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The mediating effect of traffic safety climate between pedestrian inconvenience and pedestrian behavior

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ABSTRACT

Because most people are pedestrians at some point on any given day and walking is the most indispensable means of transportation, pedestrian safety should be investigated. The primary aim of this study was to investigate the relationships among the inconveniences that pedestrians perceive in city traffic, the traffic safety climate and pedestrian behavior. A total of 311 participants voluntarily and validly completed a survey that included the Pedestrian Inconvenience Questionnaire (PIQ), the Traffic Climate Scale (TCS) and the Pedestrian Behavior Scale (PBS). We discovered that pedestrians' perceived inconvenience was positively correlated with transgression and positive behavior by pedestrians and it also positively correlated with the external affective demands (emotional engagement facet of TCS) while negatively correlated with the functionality (functional traffic system facet of TCS). We determined that the external affective demands were positively correlated with pedestrian risk behaviors (i.e., transgression, aggressive behaviors and lapses), internal requirements (traffic participants' skills facet of TCS) were positively correlated with positive behaviors, and functionality was negatively correlated with transgression and lapses. Moreover, the results indicate that the relationship between the inconveniences pedestrians perceive in city traffic and pedestrians' transgressive behavior was fully mediated by the functionality dimension of the traffic safety climate. Pedestrians' perceived inconvenience is an important factor that affects pedestrian behavior, and the influence of pedestrians' perceptions of the traffic safety climate cannot be disregarded.

1. Introduction

Different types of transportation users, such as drivers, cyclists, motorcyclists and pedestrians, share roads. Walking is the most indispensable means of transportation, especially for short-distance commutes (Guo et al., 2005); walking accounts for 56.5% of transportation in China based on daily traffic pattern of Chinese adults (Bei-bei et al., 2014). Most people are pedestrians at some point on any given day, and pedestrians are vulnerable road users. The unprotected human body cannot withstand the impact of a car collision (Mckay, 2009), and the heavier the vehicle type is, the higher the risk of a pedestrian fatality (Paulozzi, 2005). According to the National Highway Traffic Safety Administration (NHTSA), 5376 pedestrians in the United States were killed in 2015, which is an increase from the 4884 pedestrian fatalities reported in 2014 (increased by 10.07%). According to the Chinese National Bureau of Statistics (CNBS), 1304 pedestrians/passengers in China were killed in 2016, which is an increase from the 1192 pedestrian fatalities in 2015 (increased by 9.40%). To reduce pedestrian casualties and ensure the safety of pedestrians, efforts to understand pedestrian behavior are needed.

Many factors are associated with pedestrian crashes (Peden et al., 2004; Barrero et al., 2013; Jiménezmejías et al., 2016). Although some accidents are caused by contextual variables (e.g., environmental conditions), such as heavy fog which reduces roadway visibility, other accidents are caused by human-related variables (i.e., driver-related factors and pedestrian-related factors). With regard to driver-related factors, researchers discovered that drivers that were impaired due to alcohol or fatigue or who are distracted may fail to see a pedestrian or react too slowly to avoid a collision (Mckay, 2009; Jelen et al., 2011; Zuriaga et al., 2011). These risky driving behaviors may place pedestrians in danger. With regard to pedestrian-related factors, some characteristics increase the probability that a pedestrian will be injured in a collision. According to NHTSA, the male pedestrians' injury and fatality rate per 100,000 people (24 and 2.01 respectively) are higher than the

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female pedestrians' injury and fatality rate per 100,000 people (20 and 0.85 respectively) (NHTS, 2013). In addition, Naumann and Beck (2013) revealed that pedestrian death rates increase with age. A more important factor is pedestrians' behaviors while crossing a street (Clifton et al., 2009; Dommes et al., 2014; Mwakalonge et al., 2015).

Previous studies have focused on pedestrian jaywalking (Jason and Liotta, 1982; Romero, 2015), pedestrian group movement (Wei et al., 2015), pedestrian behavior prediction (Chen and Yung, 2009) and the relationship between personality and pedestrian behavior (Zheng et al., 2017). In some circumstances, inappropriate pedestrian behavior can produce a dangerous situation; however, improper infrastructure (such as less "pedestrian-friendly" designs, which are designed to focus on the benefits of vehicles rather than to engineer an optimal flow of both vehicle movement and pedestrian movement) may encourage individuals to violate traffic regulations (Jason and Liotta, 1982). Early in 1982, Jason and Liotta (1982) found that a significantly larger number of jaywalking episodes were observed in inhospitable roadway conditions for pedestrians. Disobeying a red signal is a serious problem (Olszewski et al., 2016), and signal timings and phase sequences are the most important factors that predict pedestrians' risk of accidents at signalized crossings (Tarko and Tracz, 1995). Stasi et al. (2014) discovered that steady signals (compared with flashing signals that continuously flashed at a rate of 60 times per minute) are the best solution for avoiding unsafe pedestrian behaviors when crossing intersections. Liu and Jian (2009) determined that the maximum bearable waiting time for pedestrians when crossing intersections is 90 s, whereas the maximum bearable waiting time when crossing central refuge islands to another curb side is only 50 s. To encourage pedestrians to comply with regulations, more "pedestrian-friendly" infrastructure (e.g., traffic signals with pedestrian green signal extensions) is needed. The lack of "pedestrian-friendly" infrastructures may cause inconvenience for pedestrians. Therefore, the relationship between the inconveniences pedestrians perceive in city traffic and pedestrian behavior should be investigated. Previous studies have not explored this issue.

The attitudes of pedestrians toward traffic can also influence their behaviors. Lajunen (2011) defined "road users' (e.g., drivers') attitudes and perceptions of traffic in a context (e.g., country) at a given point in time" as the traffic safety climate. This definition represents road users' thoughts and feelings toward traffic conditions and their possible behavioral intentions (Zhang et al., 2018). Pedestrians as one of the most important road users, their perception of local traffic should not be neglected. The concept of a safety climate has been measured and investigated in different fields, such as healthcare organizations (Flin et al., 2006; Kumud et al., 2015), industrial organizations (Zohar, 1980), the trucking industry (Li and Itoh, 2014; Jin et al., 2015), and offshore installation (Mearns et al., 1998), and it has been applied to road traffic (Helmreich and Merritt, 2001; Håvold, 2005; Wills et al., 2006; Naveh and Katznavon, 2015). Attitudes consist of cognitive, affective and behavioral components (Gehlert et al., 2014). Pedestrians' various experiences may shape their different cognitions, emotions or behaviors toward city traffic. The inconvenience perceived by pedestrians in city traffic may influence their attitude toward the road environment, that is, the traffic safety climate. However, research on this issue is lacking.

Previous traffic safety climate studies have examined the link between traffic safety climate and traffic safety outcomes, which can provide some inspiration. For example, Wills et al. (2006) performed hierarchical regression analyses and discovered that safety climate factors accounted for significant amounts of variance in work-related driving (i.e., traffic violations, driver error, driving while distracted, and pretrip vehicle maintenance), even after controlling for the influence of age, sex, and work-related driving exposure. Similarly, Amponsah-Tawiah and Mensah (2016) identified a negative relationship between the safety climate and risk work-related driving behaviors (i.e., speeding, rule violation, inattention and driving while tired). The results of a standard multiple regression analysis revealed that when drivers perceive their traffic environment to be positive, they tend to reduce their speed, adhere to traffic regulations, pay attention to the road and avoid driving when tired. Some studies have demonstrated that the traffic safety climate may serve as a mediating factor. Naveh and Katznavon (2015) found that the road safety climate mediated the relationship between road safety intervention and the number of traffic violation tickets. However, few studies have investigated the relationship between the traffic safety climate and pedestrian behavior. Gehlert et al. (2014) investigated the relation of the traffic safety climate and the behaviors of different road users in Germany and considered pedestrians' behaviors. The results demonstrated that external affective demands were negatively correlated with pedestrian risk perception, whereas functionality was positively correlated with pedestrian risk perception. That is, the less emotionally demanding and the more functional the perception of traffic is, the safer will people feel in traffic. In addition, they discovered that higher emotional demands are associated with a greater likelihood that drivers will intend to run red lights. Additional research on the relationship between the traffic safety climate and pedestrian behavior is needed.

To measure pedestrian behavior, field observations and self-reported questionnaires are frequently employed. Although field observation is better for investigating the effect of the environment on pedestrian behaviors in a given context (Sisiopiku and Akin, 2003), it hinders classification of the wide range of pedestrian behaviors into a system (Elliott and Baughan, 2004). A self-reported questionnaire can remedy these disadvantages and is a valid method for investigating pedestrian behavior (Corbett, 2001; Lajunen and Summala, 2003; Granié et al., 2013).

The Pedestrian Behavior Scale (PBS) was developed to provide a better understanding of both positive behaviors and risk behaviors of pedestrians and has been validated and implemented in many different countries (Granié et al., 2013; Nordfjærn and Şimşekoğlu, 2013; ÃzlemÅimÅekoÄlu, 2015), including China (Qu et al., 2016). Qu et al. (2016) considered the Chinese cultural background and road conditions and created a revised Chinese version of the PBS, which yielded four clear components that divided pedestrians' behaviors into four categories (positive behaviors, transgression, aggressive behaviors and lapses). This instrument can identify pedestrians who are most at risk by measuring the frequency of these different types of behaviors (Granié et al., 2013).

As previously mentioned, the first aim of this study was to investigate the relationship between the inconvenience pedestrians perceive in city traffic and pedestrian behavior. We hypothesized that the more inconveniences pedestrians encounter during their involvement in city traffic, the more likely they will violate traffic regulations. The second aim was to investigate the mediating effect of the traffic safety climate on the relationship between pedestrians' perceived inconvenience and pedestrian behavior. We hypothesized that the fewer inconveniences that pedestrians encounter in city traffic, the safer the traffic safety climate. The safer the traffic safety climate is, the more positively the pedestrians will behave while walking on a street. In addition, we hypothesized that the inconveniences pedestrians perceive in city traffic are indirectly related to pedestrian behavior through associations with specific aspects of the traffic safety climate.

2. Method

2.1. Participants

The survey was conducted in Anshun City of Guizhou Province in China. The participants in this research were recruited as follows: 1) household survey in a neighborhood (it is a typical uptown in the city that we random selected); 2) door-to-door interviews with local store owners; 3) recruiting passers-by at supermarkets that have a large flow of consumers; and 4) distributing questionnaires in an office building of a cooperating local organization. All participants were offered pencil