



Effect of exposure to aggressive stimuli on aggressive driving behavior at pedestrian crossings at unmarked roadways



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ABSTRACT

Background: Aggressive driving, influenced by the proneness of driving aggression, angry state and provoking situation, is adversely affecting traffic safety especially in developing countries where pedestrians frequently cross an unmarked crosswalk. Exposure to aggressive stimuli causes driving anger and aggressive driving behaviors, but the exposure effect on higher and lower aggression drivers and their cumulative changes under successive exposures need more investigation.

Objectives: An experiment was conducted to examine (1) driving behaviors of individuals with higher and lower aggressive driving traits when approaching pedestrian crossings at unmarked roadways with and without aggressive provocation; and (2) cumulative changes of driving performance under repeated provocations.

Method: We conducted a driving simulator study with 50 participants. Trait of aggressive driving served as a between-subjects variable: participants with an Aggressive Driving Scale (ADS) total score of 30 or more (for men) or 23 or more (for women) were regarded as higher aggressive drivers; lower aggressive drivers were those individuals whose ADS total scores were 21 or less (for men) or 13 or less (for women). Exposure to aggressive stimuli (provoked vs. non-provoked condition) served as a within-subjects variable. Several aspects of the participants' minimum driving speed, lateral distance from a simulated pedestrian, lateral deviation, and subjective measures were collected.

Results: We found that drivers with higher aggressive driving traits were more likely to feel irritated and fail to give way for pedestrians and drove closer to pedestrians when exposed to sustained honking and improper passing compared to the non-provoked condition. This trait \times state interaction only occurred when pedestrians crossed the street from the right roadway edge line. In addition, we observed an accumulation effect of exposure to aggressive stimuli on driver's aggressive behaviors at pedestrian crossings.

Conclusions: Environmental design, law enforcement, and educational campaign may have practical value for reducing pedestrian and driver conflicts at unmarked roadways.

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1. Introduction

The ever-increasing population of vehicles has resulted in increased focus on aggressive driving and road rage. All driver behaviors with an intent to harm people physically or psychologically can be regarded as aggressive driving, which include tailgating others to force move, darting in and out of lanes, speeding past other cars, yelling and gesturing at others, and failure to stop at pedestrian crossings (Tasca, 2000; Dula and Ballard, 2003). About 4–5 aggressive driving behaviors are observed per hour in a typical primary road outside the city (Shinar and Compton, 2004);

however, in urban rush hour, there is a steady increase in the number of incidences. Aggressive driving behaviors also lead to traffic violations and accidents (Hemenway and Solnick, 1993; Smart and Mann, 2002; Wells-Parker et al., 2002), thus adversely affecting public safety.

Many factors contribute to aggressive driving behavior. The first and foremost being social and environmental variables, such as anonymity and presence of passengers, traffic density, and exposure to aggressive stimuli (Ellison-Potter et al., 2001; Parker et al., 2002; Harris and Houston, 2010). For example, sighting of aggressive stimuli displayed on banners, billboards, and signs on buildings while driving increases drivers' speed and the frequency of running a red light (Ellison-Potter et al., 2001). Being exposed to unpunished aggressive driving behaviors may weaken inhibitions of other drivers (Novaco, 1998), because such spotting might imply that

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violations on the road are a norm. Second, drivers with certain characteristics tend to drive more aggressively (Massie et al., 1995, 1997; Islam and Mannering, 2006). For example, men are more likely to take hostile actions than women under the same situation, and younger drivers under 45 years of age are easier to get raged than older drivers (Shinar and Compton, 2004). More experienced drivers, who have more mileage and years of experience behind the wheel in traffic conditions, and thus older, are less quick to act aggressively than young and inexperienced drivers (Lajunen et al., 1999; Lajunen and Parker, 2001). Besides, previous experience of accidents or violations is also related to aggressive driving (Wells-Parker et al., 2002).

The personalities of drivers play an important role in aggressive driving behaviors (Krahé and Fenske, 2002; Constantinou et al., 2011; Jovanovic et al., 2011). Traits of anger and aggression are closely related to dangerous driving. Some studies indicate that the trait of aggressive driving has nothing unique compared with everyday behavior of drivers (Van Rooy et al., 2006), whereas others argue that general anger and driving anger are two distinct traits (Herrero-Fernández, 2013). With the evidence that aggression and anger-related traits are genetically associated (Manuck et al., 1999), when studying the proneness of aggressive driving, it is essential to measure anger trait to validate the general tendency of drivers toward aggressive driving. In this study, we divided all the drivers into two groups according to their aggressive driving traits in daily life (e.g., frequency of overtaking a slow driver from the wrong side). We also measured their anger-related traits and expected significant differences between these two groups of drivers. Moreover, except the exposure to aggressive driving stimuli, we controlled the majority of demographic factors, driving experience, and driving history variables at similar levels to avoid confounding effects.

Given the fact that some drivers act aggressively while others control their anger and do not engage in public display of anger, the interaction between the current state and emotional disposition of drivers has a strong effect on dangerous driving (Mesken et al., 2007; Vassallo et al., 2008; Dula et al., 2011). According to the state-trait model (Spielberger, 1988), anger trait means a chronic and general tendency of experiencing anger, and anger state is a temporary feeling of anger. By reviewing and meta-analyzing previous findings, Nesbit et al. (2007) found that irrespective of the kind of emotion, trait-based, mood-based or situation-specific, anger trait is generally associated with aggressive driving. However, they did not find any difference between these subtypes of anger. Blankenship and Nesbit (2013) found that drivers with higher driving anger traits tend to be more sensitive and have shorter reaction time to aggressive words, and such trends are intensified depending on individual scenarios. Similar trends were seen in driving simulator studies, where participants with higher driving anger traits report more anger and frustration and drive faster even in low anger-provoking situations than those with lower driving anger traits (Deffenbacher et al., 2003; Stephens and Groeger, 2009). These findings indicate the increased accessibility of aggressive schemes in individuals with higher driving anger (Fanning et al., 2014). Irritable individuals react intensely even in mild conflict situations; however, severe aggressive provocation makes both higher and lower aggressive drivers become enraged. Although previous studies show these intriguing results, how the driver reacts aggressively under repeated provocations remain unknown.

Provocations, mostly anger, have been manipulated in many studies, for the purpose of imitating aggressive driving circumstances (Dukes et al., 2001; Stephens and Groeger, 2009, 2011; Abdu et al., 2012; Blankenship and Nesbit, 2013; Lu et al., 2013; Zelinková et al., 2013). Recalling bad memories or experiences (Abdu et al., 2012) or priming with driving-related materials (Blankenship and Nesbit, 2013; Lu et al., 2013) can effectively

simulate driver anger. However, these two methods provide provocations at the beginning of the drive, and it is hard to control the frequency and intensity of provocation at the same level. In contrast, traffic impediments can provide continuous and scenario-specific aggressive stimuli with the controlled frequency and intensity of provocation (Dukes et al., 2001; Deffenbacher et al., 2003; Stephens and Groeger, 2009, 2011). For example, Tasca (2000) specifies several behaviors, including improper passing and sustained honking, which are not intended to physically harm other road users but likely to irritate or provoke them. Stephens and Groeger (2009) designed six provoking events categorized into high and low anger-provoking situations according to participants' ratings of anger. In this study, we designed two types of aggressive driving behaviors, sustained honking and improper passing, as provoking situations in simulated driving tasks, and investigated the cumulative changes of the driver performance under repeated provocations.

Measurements of aggressive driving vary across literature. Bettencourt and Miller (1996) categorized aggressive driving into three subtypes: physical, verbal, and honking. The frequency and latency of honking are widely taken as dependent variables in field studies (Doob and Gross, 1968; Deaux, 1971; Shinar, 1998). Self-reported driving histories (e.g., accident and violation) are taken as indicators of aggressive driving in survey investigations (Arnett et al., 1997; Nesbit et al., 2007; Harris and Houston, 2010; Qu et al., 2014). Driving speed and lateral deviation are mainly recorded in driving simulator studies (Ellison-Potter et al., 2001; Deffenbacher et al., 2003; Abdu et al., 2012; Roidl et al., 2014). However, these driving simulator studies focus on driver behaviors on longitudinal and lateral vehicle control (Holmes et al., 2008; Carver and Harmon-Jones, 2009) over a longer period (e.g., the whole experimental trial or in the past week), rather than a spontaneous response to a specific road event. In this study, we simulated a few pedestrian crossings at unmarked roadways and measured driver responses such as speed, deviation, and lateral distance to a pedestrian (Zhao and Wu, 2012) to such specific road events with and without repeated provocation, as well as the cumulative effects of provocation on aggressive driving.

Pedestrian crossing of crosswalks is a common phenomenon, especially in developing countries, and leads to many traffic accidents. Drivers failing to stop or forcing the pedestrians to walk faster or delay their crossings is defined as aggressive behaviors (Hauber, 1980; Virkler, 1998; Sarkar and Andreas, 2004). Previous studies indicate that pedestrian and driver conflicts are common and only 5% of drivers are willing to give way for pedestrians at zebra crossings (Varhelyi, 1998; Bella and Silvestri, 2015). Drivers stop even less and show greater aggression when pedestrians cross an unmarked crosswalk (Katz et al., 1975; Mitman and Ragland, 2008). These findings support the need for future investigations of subtle changes in aggressive driving patterns with respect to pedestrian crossings at unmarked roadways.

China, as a developing country with the largest population in the world, encounters more complicated safety challenges of pedestrian crossings compared with developed countries. The statistics on road traffic accidents show that 25.15% people killed are pedestrians, with more than 15,000 people killed every year. The majority of these casualties are those crossing through unmarked roads (Aron et al., 2004). Recent studies mostly focus on the hazard perception and crossing strategy of pedestrians (Yang et al., 2006; Zhou et al., 2009; Zhuang and Wu, 2011); however, the attention on driver responses while approaching pedestrian crossings at unmarked roadways in China is insufficient.

Based on the above review, the objectives of the present study were to examine (1) patterns of drivers with higher and lower aggressive driving traits when approaching pedestrian crossings at unmarked roadways under aggressive provocation; and (2)

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