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Neighbourhood walkability: Elderly's priorities

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ABSTRACT

The benefits of mobility in later life and active ageing have been widely documented and evidenced. Despite its clear benefits, physical activity levels among older people fall short of recommended levels. Older people can have feelings of fear when walking in the outdoor environment. In order to facilitate mobility in later life, it is important that accessible, clearly structured and predictable urban environments are provided. This study wants to understand which aspects and measures the elderly consider more important in order to encourage and improve neighbourhood walkability, considering the influence of age-related declines and experience as road users. A survey was developed in the urban area of Catania (Italy). The total sample comprised 645 participants (355 men and 290 women) aged over 70. A Multiple Correspondence Analysis (MCA) was developed to analyse the data. Results show that elderly pedestrians with minor age-related declines give stronger importance to the walkability along the road, but also focus on improper or aggressive driving behaviours. Pedestrians with major age-related declines give instead more importance to the level of comfort and safety when they cross the road. The driving experience was found to have little influence on elderly priorities for neighbourhood walkability.

1. Introduction

The world population is ageing. In 2017 there were approximately 962 million people in the world aged 60 or over, almost more than twice as many as in 1980 when the elderly global population was 382 million. This figure is expected to double again by 2050, when it is virtually projected to reach nearly 2.1 billion (United Nations, Department of Economic and Social Affairs, 2017). Consequently, elderly populations are growing in many countries. Aside from the apparent social and economic effects, the ageing population also poses mobility-related challenges in ensuring sufficient access to facilities and services for the elderly. Indeed, a maturing population cautions future transportation needs, challenges, and concerns (Turner et al., 2017).

The reality of an ageing population has made the everyday mobility of seniors an issue of growing interest. Understanding how to make neighbourhoods more walkable for older people is an important public health concern. However, walking environments are not always well-adapted to accommodate the elderly. In order for walking to become an attractive, efficient, and safe mode of transportation for the elderly, the way public spaces are designed must be rethought/reconsidered in order to accommodate to their needs and preferences. The concept of walkability has emerged as the approach to increase physical activity has gained attention. Southworth (Southworth, 2005) defined walkability as the extent to which the built environment supports and encourages walking by providing for pedestrian comfort and safety, connecting people with varied destinations within a reasonable amount of time and effort, and offering visual interest in journeys throughout the network.

Safety features that protect from falls and traffic hazards, convenient access to destinations, well-maintained pedestrian infrastructure, neighbourhood attractiveness, and public transportation have all been identified as important aspects of the neighbourhood walking context by older people (Day, 2008; Grant, Edwards, Sveistrup, Andrew, & Egan, 2010). When considering pedestrian path, it is important to differentiate between the distance of a route and the complexity of that route. Previous research has shown that there are specific factors that may affect pedestrians route choice such as distance or time, the number of obstacles or interactions with other pedestrians along the route, the directness of the route (i.e. the number of directional changes), the level-of-service provided by the roadway and traffic environment, the overall attractiveness of the environment (Hoogendoorn & Bovy, 2004). These factors can affect not only pedestrians route choice, but also the choice of walking. The built and physical environment can indeed be a strong determinant of mobility (Mifsud & Attard, 2019). Because individuals tend to spend more time in their local environments as they age, understanding how to make neighbourhoods more walkable for older

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people is an important public health concern (Grant et al., 2010).

It is therefore essential that the design of pedestrian paths takes into account the specific needs of elderly in order to make them feel safe and to improve their mobility. Hence, understanding elderly's perception and opinion of their local environments can help to improve their mobility. A specific peculiarity of elderly pedestrians are age-related declines. Age-related declines in perceptual, cognitive, and physical abilities have been shown to contribute to the high rate of fatal or serious-injury crashes found for old pedestrians (Dunbar, Holland, & Maylor, 2004). However, few researches have focused on the relationship among elderly's age-related declines in perceptual and physical abilities and their perception and opinion of pedestrian paths. The objective of this study was to develop a more thorough understanding of older people's perception and opinion of walkability in their neighbourhoods based on age-related declines and on their experience as road users. The intent of this approach was to allow older people's voices to broaden our understanding of neighbourhood walkability and to understand their priorities. This paper presents the result of an analysis developed considering the case study of the urban area of Catania (Italy). Particularly, this study wants to understand which aspects and measures the elderly consider more important in order to encourage and improve neighbourhood walkability, considering the influence of age-related declines and experience as road users.

2. Background

The term elderly is often used to refer to those who are aged 65 or above (Suen & Sen, 2004). The elderly generally have different mobility patterns than other demographic groups. They tend to have a lower level of physical fitness or function mobility (Webber, Porter, & Menec, 2010), which often affects their ability to walk (Ryan, Wretstrand, & Schmidt, 2015). Also, deterioration of their physical abilities through ageing or sickness can reduce the elderly's ability to drive or cycle, hence limiting their transport options (Rahman, Strawderman, Adamsprice, & Turner, 2016).

Mobility is one key factor that defines a good quality of life in old age (Aguiar & Macário, 2017), and is strongly linked with the phenomenon of active ageing (R. Johnson, Shaw, Berding, Gather, & Rebstock, 2017). Analysing mobility in later life is complex due to the dynamics associated with old age. Older people are increasingly healthier and are remaining much more active and mobile, are licensed to drive, are more educated and are working longer. With age, a person's functional abilities change and they can eventually limit the level of mobility and independence and consequently lead to social exclusion (Davey, 2007). Thus, transport policies should prioritise the mobility of older people to support their independence and improve their quality of life (Wong, Szeto, Yang, Li, & Wong, 2018).

In terms of road safety, the rapid growth of the elderly among the population as a whole is gaining special relevance, as the percentage of older road users (drivers, pedestrians and cyclists) in relation to the total population is rising. This trend is a cause for significant concern as older pedestrians are among the most vulnerable road users in the transportation system. Senior citizens bear an extremely high risk of being severely injured or killed in an accident, especially as pedestrians (Ståhl, Carlsson, Hovbrandt, & Iwarsson, 2008). A number of road safety researchers have identified various roadway, traffic and environmental factors influencing the injury severity of pedestrians (Campisi, Canale, & Tesoriere, 2018; Distefano, Leonardi, & Pulvirenti, 2019; Gruden, Campisi, Canale, Tesoriere, & Sraml, 2019; Montella, Aria, D'Ambrosio, & Mauriello, 2011). The main causes of this worldwide problem can be attributed to older road users' impediments in judging the speed and intentions of other road users (Gonawala, Badami, Electicwala, & Kumar, 2013). It is also well known that sight and hearing, along with ability and reaction time, decline with advancing age (Tollazzi, Renčelj, Rodošek, & Zalar, 2010).

The body of literature dealing with accessibility of urban areas for older people is extensive (Jittrapirom, Van Neerven, Martens, Trampe, & Meurs, 2019; Mifsud, Attard, & Ison, 2019; Shrestha, Millonig, Hounsell, & McDonald, 2017). Several have emphasised the importance of mobility for quality of life (Spinney, Scott, & Newbold, 2009) and for social inclusion (Delbosc & Currie, 2011). The benefits of mobility in later life and active ageing have been widely documented and evidenced. Walking provides older people with an accessible form of physical activity and a means of transport (Michael et al., 2006[a]) and provides a sense of freedom, independence and relaxation (Mindell, Rutter, & Watkins, 2019). Despite its clear benefits, physical activity levels among most people over the age of 65 fall short of recommended levels (Matthews et al., 2008).

Moreover, walking is critical to allow older people to conduct day-to-day activities, such as shopping, attending meeting places (sporting clubs, libraries and community centers) and visiting essential services like doctors and hospitals (Garrard, 2013). Walking can also reduce transport-related costs, including lower personal expenditure on fuel and vehicle maintenance. The combination of these factors can result in transport disadvantage and social exclusion, which has been identified as a significant problem facing older adults (O'Hern & Oxley, 2015).

Characteristics of the neighbourhood environment that may encourage walking in older adults can be categorized within: a higher residential density (Li, Fisher, Brownson, & Bosworth, 2005; Rodríguez, Evenson, Diez Roux, & Brines, 2009), destinations such as stores, libraries, coffee shops within walking distance of their residences (Michael, Beard, Choi, Farquhar, & Carlson, 2006; Michael, Green, & Farquhar, 2006; Wang & Lee, 2010), and design features such as pleasant surroundings, maintained sidewalks, and security (Roman & Chalfin, 2008) and traffic (Gómez et al., 2010; Michael, Green, & Farquhar, 2006; Patterson & Chapman, 2004; Shumway-Cook et al., 2003; Strath, Isaacs, & Greenwald, 2007).

In order to facilitate mobilities in later life, it is important that accessible, clearly structured and predictable urban environments are provided (Van Hoven & Meijering, 2019). Pedestrian-oriented designs (e.g., continuous, barrier-free sidewalks, four-way stop signals, and pedestrian amenities) and access to recreational facilities have been shown to be positively associated with mobility in older adults (Berke, Koepsell, Moudon, Hoskins, & Larson, 2007). Curb cuts, smooth pavement, and barrier-free sidewalks are just some of the many environmental factors that can enhance independence and social participation in older adults at greatest risk, such as those who are socially isolated, prone to falling, or those with underlying weakness in movement-related functions and balance. Without accessible built environments, older adults can find it difficult to care for their daily needs (e.g., shopping, banking) or their health (access health care facilities or a pharmacy), with subsequent risks for isolation (Debnam, Harris, Morris, Parikh, & Shiren, 2002).

3. Methods

3.1. The case study of the urban area of Catania

The metropolitan area of Catania is located on the east coast of Sicily. Catania is a medium-sized city (about 300,000 inhabitants) and it is part of a greater Metropolitan Area (about 1,100,000 inhabitants), which includes the main municipality and 26 surrounding urban centres, some of which constitute a whole urban fabric with Catania. Several attraction polarities (hospitals, main schools, shopping centres) are spread over the whole territory. Traffic congestion, limited public transport utilization, inefficiency of the parking management, little diffusion of cycling and walking for systematic trips are the main critical issues for the transport system of Catania.

In urban areas of Italy about 50% of journeys are less than 2 km long (less than half an hour walking), but only 20% of journeys are on foot. This percentage drops to 16% in Sicily (PGTU, 2012). There is therefore an enormous unexpressed potential for pedestrian mobility in Sicily.

Walking is a mode of transport to which must be given the same importance of other modes of transport; as such it must be equipped with adequate, continuous, secure infrastructures, dedicated signs and maps. It is therefore necessary to create a safe, attractive and accessible urban environment to make the walking experience safe and pleasant. A city where walking is easy is a city where children, elderly and disabled gain autonomy. Unfortunately, there is no data available with regard to active modes of transport for elderly in Catania. Thus, supporting older people's independence through walking in this context is a challenge. According to the most recent urban traffic planning programme of Catania (PGTU, 2012), the main barriers to pedestrian mobility in the city are:

- low levels of perceived safety, both in relation to the promiscuity of motorized traffic, and to the fear of being subject to criminal acts in isolated or low-light paths;
- infrastructure deficiencies, related to the lack of infrastructures dedicated to pedestrian mobility (e.g. road overpasses), their poor capacity (e.g. sidewalks width), the lack of continuity of pedestrian itineraries and inadequate crossings;
- management or administrative lacks (e.g. the presence of obstacles or cars parked on the sidewalks), no maintenance of pavements or of pedestrian crossings;
- deficiencies in the design of the urban environment, related to the paths that have low urban quality and make walking unattractive;
- low awareness of citizens about the importance of pedestrian mobility and the perception of walking as a mode of transport only for those who cannot afford a motorized vehicle;
- high levels of air pollution and noise that make the walking experience unpleasant.

The improvement of pedestrian mobility in the metropolitan area of Catania must be largely entrusted to urban redevelopment and to the design of pedestrian paths. "Car dependency" in Catania has led to difficult conditions for walking, cycling or simply being on the street, especially for vulnerable users such as elderly, who often have lost all forms of autonomy and depend on others people for their movements. The authors have already developed two studies related to elderly pedestrians' safety and perception in the urban area of Catania (Leonardi, Distefano, & Pulvirenti, 2020b; Pulvirenti, Distefano, & Leonardi, 2020). Pulvirenti et al. (Pulvirenti et al., 2020) wanted to understand how human factors influence elderly pedestrian perception of critical issues of pedestrian paths. Leonardi et al. (2020b) instead focused on the design solutions and strategies that elderly propose in order to improve the safety of pedestrian paths, considering the influence of human factor. Based on the results of these previous studies, this paper wants to understand which aspects and measures the elderly consider more important in order to encourage and improve neighbourhood walkability.

3.2. Survey and participants

A 22 items survey was used to collect the participants' opinions. Survey-based research are a very effective tool for investigating many topics of interest to (Distefano & Leonardi, 2019; Ignaccolo, Inturri, Giuffrida, Le Pira, & Torrisi, 2019; Leonardi, Distefano, & Pulvirenti, 2019). The questionnaire was divided into the following 4 sections:

- Section 1: this section regarded respondents' ***socio-demographic characteristics***, such as age, gender, city of birth, place of residence, etc.;
- Section 2: the second section contained questions about ***physical abilities declines***. Participants were asked if they had vision, hearing and/or mobility problems.
- Section 3: this section contained questions about the ***experience as road users***. Participants were asked whether they ever had a driving licence, whether they still drove, whether they ever had any accidents while driving, whether they ever had any accidents as pedestrians and the average distance they usually walked.
- Section 4: this section consisted of two multiple-choice questions relating to participants' ***Priorities for neighbourhood walkability***. The first question asked participants which part of the pedestrian path they considered to be of priority for their neighbourhood walkability. The most critical situations that pedestrians may encounter while walking can be attributed to three main aspects: walking along the road, crossing the road and safeguard from improper or aggressive driving behaviour. The possible answers for the first question were therefore these three aspects (the participants could only choose one answer):

1. walking along the road, which refers to pedestrians' level of comfort and safety when they walk on the sidewalk or along the road (when the sidewalk is not present);
2. crossing the road, which refers to pedestrians' level of comfort and safety when they cross the road; it does not necessarily imply the presence of pedestrian crossings, but it is clear that the presence of pedestrian crossings can improve pedestrians' safety and comfort when crossing the road;
3. safeguard from vehicles, which refers to pedestrian risks originating from improper or aggressive driving behaviour (typically due to illegal, overspill parking onto sidewalks, or that create obstruct visibility near the crossing areas, etc.).

The second multiple-choice question asked participants which specific measures they considered desirable for their neighbourhood walkability. The 13 possible answers to this question were selected based on the results of a previous study (Leonardi et al., 2020b). Participants could choice from one to three answers. Leonardi et al. (2020b) was an explorative analysis of elderly pedestrians' perception developed in the urban area of Catania. The final aim of the study was to identify design solutions and strategies proposed by elderly to solve the critical issues of pedestrian paths. Participants were asked to freely express their opinion on the measures they thought could improve the safety of the study sites. Results allowed to determine which measures were most frequently proposed by elderly; the answers of the second question of this Section were chosen based on these specific measures. Table 1 shows in detail the two multiple choice questions of this Section.

The questionnaire was organized to ensure that respondents did not answer in an obvious way. For this reason, the first question of Section 4 was the first question of the survey, while the second question of Section 4 was the last one. Among the first and the last questions were the

Table 1
Questions of Section 4 of the questionnaire.

SECTION 4
Which aspect do you consider most important for your neighbourhood walkability?
- Walking along the road
- Crossing the road
- Safeguard from drivers
Which measures do you consider desirable for your neighbourhood walkability?
- Presence of sidewalks
- Suitable sidewalks width
- Smooth sidewalks surface
- Prevention of parking on sidewalks
- Presence of ADA ramps on sidewalks
- Presence of pedestrian crossings
- Good conditions of pedestrian crossings
- Presence of signalized pedestrian crossings
- Good street lighting system
- Traffic calming measures
- Pedestrian areas
- Smooth road pavement surface
- Increase of police supervision

questions belonging to Sections 1, 2 and 3. It was assumed that creating a gap of about 10–12 min between the first and last question of Section 4 would have allowed respondents to answer the last question without seeing the direct connection with the first question.

The survey was carried out near attractor poles for older people in the urban area of Catania (squares, churches, pharmacy, etc.). Participants were recruited personally, so that only people over 70 were selected. Participants were briefed of the nature and time required to participate in the study prior to commencement. After their consent had been obtained, the questionnaire started. It was decided to interview the participants directly face to face to provide visual aids and detailed explanations and clarifications. Each survey lasted about 15 min. Participants were assured of anonymity and confidentiality. The total sample comprised 645 participants (355 men and 290 women). Participants who didn't complete the questionnaire or who gave uncertain answers were excluded. The respondents excluded were about 3% of the sample. The final sample was composed by 626 participants (347 men and 279 women). The majority of respondents (42%) were aged between 70 and 75, 36% of respondents were aged between 75 and 80 and 22% of respondents were over 80.

3.3. Analytical method

Multiple Correspondence Analysis (MCA) was chosen to analyse the data obtained from the survey. MCA is used in particular to represent and model datasets as "clouds" of points in a multidimensional Euclidean space. The results are interpreted based on the relative positions of the points and their distribution along the dimensions. Although mainly used as an exploratory technique, it can be particularly powerful because it "uncovers" groupings of variable categories in the dimensional spaces, providing important insights into the relationships between categories, without the need to make assumptions as required by other techniques often used to analyse categorical data (e.g., Chi-square analysis, G-statistics, and ratio test).

MCA plots are the better way of presenting information graphically and can be interpreted by examining the distribution of variable groupings in space (Fig. 1) or by examining the factorial coordinates of the points representing the categories of the variables. Usually, categories with high values on the factorial coordinates are those that contribute most to the formation of the axis itself. The value of the coordinate depends on the mass and the square cosine of the category; it may then suffer the effect of low-frequency categories. In this case, a category is located very far from the origin of the factorial axes only because of its scarce frequency.

The purpose of the MCA is to create only a few dimensions capable of reproducing most of the inertia present among the category-variables analysed in a small number of factors expressing combinations of all active categories. The MCA allows the graphical analysis of the planes constituted by the factorial axes considered two at a time. It is possible to project the category-variables and/or the cases onto these factorial planes. By estimating the positions of the dots with respect to the axes and the distances between the dots themselves, it is possible to deduce the structure of the relationships between the category-variables, and between these and the factors. Generally speaking, the farther a dot is from the origin of an axis, the greater its contribution to the formation of the axis itself; furthermore, the greater the proximity between two category-variables, the greater their interdependence.

In order to interpret the graphs produced by this kind of analysis, the main criterion is looking at the closeness between the categories. If two categories have high coordinates and are close to each other in space, they tend to be directly associated; if two categories have high coordinates but are not close to each other (e.g. they have opposite signs), they tend to be inversely associated. By assessing the absolute and relative contributions of the categories to the two factors, it is possible to interpret the axes; the categories with the highest values in relation to each factor must be given greater consideration. Closeness between the categories of the same variable means that these categories are similar in terms of the dimensions identified and may therefore be grouped without loss of information; while closeness between the categories of different variables is a sign which permits one to interpret the factor.

Multiple Correspondence Analysis has been widely used to study issues related to transportation (Das & Sun, 2016; Distefano, Leonardi, & Pulvirenti, 2018; Jalayer & Zhou, 2016; Leonardi, Distefano, & Pulvirenti, 2020a; Usami, Persia, Picardi, Saporito, & Corazziari, 2017).

3.4. Variables

The variables considered for the MCA were deduced directly from the survey. Particularly, since the final aim of the study was to understand the correlations among elderly's characteristics and their priorities for neighbourhood walkability, the variables considered were related to 4 subgroups, corresponding to the 4 sections of the questionnaire, i.e. *Socio-demographic characteristics*, *Physical ability decline*, *Experience as road users* and *Priorities for neighbourhood walkability*. It is

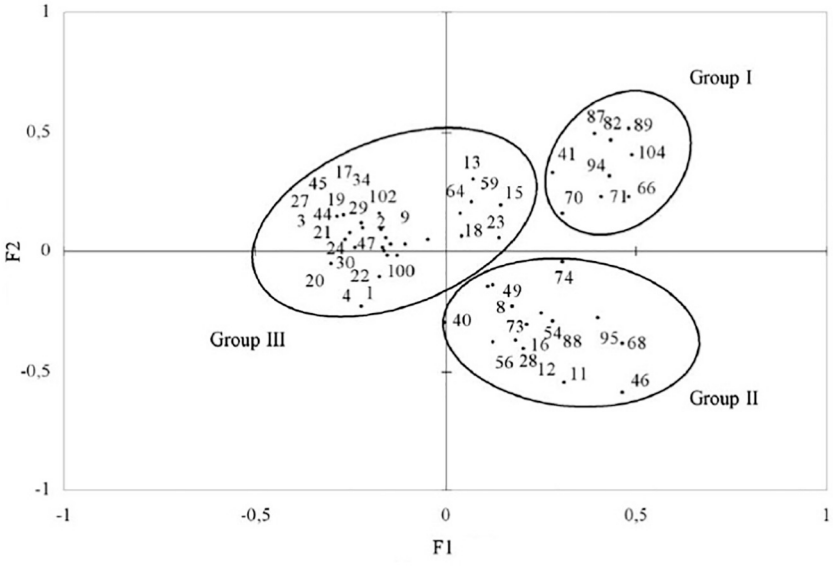

Fig. 1. Example of MCA output.

assumed that the variables considered for the MCA are categorical. Table 2 shows in detail the 12 variables considered and the 4 subgroups to which they belong.

3.5. Findings and discussion

In order to define the correspondences among the categories of each variable, an MCA was developed using SPSS 24.0. A two-dimension MCA solution was found to be the most adequate. The first and second dimension have respectively: eigenvalue 2.850 and 2.084; inertia 0.237 and 0.174; Cronbach's alpha 0.708 and 0.568. Although the generally accepted lower limit for Cronbach's alpha is 0.70, a smaller value is acceptable in exploratory research (Johnson & Wichern, 2007) where a small alpha score may be due to a reduced number of questions, poor interrelationship between items, or heterogeneous constructs.

The discrimination measures (Fig. 2a) and a joint plot of category points, called Biplot (Fig. 2b), were obtained. The dimensions discrimination measures were used to define the axis of the Biplot based on the elderly's characteristics. The category points positions in the Biplot were then used to define the correlations among the variables related to the *Priorities for neighbourhood walkability* (i.e. *Most important aspect* and *Desirable measures)* and the elderly's characteristics. The following sections shows in detail how the dimensions and the results were interpreted.

Table 2
MCA variables.

Subgroups	Variables	Categories
Socio-demographic characteristics	Age	70÷75
		76÷80
		81÷85
		>85
	Gender	Male
		Female
Physical ability decline	Hearing problems	Yes
		No
	Vision problems	Yes
		No
	Mobility problems	Yes
		No
Experience as road users	Driving licence	Yes
		No
	Still driving	Yes
		No
	Walking distance	≤100 m
		101÷200 m
		201÷300 m
		>300 m
	Driving accidents	Yes
		No
	Pedestrian accidents	Yes
		No
Priorities for neighbourhood walkability	Most important aspect	A1: Walking along the road
		A2: Crossing the road
		A3: Safeguard from drivers
	Desirable measures	M1: Presence of sidewalks
		M2: Suitable sidewalks width
		M3: Smooth sidewalks surface
		M4: Prevention of parking on sidewalks
		M5: Presence of ADA ramps on sidewalks
		M6: Presence of pedestrian crossings
		M7: Good conditions of pedestrian crossings
		M8: Presence of signalized pedestrian crossings
		M9: Good street lighting system
		M10: Traffic calming measures
		M11: Pedestrian areas
		M12: Smooth road pavement surface
		M13: Increase of police supervision

3.6. Interpretation of the dimensions

The discrimination measures quantify the variance in each indicator. An indicator proves to be equally important or more important for one dimension because its ability to discriminate between the objects under analysis is greater. There were clear differentiating values allocated to each of the obtained dimensions (Fig. 2 a).

The most discriminant variables for Dimension 1 were, hierarchically, *Driving licence*, *Accidents driving*, *Still driving* and *Gender*; for Dimension 2, the most discriminant variables were *Age*, *Hearing problems*, *Vision problems*. The variables *Walking distance*, *Mobility problems* and *Pedestrian Accidents* are not relevant discrimination measures in either dimension.

Particularly, with regard to Dimension 1, Fig. 2b shows that the "Yes" categories of *Accidents driving*, *Driving licence* and *Still driving* and the "Male" category of *Gender* are on the positive part of Dimension 1 (i.e. Dimension 1 > 0). All the dual categories of these variables are on the negative part of Dimension 1 (i.e. Dimension 1 < 0). Dimension 1 was therefore named "Driving experience". Fig. 3a shows schematically the interpretation of Dimension 1. It is noteworthy that when interpreting Dimension 1, the "Female" category was associated with poor "Driving experience", while the "Male" category was associated with strong "Driving experience". These associations are due to Italian cultural aspects. Women aged 70 years or more were young at a time when it was less common for women to drive than for men in Italy. There is therefore a significant discrepancy between elderly male and female driving experience. Even today in Italy more than 85% of men have a driving licence, while this percentage is less than 65% for women (Report, 2019).

With regard to Dimension 2, Fig. 2b shows that the "Yes" categories of *Hearing problems* and *Vision problems* and the "76÷80", "81÷85" and ">85" categories of *Age* are on the positive part of Dimension 2 (i.e. Dimension 2 > 0). The Yes" category of *Mobility problems* is also located on the positive part of Dimension 2. All the dual categories of these variables are on the negative part of Dimension 2 (i.e. Dimension 2<0). Dimension 2 was therefore named "Age-related declines". Fig. 3b shows a schematic interpretation of Dimension 2.

3.7. Interpretation of the Biplot

After the dimensions were interpreted based on the elderly's characteristics, a new Biplot was derived starting from the original Biplot (Fig. 2 b). The new Biplot contains only the categories of the variables related to the *Priorities for neighbourhood walkability* (i.e. *Most important aspect* and *Desirable measures*). Fig. 4 shows the newly obtained Biplot. The dimensions of the new Biplot are named and oriented based on the interpretation explained above (Section 4.1).

This Biplot is the summary of the entire analysis. Three different types of correlations among the categories were analysed. The following sections briefly show the interpretations of the results obtained. The first interpretation of the Biplot is based on the correlations among the category points of the two variables that define the *Priorities for neighbourhood walkability* (i.e. *Desirable measures* and *Most important aspect*). The second interpretation of the Biplot is based on the distribution of the categories points of *Desirable measures* and *Most important aspect* along the axes which were defined according to the elderly's characteristics. Finally, the third interpretation originates from a reading of the Biplot based exclusively on the distribution of the *Desirable measures* category points in the Cartesian plane. All three interpretations allow to draw similar conclusions which are useful to focus the main results of this study. However, each of the three interpretations also allows to highlight some specific results that would not have emerged if one of the

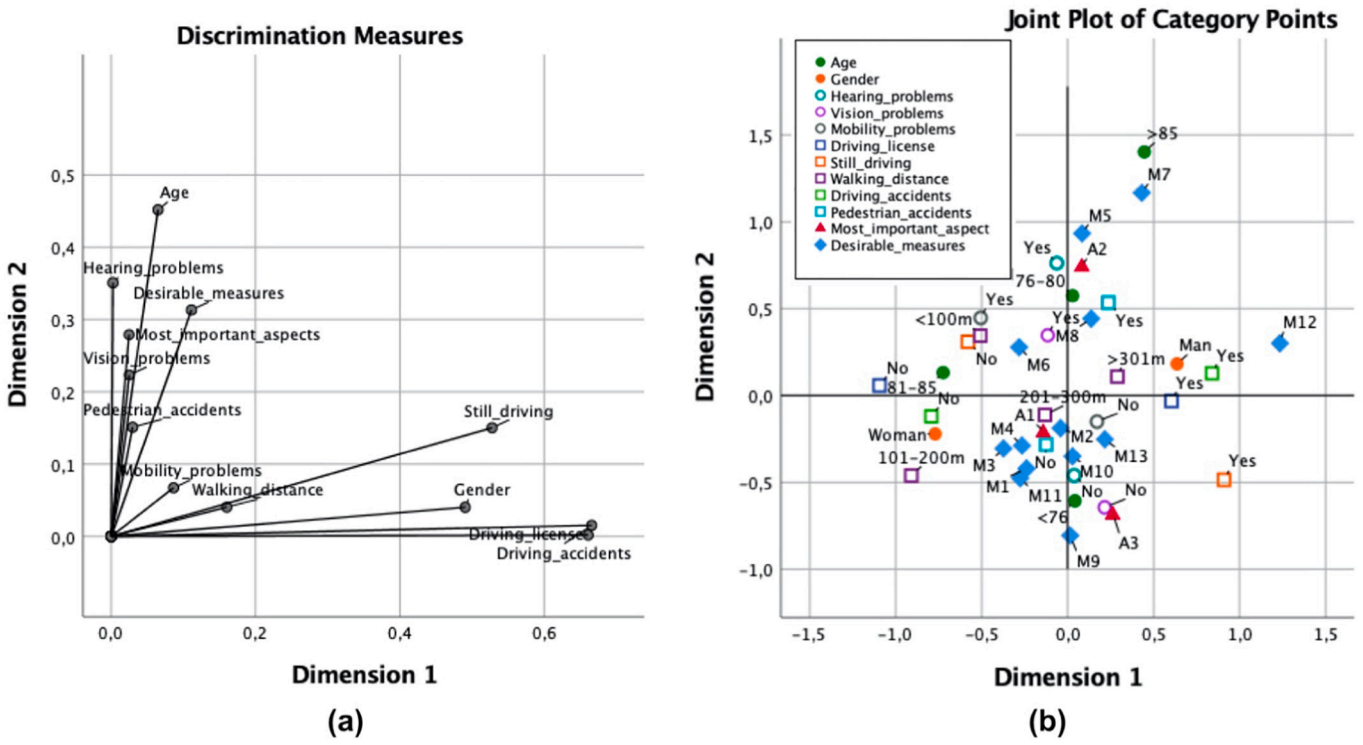

Fig. 2. (a) MCA dimensions discrimination measures. (b) MCA Joint category plot of the explored variable categories.

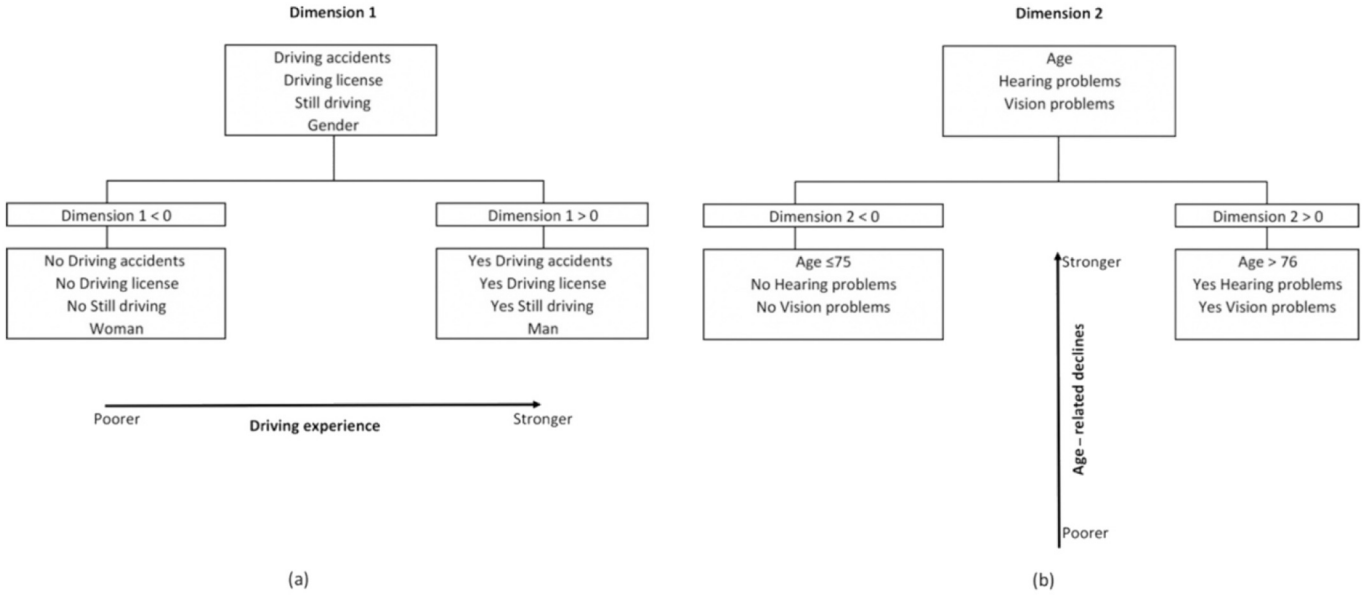

Fig. 3. (a) Interpretation of dimension 1. (b) Interpretation of dimension 2.

three interpretations had not been carried out.

3.7.1. Interpretation based on the correlations among the category points

The analysis of the Biplot of Fig. 4 allows the conclusion that the category points of *Desirable measure* are strongly correlated with the logically related category points of *Most important aspect*. In particular, the following considerations can be made:

- The category points closer to the origin, which are representative of a higher participant response rate, are category A1 (i.e. "Walking along the road") for *Most important aspect* and categories M1, M2, M3 and M4 (which are all categories related to the improvement of sidewalks) for *Desirable measures*.
- The category points A2 (i.e. "Crossing the road") and A3 (i.e. "Safeguard from drivers") are more or less equidistant from the origin, even if they are diametrically opposed. Thus, respondents give the same importance to the categories "Crossing the road" and "Safeguard from drivers". Similar considerations can be made for the category points of *Desirable measures,* which are close to A2 and A3. In fact, the category points M9, M10 and M13 (all relating to measures to mitigate inappropriate driver behaviour) are close to the category A3 (i.e. "Safeguard from drivers"). Instead, the category

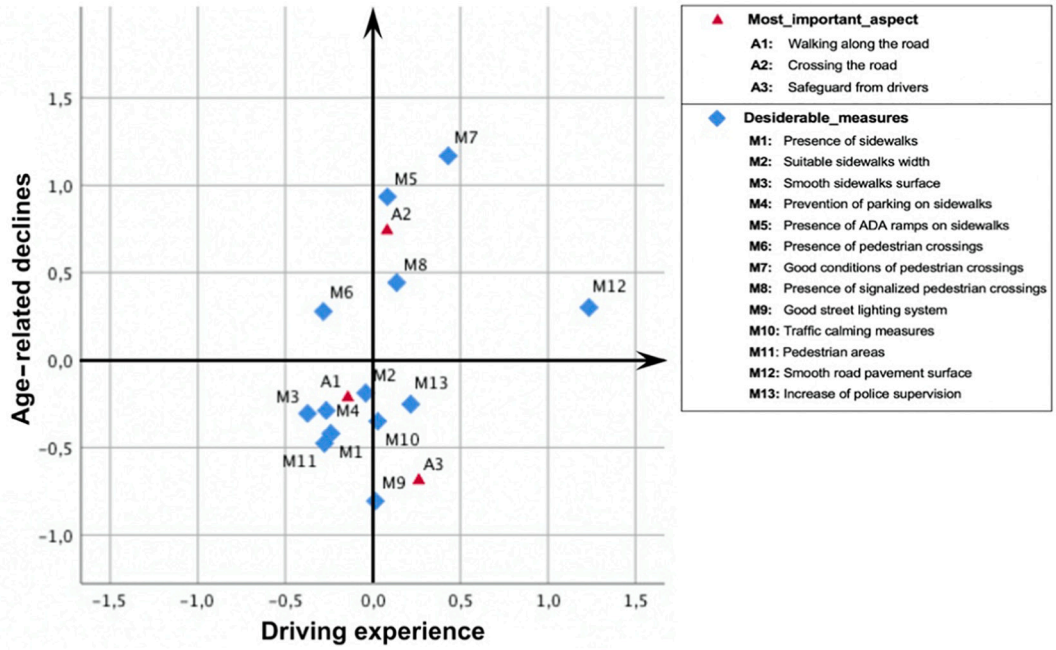

Fig. 4. MCA Joint category plot of the variables of Priorities for neighbourhood walkability.

points M5, M6, M7 and M8 (all relating to measures to improve pedestrian crossings) are close to the category A2 (i.e. "Crossing the road").

It is also interesting to observe that the correlations described above confirm the reliability of the results obtained.

The strong correlation of the category points relating to *Desirable measures* with the logically related category points of *Most important aspect* demonstrate indeed that the respondents approached the questionnaire seriously and consistently. Although the two multiple-choice questions related to priorities for neighbourhood walkability were the first and last questions of the survey, respondents gave congruent answers to each other.

3.7.2. *Interpretation based on the distribution of categories points along the axes*

The interpretation of the Biplot of Fig. 4 considering the distribution of categories points along the axes leads to the conclusion that both categories of *Desirable measure* and of *Most important aspect* are mainly distributed along dimension 2 (i.e. "Age-related declines"). Instead, there is a small variability of both variables along dimension 1 (i.e. "Driving experience"). Therefore, the following considerations can be made:

- "Driving experience" has no significant influence on elderly pedestrians' priorities for neighbourhood walkability. This is particularly true with regard to the importance attached to the categories "Walking along the road" and "Crossing the road". As far as the category "Safeguard from drivers" is concerned, the "Driving experience" seems to have a moderate influence, as the category point in the Biplot is slightly offset to the right with respect to the origin of the axes. This result could be representative of the fact that respondents with greater driving experience are also more aware that drivers often exhibit improper or aggressive behaviour.
- "Age-related declines" have a strong impact on elderly pedestrians' priorities for neighbourhood walkability. In particular, pedestrians who belong to the lower age group ($\leq$ 75) and have small hearing and vision problems attach greater importance to controls and measures aimed at mitigating improper driving behaviour such as high speed, poor visibility, etc. This finding shows that younger respondents tend to attribute their difficulties as pedestrians to improper or aggressive driving behaviour rather than to their physical and cognitive deficits. As "Age-related declines" increases, respondents attach greater importance to the inadequacy of the road environment and the need for measures to improve pedestrian safety and comfort. It can be observed that:

a) elderly respondents with small age-related declines attach more importance to the degree of comfort and safety when walking on the sidewalk or, when the sidewalk is not present, along the road; however, they also focus on improper or aggressive driving behaviour;
b) the oldest respondents with severe age-related declines appear to be aware of their cognitive and physical limitations because they do not attribute their difficulties as pedestrians to others. In fact, they attach greater importance to comfort and safety when crossing the road, i.e. when they perceive the risks associated with promiscuity with vehicles.

3.7.3. *Interpretation based on the Desirable measures*

The analysis of the Biplot of Fig. 4 also allows some considerations on the *Desirable measures* which respondents think could encourage neighbourhood walkability:

- Overall, it can be seen that the majority of respondents consider the "Suitable sidewalks width" as a priority. "Suitable sidewalks width" belongs to the group of category points of the variable *Desirable measures* logically linked to the category "Walking along the road" of the variable *Most important aspect*. This measure is considered a priority regardless of age-related decline and it is significant that it is even more desired than the presence of the sidewalk itself. This is not surprising, since the locations studied often do not have sidewalks and many users have become accustomed to the sidewalk absence. On the other hand, pedestrians clearly perceive the defects of the sidewalks when they are present. In particular, pedestrians emphasize that the narrowness of the sidewalk is the most urgent problem to be solved.

- With respect to the *Desirable measure* categories logically linked with the category "Safeguard from drivers", the majority of respondents consider the "Increasing of police supervision" a priority. In fact, respondents believe that the problems of neighbourhood walkability are mainly related to improper or aggressive driving behaviour. They therefore wish for an increasing of police supervision in order to mitigate and reduce incorrect driving behaviour. The desired measure with the lowest frequency is "Good street lighting system" which is more related to respondents with small age-related declines. These users, although not in the prime of their years, do indeed feel fully capable of dealing with situations of promiscuity with vehicular traffic. In particular, they believe that there are more useful measures than police supervision and traffic calming measures: they consider essential for their safety that pedestrian paths can also be used safely at night, i.e. during the hours when they cannot rely exclusively on their psychophysical abilities (which they can do during the day).
- As regards the *Desirable measure* categories logically linked to the category "Crossing the road", the measures that all the respondents request more is "Realization of pedestrian crossings". "Good condition of pedestrian crossings" is the *Desirable measure* category more related to respondents with the greatest age-related declines, even though it has an absolutely low frequency of answers. This is indicative of how these users are more aware than others of the difficulties associated with the comfort and safety of the crossing. A pedestrian crossing with a poorly maintained surface or with faded markings does indeed affect the movements of pedestrian, especially older pedestrians with physical declines. These users are therefore discouraged from crossing in such conditions, because, apart from the difficulties intrinsically linked to the conflict with vehicles, there are also those linked with the poor condition of the pedestrian crossing.

3.8. Further considerations

Few additional considerations can be made considering the variables which resulted not significant for the interpretation of the axes of the Biplot (i.e. the variables which resulted not relevant discrimination measures in neither dimension):

- Contrary to what could be expected, *Pedestrian accidents* and *Walking distance* were not significant for the interpretation of Dimension 1. Anyway, the Biplot of Fig. 1b shows that the category point "Yes" of *Pedestrian accidents* and the category point "> 300 m" of *Walking distance* are in close proximity to the category point "Crossing the road". This is certainly an indication that the respondents who have been victims of pedestrian accidents in the past and who cover longer distances on foot are also those who are more aware of the risk associated with crossing the road.
- *Mobility problems* were not significant for the interpretation of Dimension 2, even though Dimension 2 proved to be representative of "Age-related declines". This result is not surprising. The sample of respondents was indeed interviewed in places they normally walk to. The respondents were therefore mainly people who overshadowed their mobility problems compared to other physical declines (vision and hearing problems). However, it is interesting to note that in the Biplot of Fig. 1b the category point "Yes" of *Mobility problems* is almost coincident with the category point "< 100 m" of *Walking distance*. This shows that the majority of respondents with mobility problems also covered very short distances.

4. Conclusions

In order to meet the needs of pedestrians, it is necessary to have a clear understanding of the wide range of abilities that exists in the population. Like roads, pedestrians path should be designed to serve all users. This includes children, elderly, parents with strollers, pedestrians with vision impairments, and people using wheelchairs and other assistive devices. In the same way that a roadway is not designed for a particular type of vehicle, the design of a pedestrian path should not be restricted to a single type of pedestrian. Starting from these considerations, this study wanted to study the point of view of a specific category of road users, i.e. elderly pedestrians. Advanced age is undoubtedly the aspect that best identifies older people. This study made it clear that age plays a fundamental role in the perceptions and opinions of older people with regard to the aspects and measures they consider more important to encourage and improve neighbourhood walkability. In particular, a central conclusion of the paper is that age is the most discriminatory element in the perception of neighbourhood walkability, as it is strongly related to physical ability declines. This is fully consistent with several sector studies: the needs of elderly pedestrians in terms of walking and the built environments have been well recognised (e.g., Crews & Zavotka, 2006; Levasseur et al., 2011; Oxley, Fides, & Dewar, 2004; Ritter, Straight, & Evans, 2002). The physical disabilities that most influence the responses of the respondents in this study are vision and hearing problems. This is a confirmation of the findings of Barnett et al. (2016).

The main results of this research are the following:

1) elderly pedestrians with small age-related declines attach greater importance to the walkability along the road, but also focus on improper driving behaviour;
2) pedestrians with severe age-related declines attach greater importance to comfort and safety when crossing the road, i.e. when they perceive the risks associated with promiscuity with vehicles.

Crossing the road is therefore confirmed as the most critical moment for pedestrians, especially because they have to interact with vehicles, and this problem is more pronounced among the oldest pedestrians. These considerations are confirmed by Fontaine and Gourlet (1997) and Oxley, Fildes, Ihsen, Charlton, and Day (1997), who argued that ageing is associated with a decline in several functional abilities that may be involved in road crossing situations where dangerous crossing behaviour have been frequently observed in older pedestrians. Previous studies have also pointed to age-related declines in perceptual, cognitive, and/or motor abilities to cross the road safely (Dunbar, 2012; Holland & Hill, 2010; Lobjois & Cavallo, 2009; Oxley et al., 1997; Oxley, Ihsen, Fildes, Charlton, & Day, 2005).

In particular, the considerations derived from the three interpretations discussed in this paper are an important confirmation of the priority action items of the strategy for older-pedestrian proposed by Oxley et al. (2004). Many of these priority action items relate to the provision of a safer and more pedestrian friendly environment in high density traffic areas. A reduction in traffic speed and volume would lead to fewer conflicts between pedestrians and motorists. This is in line with the need for maximum safety during the phases in which conflicts with vehicles occur as expressed, in this study, by the older pedestrians with greater age-related decline. The importance of the above-mentioned strategic actions has also been demonstrated to a large extent in this study and it is therefore assumed that they could be the basis of policy prescriptions for improving walkability among older adults also in Italian neighbourhoods.

Public policies have an important role to play not only in removing physical barriers to social inclusion due solely to age and ability, but also in reducing overt and covert social barriers that prevent full participation in all aspects of community life. Ageing should not be seen as a problem for the community, but as an opportunity to create a better future for the community. On the basis of the desirable measures defined in this study it can be concluded that solving problems for ageing population will also help people of other age groups, as they will benefit too from these changes.

Author contribution

Author	*Authorship Contributions*
Natalia Distefano	Conceptualization, Methodology, Investigation, Validation, Software, Data curation, Formal analysis, Writing - Review & Editing
Salvatore Leonardi	Conceptualization, Methodology, Resources, Supervision, Project administration
Giulia Pulvirenti	Conceptualization, Methodology, Investigation, Validation, Formal analysis, Writing - Original Draft, Writing - Review & Editing

Taxonomy used:

- **Conceptualization:** Ideas; formulation or evolution of overarching research goals and aims
- **Methodology:** Development or design of methodology; creation of models
- **Software:** Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components
- **Validation:** Verification, whether as a part of the activity or separate, of the overall replication/ reproducibility of results/experiments and other research outputs
- **Formal analysis:** Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data
- **Investigation:** Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection
- **Resources:** Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools
- **Data Curation:** Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse
- **Writing - Original Draft:** Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation)
- **Writing - Review & Editing**: Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre-or post-publication stages
- **Supervision:** Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team
- **Project administration**: Management and coordination responsibility for the research activity planning and execution

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