An Exploration of Social Psychological Factors Leading to Distracted e-Bike Riding among Delivery Workers in China

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Keywords: delivery workers, distracted driving, theory of planned behavior, riding behaviors

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ABSTRACT

With the fast development of the Online-to-Offline market, there are over 13 million delivery workers in China, of which the primary transportation tool is electric bicycles (i.e., e-bikes). Due to the difficulty in executing enforced regulations, delivery workers usually involve in non-riding-related tasks (NRRTs) while riding e-bikes, leading to distracted riding, which can threaten traffic safety. Although distraction engagement in vehicle driving and motorcycle/bicycle riding has been extensively investigated, the prevalence of and the factors leading to distracted riding among delivery workers have not yet been explored. In this study, a survey has been designed to explore social-psychological factors leading to NRRTs engagement among delivery workers. The factors were chosen based on the theory of planned behavior (TPB) framework. We have also assessed workers' awareness of the regulation in the survey. A total of 150 delivery workers (146 males and 4 females, mean age: 27.25) participated in the study. Results show that delivery workers tended to engage more in technology-based NRRTs, and "manually operating the phone" was the most prevalent. Compared to older peers, younger workers held more positive attitudes toward engaging NRRTs and perceived engaging in NRRTs as more prevalent among their colleagues. TPB-related factors (i.e., attitudes, descriptive norms, injunctive norms, and perceived behavior control) were found to be correlated with the self-reported NRRT engagement. The awareness of the regulations, however, had limited effects in explaining NRRT engagement. This research can provide insights into the design of countermeasures aiming at reducing the prevalence of NRRT engagement among delivery workers.

Keywords: delivery workers, distracted driving, theory of planned behavior, riding behaviors

1. INTRODUCTION

With the rapid development of the Online-to-Offline (O2O) marketing in China, online food delivery has expanded tremendously since 2011. Based on the report by China Internet Network Information Center, in China, the number of online food delivery service users has reached 544 million (*1*). As the link between merchants and customers, in 2020, there were more than 13 million online delivery workers in China, and this number continues to increase (*2*). The online food delivery platforms usually guarantee delivery within 30-60 minutes in high-density urban and metropolitan areas with congested and narrow roads. Thus, to save travel time, most delivery workers choose Electric Bicycles (or e-bikes, with two wheels and a rechargeable battery) for delivery tasks, given that the e-bikes can travel at relatively high speed with high flexibility and low cost (*3*).

At the same time, in the delivery task, delivery workers are under relatively high time pressure. Thus, they are usually inclined to involve in tasks that are not related to e-bike riding (non-riding-related tasks, or NRRT), leading to distracted riding behaviors. For example, in the delivery task, the delivery workers may need to actively contact merchants and consumers to confirm their locations and customized requirements through reading and sending text messages, having phone calls, and setting the navigation. The delivery workers may also need to handle non-delivery-related affairs while doing delivery tasks considering their extremely long working hours, i.e., 10 to 12 hours per day on average, according to Beijing Social Work Development Center for Facilitators (*4*). Thus, distracted riding is common among delivery workers. Given that the designated lanes for e-bikes are rare in most cities in China, distracted riding has become a major threat to transportation safety.

Although distractions in driving have been investigated extensively (*5*-*10*), the factors leading to distracted riding among delivery workers have not yet been explored. Being different from vehicle driving, when exposed to distractions, e-bike riders are free to stop on roadsides any time before engaging NRRTs without blocking the traffic. Thus, most NRRTs in delivery tasks can be regarded as voluntary and thus might be influenced by social-psychological factors, similar to what has been observed in driving studies (*11*). Thus, in this study, we aim to investigate the social-psychological factors associated with distracted riding behaviors among delivery workers. A survey targeted toward underlying social-psychological factors leading to NRRT engagement among delivery workers has been designed, and the responses were collected on street from delivery workers in Guangzhou, China.

2. LITERATURE REVIEW

2.1 Distractions in vehicle driving and motorcycle/bicycle riding

The research from the vehicle driving and motorcycle/bicycle riding domains may provide some insights. In driver behavior studies, distraction is defined as a specific type of inattention that arises when drivers divert their attention from the driving task to some other activity instead (*5*). Driver distraction contributes to roughly 10% of all fatal crashes and 18% of all crash-related injuries in the United States (National Highway Traffic Safety Administration, 2014). It has also been found to impair drivers' ability in lane keeping, speed controlling, safe headway distance maintaining, and hazard perception (*6*–*8*).

Distraction is also a leading cause of motorcycle/bicycle accidents. For instance, a study conducted in Texas in 2016 showed that approximately 33.4% of motorcycle accidents were due to rider distraction (*9*). Another study in Belgium found that engagement in non-riding tasks contributed to 11% of minor crashes among cyclists (*10*). Specifically, using electronic devices

such as cellphones and music players has been found to impair the riding performance (e.g., peripheral vision detection and auditory perception) of motorcycle/bicycle riders (*16-22*). For example, de Waard et al. (*22*) found that engaging in non-driving tasks can delay the response times of cyclists and reduce their head movement, impairing their capability to perceive and respond to hazards. Thus, distracted riding among delivery workers can be a potential threat to traffic safety in urban areas.

2.2 Leading factors of distraction engagement

To better understand the factors leading to driving distraction, previous research categorized distraction behaviors into voluntary and involuntary ones according to whether the drivers can suppress the non-driving-related information (*23*). For example, browsing social media is voluntary as the drivers can decide when to stop; but the distraction caused by incoming phone calls is involuntary, as drivers cannot suppress the phone ringing. The involuntary distraction engagement can be modulated by one's cognitive limitation, while social-psychological factors can affect one's voluntary distraction engagement. For example, teen drivers' voluntary distraction engagement has been found to be affected by their perception of parents' distraction engagement behaviors (*24*). However, it should be noted that these previous studies all focused on distraction engagement in drivers; to the best of our knowledge, no study has focused on the leading factors of distraction engagement in e-bike riders, which, as discussed previously, are mostly voluntary.

2.3 The Theory of Planned Behaviors (TPB) and Driving Distractions

The TPB is a widely used social-psychological framework, which assumes that "*intentions to perform behaviors of different kinds can be predicted with high accuracy from attitudes toward the behavior, subjective norms, and perceived control*" (*12*). As a social-psychological framework, the TPB has been widely adopted to explain human operators' or users' behavioral motivations in diverse fields, such as healthcare (*25*), education (*26*), and marketing (*27*). In the driving domain, TPB has been adopted to explore leading factors of unsafe driving behaviors, such as speeding (*28*, *29*), drinking and driving (*30*, *31*), aggressive driving (*13, 32, 33*), and distraction engagement (*34*). For example, an expanded TPB has been adopted to explain drivers' distraction engagement behaviors (*11*). The authors materialized the construct of social norm in TPB by categorizing it into injunctive norm (i.e., expectations from people that are important to the respondent) and descriptive norm (i.e., what others do). Drivers' demographic information (e.g., age and gender) has also been considered as external variables in the expanded TPB. The results show that the expanded TPB can provide satisfactory predictive power in forecasting distracted driving behavior (*11*) and other driving violations (*35-38*). Thus, given that most distractions during riding are voluntary, the TPB might also be able to explain the voluntary distracted riding behaviors among delivery workers.

3. METHODS

In this section, we introduced the methodology of this study, which includes the instrument we used to collect the data, participants, and statistical analyses.

3.1 Instrument

To collect the data used in this study, a questionnaire was designed and distributed to delivery workers in Guangzhou, China. The NRRT behaviors during delivery are diverse. Based

on a preliminary filed observation, in this survey study, we selected six typical NRRTs according to their prevalence and potential detrimental effects on driving safety, as listed in Table 1.

Specifically, as the major communication tool of delivery workers, the smartphone-related distraction has been observed most frequently among delivery workers. We further categorized the phone usage behaviors into "hold phone call," "operate phone," and "wear earphone" corresponding to three high-risk distraction behaviors in vehicle driving, i.e., "cell talk (handheld)," "cell text (handheld)," and "in-vehicle radio" (*39*). Furthermore, we included some non-technology related NRRT behaviors, including "read roadside ads," "dwell on incidents," and "chat with others," again, corresponding to the ones in vehicle driving, i.e., "Extended glance duration to external object" and "interaction with adult/teen passengers" (*39*).

Overall, we included two parts in the questionnaire.

Table 1 TPB-related Questions

Questions for TPB-related Factors	NRRTs	Likert Scale
Self-reported engagement: When riding an e-bike in a delivery task, you…	- hold the phone to have conversations (**Hold phone call**) - manually operate the phone such as setting navigation (**Operate phone**) - read roadside advertisements (**Read roadside ads**) - chat with other delivery workers or roadside people if there are (**Chat with others**) - visually dwell on roadside incidents if there are (**Dwell on incidents**) - wear earphone or headphone (**Wear earphone**)	1: Never 2: Rarely 3: Sometimes 4: Often 5: Very often
Attitudes: You think it is alright for you to… when you are riding an e-bike in a delivery task.		1: Strongly disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly Agree
Descriptive norm: Most delivery workers around me… riding an e-bike in a delivery task.		
Injunctive norms: Most people important to me (e.g., family and friends) think it's alright for me to…when I am riding an e-bike in a delivery task.		
Perceived behavior control: You believe you can ride an e-bike safely even when you…		

Part 1: Demographic information, riding history and awareness of traffic regulation. In this part, we collected participants' demographic information (i.e., age, gender, education level, driver's license, and family income), delivery workers' self-reported incident history (i.e., number of incidents during delivery), and driving violation history (i.e., number of times stopped by the police due to traffic violation) during delivery. The factors extracted from the information in this part serve as the covariates in the model as they have been found to influence the distraction engagement behaviors in previous driving or riding studies (*3*). Further, considering that previous research has identified regulation awareness as a meditating factor influencing e-bike riders' behaviors (e.g., helmet usage) (*3*) and that the education program boosting riders' awareness of the regulations has been found to be effective in promoting e-bike safety (*14*, *15*), we also assessed participants' awareness of traffic regulations regarding three phone-related distraction behaviors investigated in this study, i.e., whether it is legal to "*talk through the handsfree phone," "talk through the handheld phone,"* and *"text on the phone"* while riding e-bikes. A 5-point Likert scale was used for the regulation awareness questions, ranging from 1

("strongly disagree") to 5 ("strongly agree"). Finally, a normalized regulation score (ranging from 0 to 100) was computed as follows:

$$score = [48 - \sum_{i=1}^{3}(D_i^2)]/48 \times 100$$

Where D_i is the distance from the scale provided by the participant to the "most" correct answer (i.e., 1: "strongly disagree" or 5: "strongly agree"). For example, the most "correct" answer to the statement "*it is legal to text on the phone*" is 1 ("strongly disagree"). If a participant rated 3 to this question, then the D_i to this question is 2 (|1-3|). Thus, 48 is the maximum possible raw score one can obtain if all three answers are correct (3 questions * $|5\text{-}1|^2$). The higher the regulation score, the better the participant's awareness of traffic regulations.

Part 2: TPB-related Factors. In this part, as shown in Table 1, we collected delivery workers' responses to TPB-related factors regarding six types of NRRT engagement behaviors, which, as mentioned, were selected based on field observations of delivery workers' daily work. We have focused on the attitude and perceived control from the original TPB framework, and the "Injunctive norm" and "Descriptive norm" from the expanded TPB framework by Chen et al. (*11*, *13*). In total, thirty questions (5 TPB-related factors * 6 types of NRRTs) were asked in this part.

3.2 Participants

In this study, we recruited participants in Guangzhou, China, through a face-to-face approach to delivery workers. To be eligible for the study, participants had to work as delivery workers with official registration in either Meituan™ or Eleme™, which are the two dominant platforms for food delivery in China. All participants were provided with a cup of soft drink (e.g., milky tea) for their participation in this study. This study has been approved by the Human and Artefacts Research Ethics Committee in HKUST (HREP-2022-0106). The average completion time of the survey was 18.15 min. In total, we obtained 150 valid responses in 2 months. The sample consisted of 146 males and 4 females with a mean age of 27.25 years old (standard deviation: 5.8, min: 18, max: 47). Table 2 summarizes the demographic information of the participants.

Table 2 Demographic information of participants

Education level	
Middle school or less	N = 35 (23.3%)
High school / Junior college	N = 101 (67.3%)
University or higher	N = 14 (9.4%)
Driver license	
Have valid driver license for motorcycle	N = 29 (19.3%)
No valid driver license for motorcycle	N = 121 (80.7%)
Household income	
< 50,000 RMB	N =59 (39.3%)
50,000 - 100,000 RMB	N =55 (36.7%)
100,000 - 200,000 RMB	N = 30 (20%)
> 200,000 RMB	N = 6 (4%)

3.3 Statistical Analyses

The statistical analyses in this study included the following five steps:

- 1. Checking of the internal consistency: To ensure the reliability of our self-designed questionnaire, the internal consistency of responses to the six types of NRRTs within each TPB-related factor was first examined using Cronbach's alpha statistics (*40*).

- 2. Descriptive statistics of self-reported engagement: To investigate the prevalence of different types of NRRTs, participants' self-reported engagement in different types of NRRTs was compared based on their descriptive statistics.

- 3. Effects of NRRT type and age on TPB-related factors: Previous research has found that drivers' self-reported engagement in, attitudes toward, perceived norms of engaging in, and perceived control of engaging NRRTs differs among drivers from different age groups (*32*). Thus, to explore the potential influence of age on TPB-related factors, five ordinal logistic regression models were constructed. Participants' responses to each TPB construct were used as the dependent variables; age and NRRT type (6 levels), as well as their interactions, were used as the independent variables.

- 4. **Correlations among TPB-related factors by distraction types**: To validate TPB-related factors in explaining the NRRT engagement among delivery workers, for each of the six distraction types, Spearman's rank correlations were used to explore the correlations among different TPB-related factors.

- 5. **Prediction of NRRT engagement:** To further assess the efficacy of using TPB to explain the NRRT engagement among the delivery workers, an ordinal logistic regression model was fitted, with the TPB constructs (i.e., attitude, injunctive norm, descriptive norm, and perceived behavior control) as the predictors and the self-reported NRRT engagement as the dependent variable. In the model, the attitudes, descriptive norms, injunctive norms, and perceived behavior control were included in the model as continuous independent variables. Further, to explore the potential effect of delivery workers' awareness of traffic regulations and their age on the self-reported NRRT engagement, we included the regulation score and age in the model. The two-way interaction terms between NRRT type and other variables (i.e., TPB-related factors, age, regulation score) were also included in the full model. However, "gender" was not considered in our analysis, given that most (146 out of 150) participants in our study were male, which is in line with the gender distribution of the delivery workers in previous studies (*3*).

In the modeling process, the model selection was conducted based on Quasi Information Criterion (QIC) (*41*), and the final model results after model selection are reported in this paper. Post-hoc comparisons were conducted if the main effects or the interaction effects were significant ($p < .05$). Besides, the Cronbach's alpha statistics were computed using *cronbach.alpha* function within the *ltm* package in R 3.6.1, and we referred to previous research (*42*) to interpret the Cronbach's alpha statistics (α) as: $\alpha < 0.5$: unacceptable; $0.5 \leq \alpha < 0.6$: poor; $0.6 \leq \alpha < 0.7$: questionable; $0.7 \leq \alpha < 0.8$: acceptable; $0.8 \leq \alpha < 0.9$: good; $\alpha \geq 0.9$: excellent. The Spearman's rank correlations analyses were conducted using the *cor.test* function within the *stats* package in R 3.6.1 (*43*). All ordinal logistic regression models were built using the *GENMOD* procedure in SAS OnDemand for Academics.

4. RESULTS

4.1 Internal consistency

Cronbach alpha statistics showed acceptable to excellent internal consistencies for each of the TPB-related factors considered in this study (attitudes: .827; descriptive norms: .926;

injunctive norms: .909; and perceived control: .882; engagement: .732). There was no missing data in the sample, given that we used a face-to-face approach to guarantee all participants completed all questions in the survey.

4.2 Descriptive statistics of self-reported engagement

Figure 1 shows the descriptive statistics of distraction engagement. It was found that "*manually operating the phone*" was the NRRT type that delivery workers were most likely to engage in, while "*reading roadside advertisements*" was the least likely NRRT during delivery. Further, following the taxonomy in Regan et al. (*5*), the six NRRTs were categorized into technology-based NRRTs and non-technology-based NRRTs based on the source of distraction. In the results, it is obvious that the delivery workers were more likely to engage in technology-based distractions compared to non-technology-based distractions.

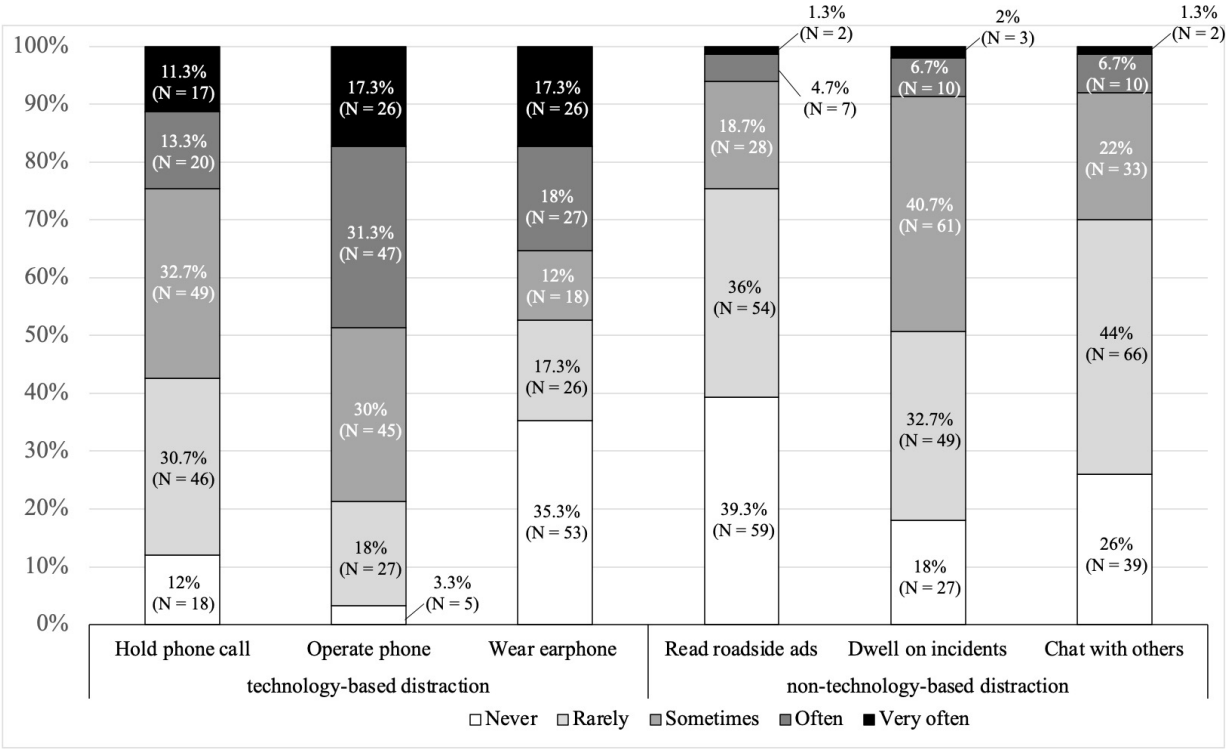

Figure 1 The distribution of the self-reported engagement in different types of NRRTs

4.3 Effects of distraction type and age on TPB-related factors

It was found that participants provided significantly different responses to the six types of NRRTs in all five TPB-related factors: engagement, $\chi^2(5) = 202.09$, $p < .0001$; attitudes, $\chi^2(5) = 91.66$, $p < .0001$; descriptive norms, $\chi^2(5) = 47.53$, $p < .0001$; injunctive norms, $\chi^2(5) = 34.15$, $p < .0001$; and perceived behavior control, $\chi^2(5) = 21.07$, $p = .0008$. Table 3 presents the pair-wise comparison results of estimated odds ratios (OR) between different NRRT types for the TPB-related factors, with 95% confidence intervals (CIs) provided.

Table 3 Estimated odds ratios (with a 95% CI) between different driving distraction types for the TPB-related factors

NRRT types compared		TPB-related factors				
		Engagement	Attitudes	Descriptive Norms	Injunctive norms	Perceived behavior control
Hold phone call vs.	Operate phone	0.40 (0.29, 0.55)	0.58 (0.44, 0.77)	**0.83 (0.66, 1.03)**	**0.93 (0.74, 1.16)**	**1.10 (0.85, 1.43)**
	Read roadside ads	4.11 (2.85, 5.92)	0.60 (0.46, 0.79)	**0.79 (0.62, 1.01)**	**0.83 (0.65, 1.07)**	**0.94 (0.72, 1.23)**
	Chat with others	2.74 (2.02, 3.71)	0.42 (0.30, 0.57)	0.61 (0.46, 0.79)	0.77 (0.60, 0.98)	**0.89 (0.67, 1.19)**
	Dwell on incidents	1.66 (1.19, 2.32)	0.33 (0.24, 0.47)	0.53 (0.41, 0.69)	0.66 (0.50, 0.85)	0.71 (0.52, 0.95)
	Wear earphone	**1.49 (0.94, 2.36)**	0.14 (0.09, 0.22)	0.39 (0.29, 0.53)	0.45 (0.34, 0.61)	0.57 (0.42, 0.77)
Operate phone vs.	Read roadside ads	10.32 (7.15, 14.89)	**1.03 (0.82, 1.30)**	0.96 (0.78, 1.17)	**0.90 (0.74, 1.09)**	**0.85 (0.66, 1.10)**
	Chat with others	6.88 (5.08, 9.31)	0.72 (0.55, 0.94)	0.73 (0.58, 0.92)	**0.83 (0.66, 1.03)**	**0.81 (0.64, 1.03)**
	Dwell on incidents	4.17 (3.10, 5.61)	0.57 (0.42, 0.78)	0.64 (0.51, 0.81)	0.71 (0.57, 0.88)	0.64 (0.48, 0.86)
	Wear earphone	3.73 (2.43, 5.73)	0.24 (0.16, 0.35)	0.48 (0.36, 0.63)	0.49 (0.36, 0.66)	0.52 (0.37, 0.73)
Read roadside ads vs.	Chat with others	0.67 (0.49, 0.91)	0.70 (0.53, 0.91)	0.77 (0.62, 0.94)	**0.92 (0.75, 1.13)**	**0.95 (0.78, 1.15)**
	Dwell on incidents	0.40 (0.30, 0.55)	0.55 (0.43, 0.71)	0.67 (0.54, 0.83)	0.79 (0.66, 0.94)	0.75 (0.61, 0.92)
	Wear earphone	0.36 (0.23, 0.56)	0.23 (0.16, 0.34)	0.50 (0.37, 0.67)	0.54 (0.40, 0.73)	0.61 (0.45, 0.83)
Chat with others vs.	Dwell on incidents	0.61 (0.46, 0.79)	**0.80 (0.62, 1.03)**	**0.88 (0.72, 1.07)**	**0.85 (0.70, 1.03)**	0.79 (0.64, 0.97)
	Wear earphone	0.54 (0.35, 0.85)	0.33 (0.22, 0.50)	0.65 (0.48, 0.88)	0.59 (0.45, 0.78)	0.64 (0.46, 0.89)
Dwell on incidents vs.	Wear earphone	**0.90 (0.61, 1.32)**	0.42 (0.28, 0.62)	0.74 (0.58, 0.96)	0.69 (0.51, 0.93)	**0.81 (0.60, 1.10)**

Note: The bold represents non-significant effects ($p > .05$).

Table 4 Spearman's rank correlations (p value) between five TPB-related factors by different distraction types

Correlation between TPB-related factors		Distraction Type					
		Hold phone call	Operate phone	Read roadside ads	Chat with others	Dwell on incidents	Wear earphone
Engagement	Attitudes	.28 (<.001)	.21 (.008)	.31 (<.001)	.21 (.009)	.13 (.11)	.31 (<.001)
	Descriptive norms	**.15 (.07)**	.27 (.001)	.30 (<.001)	**.11 (.19)**	.23 (.003)	.20 (.01)
	Injunctive norms	.32 (<.001)	.18 (.02)	.24 (.003)	.22 (.006)	**.15 (.07)**	.36 (<.001)
	Perceived behavior control	**.11 (.2)**	**.13 (.1)**	.33 (<.001)	.23 (.004)	.20 (.01)	.28 (<.001)
Attitudes	Descriptive norms	.45 (<.001)	.66 (<.001)	.54 (<.001)	.60 (<.001)	.63 (<.001)	.52 (<.001)
	Injunctive norms	.59 (<.001)	.41 (<.001)	.50 (<.001)	.61 (<.001)	.59 (<.001)	.55 (<.001)
	Perceived behavior control	.40 (<.001)	.41 (<.001)	.51 (<.001)	.49 (<.001)	.56 (<.001)	.46 (<.001)
Descriptive norms	Injunctive norms	.60 (<.001)	.46 (<.001)	.64 (<.001)	.63 (<.001)	.62 (<.001)	.63 (<.001)
	Perceived behavior control	.39 (<.001)	.47 (<.001)	.60 (<.001)	.50 (<.001)	.63 (<.001)	.46 (<.001)
Injunctive norms	Perceived behavior control	.46 (<.001)	.42 (<.001)	.61 (<.001)	.45 (<.001)	.57 (<.001)	.55 (<.001)

Note: The bold represents non-significant effects ($p > .05$).

At the same time, age was found to be a significant contributor to the attitudes and the descriptive norms. For every 1-year increase in age, the OR of having more positive attitudes toward NRRTs was 0.93, 95%CI: [0.90, 0.97], $\chi^2(1) = 10.79$, $p = .001$, and the OR of reporting higher level of descriptive norm (i.e., increasing popularity of the NRRT behaviors of colleagues) was 0.95, 95% CI: [0.91, 0.99], $\chi^2(1) = 4.47$, $p = .03$. However, the effects of age on self-reported NRRT engagement ($p = .7$), injunctive norms ($p = .2$), and perceived behavior control ($p = .055$) were not significant.

4.4 Correlations among TPB-related factors by distraction types

Table 4 presents Spearman's rank correlations among the five TPB-related factors by different distraction types. In general, it was found that the self-reported engagement was positively correlated with four social-psychological factors in TPB regardless of the NRRT types, in line with the assumptions in the TPB framework.

4.5 Prediction of NRRT Engagement

Table 5 shows the results of Wald statistics of the final model. The self-reported engagement depends on the type of NRRTs. As for the TPB-related factors, both the attitudes (OR=1.24, 95%CI: [1.02, 1.52], $p = .03$) and perceived behavior control (OR=1.33, 95%CI: [1.09, 1.61], $p = .004$) significantly influence the self-reported NRRT engagement. The significant interaction effects between descriptive norms and the NRRT type, as well as between the injunctive norms and the NRRT type, have also been observed.

Table 5 Statistical model predicting self-reported NRRT engagement

Independent variable	χ^2-value	*p*
Attitudes	$\chi^2(1) = 4.65$	.03*
Descriptive norms	$\chi^2(1) = 0.85$	.4
Injunctive norms	$\chi^2(1) = 4.75$	.03*
Perceived behavior control	$\chi^2(1) = 8.21$	.004*
Regulation score	$\chi^2(1) = 6.39$	.01*
Distraction type	$\chi^2(5) = 20.51$	.001*
Descriptive norms*Distraction type	$\chi^2(5) = 18.51$	.002*
Injunctive norms*Distraction type	$\chi^2(5) = 15.92$	.007*
Regulation score*Distraction type	$\chi^2(5) = 16.47$	.006*

Note: The * represents significant effects ($p < .05$).

Post-hoc analysis shows that the increase of descriptive norms would significantly increase the self-reported NRRT engagement in "*wear earphone or headphone*" (OR=1.86, 95% CI: [1.19, 2.89], $p = .006$). At the same time, the increase of injunctive norms would significantly increase the self-reported engagement in "*holding the phone to have conversations*" (OR=1.62, 95%CI: [1.14, 2.29], $p = .007$), "*read roadside advertisements*" (OR=1.74, 95%CI: [1.12, 2.71], $p = .014$), and "*chat with other delivery persons or roadside people if there are any*" (OR=1.49, 95%CI: [1.05, 2.11], $p = .026$). Further, the increase of the regulation score (i.e., better knowledge about traffic regulations) would significantly increase the distraction engagement in "*visually dwell on roadside accident scenes if there are any*" (OR=1.03, 95%CI: [1.01, 1.05], $p = .019$) and "*wear earphone or headphon*e" (OR=1.06, 95%CI: [1.03, 1.09], $p < .001$). No other significant effects have been observed.

5. DISCUSSION

We conducted a survey study among 150 delivery workers in Guangzhou, China, to explore the social-psychological factors leading to self-reported engagement in non-riding-related tasks (NRRTs) during delivery tasks. All the participants were probed on six types of NRRTs that are commonly observed during delivery tasks.

5.1 Characteristics of the delivery worker population

We have noticed some worth-noting features of the delivery worker population in China. First, male is the majority of the delivery worker population (97.3%), which matches well with the statistics (97%) in a previous study conducted in Shanghai, China (*3*). Further, although contradictory results exist (*44*, *45*), in general, males tend to drive more aggressively (*46*) and have higher crash risks compared to females (*47*).

At the same time, the delivery workers are generally young adults, with a mean age of 27.25 years old in our study. Previous research has found that younger drivers are more likely to engage in driving distraction compared to older drivers (*48*). Our results expanded this result to distracted e-bike riding among delivery workers. In our study, age has also been found to be a significant predictor of delivery workers' attitudes toward the NRRTs and the descriptive norms, with younger delivery workers holding more positive attitudes toward the NRRT engagement and reporting a higher prevalence of NRRT engagement in their colleagues.

At the same time, the education levels of most delivery workers (i.e., 90.6%) are equal to or lower than high school/junior college. Education has been found to be positively correlated with some safe driving behavior or habits, such as safety belt usage (*49*). Besides, the yearly household income of most delivery workers (i.e., 76%) was lower than 100,000 RMB (i.e., around 14,000 US dollars). Lower household income has been observed to be associated with an increased chance of speed limit violations (*49*). In summary, the delivery worker population consists of young males who are less educated and have relatively low household incomes. This population is traditionally considered to have a high risk of distracted driving.

5.2 Popularity of the NRRT task engagement among delivery workers

In line with our expectations, participants reported different levels of self-reported engagement in different types of NRRTs. In general, delivery workers tended to engage more in technology-based distraction (i.e., hold phone call, operate phone, and wear earphone) compared to non-technology-based distraction (i.e., read roadside ads, chat with others and dwell on incidents). Specifically, the statistic results show that, among all the NRRT types we investigated, delivery workers are most likely to operate phones. This finding is in line with previous research on distracted driving, in which the mobile phone was identified as the leading source of distraction in vehicles (*50*, *51*). This result is alerting, considering that operating phone can significantly increase the crash risk according to driver distraction research. Although not quantitatively investigated yet, riding an e-bike potentially involve more manual visual resources compared to driving a vehicle, as the riders need to constantly adjust the direction in order to keep balance. Thus, being visually and manually distracted by the phone operating task may significantly increase the crash risk of e-bike riders. Future work is needed to investigate the association between crash risk and NRRT engagement, similar to the ones that have been conducted in vehicle driving studies (*52*, *53*).

5.3 The relationships among TPB-related factors, the awareness of regulations, and the NRRT engagement among delivery workers

First, as expected, the participants' responses to TPB-related questions were found to be different across different types of NRRTs. This is not surprising, considering that participants reported different levels of engagement in different NRRTs. To further examine how the social-psychological factors from TPB can explain NRRT engagement among delivery workers, we then examined the correlations among TPB-related factors within each type of NRRT. Overall, we have observed strong correlations among all social-psychological factors (i.e., attitudes, descriptive norms, injunctive norms, and perceived behavior control) for all types of NRRTs. Ajzen found that the correlations among the TPB constructs were from 0.4 to 0.6 in studies with good measures (*54*). Our correlation results generally fall within or above this range (see Table 4). At the same time, the correlations between the self-reported NRRT engagement and the social-psychological factors explored in our study vary across different types of NRRTs: some TPB-related factors were not found to be correlated with the engagement in some types of NRRTs. This indicates that some TPB-related social-psychological factors may not be predictors of the specific NRRT engagement behaviors among delivery workers.

We then explored how the TPB-related factors and the awareness of regulations can predict the self-reported NRRT engagement. As expected, the positive attitudes toward the NRRT and the increased perceived behavior control while engaging in NRRTs can lead to higher levels of NRRT engagement for all types of NRRTs explored in our study. This is in line with the findings in distracted driving research – the drivers who are less aware of the potential risk of distracted driving behaviors are more likely to engage in non-driving-related tasks (*34*). The other social-psychological factors from TPB, however, exhibited different effects on predicting engagement in different types of NRRTs, which is not surprising, considering that TPB provides only a framework and not all factors from TPB are predictors of specific behaviors. Among all these results, it is worth mentioning that the awareness of the regulations had no effects on the obviously "illegal" NRRT engagement behaviors (e.g., hold phone call and operate phone). This is potentially because engaging in "illegal" NRRTs is rarely punished. Thus, although the delivery workers are aware that these NRRTs are illegal, they may still choose not to obey the laws, especially engaging in these NRRTs can increase their work efficiency. This phenomenon is different from that in the driving domain, as the violation of laws while driving may result in punishment.

5.4 Limitations and future research

Several limitations of this study should be noted. In this study, we analyzed the self-reported distraction behaviors, which might be different from the actual NRRT engagement behaviors of delivery workers. Previous study has observed that some TPB-related social-psychological factors may predict self-reported behaviors but not actual behaviors (*29*). Therefore, it should be cautious when interpreting our results. Further, we did not consider the self-regulation of NRRT engagement. The self-regulation of non-driving-related task engagement has been widely observed in driver distraction research (*55*) and may also exist among delivery workers. Future research can explore whether delivery workers can modulate NRRT engagement under different conditions. Lastly, although we have focused on six NRRTs that are common among delivery workers, we were not able to quantify the actual prevalence and risk of these NRRT engagement behaviors. Future observational studies in naturalistic

environment and simulation experiments in controlled environment are needed to address these research gaps.

6. CONCLUSION

In this study, we explored the underlying social-psychological factors leading to distracted e-bike riding among delivery workers in China. The factors were selected based on the framework of TPB. In addition, we investigated how riders' awareness of the regulation can affect their distraction engagement. Results show that, among the NRRT tasks we probed, delivery workers are most likely to "manually operating the phone" when riding e-bikes. Further, younger workers held more positive attitudes toward engaging NRRTs and perceived engaging in NRRTs as more popular among their colleagues. The social-psychological factors explored in our study (i.e., attitudes, descriptive norms, injunctive norms, and perceived behavior control) were all found to be correlated with the self-reported NRRT engagement. The awareness of the regulations, however, had limited effects in explaining NRRT engagement, especially the tasks with high risk (e.g., operating the cellphone). This research indicates that NRRT-related laws may not be as effective as we imagined in regulating delivery workers' distracted riding behaviors, and more efforts may need to be devoted to shape the social-psychological factors, as well as other potential work-related factors (e.g., optimization of delivery task procedures).

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Author contributions

The authors confirm contribution to the paper as follows: study conception and design: G.W., C.H., D.H.; data processing: G.W., C.H.; analysis and interpretation of results: G.W., C.H., D.H.; draft manuscript preparation: G.W., C.H., D.H. All authors reviewed the results and approved the final version of the manuscript.

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