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## Italians' public opinion on road roundabouts: A web based survey

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### Abstract

Roundabouts have been shown to provide significant safety and operational benefits, but a better understanding of public perceptions of roundabouts is critical in order to assess the contribution of the driving behavior of the users on their safety. Therefore, research on user behavior and preferences is a helpful tool in improving road safety and accident prevention. The aim of this study is to increase knowledge about Italian users' public opinion on road roundabouts. The authors estimated cross-national differences, and assessed correlations with personal variables, such as age, gender, travel mode most frequently used, perception of roundabout safety, etc. In order to collecting data, the instrument used is a national web based survey, the total sample comprised 1.728 participants. The data collected were analyzed by both Ordinal regression method and Multiple Correspondence Analysis. The results of this study show that the overall opinion that the respondents expressed against roundabouts is favorable. There are no substantial differences between the judgment of male drivers and that of females. Although for some categories of users the roundabouts are not considered safe and have no advantages in terms of functionality, their general opinion is always positive. The categories of respondents who expressed "Favorable" opinion are: women, those who travel daily with the private car or with public transport and who is a pedestrian. The categories of respondents who expressed "Very favorable" opinion are: men, and those who use the motorcycle as their main means of transport.

Moreover, this study showed that web-based surveys provide an efficient means of collecting detailed public opinion data.

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## 1. Introduction

Today the roundabouts are among the most common road intersections. They are considered by experts to be the type of intersection that offers better performance in terms of safety (De Brabander and Vereeck, 2007; Gross et al., 2013; Jensen, 2013; Qin et al., 2013) and traffic performance (Polus and Shmueli, 1997; Hu et al., 2014). Moreover, there are other positive effects provided by roundabouts, such as the reduction of air pollution and acoustic emissions (e.g., Distefano and Leonardi, 2019). The aim of this study is to understand whether in Italy the "consensus of experts" corresponds to a similar consensus by "public opinion". Some studies have shown an unfavorable opinion of drivers regarding roundabouts. There are many studies that inquired why drivers opposed to the roundabouts felt this way. Often, the same reasons were cited for both that the drivers found the intersection to be confusing, unsafe, and/or they just preferred a signalized intersection over a roundabout (Redington, 1997; Hu et al., 2014). Another reason drivers stated for opposition was a belief that the roundabout caused more congestion, yet the study in which this remark was made found significant reductions in delay and the number of vehicles stopping (Hu et al., 2014). Generally younger drivers were most supportive, and support was found to decrease consistently with age. Older drivers comprised a high percentage of respondents that opposed roundabouts, where some acknowledged they opted for alternative routes in order to avoid trying to navigate the roundabout (Martens and Fox, 2007). Likewise, in another study in Kansas showed that after construction, there was a substantial change in public opinion. The large reduction in the proportion of drivers strongly opposed to the roundabout provides evidence that opinions of even those with strong negative perceptions initially tend to become more accepting of roundabouts over time (Retting et al., 2007). A study conducted by the City of Olathe (Retting et al., 2002), provides further evidence that exposure increases driver familiarity, comfort, and perceived safety of roundabouts. Also, the results of a more recent Retting study (2007) indicate that public support continued to increase with time, presumably because drivers became more familiar and comfortable with this form of traffic control. The present study aims to assess the current opinion of Italian public opinion on roundabouts, considering that by now the roundabouts represent a type of intersection widespread throughout the national road network, and that the user is therefore used to in its presence. For this purpose, a web survey was carried out. The investigation techniques based on the surveys represent a very effective tool for the study of many issues of transport interest (Distefano et al., 2019a; Distefano et al., 2019b; Ignaccolo et al., 2019; Distefano et al., 2018). In particular, the use of these techniques becomes indispensable in cases where it is not possible to evaluate through experimental investigations the indicators associated with the subjective judgments of the different road users. The power of Web surveys is that they make survey data collection (as opposed to survey participation) available to the masses. In this way, it is possible get access to undreamed of numbers of respondents at dramatically lower costs than traditional methods and easily monitor the quality of the data acquired. In recent years, studies have been carried out to assess the public perception of road safety. Jankowska-Karpa et al. (2016) had conducted an on-line questionnaire that had as its main objectives to understand respondents' attitudes regarding travel preferences and the link between road safety and sustainable mobility. Cardamone et al., (2014) had investigated on the perceptions of the drivers on the risk of road accident. From the results of this study, it is possible to state that online surveys are reliable, and a valid alternative to traditional methods such as face-to-face survey, especially if we consider the advantages linked to the lower cost and the reduced risks of social desirability bias associated with self-administration. Distefano et al. (2018) in order to evaluate the roundabout geometric characteristics affecting the safety perception during the typical maneuvers (entry, circulation, exit) had used a method of acquisition of opinions was an on-line questionnaire that has generated a very large database of interviews.

## 2. Methodology

### 2.1 Survey

A 30 items questionnaire was used to collect the participants' opinions. The questionnaire was divided into the following 5 sections:

- Section 1: participants reported their age, gender and other basic demographic information in this section.

- Section 2: questions were asked about the means of transport mainly used, the overall opinion on roundabouts, the frequency of roundabouts use, the opinion on the functional performances of the roundabouts, and the knowledge of how a roundabout works.
- Section 3: questions about the safety perception in roundabouts from the point of view of different categories of users (drivers, pedestrians, cyclists, motorcyclists).
- Section 4: questions about the safety perception in roundabouts as for the different maneuvers (entry, circulation, exit) and in relation to the geometry (single lane, double lane). The fourth section questions have been formulated in such a way as to solicit spontaneous opinions on safety, based on the respondents' driving experiences on roundabouts without reference to roundabouts actually existing.
- Section 5: 4 pairwise comparisons related to 8 existing roundabouts located in different urban Italian context. These roundabouts were chosen as representative examples of different geometric design options. The roundabouts have been proposed to the respondents through Google images. For each couple of roundabouts, respondents were only asked to choose the roundabout they perceived as safer.

The questionnaire underwent thorough piloting and revision, through 20 interviews face to face with professors and researchers of the University of Catania. This was done to ensure the suitability of the questions for the target people and to assess the acceptability of the wording, as well as the understanding of the questions.

The online survey was created with Google Forms Software. Then it was made available online on the DISS (Italian Centre of Road Safety) web-site. DISS is an Applied Research Center actively involved in all sectors of road safety. DISS members are university professors and researchers engaged in road safety issues (infrastructures, vehicles, human factor). The survey data were collected over a 9-month period in 2016/2017.

## 2.2 Participants

Participants for this study were recruited through an online survey. The total sample comprised 1,790 participants. The participants who didn't complete the questionnaire or who gave uncertain answers (e.g. "I don't know") were excluded. The respondents excluded were only 4% of the sample. This low percentage was probably due to the fact that all Italian citizens have a clear opinion on the roundabouts, as these are now widespread in the national road network. Indeed, almost all participants (95,57%) declare to travel through a roundabout at least once a day. The final sample was 1,718 participants. Participants' characteristics are summarized in Table 1.

Table1. Features of survey respondents.

Category	Number	Percent %	Category	Number	Percent %
			<i>Travel mode</i>		
<i>Age</i>			Car	1,232	71.68
18-25	619	36.02	Public Transport (bus, metro, train)	149	8.67
26-35	418	24.32	Bicycle	175	10.19
36-50	406	23.65	On foot	95	5.52
51-70	275	16.01	Motorcycle	68	3.94
Total	1,718	100.00	Total	1,718	100.00
			<i>Frequency of roundabout use</i>		
<i>Gender</i>			At least once a day	1,642	95.57
Male	965	56.16	Less than once a day	76	4.43
Female	753	43.84	Total	1,718	100.00
Total	1,719	100.00			

## 2.3 Methods for analysis

In this study database data analyzed both using Ordered probability models (OPM) and Multiple Correspondence Analysis (MCA). The first method will be used to identify the significant variables while the second one will be applied to define the correlations between the categories of the variables.

Ordered probability models are a form of discrete outcome models that relate dependent variables on an ordered discrete scale to a series of predictor variables (Greene and Hensher, 2010). Ordered probability models are derived by defining a latent variable  $z$  as a basis for modelling ordinal ranking data. In order to obtain a better understanding

of road user perceptions of roundabouts, as well as to identify factors affecting these perceptions, a multivariate analysis is necessary. Particularly, discrete choice models provide an appropriate framework for conducting such an analysis. Furthermore, each of the response categories can be represented by a natural ordering structure (e.g., very favorable, favorable, unfavorable, very unfavorable). The Ordered probability models holds specific advantages for fitting the data structure of an ordinal response and has been widely used. Based on the overall opinion on roundabouts data that were defined as ordinal variables, an OP model was established to relate overall opinion on roundabouts to various explanatory variables. The fundamental characteristic of OP model is briefly described in this section. Assuming that  $z$  represents the overall opinion on roundabouts, then a latent variable  $z$  is introduced as equation (1):

$$z = \beta X + \varepsilon \quad (1)$$

where  $X$  is the vector containing the full set values of explanatory variables,  $\beta$  is the vector of coefficients associated with the explanatory variables, and  $\varepsilon$  is a random error term following standard normal distribution.

Multiple Correspondence Analysis (MCA) is part of a family of Structural Equation Modelling (SEM). Specifically, MCA is used to represent and model datasets as “clouds” of points in a multidimensional Euclidean space. The results are interpreted on the basis of the relative positions of the points and their distribution along the dimensions; as categories become more similar in distribution, the closer (distance between points) they are represented in space (Hjellbrekke, 2018). MCA plot are a better way of presenting information graphically and one can interpret them by examining the distribution of variable groupings in space. Points (categories) that are close to the mean are plotted near the MCA plot's origin and those that are more distant are plotted farther away. Categories with a similar distribution are near one another in the map as groups, while those with different distributions stay farther apart. In a two-dimensional graphical display of the data, categories sharing similar characteristics are located close together, forming point clouds (Roux and Rouanet, 2010). Moreover, rules with a large number of item sets are difficult to interpret in association rules mining. MCA overcomes these difficulties by performing efficient dimensionality reductions and compiling results into easy-to-read plots. In recent years some researchers have applied the MCA to study issues related to transport safety (Usami et al., 2017; Das and Sun, 2016; Distefano and Leonardi, 2018; Giuffrida et al., 2018; Leonardi et al., 2019).

#### 2.4 Data

Since the goal of this study was to understand how as the opinion expressed by users on roundabouts is linked to the different characteristics of the users and their driving experience on roundabouts, the primary dataset was created by answers of the respondents to the first three sections of the questionnaire. The answers to the questions in section 4 and section 5 of the questionnaire have already been used by the authors for a study which allowed for to identify the roundabout geometric characteristics affecting the safety perception while the typical maneuvers (entry, circulation, exit) are being carried out (Distefano et al., 2018). Table 2 shows the questionnaire questions analyzed in this study. It is necessary to note that the answers of the respondents to these questions are not referred to specific roundabouts, but they are based on the respondents' driving experience on roundabouts that everyone travels in their movements. The table 3 shows the variables used in analytical methods. The variable “Knowledge of rules for the use of roundabouts” has been deduced starting from 7 items in the questionnaire (Items from 1 to 7 of Table 2); if at least 5 answers were correct the participant was given a good knowledge, if at least 4 answers were wrong the participant was given poor knowledge, in the other cases the participant was given an average knowledge.

The variable “Opinion on functionality of roundabouts compared to other types of intersections” has been deduced starting from 3 items in the questionnaire (Items from 8 to 10 of Table 2); if three responses were “Less functional” or two responses were “Less functional” and one was “Equal” then the participant's opinion was considered “Less functional”, if three answers were “Equal” or one answer was “Less functional” and two were “Equal” then the participant's opinion was considered “Equal”, if three answers were “More functional” or two answers were “More functional” and one was “Equal” or one answer was “More functional” and two were “Equal” then the participant's opinion was considered “More functional”, in the other cases the participant's opinion was considered “Not unique”, that is it depends on the type of user. The variable “Opinion on safety of roundabouts” has been deduced starting from

4 items in the questionnaire (Items from 11 to 14 of Table 2); if at least three answers were “Very dangerous” then the participant's opinion was considered “Very dangerous”, if at least three answers were “Dangerous” or if three were negative opinions (Dangerous or Very dangerous) then the participant's opinion was considered “Dangerous”, if at least three answers were “Safe” or if three were positive opinions (Safe or Very safe) then the participant's opinion was considered “Safe”, if at least three answers were “Very safe” then the participant's opinion was considered “Very safe”, in the other cases the participant's opinion was considered “Not unique”, that is it depends on the type of user.

Table 2. Questionnaire questions analyzed

QUESTIONS	
1-What is the direction of travel on roundabouts?	Counterclockwise; Clockwise
2- Approaching a roundabout, before entering, it is advisable:	Increase speed; Decrease the speed; Stop
3- When entering a roundabout, you must give priority to the vehicles on the circulatory ring when:	Never; Always; Only if there is the “Give way” sign
4- During the maneuver on the circulatory ring of the roundabout it is opportune:	Increase speed; Decrease the speed; Keep the same speed
5- Can the vehicles on the circulatory ring overcome both the right and the left?	True; False
6- During the exit maneuver from the roundabout it is opportune:	Increase speed; Decrease the speed; Keep the same speed
7- When it is necessary to operate the direction indicator?	Entering the roundabout; Exiting the roundabout; On the circulatory ring
8- How do you think roundabout influences the path to be taken for vehicles, compared to other types of intersections?	Roundabout make it less fluent; Roundabout make it equally fluent; Roundabout make it more fluent
9- How do you think roundabout influences the path to be taken for pedestrians, compared to other types of intersections?	Roundabout make it longer; Roundabout make it equally long; Roundabout make it less long
10 -How do you think roundabout influences the path to be taken for cyclists, compared to other types of intersections?	Roundabout make it longer; Roundabout make it equally long; Roundabout make it less long
11- How safe are the roundabouts for car drivers?	Very safe; Safe; Dangerous; Very dangerous
12- How safe are the roundabouts for motorcyclists?	Very safe; Safe; Dangerous; Very dangerous
13- How safe are the roundabouts for pedestrians?	Very safe; Safe; Dangerous; Very dangerous
14- How safe are the roundabouts for cyclists?	Very safe; Safe; Dangerous; Very dangerous
15- What is your overall opinion on roundabouts?	Very favorable; Favorable; Unfavorable; Very unfavorable

Table 3. Variables and related categories for analytical methods

Variable	Categories
001-Gender	1-Male; 2-Female
002-Age	1-18-25; 2-26-35; 3-36-50; 4-51-70; 5->70
003-Region	1-Northern Italy; 2-Center of Italy; 3-Southern Italy
004-Travel mode	1- Pedestrian; 2- Bicycle; 3- Motorcycle 4- Car; 5- Public Transport (bus, metro, train)
005-Frequency of roundabout use	1-At least once a day; 2-Less than once a day
006- Knowledge of rules for the use of roundabouts	1- Good; 2-Average; 3- Poor
007-Opinion on functionality of roundabouts compared to other types of intersections	1-Less functional; 2-Equal; 3-More functional; 4-Not unique
008-Opinion on safety of roundabouts	1- Very dangerous; 2- Dangerous; 3- Safe; 4- Very safe; 5- Not unique
009-Overall opinion on roundabouts	1- Very unfavorable; 2- Unfavorable; 3- Favorable; 4- Very favorable

### 3. Results and discussion

The research team used statistical software SPSS version 24.0 to perform both analytical methods. Ordered probability models were estimated the “Overall opinion on roundabouts” expressed by users in according to the different characteristics of the users and their driving experience on roundabouts. The sets of results are shown in Table 4. Note that some variables have a low statistical significance ( $p > 0,05$ ); therefore, these variables are not of interest and expected to have not some effect on users’ opinion. The analysis of the results of the Ordered probability models shows that the variable “Age”, the variable “Region”, the variable “Frequency of roundabout use” and the variable “Knowledge of rules for the use of roundabouts” are not significant in order to define the general opinion on roundabouts and therefore in the subsequent analysis they will be discarded. Also, the "Bicycle" category of variable “Travel mode” is not significant and will not be taken into consideration in future analyses.

Table 4. Ordered Probit Model (normalized coefficients).

Variable	Coefficient	Std. Error	Sign.	95% Confidence interval
<b>Gender</b>				
Male	0.124	0.061	<b>0,043</b>	(0.004. 0.243)
Female	0.000	0.000		
<b>Age</b>				
18-25	0.315	0.437	0,471	(-0.542. +1.171)
26-35	0.365	0.437	0,404	(-0.493. +1.222)
36-50	0.289	0.437	0,508	(-0.566. +1.145)
51-70	0.431	0.439	0,326	(-0.429. +1.291)
>70	0.000	0.000		
<b>Region</b>				
Northern Italy	0.027	0.095	0,777	(-0.158. +0.212)
Center of Italy	0.021	0.144	0,884	(-0.262. +0.304)
Southern Italy	0.000	0.000		
<b>Travel mode</b>				
Pedestrian	0.212	0.159	<b>0,018</b>	(-0.100. +0.525)
Bicycle	-0.010	0.130	0,938	(-0.265. +0.245)
Motorcycle	0.547	0.180	<b>0,002</b>	(+0.194. +0.900)
Car	0.251	0.104	<b>0,016</b>	(+0.047. +0.454)
Public Transport (bus, metro, train)	0.000	0.000		
<b>Frequency of roundabout use</b>				
At least once a day	-0.032	0.146	0,825	(-0.319. +0.254)
Less than once a day	0.000	0.000		
<b>Knowledge of the rules for the use of roundabouts</b>				
Good	-0.079	0.087	0,365	(-0.249. +0.092)
Average	0.065	0.065	0,323	(-0.063. +0.193)
Poor	0.000	0.000		
<b>Opinion on the functionality of roundabouts</b>				
Less functional	-1.635	0.130	<b>0,000</b>	(-1.890. -1.380)
Equal	-1.126	0.143	<b>0,000</b>	(-1.406. -0.846)
More functional	0.057	0.067	<b>0,039</b>	(-0.074. +0.189)
Not unique	0.000	0.000		
<b>Opinion on the safety of roundabouts</b>				
Very dangerous	-1.071	0.154	<b>0,000</b>	(-1.373. -0.769)
Dangerous	-0.417	0.079	<b>0,000</b>	(-0.572. -0.262)
safe	0.285	0.079	<b>0,000</b>	(+0.130. +0.440)
Very Safe	1.354	0.199	<b>0,000</b>	(+0.964. +1.744)
Not unique	0.000	0.000		

Multiple correspondence analysis was used to investigate the links between the respondents' socio-demographic characteristics, that were significant from the OPM (gender and travel mode) and their opinions on various aspects of roundabouts (functionality, safety and overall opinion). MCA interpretation consists of: (a) assigning a meaning to the factorial axes, depending on the variables they are formed and (b) interpreting the relationships between modalities using the aforementioned factorial axis meanings. Using the variables (table 3) that were significant from OPM the MCA generated a 2-dimension map representing the independent variables (Fig. 1).

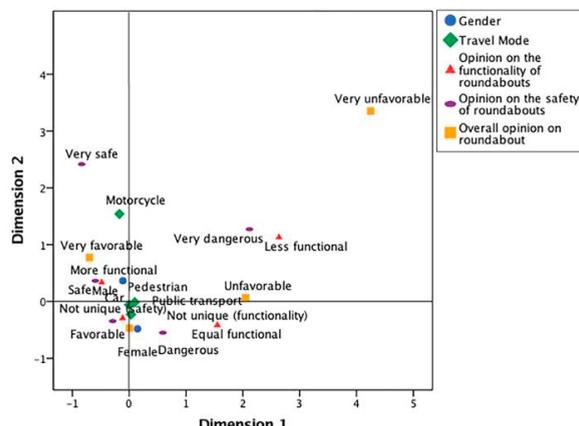


Fig. 1- MCA Bplot

On its own, Dimension 1 (horizontal axis) explains 36,7% of the inertia of data and Dimension 2 (vertical axis) explains 28,2%. Dimension 1 was principally explained by the variable “Overall opinion on roundabouts” (Unfavorable and Very unfavorable categories on the right, Very favorable and Favorable on the left), and slightly less by the variable “Opinion on the safety of roundabouts”. Dimension 2 is more difficult to interpret, so it has not been defined. The results of the MCA show that in general Italians have a favorable opinion on roundabouts. In fact, the categories "Very unfavorable" and "Unfavorable" are far from the origin of the axes and do not fall into sectors in which socio-demographic aspects are present, this indicates that these opinions are less frequent and cannot be associated with any category of respondents. The "favorable" category of the Overall opinion variable is associated both the "dangerous" or "not unique" categories of the Safety opinion variable and judgements on the functionality that is also not unique. But despite for particular categories of users, the roundabouts are not considered safe and have no advantages in terms of functionality, their general opinion is always positive. The categories of respondents who expressed the most this opinion are: women, those who travel daily with the private car or with public transport and who is a pedestrian. The "Very favorable" category of the variable Overall opinion is associated with the "Safe" and "Very safe" categories of the variable opinion on safety and it is expressed by those who consider roundabouts more functional than the other types of intersections. The categories of respondents who expressed the most this opinion are: men, and those who use the motorcycle as their main means of transport. The not always positive judgment on safety conditions is certainly linked to the different types of users of the sample of interviewees. Indeed, it is known that roundabouts provide a lower level of safety to vulnerable users (cyclists and pedestrians). The non-uniqueness of the judgment on the functionality of the roundabouts is above all associated with the different traffic conditions that users face. Indeed, as demonstrated by Leonardi et al. (2019) in conditions of equal geometric characteristics, users perceive a lower level of safety due to operating conditions close to traffic congestion. Although the judgment of the Italians is not always positive regarding the safety and functionality requirements of the roundabouts, this study shows that the overall opinion on roundabouts is always favorable. The authors believe that this result derives from the familiarity acquired by the drivers with this type of intersection, now widespread in the territory.

#### 4. Conclusion

In Italy, from the 1980s to today, roundabouts are the type of intersection most often used as the redevelopment of existing intersections or new realizations. The Italian legislation for the design of road intersections (DM 19/04/2006) was issued after a widespread dissemination of these roundabouts. Therefore, on the Italian road network there are roundabouts with geometric characteristics that do not comply with the safety and functionality criteria considered suitable by the experts in the sector. Sometimes even recently realized roundabouts have unsuitable safety and functionality requirements. The survey carried out in this study, conducted at national level, collected the opinions of users with different experience deriving from territorial areas that differed in quality and quantity of infrastructures.

For this, in addition to "Very favorable" opinions associated with the "Safe", "Very safe" and "More functional" judgements, there are "favorable" opinions associated both the "dangerous" or "not unique" categories of the Safety opinion variable and judgements on the functionality that are also not unique. The not always positive judgment on safety conditions is certainly linked to the different types of users. Indeed, it is known that roundabouts provide a lower level of safety for vulnerable users (cyclists and pedestrians). The authors believe that, although the judgment of the Italians is not always positive regarding the requirements of safety and functionality of the roundabouts, the general opinion always favorable derives from the familiarity acquired by drivers with this type of intersection, now widespread in the territory. For this reason, in Italy the tendency of users to support the realization of this type of intersection is becoming increasingly evident. Experience from countries with the best road safety records showed that road safety measures can only be successful when supported by the public (Mikusova and Hrkù, 2014). Getting public support is therefore vital to road safety and there is nothing worse than installing road safety schemes that have to be subsequently removed because the local population does not accept them. Road safety measures will be more successful when the local population is actively supportive of the proposed interventions, declaring their judgement. It is important to know where and when road safety initiatives have the best chance of public support and hence success.

These findings need to be taken into account in the road safety draft strategy and action plans to address crucial problems of local road safety. Moreover, this study showed that web-based surveys provide an efficient means of collecting detailed public opinion data.

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