Accident Analysis and Prevention 120 (2018) 219–232

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Red-light running behavior of cyclists in Italy: An observational study

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ARTICLE INFO

Keywords:
Cycling behavior
Red-light violation
Cycling safety
Observational study
Classification tree

ABSTRACT

Accident analysis and studies on traffic revealed that cyclists' violation of red-light regulation is a typical infringement committed by cyclists. Furthermore, an association between cyclists' crash involvement and red-light violations has been found across different countries. The literature on red-light running cyclists' behavior in relation to their characteristic is still scarce. The present study, adopted an eye-observational methodology to investigates differences in cyclists' crossing behavior at intersections, with a particular attention to their demographical characteristics. The classification of cyclists' red-light behavior in risk-taking, opportunistic and law-obeying, was adopted and re-adapted to reflect more objective behaviors, eliminating any inference or judgment. Two researchers at a time observed unobtrusively at four different intersections, during morning and late afternoon peak hours, 1381 cyclists approaching the traffic light during the red phase. More than 60% of the observed cyclists violated the traffic control. Results showed that the visual search strategy displayed by the cyclists and the presence of other cyclists at the intersection are important factors in predicting the probability of red-light running behavior.

1. Introduction

Using bicycle as a transport mode is healthy, economical, and environmentally friendly. In Europe, for 8% of people bicycles are the most common mode of daily transport (European Commission, 2014). Nevertheless, cyclists still represent one of the road user categories with the highest risk of injuries and fatalities (European Road Safety Observatory, 2015). From 2004 to 2013, cyclists' fatalities decreased by 32%, but from 2010 this tendency has stagnated, with less than a 1% year-to-year reduction. Furthermore, 31% of these fatalities happen at junctions (European Road Safety Observatory, 2015). In 2014, in Italy, there were 18.055 bicycle crashes recorded, and 273 fatalities (Automobile Club d'Italia - Istat, 2014). The mortality index (deaths per 100 crashes) for cyclists is 1,42 which is more than double compared to car users (ISTAT Italian National Institute of Statistics, 2015).

From 2011 to 2015, the city of Bologna registered an increase in cyclist flow of 42%, as well as an enlargement of 16.50 km of the cycling road infrastructure (Rupi, 2015). However, in the period from 2012 to 2014 bicycle crashes increased as well (from 201 to 237). 47.7% of the 237 crashes happened at intersections (Comune di Bologna, 2015). Such high prevalence of crashes at intersection underscores the relevance of studying potentially dangerous behaviors at intersections.

Accident analysis reveals that violation of traffic rules plays a key role in fatal crashes involving cyclists. Red-light violation is one typical violation behavior among cyclists (Pai and Jou, 2014; Wu et al., 2012). Specifically, the rate of red-light violations among cyclists has been measured in different countries and cultures, varying from the 6.9% rate in Melbourne (Johnson et al., 2011) to 87.5% in Dublin (Lawson et al., 2013). Several studies have shown an association between cyclist crash involvement and red-light violations (Johnson et al., 2008; Retting et al., 1999). Cyclists' violations at intersections (e.g. bicyclists ride through at signalized intersections during the red phase) are estimated to account for the 8.8% of total bicyclists' crashes among North Carolina municipalities (University of North Carolina - Highway Safety Research Center, 2014). Assessing which are the most frequent behavioral and demographical characteristics of red-light running cyclists and which is their behavior at signalized intersection can help craft better policies and develop appropriate interventions to prompt cyclists to respect the red-light signal and, possibly, reduce the amount of traffic crashes due to them.

To analyze cyclists' behavior at intersections, in relation to their demographical characteristics, we need to mention that red-light violations may differ and cannot be included in one category. Based on previous studies (Wu et al., 2012; Johnson et al., 2008; Yang et al., 2006) that investigated pedestrian and bicycle road-crossing behavior, Pai and Jou (2014) classified bicyclists red-light crossing behavior into three types: the (1) risk-taking behavior, that is, ignoring the red-light

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https://doi.org/10.1016/j.aap.2018.08.013
Received 12 March 2018; Received in revised form 29 June 2018; Accepted 13 August 2018
Available online 29 August 2018

and travelling through the junction without stopping (but may slow down); the (2) opportunistic behavior, that is, initially stopping at red-lights but being too impatient to wait for red-lights to turn green and subsequently crossing the junction by seeking gaps among crossing traffic; and the (3) law-obeying behavior, that is, stopping to obey the red-light. While the classification presented by Pai and Jou (2014) is pertinent and relevant it may be argued that it entails inferences or judgements about the cause of the behavior, leading to biased ratings. Thus, the classification is kept in the present study, but names have been changed using a strictly objective description of each behavior: so (1) risk-taking behavior has been renamed as *not stopping at red-light;* (2) opportunistic behavior has been renamed as *violating red-light after an initial stop;* (3) law-obeying behavior has been renamed as *stopping for the whole duration of the red-light*. In particular, distinguishing between not stopping at red-light violations and violating red-light after an initial stop is of utmost importance in order to understand the different levels of risk entailed by different behaviors. Since the violating red-light after an initial stop category involves a stop at the intersection and a violation of the red-light after an evaluation of the situation and eventually the identification of relatively "safe gaps" in the traffic flow, it is considered less dangerous compared to not stopping at red-light (Johnson et al., 2008). Indeed, not stopping at red-light behavior refers to crossing the intersection without stopping and, therefore, leaving less time to identify risks and take necessary maneuvers to avoid potential crashes.

Gender differences in red-light behavior has been broadly investigated in previous studies. General findings indicate that males are more prone to violate the red traffic signal. This was confirmed in the Australian population, both from observational studies (Johnson et al., 2011, 2008), and self-reported measures (Johnson et al., 2013), as in Europe (Richardson and Caulfield, 2015) and China (Wu et al., 2012; Huan and Yang, 2015). Males have been previously found to be more likely to commit not stopping at red-light violations (Pai and Jou, 2014; Wu et al., 2012). The relation between age and red-light infringements has been investigated as well. Johnson et al. (2013) found that, in Australia, young cyclists are the age class that commits more violations (43.9%), followed by middle-age (38.5%) and elderly cyclists (29.9%). Moreover, in a study by Wu et al. (2012) in China, was found that young (under 30 years old) and middle-aged (between 30 and 50) cyclists were 7.63 and 7.92 times respectively more probable to skip a red-light in comparison with old cyclists (older than 50). Furthermore, young cyclists have been found to be more likely to commit not stopping at red-light violations (Pai and Jou, 2014; Wu et al., 2012).

It is not clear if red-light violations are associated with other violations. Pai and Jou (2014) found unhelmeted cyclists to be more prone to skip red-lights whereas cyclists carrying passengers were less prone to violate red-lights. de Waard et al. (2015), in an observational study, found a changing tendency from calling to operating phone screens while bicycling. They also reported that cyclists texting used to cycle further from curbs and used to gaze with less frequency at intersections when generally using a phone. A previous study (de Waard et al., 2010) found that cyclists tended to engage in risk and speed compensation behavior when using the phone and cycling (e.g., by reducing the speed). de Waard et al. (2010) found no speed differences in cyclists that were listening to music, probably meaning that such cyclists did not consider it a mentally demanding task. Nevertheless, other studies suggest otherwise. Kircher et al. (2015) found that cyclists listening to music slightly increased their speed in a real traffic track. Moreover, a study conducted on drivers (Hughes et al., 2013) also found that participants listening to music showed increased peripheral task detection time and reduced driving performance, even if they did not report any increase in subjective mental workload.

To better understand the risk level entailed by cyclists that display different red-light behavior, it can be interesting to investigate their visual search strategies before the crossing phase, exploring if cyclists undertake some kind of risk-evaluation before taking the decision to cross the red-light or not. In relation to smartphone use while cycling, de Waard et al. (2015) found that when at an intersection, cyclist's operating their phone made less head movements to the right than cyclists who were just cycling. In a study on car drivers and cyclists' interaction at bicycle crossing (Summala et al., 1996) was found that the drivers turning right scanned the right leg of the intersection less frequently and later than those turning left, increasing the probability to overlook a cyclist coming from the right. Visual search strategy, assessed in terms of head movement of the cyclist at the intersection, is really an important variable to be considered if there is an interest in assessing different safety level of cyclists' behavior at the intersection.

Several authors have delved into psychological and social determinants (e. g., social influence) of red-light violations of different road users. Cyclists are vulnerable road users as well as pedestrians and, since the literature on the effect of social influence on red-light behaviors of cyclists is still scarce, it can be useful to examine some studies on pedestrians to emphasize the main determinants highlighted so far. For example, Rosenbloom (2009) argued that people would feel higher commitment in respecting social norms when they are grouped, thus complying more with the law, whereas, when alone, people are less concerned with the social criticism and will violate the law more easily. In his study, Rosenbloom (2009) observed pedestrians' red-light crossing and indicated that, the presence of other pedestrians waiting at the crosswalk upon a pedestrian's arrival, as well as the arrival of other pedestrians to the crosswalk, decreased the likelihood of crossing on a red-light. Also, van der Meel (2013) suggested that pedestrians tend to wait for the red-light more often when there are other pedestrians waiting.

For what concerns cyclists, Wu et al. (2012), studying differences on the red-light behavior between electric bike riders and cyclists, found that the smaller the group size of cyclists waiting at the intersection, the less people waiting at the stop line, and the more other riders crossing against the red-light, the more likely a rider would run a red-light. In other words, the number of cyclists crossing illegally was positively associated with the probability of infringing the red-light, that is, the more cyclists skipped the red-light, the more probable it was for other cyclists to infringe it (Wu et al., 2012). Johnson et al. (2011) found that the presence of other road users, both cyclists and drivers, travelling in the same direction had a deterrent effect on cyclists' red-light infringements. Similarly, in an older study (Bureau Goudappel Coffeng, 1985), has been found that the presence of other cyclists was associated with a reduced probability of infringement by the observed cyclist. This phenomenon could be explained according to the social validation principle of social influence, which states that people tend to consider the appropriateness and correctness of their behavior in a given situation taking into consideration similar people's behavior (Cialdini and Griskevicius, 2010). This formulation derives from classic literature findings in Social Psychology, stating that individuals decide on appropriate behavior for themselves in a given situation by searching for information as to how similar others have behaved or are behaving in that situation (Asch, 1956; Darley and Latane, 1970).

Social influence is related to group pressure, and thus it could have a relationship with the size of the group. Findings from literature regarding the effect of group size on group pressure are discordant: whereas some authors (Bureau Goudappel Coffeng, 1985) found group pressure on red-light running behavior to increase with larger group size, van der Meel (2013) did not find statistically significant results regarding the relation between group sizes and violating the red-light.

The present study aims at exploring the relationship between red-light violations and behavioral and demographical characteristics of a sample of Italian cyclists. The results of this research will contribute in better defining how the mentioned variables play a role in the widespread phenomenon of red-light running among cyclists.