Crossing at a Red Light: Behavior of Tourists and Commuters

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Abstract: - Road crossing is a potentially dangerous activity: most pedestrian road accidents happen when pedestrians are crossing roads. During last decade, in Italy, more than 17-18%, out of the yearly total road traffic fatalities, were pedestrians, and the percentage of pedestrian deaths is growing up. Pedestrians attempt to cross the road when they perceive a safe gap in traffic, but they also attempt to cross quickly: so sometimes illegal pedestrian crossings are observed. Many factors were identified in literature as having an impact on the proportion of violations: gender, age, group size, conflicting vehicle flow, maximum waiting time and crossing speed. The main objective of this study is to observe pedestrian behavior in two different urban contexts: a tourist context and a typical working urban context and to highlight if there is any influence, of the specific urban context, on the non-compliance behavior of pedestrians.
From an engineering point of view in order to identify unsafe intersections, where priority should granted to pedestrians it looks important to understand their crossing behavior as the extent of individual, environmental, location and context factors.
Digital video camera images were gathered in the two different urban contexts, data were processed using an automated software self-written in MatLab. The tourist context is the beach town of Viareggio. The typical working urban context is the historical city of Lucca. Both the two test places are located in Tuscany (Italy) and only 20 km are in between them. Factors as age, sex and group size, were analyzed. Pearson's chi-square test has been applied to investigate whether the difference between observed values and expected values of variables were statistically significant. The obtained results highlight that pedestrians in a tourist context are generally more compliance to traffic lights than in a working urban context.
The obtained results of this exploratory study on pedestrians, in a recreational context as compared to a working one, raise some interesting questions whose deserve further research work.

Key-Words: - Pedestrian crossing behavior; red light violations; compliance rule; commuters behavior and tourists behavior at crosswalks; urban context influence.

1 Introduction

There exist a lot of previous researches addressing many aspects of interest regarding pedestrian injuries. During last decade, in Italy, more than 17-18%, out of the yearly total road traffic fatalities, were pedestrians, and year-by-year the percentage of pedestrian deaths grows up. One of the most recurrent reasons for pedestrian injury is pedestrian compliance or lack of compliance with the traffic light road rules. Koh et al. [1] showed that 22% of pedestrian fatal accidents in Singapore occurred at signalized intersections, and one in three of such accidents occurred during the pedestrian red-light phase. Keegan and O'Mahoney [2] reported that 35% of pedestrians, namely more than one in three, entered illegally at a signalized intersection. Behavioral observations conducted at signalized intersections in Sweden and Belgium showed that pedestrians often do not yield when they violate the traffic signal, although they are at fault [3].
The present study investigates pedestrian behavior at crosswalks with traffic lights: the individuals have been extracted from both a working urban context and a tourist context. The road behavior of individual pedestrians belonging to commuters in a traffic light controlled intersection is compared to the behavior of pedestrian tourist at a traffic light crosswalk.

A pedestrian would generally want to cross where it is convenient in order to get to his or her destination with as little delay as possible [1]. There are a lot of previous researches addressing many aspects of interest regarding pedestrian behavior in violating signals at crosswalks. Many factors were

identified as having an impact on the proportion of violations, such as: age, sex, group size, conflicting vehicle flow, waiting time and times of pedestrian signals [4, 5].
There are some studies that have shown that males have a greater propensity to commit red light violations than female, as well as young people tend to violate a traffic light more frequent than other age groups [4, 6]. Nesic et al. [7] observed that over 14% of pedestrians cross the street during red light, which means a 14% rate of potential conflict situation which can lead to a traffic accident.
Pedestrians may also be affected by the closeness and behavior of others at traffic lights [4]. Pedestrians crossing the road in groups can access to a source of social information: if someone crosses the road, it may indicate that it is possible and there is a gap sufficiently large to permit a safe crossing [8]. Practically, pedestrians embedded in large groups should have a stronger feeling of safety than of pedestrians alone have, due to the so-called "safety number" effect that they feel when many other individuals are also crossing [9].

The environmental context could be also very important [10]. Individual behavior differ from place to place, and factors that involved pedestrians' subjective willingness were found to play an important role in street crossing behavior [11, 12].

Noncompliance behavior with signals at traffic light intersections is quite generalized for pedestrians. It is important to understand pedestrian crossing behavior because it is reported as a main factor in many pedestrian accidents. If the reasons of noncompliance are understood, appropriate countermeasures can be suggested to increase safety. This research hypothesizes that an additional factor to compliance behavior might be the urban context. Consequently, in the study pedestrian behavior were observed into two different contexts: working urban and tourist; two different main groups were considered namely: commuters and tourists.

The paper has divided as follows. Observed locations and data recording methodology are described in the following section. Section 3 is related to a statistical analysis of Viareggio data and Lucca data considered separately; while in section 4 the two classes of data are compared. Finally, section 5 resumes the main results and the conclusions are drawn.

2 Methodological Approach

Field observation data has collected through video recording. In the tourist context, data was observed on a signalized intersection located on the main beach avenue of Viareggio, a popular tourist location in Tuscany, during morning and late afternoon of a few days of Summer vacation on August 2015, typical periods when tourists come and go from the beach. The signal cycle was 50 s, the crosswalk was 12 m length and there were four lanes marked (Fig. 1a).
In the commuter context data was gathered on a large signalized intersection located on the main urban arterial of Lucca, a historical city in Tuscany, during a weekday midday peak period on February 2017, typical period in which the workers move for lunch break and the students return home. The signal cycle was 130 s, there were four lane marked and the crosswalk length was 17 m (Fig. 1b).

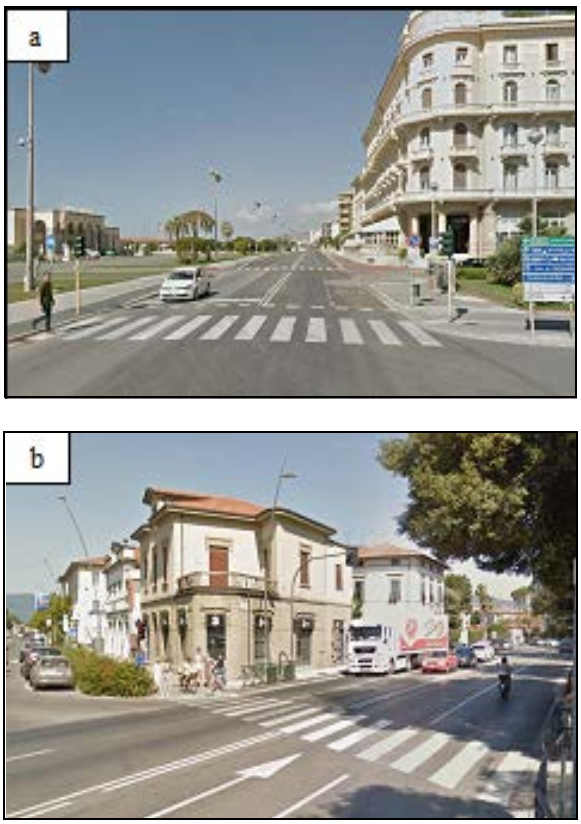

Fig. 1: Street view of the two research signalized intersections: (a) in the tourist context of Viareggio; (b) in the commuter context of Lucca.

In both cases, video recording has performed during several hours. Videos have processed successively, and data extracted, by an automated software self-written in MatLab™. The video analysis has developed separately, leading to two different samples, on for tourists and on for commuters. For each one of the two samples, the video analysis gave information about: pedestrian gender and age (estimated); pedestrian walking

alone or in groups; crossing movement (like walking, or running, or plodding); crossing direction (such as straight or diagonal); pedestrian crossing phase light (whether pedestrians cross during green phase or not).

3 Observation and Results

The Italian Highway Code states that in a traffic light the different phases that one by one appear to pedestrians are steady red man, steady yellow man, green walking man. In Italy, pedestrian commit a dangerous violation when start crossing during the red or the yellow phases. In a previous research, pedestrians tourist behavior at the same large signalized intersection placed in Viareggio were analyzed [10]. Now, the present study considers an enlarged sample, from 289 to 605 tourist pedestrians, and practically gives a confirmation of the results reached by previous one. The tourist sample analysis shows that only 2.98% of pedestrians start to cross during the red phase and 5.79% on the yellow one, while 91.24% start on the green light, so only a few of pedestrians analyzed commit a violation.

Whilst the commuter sample is 323 pedestrians and shows that only 15.95% of them start to cross during the red phase and 20.55% on the yellow phase, while 63.50% start on the green light, so a large percentage (36.50%) of observed pedestrians commit a violation.

In Table 1, traffic light phase and number of approaching and crossing pedestrians are reported, both for the tourist and commuter samples.

Chi-square test has applied to investigate whether there is a significant association between variables by comparing, under the hypothesis of independence, observed values with expected values.

Comparison per gender (Table 2) shows no statistically significant difference between male and female in noncompliance behavior for tourists (χ^2 = 0.664 < $\chi^2_{0.05}$ = 3.841).

On the contrary, among the observed commuters about 43% men made a noncompliance crossing, against 31,5% of women (Table 2). It results a statistically significant difference between male and female in noncompliance behavior for commuters (χ^2 = 4.522 > $\chi^2_{0.05}$ = 3.841). Therefore, male commuters resulted more prone to illegal crossing than female; similar results have been found in Belgrade by Nesic et al. [7]. Instead of quite different results have been found in a study developed in the commuter urban contexts of some cities in Greece, where Galanis and Nikolaos [13] noticed a more illegal crossing behavior in women than in men.

Tourists (a)	Red	Green	Yellow
Arrival	338 (55.87%)	218 (36.03%)	49 (8.10%)
Started	18 (2.98%)	552 (91.24%)	35 (5.79%)
Finish	118 (19.50%)	349 (57.69%)	138 (22.81%)

Commuters (b)	Red	Green	Yellow
Arrival	212 (65.03%)	48 (14.72%)	66 (20.25%)
Started	52 (15.95%)	207 (63.50%)	67 (20.55%)
Finish	87 (26.69%)	30 (9.20%)	209 (64.11%)

Table 1: Traffic light phase and number of approaching and crossing pedestrians.

Tourists (a)			
Gender	Start on Red	Start on Yellow	Total noncompliance
Male	10 (3.62%)	17 (6.16%)	27 (9.78%)
Female	8 (2.43%)	18 (5.47%)	26 (7.90%)

Commuters (b)			
Gender	Start on Red	Start on Yellow	Total noncompliance
Male	29 (20.42%)	32 (22.54%)	61 (42.96%)
Female	23 (12.50%)	35 (19.02%)	58 (31.52%)

Table 2: Noncompliance behavior for pedestrian gender category.

Comparison of differences, in noncompliance behavior (Table 3), among pedestrians who are crossing alone and pedestrians who are crossing in group (i.e., two or more) show that in the observed tourist sample a higher percentage, 11.24%, of noncompliance crossings is recorded for alone pedestrians, while a lower percentage, 7.80%, of non-compliance crossings is recorded for pedestrians in group. Nevertheless, these differences in tourists behavior resulted no statistically significant (χ^2 = 1.808 < $\chi^2_{0.05}$ = 3.841).

The same comparison for the commuter sample show that there is about 40% of noncompliance

crossings for alone pedestrians, while about 33% of noncompliance crossings is recorded for pedestrians in groups. As for tourists, also for commuters, these differences resulted no statistically significant (χ^2 = 1.396 < $\chi^2_{0.05}$ = 3.841).

Tourists (a)			
Ped. Comp.	Start on Red	Start on Yellow	Total noncompliance
Alone	8 (4.73%)	11 (6.51)	19 (11.24%)
Group	10 (2.29%)	24 (5.50%)	34 (7.80%)

Commuters (b)			
Ped. Comp.	Start on Red	Start on Yellow	Total noncompliance
Alone	39 (23.78%)	26 (15.85%)	65 (39.63%)
Group	13 (8.02%)	41 (25.31%)	54 (33.33%)

Table 3: Noncompliance behavior for pedestrians crossing alone against pedestrians crossing in groups.

Tourists (a)	
Dir.	End on Red
Straight line	101 (19.54%)
Diagonal path	17 (19.32%)

Commuters (b)	
Dir.	End on Red
Straight line	86 (27.48%)
Diagonal path	1 (7.69%)

Table 4: Dangerous situation for direction of crossing.

Some pedestrians walk across the street following a straight line, others follow a diagonal direction traveling a longer path. There can be a dangerous situation when crossing finishes after the red light appearance.

Table 4 shows that, out of the observed tourist sample data, 19.54% of pedestrians cross in straight line, and 19.32% of pedestrians follow a diagonal path. Comparison of differences, per direction of crossing for tourists shows no statistically significant difference between straight line and diagonal path in ending on red light (χ^2 = 0.002 < $\chi^2_{0.05}$ = 3.841).

Equally, in the commuter sample has observed that 27.48% of pedestrians cross in straight line, and 7.69% of pedestrians follow a diagonal path. As for tourists also for commuters, the comparison per direction of crossing (Table 4) resulted no statistically significant (χ^2 = 2.497 < $\chi^2_{0.05}$ = 3.841).

Tourist (a)			
Age	Start on Red	Start on Yellow	Total noncompliance
< 20	2 (2.11%)	9 (9.47 %)	11 (11.58%)
20-40	11 (4.01%)	15 (5.47%)	26 (9.49%)
40-65	5 (2.51%)	11 (5.53%)	16 (8.04%)
> 65	--	--	--

Commuters (b)			
Age	Start on Red	Start on Yellow	Total noncompliance
< 20	17 (10.90 %)	41 (26.28 %)	58 (37.18%)
20-40	18 (21.43 %)	19 (22.62 %)	37 (44.05 %)
40-65	17 (20.48 %)	7 (8.43 %)	24 (28.92 %)
> 65	--	--	--

Table 5: Noncompliance pedestrian behavior for different age groups.

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Finally, to test if age has an influence on the attitude towards traffic signal violations, noncompliance behavior of young pedestrians has been compared to noncompliance behavior of both

adult and old pedestrians Table 5 resumes the observed percentages both in the tourist sample, and in the commuters one.

The differences among the age groups in the tourist sample resulted not statistically significant (χ^2 = 4.808 < $\chi^2_{0.05}$ = 7.815). Similarly, the differences among the age groups in the commuter sample turn out to be no statistically significant (χ^2 = 5.880 < $\chi^2_{0.05}$ = 7.815).

3.1 Walking speeds

It is well known that many factors influence the walking speeds of pedestrians [13, 14], such factors are related to person (age, gender, etc.), trip (purpose, path length, etc.), facility (type, grade, etc.) and environment (geometry, weather conditions).

In Table 6 is presented the pedestrian crossing speed (m/s) observed in both cases under exam. The pedestrian crossing speed has analyzed according to gender, age, direction of crossing, alone or in groups [15, 16]. Such analysis has performed relating to both tourists in Viareggio and commuters in Lucca.

	Viareggio *(tourists)*	Lucca (*commuters*)
L (m)	12.0	17.0
Male	1.53	1.82
Female	1.48	1.75
Alone	1.58	1.93
Group	1.47	1.63
Straight line	1.52	1.78
Diagonal path	1.41	1.71
< 20	1.61	1.69
20 - 40	1.55	1.96
40 - 65	1,45	1.77
> 65	1.19	1.34

Table 6: Observed walking speeds (m/s).

The values of Table 6 are depicted in Fig. 2 and clearly show that the walking speed of commuters in any category (gender, age, group, type of crossing) is higher than the corresponding one of tourists. In particular, alone commuter walked faster (1.93 m/s) than alone tourists (1.58 m/s) when crossing the street.

Furthermore, pedestrians from 20 to 40 years old walked faster when commuters (1.96 m/s) than tourists (1.55 m/s).

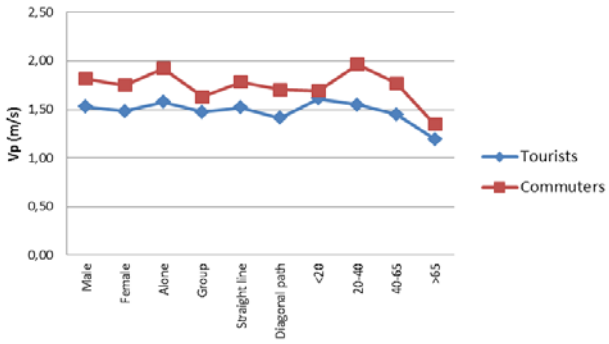

Figure 2: Observed walking speeds (m/s).

4 Comparison between Contexts

The Chi-square test has also applied to investigate whether there is or not a significant association between the analyzed compliance and noncompliance behavior in the two samples of tourists and commuters (Table 7 and Fig. 3).

	Compliance	Noncompliance
Tourists (Viareggio)	552 (0.91 %)	53 (0.09 %)
Commuters (Lucca)	207 (0.63 %)	119 (0.37 %)

Table 7: Tourists vs. Commuters: compliance and noncompliance behavior in the two observed samples.

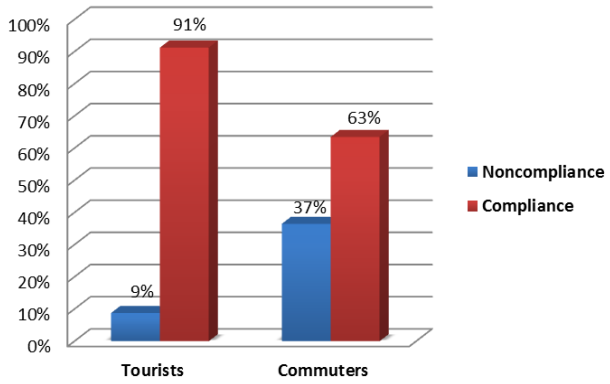

Figure 3: Percentages of legal and illegal behavior in the two observed samples.

Such a comparison points out a quite marked statistically significant difference between tourists and commuters behavior (χ^2 = 108.255 > $\chi^2_{0.05}$ = 3.841). This way it results that differences in pedestrian crossing behavior at lighted crosswalks

between tourists and commuters have to be retained not belonging to random factors.

To investigate if the walking speeds observed in the two samples could belong to the same population a statistical test on sample averages difference and variances homogeneity has performed. The average speed and the speed standard deviation were calculated for each one of the two sample (Table 8).

	n	Average Speed (m/s)	Speed St.Dev. (m/s)
Commuters	326	1.78	0.52
Tourists	605	1.50	0.43

Table 8: Sampled walking speed averages and standard deviations.

The t-Student test has applied to verify if the difference between the two sample speed averages is statistically significant. It resulted that the observed sample difference in walking speed averages is strongly significant ($t = 8.23 >> t_{0.05,929} = 1.96$).

Furthermore, the hypothesis that the two sample belong to the same population has been refused because the ratio of their respective variances is greater than the critical value ($F = 1{,}48 > F_{0.05,604,325} = 1$). As it could be expected, the average crossing speed is fairly different between commuters and tourists. The main reason for this is that commuters are generally in a hurry to cross, while tourists walk in a less stressed mood.

5 Conclusion

This research hypothesizes that an additional factor to compliance in pedestrian crossing behavior might be the urban context. The results of this exploratory research cannot be claimed as generalizable. The study limits mainly rely in the differences among the observed sites and must be acknowledged.

Nevertheless, the consistency between the two sites may have been due to their deep differences in terms of pedestrian profile and mood (tourist vs. commuter), and different results might be obtained at other sites.

Moreover, some interesting issue and insights arose that should be analyzed into more detail in further researches.

Pedestrian crossing behavior at signalized crosswalks has analyzed in two different instances of urban context, i.e. two different populations: tourists and commuters. The tourist sample addresses that there are no significant differences in pedestrian crossing behavior, with respect to factors such as gender, walking alone or group, direction of crossing, age. Therefore, the observed differences in the tourists are mainly due to random factors [4].

The commuters sample addresses to the same above results, except for gender factor where men are statistically significant more prone to illegal crossing than women. However, as far as the comparison in noncompliance behavior between the two samples, tourists and commuter, it is markedly different and a statistically significant difference was observed.

Basing on this statistical evidence, it can be concluded that crossing behavior, at signalized intersection, of a tourist pedestrian has to be expected more legal than that of a commuter pedestrian. It may be that a less stressed person has more attitude to a compliance behavior.

Finally, a higher sample walking speed was observed in commuters, especially in alone pedestrians. Statistical tests highlighted how the two samples belong to different populations, enforcing the previous obtained results on crossing behavior. Therefore, at least in the limits of these results, an average walking speed value calibrated in a commuter urban context is not properly well suited for design applications in a tourist recreational context, and vice versa. These findings also suggest that pedestrians cannot be assumed to have an attitude towards road safety in their behavior and that they are more or less compliant depending on several factors.

The conclusions of this research may be useful for local authorities to understand better the pedestrian crossing behavior in developing road safety training programs in order to improve pedestrian safety.

Future implementations can be made in searching for confirmation and improve understanding of the crossing behavior of pedestrians embedded in different urban contexts and faced to various external factors, such as intersection geometry and type of control devices.

It is however quite established [17] that the crosswalk safety has to be sought not only on influencing pedestrians behavior toward traffic lights, but also on adjusting traffic control patterns toward pedestrians by calming traffic devices and improving driver alerts.

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