PATTERNS OF PEDESTRIAN ATTITUDES, PERCEPTIONS AND BEHAVIOUR IN EUROPE

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Abstract

This study aims to identify patterns of pedestrian attitudes, perceptions and behaviour in Europe, on the basis of the results of the SARTRE 4 (Social Attitudes to Road Traffic Risk in Europe) pan-European survey carried out in late 2010 and early 2011 (questionnaire-based personal interviews in 19 European countries involving 4,290 pedestrians). The various components of pedestrian attitudes and behaviour (e.g. acceptance of measures and penalties, risk-taking behaviour, perceived level of service etc.) were determined by means of a Principal Component Analysis (PCA) on 33 variables contained in the survey. Moreover, groups of pedestrians with similar attitudinal and behavioural characteristics were identified by means of a Two Step Cluster Analysis. The results revealed 8 components, from which six are associated with pedestrian attitudes and two with pedestrian behaviour and were further analysed for different countries and different age and gender groups. Furthermore, the cluster analysis revealed 3 types of pedestrians. The first type concerns pedestrians with 'positive behaviour and positive attitudes'. The second type concerns pedestrians with 'negative behaviour and negative attitudes', a group into which male and young pedestrians are over-represented. The third type concerns neutral pedestrians with 'positive behaviour but mixed attitudes', a group that presents the largest dispersion between countries and whose proportion defines the dominant type of pedestrian in each country. However, the proportion of the different types of pedestrians in each country does not appear to be associated with pedestrian fatality rates.

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1. INTRODUCTION

1.1 Background and objectives

Road safety is dependent to a large extent on actual road users' behaviour, which is influenced by their attitudes, beliefs and perceptions. Consequently, knowing opinions and beliefs may help understanding traffic behaviour. More specifically, road users' perceptions and opinions about transport, road safety, control measures etc., are very relevant to policy makers for understanding the road users' needs, the limitations of their policies and the potential support for new policies, at national or international level (SARTRE 4, 2011).

Pedestrians are the most vulnerable users of road transport networks, and their increased vulnerability is attributed on one hand on the lack of speed, mass and protection, compared to other road users ,and on the other hand on their particular characteristics and behaviour, affecting the nature of their interaction with motorized traffic (OECD, 2001&2011; ERSO, 2008; Yannis et al., 2007a). The knowledge of pedestrian attitudes, perceptions and behaviour may thus assist policy makers in the better understanding of pedestrian behaviour issues and safety needs, and eventually in the planning and implementation of measures to improve pedestrian safety (Yannis et al., 2007b).

Various studies examine road users' social attitudes and behaviour, out of which several (Assum, 1997; Louka et al., 2004; Vanlaar and Yannis, 2006) are based on the SARTRE 1, 2 & 3 (Social Attitudes to Road Traffic Risk in Europe) research projects, which aimed to analyze social attitudes and behaviour towards risk and safety in Europe by means of questionnaires and personal interviews. However, there are not many studies associated with pedestrians' attitudes and behaviour, especially at international level.

Pedestrians' attitude and behaviour data can be obtained through interviews with questionnaires, telephone surveys, direct observations, or through more integrated methods. The majority of researchers use questionnaires to grasp attitudes and behaviour. More specifically, a study made by Yagil (2000) examined the self-reported road-crossing behaviour of young student pedestrians by means of questionnaire. The results revealed significant gender differences. Another study (Granié, 2009) explored the effects of sex-stereotype conformity, perception of danger and risky behaviour of adolescent pedestrians and found that females are more compliant than males and that declared compliance was connected to behavioural compliance among females and not among males.

Bernhoft and Carstensen (2008), analyzed preferences and behaviour of older pedestrians and cyclists by means of a questionnaire. It was found that older pedestrians appreciate pedestrian facilities more than the younger ones, and are also more influenced by the fact that an action is illegal. In a study using the same methods by Zhou et al. (2009), 426 pedestrians completed a demographic questionnaire, in order to measure their tendency towards social conformity, and another questionnaire based on the theory of planned behaviour in order to measure their intentions, behaviour, perceived risk etc. The results indicate that pedestrians were more likely to cross the road when other pedestrians were crossing the road too. In addition, those who showed higher social conformity tendencies had stronger road crossing intentions than low conformity participants.

Lam (2000), carried out a population-based randomized telephone survey targeting parents with children in Australia, in order to investigate which factors are associated with the

behaviour of parents as pedestrians with their young children. Results show that parents do not exhibit safe behaviour adequately in front of their children.

Direct observations as a method of data collection was applied (Khan et al., 1999), in a study that observed 250 pedestrians in Karachi, Pakistan, focusing solely on pedestrians' behaviour and not attitudes. 35% of the pedestrians crossing the street caused the traffic to swerve in order to avoid a conflict. Roadside observations were also applied to investigate the differences in pedestrians' behaviour by observing two entirely different urban places in terms of religion (Rosenbloom et al., 2004). Results showed that young and male pedestrians have a tendency to commit violations.

More complicated methods to collect data on pedestrian attitudes, perceptions and behaviours were also present in literature. For example, Granié (2007) examined gender differences in compliance with pedestrian rules among preschool children. First, children's behaviour as pedestrians was assessed and then each one was interviewed on pedestrian-danger appraisal, rule knowledge, rule compliance etc. Moyano Diaz (2002), examined pedestrians' attitudes towards traffic violations and self-ratings of violations, errors and lapses, amongst a non-random balanced sample of 146 pedestrians from the city of Santiago, Chile. The results showed that young male pedestrians are at least in part responsible for high accident rates.

Sisiopiku and Akin (2003), analyzed behaviours at and perceptions towards various pedestrian facilities, such as crosswalks, physical barriers and pedestrian warning signs. Pedestrian behaviour data were obtained from the reduction of video images of pedestrian movements recorded throughout the study site, while pedestrian perceptions were obtained through a user survey. The majority of respondents believe that motorists should yield to pedestrians only at designated crosswalks. Pedestrian replies in general, showed that '*pedestrians understand the purpose of streets with mixed traffic and are willing to compromise in order to have a fair and safe environment for all users'*.

It is noted that the attitudes of pedestrians towards driving rules, as well as towards annoyance from other road users, have not been adequately addressed in the existing literature. A recent report (NHTSA, 2008), summarized the key findings of the National Survey of Bicyclist and Pedestrian Attitudes and Behaviour in the U.S. It was found that the most important reason pedestrians felt threatened for their personal safety was due to other motorists (62%). Moreover, almost 40% of those who walk in the dark made efforts to make themselves visible to other motorists by means of light colour or reflective clothing etc.\

From the review of the existing literature it is concluded that pedestrian attitudes, perception and behaviour issues have attracted the interest of several researchers. Moreover, different yet quite standardised methodologies exist and have been tested for capturing these attitudes and behaviours, and the existing literature provides useful and insightful results on pedestrian attitudes, perceptions and behaviour. However, the existing studies mostly focus on particular aspects (i.e. only attitudes or only behaviour, specific behaviour e.g. road crossing etc.) and on particular populations (i.e. children, elderly), the samples examined are small, whereas no results comparing different countries are available. In the ongoing SARTRE 4 research project, the attitudes, perceptions and behaviour of a large sample of pedestrians are examined at European level for the first time.

The objective of the present study is to identify patterns of pedestrian road safety attitudes, perceptions and behaviour in Europe, on the basis of the results of the SARTRE 4 Pan-

European survey. More specifically, the study aims to identify the components of pedestrian attitudes, perceptions and behaviour (e.g. acceptance of measures and penalties, risk-taking behaviour, perceived level of service etc.). Moreover, it aims to identify groups of pedestrians with similar attitudinal, perceptual and behavioural characteristics, and analyse the results for different countries and different age and gender groups. Finally, it aims to explore the association of pedestrian attitudes, behaviours and perceptions with the fatality rates of pedestrians per country.

2. DATA

2.1. The SARTRE 4 European Survey

The SARTRE 4 project (SARTRE 4, 2011) deals with road users' attitude and perceptions in Europe in relation to road traffic risk. More specifically, the objective of the project is to survey and highlight with a uniform methodology many important issues such as mobility experiences, perception of safety needs by different types of road users, opinions and experiences about speeding and impaired driving, attitudes towards motorcycle riders, pedestrians and other road users. It is based upon a common survey carried out in each participating country and upon a shared analysis of the database. It is noted that the survey involved a personal interview for the filling of an extensive questionnaire.

The project provides a follow-up of the previous three SARTRE projects, with the inclusion of additional groups (other road users such as pedestrians, public transport users, cyclists and motorized two-wheelers), and a more policy-focused questionnaire. The questionnaire also includes issues that gained importance during the last years, e.g. 'eco-driving' and mobility, harmonization, safety of motorized two-wheelers, risk to pedestrians in urban areas, security concerns or new traffic enforcement technologies. The gathered data aim to provide a current picture of road users' attitudes and opinions, with possibilities to compare between countries and identify possible reasons for differences.

In total, 21 280 questionnaires were collected, between November 2010 and February 2011, from 19 European countries, namely Austria, Belgium, Cyprus, Czech Rep., Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Netherlands, Poland, Serbia, Slovenia, Spain and Sweden. In each country, at least 200 pedestrians were interviewed, on the basis of simple random sampling at national level.

2.2. The SARTRE 4 Data

The SARTRE4 database, developed from the coding of the questionnaire responses, involved various common questions that all road users had to fill, followed by a separate section for each category of road user (car drivers, motorcyclists and other road users). The questions that were examined within the present research were those of the common part (CO) of the questionnaire that were considered to be relevant to the aim of the analysis (i.e. several questions of the common part questions described pedestrians' opinions and attitudes on more general topics) and those of the Other Road Users' (ORU) part of the questionnaire which were associated with pedestrians. For details on the questionnaire design and selection of questions the reader is referred to the final SARTRE4 report (SARTRE4, 2012).

The selection of pedestrians was carried out according to the following criterion: pedestrians were identified as those respondents who reported that their most frequent transport mode in the last 12 months was neither passenger car nor motorcycle and who reported non-zero daily walking distance travelled. Questions that concerned other personal information (such as occupation, age, marital status, education, place of living), respondents' concern about various issues (crime, pollution etc.), or general opinions about government policies or road safety were not examined in the present study.

It is important to note that the pedestrians included in the sample were not 'exclusive' pedestrians. The analysis of their motivations and travel habits, carried out within the SARTRE 4 project, revealed four different types of pedestrians (SARTRE4, 2012): the 'average distance traveller, short distance pedestrian and user of public transport' (44.5% of pedestrians), the 'long distance traveller and pedestrian' (9.9%), the 'short distance traveller - mostly walking and cycling' (24.1%) and the 'average distance traveller, short distance pedestrian and frequent cycling' (21.5%). It is revealed that most pedestrians do not fit a stereotype, i.e. a large proportion of their daily travel is carried out by other means of transport.

Table 1 summarises the questions that were selected for further analysis. These questions concern:
• the pedestrians' attitudes towards various road safety measures, penalties and devices, as well as dedicated measures for pedestrians. Pedestrians' attitudes towards driver rules are important because driver rules and driver behaviour may have a direct impact on pedestrian safety. Stricter traffic rules may increase the perceived level of safety of pedestrians.
• the satisfaction of pedestrians with the road environment and the traffic conditions
• the degree to which pedestrians are annoyed by the driving behaviour of cars or motorcycles, indicating the satisfaction of pedestrians by their interaction with other road users (in terms of e.g. yielding behaviour).
• the walking and crossing behaviour of pedestrians
• Pedestrian distraction, i.e. using a handleld phone or an Mp3/iPod device, which have been found to increase accident risk in several recent studies (Hatfield and Murphy, 2007; Nasar et al. 2008)
• factors that may lead to the change of this behaviour. For example, the fact that pedestrians may have to use the road instead of the pavement implies that first, barriers prevent the pavements from being accessible and second that this action poses a threat to pedestrians since they are more exposed to traffic. The fact that they may avoid streets or intersections which they consider to be dangerous implies increased perceived risk and adaptability.

In all cases, the scoring goes from "positive" to "negative" attitudes and from "safe" to "unsafe" behaviours.

*****Table 1 to be inserted here*****

Tables 2, 3 and 4 illustrate the gender, age and area type distribution of pedestrians per country and totally. The majority of pedestrians are females in almost all countries. The age distribution of participants is rather uniform, with the young and the elderly being slightly over-represented in total, and more over-represented in several countries.

*****Table 2 to be inserted here*****

*****Table 3 to be inserted here*****

*****Table 4 to be inserted here*****

3. METHODS

3.1. Principal Component Analysis for Grouping Variables

The first step of the analysis is to identify meaningful groups of variables reflecting pedestrians' attitudes, behaviour and perceptions. For that purpose, a Principal Component Analysis (PCA) was carried out. This technique has two main objectives: the first is to understand the structure of a large set of variables, and the second is to reduce the dataset to a more manageable size while at the same time retaining as much of the original information as possible. In practice, PCA may allow the identification of a limited number of Components describing the examined issues, on the basis of a large number of questions.

All the variables from the questions presented in Table 1 (CO06, CO07, CO08 and ORU03, ORU04 and ORU08) were included in this part of the analysis. It is noted that question ORU3d that refers to "reflective clothing" was eliminated because in most countries only a minor proportion of pedestrians reported using it. Eventually, a total of 33 variables were selected for the analysis. Those 33 variables were tested on how much variance they share and then they were 'clustered' together into Components.

In order to perform PCA with robust results, it is crucial that the size of the sample is adequate. The general rule is that at least 10-15 participants (e.g. respondents) per variable should be available, which was obviously met in the present dataset. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was also used in which values above 0.7 are considered to be very satisfactory.

In addition, the variables' communalities were calculated, which show how much of each variable's variance is common between variables and how much is unique. More specifically, the communality h^2, is the squared multiple correlation for the variable as dependent using the Components as predictors. The communality measures the percent of variance in a given variable explained by all the Components jointly. Variables with low values of communality can be eliminated from the analysis, as they do not share important variance with other variables.

The final step is to try to determine the optimal number of Components, and to calculate and save the Component scores. The number of Components retained was defined through a combination of more than one criterion and more specifically the criteria of Kaiser, the Scree plot and the share of variance explained. The Kaiser rule suggests dropping all components with eigenvalues under 1.0. The Cattell scree test plots the components on the X axis and the corresponding eigenvalues on the Y axis. As the number of components increases, the eigenvalues are reduced. Cattell's scree test suggests that all further components after the number for which the reduction becomes too small should be dropped out of the analysis. The Variance Explained criterion can be used in order to keep enough components to account for as much variance as possible.

3.2. Cluster Analysis for Grouping Pedestrians

After the implementation of PCA to group variables according to shared variance, a cluster analysis was carried out. Cluster analysis is a similar technique to PCA except that, rather than trying to group together variables, the aim is to group cases (i.e. individuals). The clustering was based upon the Component Scores that were calculated in the PCA.

The type of cluster analysis that was chosen was the Two Step Cluster Analysis. This method of clustering is most appropriate for very large data files and it can produce solutions based on both continuous and categorical variables. The clustering algorithm is based on a distance measure that gives the best results if all variables are independent, continuous variables have a normal distribution, and categorical variables have a multinomial distribution, and these assumptions are adequately met in the present analysis.

The first step of the two-step procedure is the formation of pre-clusters. The goal of pre-clustering is to reduce the size of the matrix that contains distances between all possible pairs of cases. In the second step, the standard hierarchical clustering algorithm is applied on the pre-clusters. The two-step cluster algorithm requires that all continuous variables are standardized; in this case all the Component Scores were standardized with a mean value of 0 and a standard deviation of 1. As far as the distance measures are concerned, the log-likelihood method was selected.

The clustering criterion (in this case the BIC - Bayesian Information Criterion) is computed for each potential number of clusters. Smaller values of the BIC indicate better clustering outcome. Also, a satisfactory solution should have a large ratio of BIC Changes and a large ratio of distance measures.

4. RESULTS

4.1. Identification of Attitude, Perception and Behaviour Components

The PCA revealed the value of the KMO measure was 0,867 and this shows that the sample size is very sufficient. The results showed that the communalities of most variables were above 0.5 and therefore no variables were eliminated. According to the combination of criteria discussed in section 3.1, it was decided to extract 8 Components which explain almost 60% of the variance (59.4%). The interpretability of the 8 Components was improved through rotation. Orthogonal rotation was selected in order to be sure that the estimated Components are unrelated. It was decided to suppress all Component loadings less than 0.4 to make the interpretation substantially easier. Finally, the Components scores were calculated according to the Anderson-Rubin method to ensure that Component scores are uncorrelated. More specifically:

Component 1: The first Component is correlated with the variables which concern satisfaction with the road and traffic conditions, the pedestrian facilities etc. It can be thus labelled as “Satisfaction with the pedestrian environment”.

Component 2: The second Component is correlated with the variables which concern the acceptance of various penalties for inappropriate driver behaviour. It can be labelled as “Attitude towards penalties”.

Component 3: The third Component is correlated with the variables which concern the implementation of various in-vehicle devices aiming to improve driver behaviour or prevent inappropriate driver behaviour. It can be labelled as "Attitude towards electronic in-vehicle devices".

Component 4: The fourth Component is correlated with the variables which concern measures for speed management and traffic surveillance measures. This Component can be labelled "Attitude towards speed limitations and surveillance".

Component 5: The fifth Component is correlated with the variables which concern pedestrians' self-reported behaviour. This Component can be labelled "Pedestrian behaviour and distraction".

Component 6: The sixth Component is correlated with the variables which concern dedicated pedestrian safety measures, such as 30km/h zones, bicycle lanes, sidewalks, and car- and motorcycle-free zones). This Component can be labelled "Attitude towards pedestrian safety measures".

Component 7: The seventh Component is correlated with the variables which concern pedestrians who get annoyed with car drivers, motorcycles and cyclists. This Component can be labelled "Annoyance with other road users".

Component 8: This reflects on the one hand the avoidance of streets or intersections because they are considered to be unsafe, and on the other hand the presence of barriers impeding pedestrians from using the sidewalks. It can be thus labelled "Lack of accessibility". However, the interpretation of this component is not straightforward, as the one variable concerns risk avoidance and the other one concerns engagement in risky behaviour.

A full description of the 8 Components is provided in Table 5:

*****Table 5 to be inserted here*****

Overall, the Components identified are largely in accordance with the structure of the survey questionnaire, as was expected. In some cases, however, the estimated Components provide further insight into aspects of pedestrian attitudes and behaviour. Table 5 shows that Components 1 (Satisfaction with the pedestrian environment), 2 (Attitude towards penalties), 3 (Attitude towards electronic in-vehicle devices) and 7 (Annoyance with other road users) are highly associated with questions ORU04, CO08, CO06 and ORU08 respectively. Component 4 (Attitude towards speed limitations and surveillance) and 6 (Attitude towards pedestrian safety measures) are highly associated with almost half of the questions of CO07 each, while Component 5 (Pedestrian behaviour and distraction) with most of questions of ORU03 of the questionnaire. Finally, Component 8 (Lack of accessibility) is highly associated with 2 out of 7 questions of ORU03 of the questionnaire.

4.2. Identification of Types of Pedestrians

The cluster analysis that was carried out upon the Component scores resulted in 3 clusters of pedestrians according to the two step cluster criteria discussed in section 3.2. The distribution of pedestrians in those clusters is as follows: 44.4% of pedestrians are in the 1st cluster, 30.7% are in the 2nd cluster and 24.9% are in the 3rd cluster.

Table 6 illustrates the clusters Centroids, which are the mean standardized Component scores of each cluster centre and indicate the cluster's distance from the Component 'centre'. Given that the Component scores are standardized, it is reminded that the mean Component score has a value equal to 0.

*****Table 6 to be inserted here*****

The significance of each Component in each cluster was tested by means of a t-test. The t-test of the Components that is higher than the critical value of 1.64 shows that the Component score is statistically different from zero at 95% confidence level, i.e. significantly different from the mean Component score. The meaning of the sign of the Component score depends on the way that each variable is coded and the sign of the Component loadings. For example, people in Cluster 1 and 3 seem to agree with penalties (Component 2) while people in Cluster 2 seem to disagree with penalties, because the questionnaire variables that comprise this Component have positive loadings and are coded from 1=strongly agree to 5=strongly disagree. Therefore, a negative cluster centre indicates a departure from the mean Component score towards lower values (i.e. agreement) and a positive (significantly) cluster centre indicates a departure from the mean Component score towards higher values (i.e. disagreement). A cluster centre not significantly different from zero corresponds to the average Component score. A detailed description of the 3 clusters follows:

Cluster 1: This group has the lowest score in Component 1 (satisfaction with pedestrian environment). This means that this cluster involves people who are satisfied with pedestrian environment. Furthermore, it has the lowest score on Component 2 (attitudes towards penalties) , on Component 3 (attitude towards in-vehicle devices) and on the Component 4 (attitudes towards speed limitations and surveillance), which indicates that they agree with the implementation of these measures. On the other hand, this cluster has a mean score on Component 5 (behaviour and distraction), which means that pedestrians in this group are more distracted and have more dangerous behaviour than those in cluster 3 but less than those in cluster 2. It has the lowest mean score on Component 6 (acceptance of pedestrian safety measures), suggesting that they accept those measures more than pedestrians of the other 2 clusters. Finally, it has an average score on Component 7 (annoyance with other road users) and also an average score on Component 8 (lack of accessibility).

Cluster 2: This group of pedestrians has the highest score on Component 1, so pedestrians in this cluster are less satisfied with the pedestrian environment than the other two groups. This group has a higher score on Component 2 (attitudes towards penalties), on Component 3 (attitude towards in-vehicle devices) and also on Component 4 (attitudes towards speed limitations and surveillance), and that means that pedestrian disagree with these measures and penalties. It has the highest score on Component 5 (behaviour and distraction), so pedestrians in this group are more distracted and have more dangerous behaviour. This cluster has an average value on Component 6 (acceptance of pedestrian safety measures) and 7 (annoyance with other road users). On the other hand, this cluster has the highest value on Component 8 (lack of accessibility) suggesting that pedestrians avoid dangerous streets/intersections and walk on the streets because of barriers.

Cluster 3: This group has an average score on Components 1, 3 and 4. It has a low score on Component 2 (attitude towards penalties) and that means that they agree with them. Moreover, this cluster has the lowest score on Component 5 (behaviour and distraction),

suggesting that pedestrians in this cluster are less distracted and have less dangerous behaviour. It has the highest score on Component 6 (acceptance of pedestrian safety measures), corresponding to a low acceptance of those measures. This cluster has the lowest score on Component 7(annoyance with other road users) and Component 8 (lack of accessibility).

Overall, the attributes of the three clusters can be summarized as follows:

CLUSTER 1: "Positive attitudes, positive behaviour"
- Satisfied with road environment
- Agree with measures and penalties
-Agree with in-vehicle devices
-Agree with speed limitations and surveillance
- Average risk-taking and distraction
- Accept pedestrian measures
- Average annoyance with other road users
- Lack of accessibility

CLUSTER 2: "Negative attitudes, negative behaviour"
- Not satisfied with road environment
- Disagree with measures and penalties
- Disagree with devices
-Disagree with speed limitations and surveillance
- High risk-taking and distraction
- Average acceptance of pedestrian measures
- Average annoyance by other road users
- Lack of accessibility

CLUSTER 3: "Mixed attitudes, positive behaviour".
- Average satisfaction with road environment
- Agree with penalties
-Average agree with devices
- Average agree with speed limitations and surveillance
- Low risk-taking and distraction
- Disagree with pedestrian measures
- Not annoyed by other road users
- No lack of accessibility

Figures 1, 2 and 3 illustrate the distribution of pedestrians in the 3 clusters per gender, age group and country respectively.

Figure 1 shows that 37% of male pedestrians are in Cluster 1, which suggests that they have positive attitudes and positive behaviour, while 38% have negative attitudes and negative behaviour. Only 25% has mixed attitudes. Figure 2 shows that almost half of females have positive attitudes and positive behaviour while 25% and 27% are assigned to the other two clusters.

*****Figure 1 to be inserted here*****

*****Figure 2 to be inserted here*****

In Figure 3 it can be observed that most pedestrians in most age groups belong to Cluster 1 (positive attitudes and positive behaviour) and the lowest percentage belongs to Cluster 2 (negative attitudes and negative behaviour). This trend is not observed, however, for pedestrians younger than 34 years old. It can be seen that most of them have negative attitudes and behaviour. Those age groups (17-24 and 25-34) have the lower percentage of mixed attitudes (Cluster 3).

*****Figure 3 to be inserted here*****

Figure 4 shows that the percentage of pedestrians that belong to Cluster 1 (positive attitudes, positive behaviour) is higher than 40% almost all countries, apart from Austria, Netherlands, Spain and Germany. In those 4 countries pedestrians are equally distributed across the 3 clusters. As far as Cluster 2 (negative attitudes, negative behaviour) is concerned, the highest percentages can be found in Italy, Cyprus, Sweden and Greece (48.2%, 46.5%, 39.3% and 38.9% respectively). The most dispersed cluster is Cluster 3 which has some notably low percentages such as 5.6% (Greece), 6.9% (Cyprus) 8.1% (Estonia), while at the same time has some high percentages such as Hungary (40.5%), Finland (39.2%) and Spain (38.7%).

*****Figure 4 to be inserted here*****

It is interesting to note that the type of pedestrian dominating in each country can be identified only when examining the proportion of pedestrians with mixed attitudes but positive behaviour in combination with one of the other groups. For example, the proportions of 'positive' and 'negative' pedestrians are practically equally distributed in Italy and in Greece, with only a minor proportion of 'mixed' pedestrians. On the other hand, in the Netherlands, pedestrians are equally distributed to the 3 clusters and therefore a dominance of 'positive behaviour' is identified (i.e. taking into account that positive behaviours reflected in clusters 1 and 2 reach 70%). The dominant attitude is however less identifiable, given the large proportion of pedestrians with 'mixed' attitude in that country.

4.3. Linking pedestrian attitudes and behaviour with pedestrian safety

On the basis of these results, it was attempted to link pedestrian attitude and behaviour with the pedestrian safety problem in the examined European countries. In Figure 5, the SARTRE 4 countries are plotted in terms of their pedestrian fatality rates (pedestrian fatalities per million inhabitants) and the share of pedestrians with "negative attitudes and negative behaviour". Pedestrian fatality and population data were obtained by the European Road Safety Observatory (ERSO, 2010). The purpose of this analysis is to test whether increased share of negative pedestrian attitudes and behaviour is associated with a pedestrian safety problem of greater extent.

The results show no clear correlation between pedestrian fatality rates and "negative attitudes / behaviour". In fact, there are few countries with increased fatality rates and increased share of "negative" pedestrians (Greece, Slovenia), but there are also countries with increased fatality rates but small share of "negative" pedestrians (Poland, Hungary). On the other hand, there are several good performing countries in terms of pedestrian safety that show high share of "negative" pedestrians (France, Germany, Sweden).

Figure 5 to be inserted here

The above results can be considered suggestive of a lack of strong correlation between pedestrian fatalities and attitudes / behaviour and of a need for further investigation. It is noted that 'positive' and 'mixed' attitudes and behaviours were also correlated with pedestrian fatality rates, with no significant results.

This lack of relationship may be initially attributed to the fact that the attitudes, perceptions and behaviour of pedestrians may not actually affect their safety to a considerable degree. It is likely that pedestrian safety is more affected by the attitudes and behaviour of motorists. For example, low acceptance of stricter enforcement and penalties from pedestrians may not significantly affect their own safety, but on the other hand low acceptance of such measures from the motorists' part may suggest poor awareness of road safety problems and risk factors, which may increase their accident risk, as well as the accident risk of their opponents, including pedestrians. Furthermore, inappropriate behaviour of pedestrians (i.e. red light violation, crossing outside designated locations etc.) may indeed be a risk factor, but inappropriate driver behaviour, ranging from failure to detect or yield for pedestrians, to speeding or drink-driving, may be an equally or more critical risk factor.

5. CONCLUSIONS

The present study was based upon the SARTRE 4 research project which is currently carried out in Europe. In this project a sufficient sample of pedestrians (and other road users) from nineteen countries was interviewed by means of an extensive questionnaire on attitudes and behavioural characteristics and demographics. This study as a consequence, aims to shed some light on how people in Europe behave as pedestrians with regard to traffic rules (e.g. red signal, designated crossing locations etc.) and road traffic environment (e.g. walking on the pavement because of obstacles etc.). Furthermore, their attitudes and perceptions towards some important issues such as pedestrian environment, implementation of safety devices in cars, measures and penalties on car drivers, and interaction with other road users were measured.

A Principal Component Analysis was carried out in order to identify meaningful groups of variables (Components) reflecting specific attitudinal and behavioural aspects of pedestrians. Moreover, a Two-Step Cluster Analysis was conducted in order to obtain meaningful groups of pedestrians on the basis of the estimated Components.

The results revealed that the 33 variables of the study can be optimally clustered together in 8 Components. In addition, those Components can be broadly classified into two sub-groups, one group associated with attitudes and one with behaviour. More specifically, Components 1 (Satisfaction with the pedestrian environment), 2 (Attitude towards penalties), 3 (Attitude towards electronic in-vehicle devices), 4 (Attitude towards speed limitations and surveillance), 6 (Attitude towards pedestrian safety measures) and 7 (Annoyance with other road users) are associated with stated-preferences and attitudes while Components 5 (Pedestrian behaviour and distraction) and 8 (Lack of accessibility) are associated with stated-behaviour.

The Cluster analysis revealed 3 groups of pedestrians on the basis of the 8 Components, one associated with positive attitudes and positive behaviour, one with negative attitudes and negative behaviour and one with more diverse (i.e. mixed) attitudes and positive behaviour. In addition, pedestrian attitudes and behaviour seem to have a direct link, in a sense that those

pedestrians who have negative attitudes towards safety measures and safety devices have also dangerous behaviour and commit violations. On the other hand, pedestrians who are positive to safety measures and safety devices do not behave dangerously and avoid violations. The results showed that in total almost 70% of pedestrians have neutral to positive behaviour and attitudes while a non negligible 30% are expressing negative attitudes towards measures and interventions as well as towards existing pedestrian environment and safety; this needs to be taken into account by policy makers in each country and at European level.

It is also interesting to note that overall, pedestrians with negative attitudes were strongly associated with negative behaviour, whereas pedestrians with positive or mixed attitudes were associated with positive behaviour. As expected, the percentage of male pedestrians who show negative attitudes/behaviour is higher than those of females and the percentage that shows positive attitudes/behaviour is lower.. Moreover, an equal proportion of males and females are 'positively' neutral (mixed attitudes, positive behaviour). Young individuals are also over-represented in the cluster of pedestrians with negative attitudes and behaviour. More specifically, percentages of negative attitudes/behaviour increase as the age of pedestrian decreases. These differences confirm the age and gender effects of pedestrians' attitudes and behaviour, which were identified in previous research (Granié, 2009, Bernhoft & Carstensen, 2008).

The distribution of pedestrians of the nineteen countries of the European Union to the three clusters reveals some interesting findings. For instance, in very few countries is one of the three types of pedestrians dominant; in most cases, a non-negligible proportion of 'negative' pedestrians is observed. In terms of behaviour, positive behaviour (clusters 1 and 3) dominate in most countries, however in terms of attitudes, mixed or negative attitudes (expressed by clusters 2 and 3) dominate in most countries. Country comparisons show that in general, the neutral pedestrians (mixed attitudes, positive behaviour) have the lowest percentage in the countries with the highest negative attitudes/behaviour.

However, when attempting to correlate the proportion of negative attitudes / behaviours with the magnitude of the pedestrian safety problem in each country (fatality rate), it is revealed that practically no such correlation exists; in fact, there are countries that perform better than average in terms of pedestrian safety, although the share of "negative" pedestrians is relatively high, or vice versa. It is suspected that motorists' attitudes and behaviours may be a much stronger determinant of pedestrian safety, than pedestrians' attitudes and behaviours.

Further research is necessary, in particular towards the development of statistical models linking the road safety level for pedestrians in each country with the attitudes and behaviours of all road users, and other parameters. Moreover, countries which seem to have higher percentage of "positive" pedestrians should be examined more in depth in order to examine whether these positive attitudes and behaviour result from related policy measures, education and infrastructure or other good practices, and whether these good practices may be transferred in other countries.

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FIGURE CAPTIONS

Fig. 1. Distribution of Male Pedestrians in Clusters (%).

Fig. 2. Distribution of Female Pedestrians in Clusters (%).

Fig. 3. Proportion of Pedestrian Types per Age Group (%).

Fig. 4. Proportion of Pedestrian Types per Country (%).

Fig. 5. Pedestrian fatality risk and pedestrian negative attitudes / behaviours (%) per country

Table 1. SARTRE4 Selected Questions for Pedestrians

CO06	**How much would you be in favour of using...?**	Very	Fairly	Not much	Not at all		
a)	Speed limiting devices fitted to cars that prevented drivers from exceeding the speed limits	1	2	3	4		
b)	A 'black box' to identify what caused an accident	1	2	3	4		
c)	An "alcolock" that prevented the car to start if the driver exceeds the legal alcohol limit for driving	1	2	3	4		
d)	An "alcolock" that prevented the car to start for recidivist driver that exceeds the legal alcohol limit for driving	1	2	3	4		
e)	Fatigue detection devices that warn the driver to stop if he/she was too tired to drive	1	2	3	4		
CO07	**How much would you be in favour of the following measures?**	Very	Fairly	Not much	Not at all		
a)	Automated cameras for red light surveillance	1	2	3	4		
b)	Surveillance of speeding at a single point by automated cameras	1	2	3	4		
c)	Surveillance of speeding between two distant points by automated cameras	1	2	3	4		
d)	More "30 km/h" zones in built-up areas	1	2	3	4		
e)	More bicycle lanes	1	2	3	4		
f)	More sidewalks for pedestrians	1	2	3	4		
g)	More car and motorcycle free zones in built-up areas	1	2	3	4		
CO08	**Do you agree or disagree with the following statements?**	Strongly agree	Agree	Neither	Disagree	Strongly disagree	
a)	Penalties for speeding offences should be much more severe	1	2	3	4	5	
b)	Penalties for drink-driving offences should be much more severe	1	2	3	4	5	
c)	Penalties for not using restraint systems should be much more severe	1	2	3	4	5	
d)	Penalties for not wearing a helmet on a motorcycle should be much more severe	1	2	3	4	5	
e)	Penalties for using a handheld phone while driving should be much more severe	1	2	3	4	5	
ORU03	**As a pedestrian, how often do you...?**	Never	Rarely	Sometimes	Often	Very often	Always
a)	Cross the road when it's a red light for pedestrian	1	2	3	4	5	6
b)	Cross streets at places other than the pedestrian crossing	1	2	3	4	5	6
c)	Avoid certain streets or intersections because they are too dangerous	1	2	3	4	5	6
d)	Wear reflective clothing	1	2	3	4	5	6
e)	Have to walk on the street because of parked cars or other barriers	1	2	3	4	5	6
f)	Make/answer a call with handheld phone	1	2	3	4	5	6
g)	Use MP3/iPod/music devices	1	2	3	4	5	6
ORU04	**As a pedestrian, thinking about the area in which you walk on, how satisfied are you with the following?**	Very	Fairly	Not much	Not at all		
a)	Pavements	1	2	3	4		
b)	Separation of pedestrians and cyclists	1	2	3	4		
c)	Safety	1	2	3	4		
d)	Speed of the traffic	1	2	3	4		
e)	Volume of traffic	1	2	3	4		
f)	Number of street lights	1	2	3	4		
g)	Number of places to cross the street	1	2	3	4		
ORU08	**When travelling in general, as a pedestrian, how often do you...**	Never	Rarely	Sometimes	Often	Very often	Always
a)	Get very annoyed with car drivers	1	2	3	4	5	6
b)	Get very annoyed with motorcyclists	1	2	3	4	5	6
c)	Get very annoyed with bicyclists	1	2	3	4	5	6

Table 2. Pedestrian gender distribution per country

Country	Male	Female
Austria	43,5%	56,5%
Belgium	37,0%	63,0%
Cyprus	35,7%	64,3%
Czech Rep	47,5%	52,5%
Estonia*	13,1%	84,7%
Finland	21,6%	78,4%
France	39,7%	60,3%
Germany	28,2%	71,8%
Greece	12,6%	87,4%
Hungary	28,9%	71,1%
Ireland	34,6%	65,4%
Israel	37,5%	62,5%
Italy	51,3%	48,7%
Netherlands	38,8%	61,2%
Poland	39,8%	60,2%
Serbia	46,7%	53,3%
Slovenia	21,4%	78,6%
Spain	32,8%	67,2%
Sweden	29,6%	70,4%
Total	34,3%	65,6%

* In Estonia there is a percentage of 2.2% unknown

Table 3. Pedestrian age distribution per country

Country	17-24	25-34	35-44	45-54	55-64	65+
Austria	17,0%	12,5%	15,0%	11,0%	16,5%	28,0%
Belgium	17,1%	12,2%	13,8%	13,3%	17,1%	26,5%
Cyprus	63,3%	4,8%	3,3%	7,1%	11,0%	10,5%
Czech Rep	14,6%	12,6%	15,7%	16,2%	22,7%	18,2%
Estonia	24,1%	16,1%	14,6%	21,9%	18,2%	5,1%
Finland	14,4%	13,4%	8,8%	14,9%	16,0%	32,5%
France	25,8%	13,9%	12,4%	14,4%	15,5%	18,0%
Germany	12,2%	17,4%	16,4%	10,3%	12,7%	31,0%
Greece	16,2%	16,2%	22,2%	25,3%	12,1%	8,1%
Hungary	11,9%	10,0%	12,9%	10,4%	24,4%	30,3%
Ireland	20,9%	13,1%	13,6%	16,2%	21,5%	14,7%
Israel	22,7%	19,0%	11,6%	8,3%	15,7%	22,7%
Italy	12,6%	12,6%	9,4%	13,6%	16,8%	35,1%
Netherlands	25,9%	12,9%	16,4%	17,9%	20,4%	6,5%
Poland	11,6%	16,1%	15,9%	19,6%	23,0%	13,8%
Serbia	25,8%	22,5%	15,9%	13,9%	16,6%	5,3%
Slovenia	14,1%	7,8%	8,3%	20,3%	31,8%	17,7%
Spain	19,7%	14,6%	14,0%	14,6%	12,5%	24,5%
Sweden	49,7%	18,6%	7,5%	9,5%	6,5%	8,0%
Total	21,2%	14,1%	13,2%	14,9%	17,6%	18,9%

Table 4. Pedestrian regional distribution per country

Country	Rural/Small towns	Suburban city/Outskirts	Urban city/Large towns
Austria	43,0%	5,5%	51,5%
Belgium	51,4%	6,1%	42,5%
Cyprus	38,6%	10,5%	51,0%
Czech Rep	69,7%	5,1%	25,3%
Estonia	35,8%	5,1%	59,1%
Finland	38,7%	31,4%	29,9%
France	45,4%	18,0%	36,6%
Germany	44,6%	15,5%	39,9%
Greece	33,3%	28,8%	37,9%
Hungary	53,7%	6,5%	39,8%
Ireland	55,5%	23,0%	20,9%
Israel	11,1%	0,0%	88,9%
Italy	52,4%	13,1%	34,6%
Netherlands	49,8%	14,4%	35,8%
Poland	53,8%	4,9%	41,3%
Serbia	27,6%	18,4%	53,9%
Slovenia	59,4%	19,8%	19,8%
Spain	43,6%	6,6%	49,9%
Sweden	11,1%	0,5%	88,4%
Total	44,0%	11,4%	44,5%

Table 5. Description of Components

Components	Questions	Variables	Loading
Component 1 'Satisfaction with pedestrian environment'	ORU4c	Dissatisfied with safety	0,761
	ORU4a	Dissatisfied with pavements	0,723
	ORU4d	Dissatisfied with speed of the traffic	0,713
	ORU4g	Dissatisfied with number of crossing places	0,705
	ORU4e	Dissatisfied with volume of traffic	0,673
	ORU4f	Dissatisfied with number of street lights	0,648
	ORU4b	Dissatisfied with separation of pedestrians and cyclists	0,643
Component 2 'Attitudes towards penalties'	CO08d	Disagreement with no-wearing helmets penalty	0,807
	CO08c	Disagreement with severe penalties for not using restraint systems	0,785
	CO08e	Disagreement with more severe penalties for handheld phone use	0,719
	CO08b	Disagreement with more severe penalties for drink-driving	0,703
	CO08a	Disagreement with more severe speeding penalty	0,693
Component 3 'Attitudes towards electronic in-vehicle devices'	CO06c	Dissaproval of alcolock	0,823
	CO06d	Dissaproval of alcolock for recidivist driver	0,809
	CO06e	Dissaproval of fatigue detection device	0,690
	CO06b	Dissaproval of black box	0,653
	CO06a	Dissaproval of speed limiting devices	0,551
Component 4 'Attitudes towards speed limitations and surveillance'	CO07b	Dissaproval of speed cameras at a single point	0,811
	CO07c	Dissaproval of speed zone cameras between two points	0,795
	CO07a	Dissaproval of red light cameras	0,731
	CO07d	Dissaproval of 30km/h zones	0,465
Component 5 'Pedestrian behaviour and distraction'	ORU3a	Frequency of red light crossings	0,718
	ORU3f	Frequency of handheld phone use	0,704
	ORU3b	Frequency of crossings in places other than pedestrian crossings	0,703
	ORU3g	Frequency of music devices use	0,686
Component 6 'Attitudes towards pedestrian safety measures'	CO07e	Dissaproval of bicycle lanes	0,790
	CO07f	Dissaproval of sidewalks	0,788
	CO07g	Dissaproval of car and motorcycle free zones	0,676
	CO07d	Dissaproval of 30km/h zones	0,446
Component 7 'Annoyance with other road users'	ORU08b	Annoyance with motorcyclits	0,812
	ORU08a	Annoyance with car drivers	0,772
	ORU08c	Annoyance with cyclists	0,722
Component 8 'Lack of accessibility'	ORU03c	Frequency of avoiding too dangerous streets/intersections	0,842
	ORU03e	Frequency of walking on the street because of parked cars/barriers	0,568

Table 6. Clusters' Centroids (Final Clusters' Centers)

Components	Label	Cluster 1	Cluster 2	Cluster 3
1	*Satisfaction with pedestrian environment*	-0,08923	0,12876	0,00049
2	*Attitude towards penalties*	-0,30251	0,64728	-0,25797
3	*Attitude towards electronic in-vehicle devices*	-0,41307	0,64893	-0,06287
4	*Attitude towards speed limitations and surveillance*	-0,35964	0,54795	-0,03374
5	*Pedestrian behaviour and distraction*	0,03574	0,24045	-0,35996
6	*Attitude towards pedestrian safety measures*	-0,50943	-0,07808	1,00458
7	*Annoyance with other road users*	0,07156	0,01860	-0,15052
8	*Lack of accessibility*	0,12444	0,22458	-0,49856

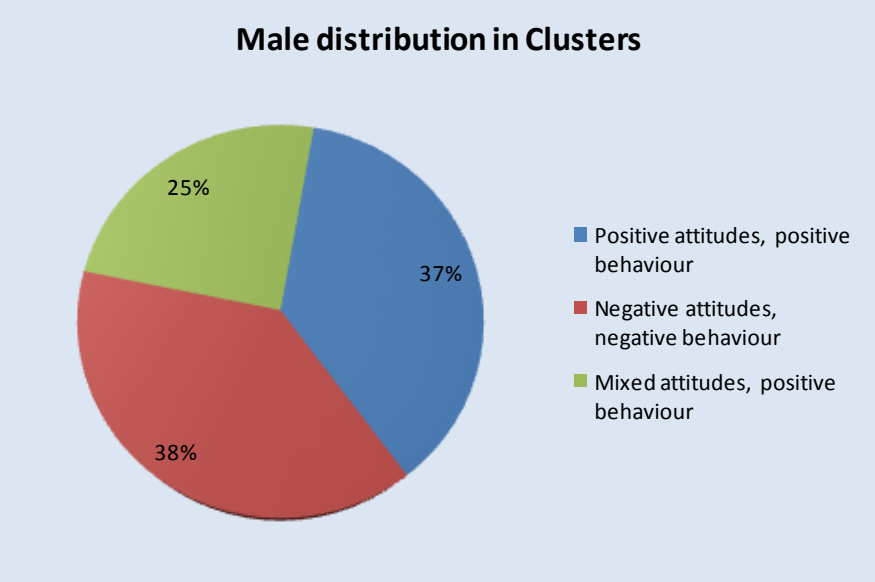

Figure 1. Distribution of Male Pedestrians in Clusters (%).

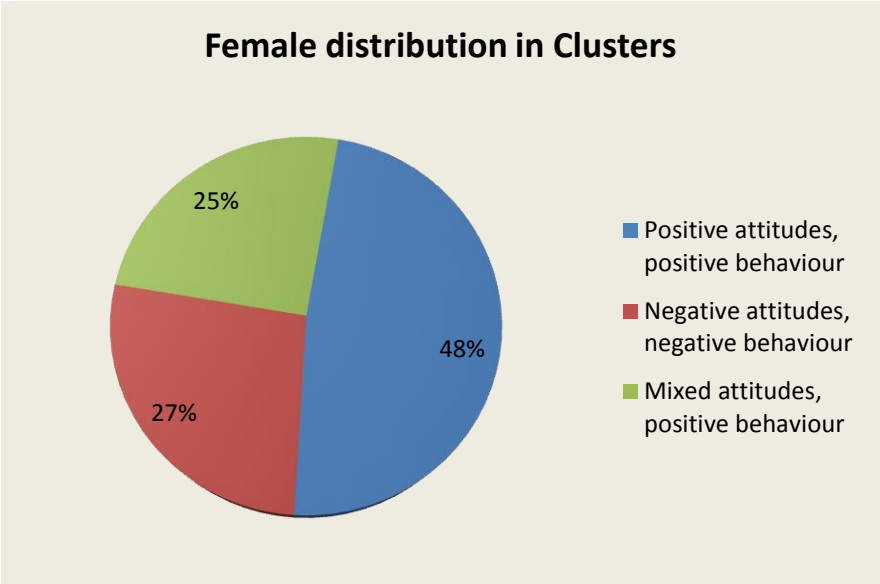

Figure 2. Distribution of Female Pedestrians in Clusters (%).

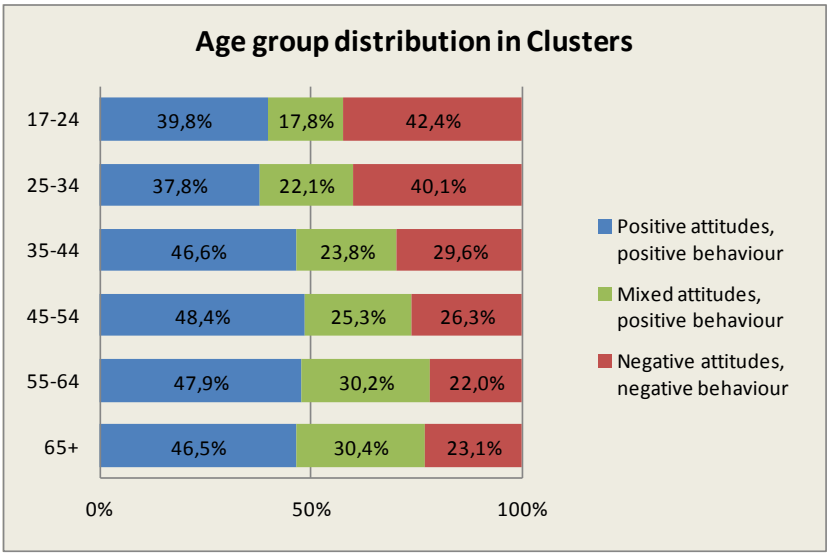

Figure 3. Proportion of Pedestrian Types per Age Group (%).

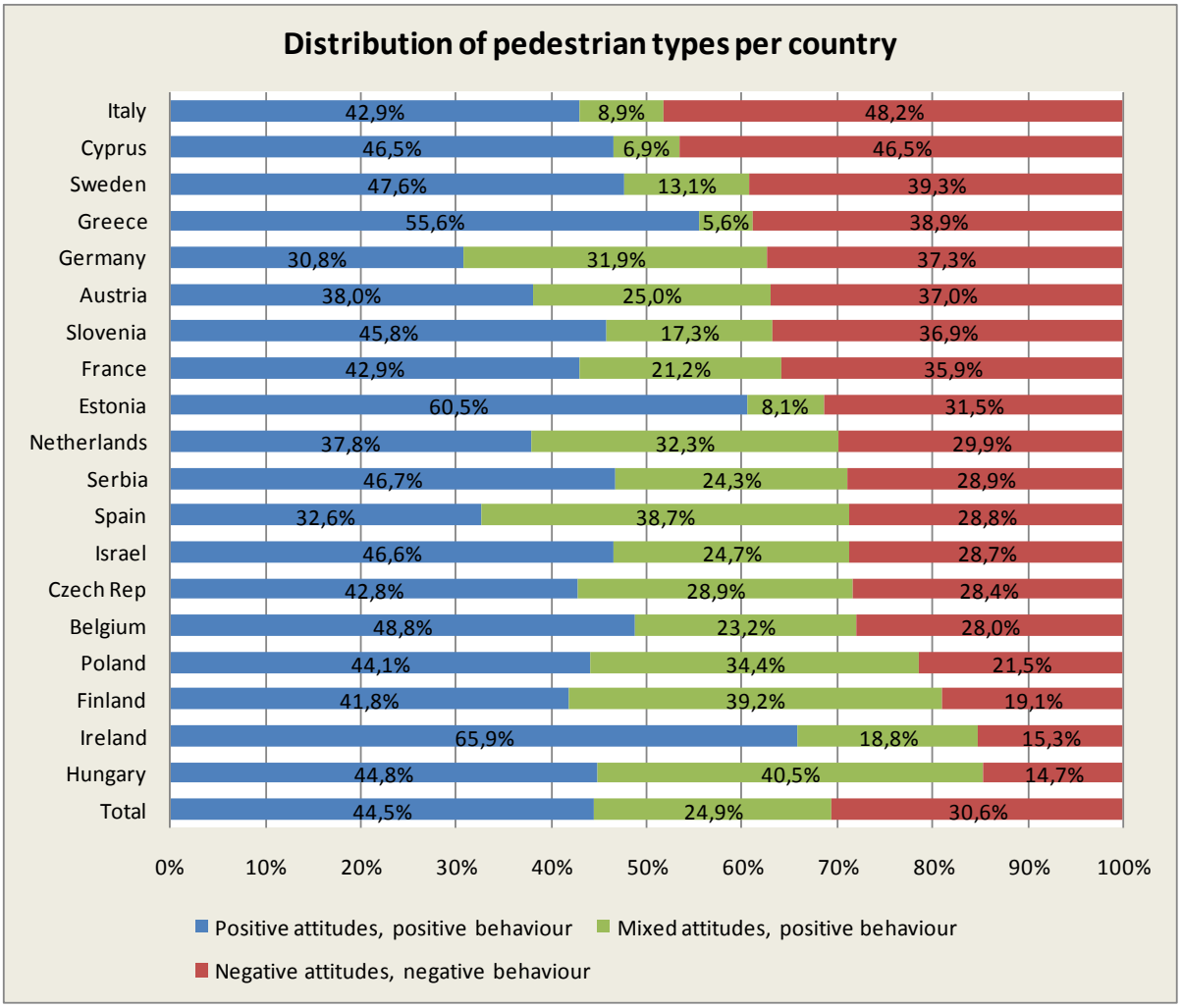

Figure 4. Proportion of Pedestrian Types per Country (%).

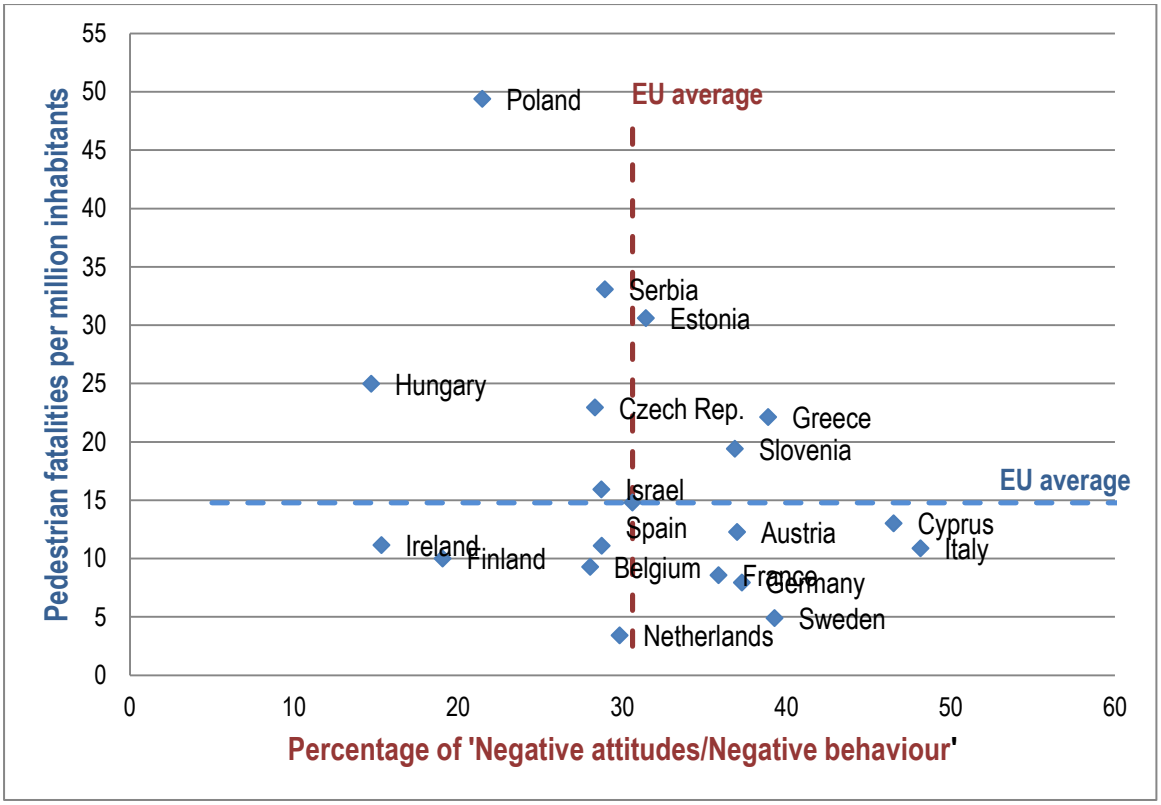

Figure 5. Pedestrian fatality risk and pedestrian negative attitudes / behaviours (%) per country