* Behavioral intentions had a significant effect on cycling behaviors. The explained variance in the PWM and integrated models is higher than that of the TPB, indicating the validity of the predictions of these two models. Psychological factors are more applicable to the exploration of the behavior of cycling to school. Cycling for leisure requires considering the influence of external factors.

## 1. Introduction

In developing countries, obesity prevalence in adolescents is rising (Ng et al., 2014). Specifically, obesity prevalence among Chinese adolescents has already reached 12% due to the rapid economic expansion experienced in China (Li et al., 2021). Obesity and overweight cause many noncommunicable diseases that can also be life-threatening to the young population (Masoud Abd El Gayed et al., 2021). Aerobic exercise can enhance sleep quality and reduce illness incidence in obese people (Sen et al., 2018; Tan et al., 2016). Therefore, it is especially crucial to improve the physical fitness of this population and, consequently, lower their obesity rates (see Fig. 1).

The World Health Organization (WHO) encourages adolescents to participate in regular physical exercise for at least 60 min a day

* Corresponding author.
*E-mail addresses:* ctjrliu@scut.edu.cn (J. Liu), 202121010142@mail.scut.edu.cn (X. Chen), mingyang@scut.edu.cn (M. Pei).

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to protect against obesity.[1] However, Chinese children aged 6 to 17 do not engage in many physical activities, and sedentary time has increased (Yang et al., 2021).

Bicycling has been considered a convenient alternative for quick journeys and activities concerning aerobic exercise in this scenario. Generally, cycling has a positive impact on the mind and plays an important role in creating a sustainable environment. People who regularly commute by bicycle have lower levels of psychological distress and higher life satisfaction (Ma et al., 2021). Bicyclists receive 20% more exercise than individuals who use passive modes of transport, such as public transportation (de Jesus et al., 2021). Therefore, the WHO recommends bicycles as an alternative to automobiles.[2]

Cycling increases daily physical activity and meets the individual needs in short-distance journeys. Many scholars have investigated the factors that influence the cycling behaviors of adolescents, but few have been conducted in China. Additionally, the impact of psychological characteristics on cycling behavior in Chinese adolescents has not been considered (Gao et al., 2018). Therefore, it is vital to comprehend the constructs that may influence these cycling behaviors to support strategies to engage them in more physical activities.

Researchers have used socioecological or social-cognitive models to analyze individual behavior (Bird et al., 2018). The theory of planned behavior (TPB) is one of the main social-cognitive models used in this sense (Ajzen, 1991). In addition, the prototype willingness model (PWM) has been used to analyze individual risky behaviors (Gibbons et al., 1998).

Although several studies have analyzed the cycling behaviors of adolescents, most studies have been conducted in developed countries. Whether these research results apply to China is worth further investigation. Few studies have been conducted comparing TPB with PWM to explain the variance in cycling behaviors among adolescents. Therefore, the purpose of this study is to analyze cycling behaviors among Chinese adolescents through TPB, PWM, and the integrated model (integrating TPB and PWM constructs and the descriptive norm), comparing the explanatory powers of these models.

The paper is organized as follows. We review the literature on the aforementioned models in Section 2. The methods and data used in this analysis are described in Section 3. The results are provided in Section 4. Discussions and implications are analyzed in Section 5, followed by conclusions in the final section.

## 2. Literature review

Sociodemographic factors may affect cycling behaviors among adolescents. Girls, older students, and those from low socioeconomic backgrounds were the adolescents who bicycled the least (Frater, 2015). Male adolescents are more likely than girls to ride bicycles for several reasons. Leslie et al. (2010) argued that boys are more active than girls in general. Frater and Kingham (2018) found that female teenagers feel that cycling inhibits them from exhibiting their femininity, in part because cycling in appealing clothing is inconvenient. Bunik et al. (2021) found that children with low BMI are more likely to select bicycles or walking as their primary travel mode. Another type of influence on cycling behaviors is related to environmental factors such as lane quality, trip distance, and living environment (Easton and Ferrari, 2015; Fitch et al., 2019; Stark et al., 2018b).

In addition to the aforementioned aspects, psychologists have focused on psychological constructs, and socioecological or social-cognitive models have been employed to study people's behaviors.

### 2.1. The theory of planned behavior

The TPB suggests that individual behavior is affected by behavioral intentions (BIs) and perceived behavioral control (PBC), and in turn, BI is affected by subjective norms (SNs), attitudes (ATTs), and PBC. ATT is the degree to which an individual favors a behavior of interest, SN is the degree to which people around an individual approve or disapprove of the individual specific behavior, and PBC describes how easily an individual can control the behavior of interest (Ajzen, 1991; Demir et al., 2019; Forward, 2009). BI represents an individual's expected and scheduled future actions.

The TPB has been used to study several travel behaviors, including bicycle commuting, pollution-aware walking, and low-carbon transport (Lin and Wang, 2021; Muñoz et al., 2016; Oviedo-Trespalacios et al., 2021), inclusively in adolescents (Frater et al., 2017b; Gao et al., 2018; Stark et al., 2018a).

One of the shortcomings related to TPB is that it considers only four structures (Bird et al., 2018; Lo et al., 2016). Other factors, such as descriptive norms (Salmivaara et al., 2021) and prototypes (Frater et al., 2017a), may impact BIs. Additionally, the TPB model argues that people make decisions based on logic. Individual behavior is sometimes more active than reasoned (Gibbons et al., 2020), and in these cases, the TPB could not explain these behaviors adequately.

### 2.2. The prototype willingness model

There are six constructs in the PWM: ATT, SN, prototype favorability (PF), prototype similarity (PS), behavioral willingness (BW), and BI. PF is the degree to which an individual favors the prototype, and PS is the degree to which an individual is similar to the prototype (Elliott et al., 2017). BW is the individual's willingness to engage in behavior in a given context (Gibbons et al., 1998). There are two pathways in PWM that affect individual behavior: the reasoned and the social reactive. The reasoned pathway states that ATTs

[1] https://www.who.int/zh/news-room/fact-sheets/detail/obesity-and-overweight.

[2] https://www.euro.who.int/coronavirus-covid-19/moving-around-during-the-covid-19-outbreak.

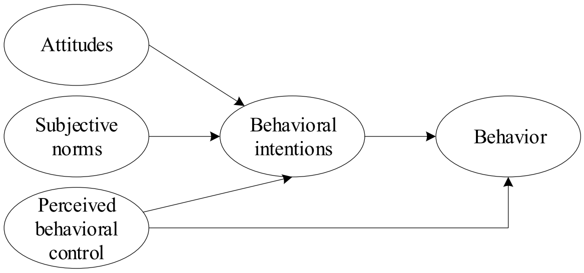


**Fig. 1.** The theory of planned behavior.

and SNs affect BIs and actual behaviors. Thus, the reasoned pathway is comparable to the TPB except that the first does not consider the PBC. On the other hand, the social reactive pathway states that ATTs, SNs, and prototype perceptions affect willingness, which further influences intentions and actual behavior. The reasoned pathway is based on analytic processing and contends that individual behavior is the consequence of the evaluation between possibilities and expected outcomes, and the social reaction argues that some behaviors are more reactive (Gibbons et al., 2003, 2020).

Concerning the decision-making process, it is known that people, especially adolescents, are easily influenced by their social contexts (van Hoorn et al., 2019). Furthermore, adolescents' risk-taking behaviors are influenced by their peers and parental behaviors due to their mental and physical immaturity. The PWM has been utilized by several researchers to investigate the factors that affect adolescent behaviors (Frater et al., 2017a; Hukkelberg and Dykstra, 2009). The PWM, unlike the TPB, is a two-step decision-making process in which prototype perception takes the role of PBC. The prototype perception is composed of PF and PS, and these two constructs have a meaningful impact on BW (Elliott et al., 2017).

The PWM is usually used to analyze the risk behaviors of individuals (especially adolescents), such as smoking habits, pedestrian violations, and speeding behavior (Demir et al., 2019; Hukkelberg and Dykstra, 2009; Preece et al., 2018).

### 2.3. *The integration of the TPB and PWM*

Several studies have integrated TPB and PWM to analyze individual behavior. Some have found that the integrated model can explain more variance than the TPB (Demir et al. (2019); Rivis et al. (2006); Tang et al. (2020)). Frater et al. (2017a) found that the prototype from the PWM had a trivial impact on the TPB's explanatory power. Therefore, whether the model that integrates TPB and PWM has higher efficacy than TPB alone may depend on the research object.

## 3. Survey design

### 3.1. *Participants and procedure*

The survey was conducted from July to August 2021 in the Liwan District of Guangzhou, China. As one of the central urban areas of Guangzhou, Liwan District had a resident population of 1,238,000 in the 2021 census. The area has more sunny days in July and August. Liwan District has several bicycle lanes and bicycle parking areas, and nonmotorized signals have been installed at two intersections on a pilot basis. The students selected for the survey were day students, all from Xi Guan Pei Ying Middle School (including middle school and high school students). Xi Guan Pei Ying Middle School is located on Duo Bao Road, which has convenient traffic and bicycle lanes. The road is flat, with no significant steep slopes, and the main users are residents and students. The average distance from home to school was 2 km, and 92.5% of the students lived within 5 km of the school. This is the reason some students ride bicycles to school.

With the consent of the teachers, the rationality of the questionnaire was explored to determine whether it would have a negative impact on the students. Additionally, students are informed that this survey is for academic research only and would take approximately 20 min to complete. The questionnaire was divided into two parts, with the students reporting their basic information and each psychological factor scale first. The students completed the first part of the questionnaire and then reported their travel behavior two weeks later, including the average number of times per week they biked to school and the number of times they biked for leisure. Due to the impact of the epidemic, the questionnaire was distributed to parents using a web link, and the students completed it together with their parents. Of the 424 students interviewed, 413 completed the questionnaires. There were 199 and 214 junior and senior high school students in the sample, respectively, ranging in age from 12 to 19 (mean: 15.8 years old), and 249 (60.3%) were female students. Fifty-four percent of the students had a BMI in the normal range, with the high school students having a higher normal rate than the middle school students. Sixty-seven percent of students owned bicycles, and their average biking time per trip was higher than those without bicycles.

### 3.2. *Model framework and questionnaire*

Since TPB and PWM constructs are latent variables, they cannot be measured directly and are reflected through the manifested variables. Structural equation modeling (SEM) is used to study cycling behaviors among adolescents. There are two models in SEM: the measurement and structural models. The measurement model analyzes the causal relationship between the latent variable and the manifest indicators, and the structural model verifies the causal and correlated relationships among latent constructs (Wang and Wang, 2012). The maximum likelihood estimation method (ML) is applied to estimate the parameters in the SEM (Hox and Bechger, 1998) (see Fig. 2).

According to the above analysis, we explored cycling behaviors through the TPB, PWM, and integrated models (which integrate TPB and PWM constructs and descriptive norms), comparing the consistency of these three models. We focus on two types of cycling behaviors: cycling to school and leisure. Fig. 3 depicts the conceptual structure of the integrated model. The specific manifest indicators for the latent variables are discussed below.

The questionnaires to assess ATTs were based on previous studies (Frater et al., 2017a); Lizana et al. (2021) and updated to reflect the purposes of our investigation. The respondents were asked to respond to the five questions (for me, riding a bicycle would be entertaining, pleasant, interesting, cool, and healthy). The level of agreement with these statements was assessed through a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). The other questionnaires used in this study, described below, were also evaluated based on this scale.

SNs were measured through a four-item questionnaire based on the study conducted by Lee et al. (2016). The statements were as follows: 1) my parents approve of me cycling to school; 2) my friends approve of me cycling to school; 3) my teachers approve of me cycling to school; and 4) my parents approve of me cycling for leisure.

DNs are how individuals typically act in a given social context. They differ from SNs, which consider only perceived social pressure from others and ignores other social factors that affect behavior (Forward, 2009). Some studies have found that DN has a significant impact on BIs and BW (Eriksson and Forward, 2011; Forward, 2009; Frater and Kingham, 2018). Therefore, the present study investigated the effects of DNs on BIs and BW and discussed how this factor plays a role in cycling behaviors among adolescents. In this sense, the participants completed a 4-question questionnaire to determine the frequency with which those close to them ride bicycles: 1) My families ride bikes frequently; 2) My classmates ride bikes frequently; 3) My neighbors ride bikes frequently; and 4) My teachers ride bikes frequently).

Cycling PBC described the student's mastery of riding technique based on (Zhang et al., 2019) and was measured through four questions: 1) I have enough physical strength to ride a bike for long distances.; 2) Cycling is easy for me; 3) I can ride a bike for more than 30 min; and 4) Riding up and down hills is easy for me.

PF was measured through the level of agreement with the following statements, which were based on a study by (Harbeck and Glendon, 2018): 1) My peers who cycle are attractive; 2) My peers who cycle are vigorous; 3) My peers who cycle are confident; and 4) My peers who cycle are independent.

PS was measured through the level of agreement with the following statements, which were based on a study by (Rivis et al., 2006): 1) I am as attractive as my peers who cycle frequently; 2) I am as vigorous as my peers who cycle frequently; 3) I am as confident as my peers who cycle frequently; 4) I am as handsome as my peers who cycle frequently; and 5) I am as independent as my peers who cycle frequently;

BI was measured through the following five scenarios: I would like to ride a bike when 1) I go to a classmate's home; 2) I go to school; 3) I go to a friend's home; 4) I go to play; and 5) I go to a place that is not too far away.

The questionnaire to assess BW was based on previous studies (Basse et al., 2020; Frater et al., 2017a) and updated to reflect the purposes of the present study. It measured the participants' willingness to cycle using five prompts: 1) When I go out, I always prefer to ride a bike; 2) When the park is 3 km away, even though the bus can transport me directly from home to the park, I like to cycle to the park; 3) When a relative's house is 3 km away and the bus can transport me directly from home to the house, I like to go there by bicycle; and 4) When a friend's house is 3 km away, and the bus can transport me directly from home to the house, I like to go there by bicycle.

## 4. Result

### 4.1. Measurement model analysis

The measurement model's reliability and convergent validity should be examined before assessing the structural model of the SEM

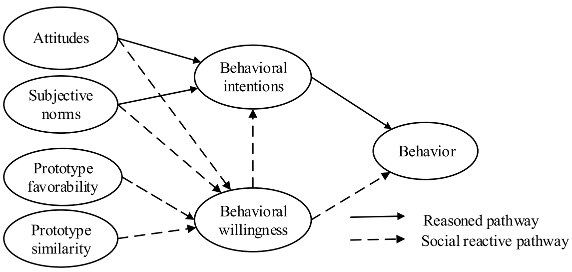


**Fig. 2.** The prototype willingness model.

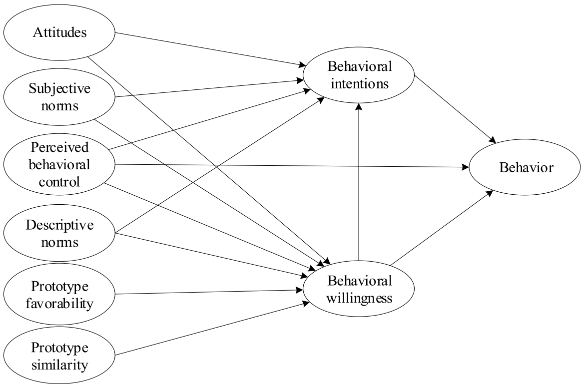


**Fig. 3.** The conceptual framework of the integrated model.

to see how properly the manifest indicators describe the latent variables (Hulland, 1999). Thus, a confirmatory factor analysis (CFA) was used to assess the manifest indicators of the constructs in Fig. 3 separately. The results are shown in Table 1.

The standardized factor loadings are acceptable when they are not less than 0.6 (Hair, 2009). The composite reliability (CR), also known as construct reliability, measures scale items' internal consistency and is acceptable when higher than 0.7 (Chin, 1998; Hair et al., 2011). The average variance extracted (AVE) is a metric that indicates how much variation in manifest indicators can be explained by the construct, considered acceptable when it exceeds 0.5 (Fornell and Larcker, 1981). Table 1 describes the reliability and convergence validity of the latent variables of the present study. The convergent validity of the latent variables is acceptable.

Discriminant validity determines whether constructs are unconnected are not. The inter-construct correlations should be less than the square root of the AVE (Hulland, 1999). In Table 2, the data on the diagonal are the square root of the AVE, and the data of the lower triangle are the correlation of correspondent constructs. As shown in Table 2, the datum on the diagonal is higher than the data on the same column and the data on the same row, confirming the discriminant validity.

### *4.2. Structural model analysis*

#### *4.2.1. Comparison of the three models*

We analyzed the cycling behaviors of adolescents using the TPB, PWM, and integrated models. The model suitability was evaluated by the chi-square freedom ratio ($\chi^2$/DF), comparative fitting index (CFI >0.9), Tucker–Lewis coefficient (TLI >0.9), approximate error root mean square (RMSEA <0.08), and standardized residual root mean square (SRMR <0.08) (Hox and Bechger, 1998; Hu and Bentler, 1999). The model fit indices of the three models are shown in Table 3. All three models were acceptable, indicating that these models are appropriate for exploring cycling behaviors in adolescents.

We compared the explanatory powers of the three models further, and the result is shown in Table 4. The TPB explains 54.1%, 26.9%, and 26.5% of the variance in BI, "cycling to school", and "cycling for leisure", respectively. The PWM explains 72.8%, 34.8%, 27.5%, and 28.2% of the variance in BI, BW, "cycling to school" behavior, and "cycling for leisure" behavior, respectively. Therefore, the PWM has a much stronger explanatory power in explaining the BI variance and a slightly higher explanatory power in explaining the variance in actual cycling behaviors in adolescents (e.g., cycling to school, cycling for leisure).

The integrated model explains 72.5%, 42.3%, 27.4%, and 28.5% of the variance in BI, BW, "cycling to school", and "cycling for leisure", respectively. Many studies have shown that the prediction effect of integrated models and PWM is better than that of TPB (Frater et al., 2017a; Hyde and White, 2010). The explained variance of the integrated model was close to that of the PWM for both intentions and "cycling to school" but was higher for both willingness ($\Delta R^2 = 0.075$) and "cycling for leisure" ($\Delta R^2 = 0.003$). Although the explanations of these two models are similar, considering that DN has a significant influence on BW and BI, PBC has a significant influence on BW. Therefore, this study focuses on analyzing the integrated model.

**Table 1**
The reliability and convergence validity of the latent variables.

| Constructs | Standard loading | CR | AVE |
|---|---|---|---|
| ATT | 0.670–0.839 | 0.866 | 0.565 |
| SN | 0.655–0.782 | 0.819 | 0.531 |
| DN | 0.711–0.816 | 0.835 | 0.559 |
| PBC | 0.780–0.903 | 0.920 | 0.742 |
| PF | 0.809–0.908 | 0.914 | 0.726 |
| PS | 0.887–0.917 | 0.958 | 0.820 |
| BI | 0.833–0.932 | 0.948 | 0.786 |
| BW | 0.676–0.962 | 0.935 | 0.786 |

**Table 2**
Discriminant validity of constructs.

| | ATT | SN | DN | PBC | PF | PS | BI | BW |
|---|---|---|---|---|---|---|---|---|
| ATT | 0.752 | | | | | | | |
| SN | 0.506 | 0.729 | | | | | | |
| DN | 0.248 | 0.575 | 0.748 | | | | | |
| PBC | 0.454 | 0.584 | 0.454 | 0.861 | | | | |
| PF | 0.475 | 0.605 | 0.553 | 0.572 | 0.852 | | | |
| PS | 0.474 | 0.502 | 0.502 | 0.484 | 0.762 | 0.906 | | |
| BI | 0.525 | 0.686 | 0.576 | 0.567 | 0.693 | 0.667 | 0.887 | |
| BW | 0.411 | 0.473 | 0.538 | 0.473 | 0.513 | 0.519 | 0.737 | 0.887 |

**Table 3**
The goodness of fit indices.

| Fit index | Criterion | TPB | PWM | The integrated model |
|---|---|---|---|---|
| $\chi^2$ | | 379.604 | 973.737 | 1446.615 |
| DF | | 129 | 309 | 532 |
| $\chi^2$/DF | $1< \chi^2/DF < 3$ | 2.943 | 3.012 | 2.719 |
| CFI | >0.9 | 0.954 | 0.940 | 0.929 |
| TLI | >0.9 | 0.945 | 0.932 | 0.920 |
| RMSEA | <0.08 | 0.069 | 0.070 | 0.065 |
| SRMR | <0.08 | 0.039 | 0.051 | 0.051 |

**Table 4**
Explanatory power for each model (%).

| Models | BI | BW | Behavior | |
|---|---|---|---|---|
| | | | Cycling to school | Cycling for leisure |
| TPB | 54.1 | | 26.9 | 26.5 |
| PWM | 72.8 | 34.8 | 27.5 | 28.2 |
| The integrated model | 72.5 | 42.3 | 27.4 | 28.5 |

*4.2.2. Further analysis of the integrated model*

Since the integrated model had greater explanatory power, in this part, we analyze the integrated model further, and the result is shown in Table 5 and Fig. 4. In Fig. 4, a dashed line indicates that the parameter is nonsignificant at the 95% confidence level, whereas a solid line indicates that the parameter is significant at the 95% confidence level.

ATT ($\beta = 0.213$, $p < 0.05$), SN ($\beta = 0.368$, $p < 0.05$), DN ($\beta = 0.109$, $p < 0.05$) and BW ($\beta = 0.552$, $p < 0.001$) had significant influences on BI. SN has a greater impact on BI than ATT, DN, and PBC. PBC had a nonsignificant impact on BI, and the result is inconsistent with most studies analyzing cycling behavior through TPB (Acheampong, 2017; Frater et al., 2017a; Jakovcevic et al., 2019; Leong et al., 2015; Milković and Štambuk, 2015; Zhang et al., 2020). ATT ($\beta = 0.203$, $p < 0.01$), DN ($\beta = 0.282$, $p < 0.001$) and

**Table 5**
The results regarding the integrated model.

| Explained variable | Explanatory variable | Estimate | S.E. | Est./S.E. | P Value |
|---|---|---|---|---|---|
| BI | ATT | 0.213 | 0.067 | 3.173 | 0.002 |
| | SN | 0.368 | 0.067 | 5.512 | 0.000 |
| | PBC | 0.066 | 0.046 | 1.427 | 0.154 |
| | DN | 0.109 | 0.054 | 2.005 | 0.045 |
| | BW | 0.552 | 0.060 | 9.252 | 0.000 |
| BW | ATT | 0.203 | 0.073 | 2.768 | 0.006 |
| | SN | 0.010 | 0.067 | 0.147 | 0.883 |
| | PBC | 0.123 | 0.050 | 2.435 | 0.015 |
| | DN | 0.282 | 0.060 | 4.742 | 0.000 |
| | PF | 0.034 | 0.075 | 0.453 | 0.651 |
| | PS | 0.160 | 0.060 | 2.653 | 0.008 |
| Cycling to school | BI | 0.908 | 0.196 | 4.628 | 0.000 |
| | BW | 0.352 | 0.196 | 1.794 | 0.073 |
| | PBC | 0.077 | 0.159 | 0.484 | 0.629 |
| Cycling for leisure | BI | 0.733 | 0.182 | 4.027 | 0.000 |
| | BW | 0.569 | 0.191 | 2.985 | 0.003 |
| | PBC | 0.164 | 0.150 | 1.091 | 0.275 |

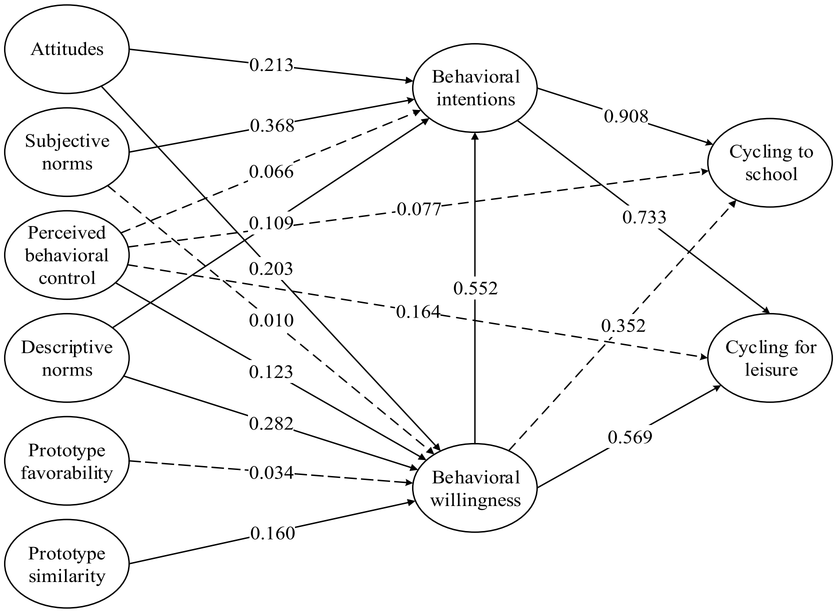


**Fig. 4.** The result of the integrated model.

PS ($\beta = 0.160$, $p < 0.01$) significantly influenced BW, whereas SN and PF did not.

In terms of actual cycling behaviors, only BI had a significant impact on cycling to school, whereas BW and PBC did not. BI and BW significantly affected cycling for leisure, whereas PBC did not. Therefore, "cycling to school" behavior was based on analytic processing rather than reactive processing, while "cycling for leisure" behavior included both analytic and reactive processing.

We further analyzed the direct and indirect effects of the integrated model, and the results are shown in Table 6. ATT, DN, and PS had a significant direct and indirect impact on BI, whereas SN, PF, and PBC did not.

Regarding the impact of the exogenous constructs on actual cycling behavior, ATT, SN, DN, and PS significantly affected "cycling to school" and "cycling for leisure". PBC had a significant indirect effect on "cycling for leisure" behavior but did not have an indirect effect on cycling to school. Finally, PF did not present a significant indirect effect on actual cycling behavior.

## 5. Discussion and implications

Cycling can help reduce traffic congestion, lower harmful gas emissions, improve public health, and decrease obesity prevalence (Gu et al., 2019). It is urged that the government propose more programs to increase population cycling habits, thus maintaining a low-carbon, environmentally friendly, and health-benefit mode of transportation. Depending on the social background, the impacts of constructs on cycling behavior may vary. The present investigation analyzed cycling behaviors among Chinese adolescents through TPB, PWM, and descriptive norm constructs.

Attitude affects cycling intentions as well as "cycling to school" and "cycling for leisure" behaviors in adolescents; that is, the degree to which an adolescent favors cycling has a considerable effect on cycling behavior. The significant effect of attitude was also verified by the findings of (García et al., 2019) and (Lois et al., 2015). To change students' negative attitudes toward cycling, schools should provide safety instruction and publicity. Additionally, bicycle benefits should be promoted in public places, such as bus stops and subways, on relevant television programs, and in online videos. Students are more likely to ride when they feel that it is convenient.

Ghekiere et al. (2016) stated that parents' conceptions of cycling and how much they push their children to cycle are relevant factors influencing cycling habits in children, agreeing with the findings of our study. Parental subjective norms play the same role in children's reluctance to ride their bikes to school (Frater et al., 2017a). In this study, parents and friends are most in favor of students' riding, while the school's support is relatively low. The most important concern for parents is travel safety, including traffic chaos and distance from home (Nasrudin and Nor, 2013; Woldeamanuel, 2016). To change parents' perceptions of their children's active travel, relevant authorities can increase bicycle lanes, adjust streetlights, and increase the patrol of traffic police during school hours. Parents also agree that students should wear helmets and booster seats for safer riding (Piotrowski et al., 2020).

It has been demonstrated that seeing an increased number of cyclists can influence cycling habits among individuals (Wang et al., 2015). We have found that descriptive norms affect cycling intentions and behaviors, indicating that the cycling preferences of nearby people have a significant impact on adolescents' choices. (Eriksson and Forward, 2011) also found descriptive norms to be significant predictors of the intention to use buses and take bicycle trips. Active travel is a key component of sustainable transportation (Maltese et al., 2021). Besides promoting the benefits of cycling, teachers should also engage in cycling commuting to influence their students. It is necessary to add bicycle parking spots on campus to facilitate the parking of teachers and students.

Prototype similarity impacts both cycling intentions and behaviors, suggesting that adolescents' identification with their peers can

**Table 6**
Direct and indirect effects of the integrated model.

| | BI | | | Cycling to school | | | Cycling for leisure | | |
|---|---|---|---|---|---|---|---|---|---|
| | Direct | Indirect | Total | Direct | Indirect | Total | Direct | Indirect | Total |
| ATT | 0.213* (0.002) | 0.112* (0.007) | 0.325* (0.000) | – | 0.366* (0.000) | 0.366* (0.000) | – | 0.354* (0.000) | 0.354* (0.000) |
| SN | 0.368* (0.000) | 0.005 (0.883) | 0.373* (0.000) | – | 0.342* (0.002) | 0.342* (0.002) | – | 0.279* (0.007) | 0.279* (0.007) |
| DN | 0.109* (0.045) | 0.156* (0.000) | 0.265* (0.000) | – | 0.340* (0.000) | 0.340* (0.000) | – | 0.355* (0.000) | 0.355* (0.000) |
| PBC | 0.068* (0.018) | 0.066 (0.154) | 0.134* (0.012) | 0.077 (0.629) | 0.165* (0.010) | 0.242 (0.125 | 0.164 (0.275) | 0.168* (0.007) | 0.332* (0.028) |
| PF | – | 0.019 (0.652) | 0.019 (0.652) | – | 0.029 (0.652) | 0.029 (0.652) | – | 0.033 (0.652) | 0.033 (0.652) |
| PS | – | 0.088* (0.010) | 0.088* (0.010) | – | 0.136* (0.018) | 0.136* (0.018) | – | 0.156* (0.014) | 0.156* (0.014) |

Notes: *$p < 0.05$; P value is described in parentheses.

increase their willingness, influencing their actual cycling behavior. Adolescents believe that people who ride regularly are energetic. The act of riding provides positive feedback to students. It is essential for the community to promote the image of cyclists as autonomous and mature to attract more students to commute by bicycle. However, the effect of prototype favorability was not significant, probably due to the inclusion of perceived behavioral control in the integrated model (Tang et al., 2020).

From the comparative analysis of the three models, the fit indices and predictions of the PWM and integrated models were significantly better than those of TPB. More psychological factors respond to the influence of riding behavior in these two models. Similar results have been found in several travel behavior studies (Demir et al., 2019; Frater et al., 2017a; Lee et al., 2016).

## 6. Conclusions and limitations

This study explored the psychological factors influencing adolescents' cycling behavior. Attitudes, subjective norms, and descriptive norms had a significant effect on intentions. In addition, attitudes, perceived behavioral control, descriptive norms, and prototypical similarity had a significant effect on willingness. Positive intentions and willingness lead to more cycling behaviors. Although the PWM and integrated models increased the explained variance in intention and willingness, there was little change in the explained variance in cycling behavior. First, because the direct effects on behavior were not evident in the model, the role of indirect effects of the factors was insufficient. Second, the purposes of the two actual riding behaviors are different. Cycling to school is mostly related to the psychological factors of students, while cycling for leisure can be influenced by external factors. (Kaplan et al., 2015) found that individual use of bicycles on holidays was associated with collective behavior, especially among family and friends. When the traffic volume around the residence increases, cycling for leisure declines, while cycling commuting does not (Foster et al., 2011). Furthermore, students may have been influenced by the content of the questionnaire to change their behaviors. Some scholars have also added past behavior as an independent variable to explore the effect on intention and willingness, which can yield valid prediction results (Bamberg et al., 2010; Forward, 2009). The effect of past behavior on future riding should be verified in subsequent studies.

Some researchers have found that the physical environment and socioeconomic characteristics may affect individual travel behaviors (Frater and Kingham, 2018; Gutiérrez et al., 2020; Lois et al., 2015; Mertens et al., 2019; Van Cauwenberg et al., 2012; Zhang et al., 2020). In our study, TPB, PWM, and descriptive normative constructs were taken into account, but we did not consider the influence of the perceived environment or social context. Further research should analyze the influence of the environment on youth cycling behavior or consider the students' standard of living, parents' commuting patterns, etc. Additionally, as the survey was conducted in a large city, Guangzhou City, whether these findings can be applied to small towns and rural locations remains to be confirmed.

## CRediT and authorship contribution statement

First author: conceptualization; formal analysis; roles/writing - original draft; second author: investigation; roles/writing - original draft; third author: supervision; writing - review & editing.

## Declaration of competing interest

The authors declare they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

## Author statement

First author: conceptualization, formal analysis, roles/writing - original draft; second author: investigation, roles/writing - original draft; third author: supervision, writing - review and editing.

## Data availability

The data that has been used is confidential.

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