Do Seniors Get to the Disco by Bike or in a Taxi?—Classification of Seniors According to Their Preferred Means of Transport

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Abstract Analysis of the preferences of the oldest group of citizens seems especially important and up to date in the context of an ageing Polish society. It is important to determine the mobility of this group by examining the most frequently used means of transport for different travel needs. Studies that define the mobility types of older people can be found, but there are not many and they would require modifications to reflect Polish society specifically. In this paper, an attempt to classify elderly people in Poland in terms of their transport preferences has been made, based on literature research and expert knowledge. At the same time, using primary data from a survey of seniors, a cluster analysis was performed using the Ward's method based on a distance matrix, calculated using the Sokal–Michener metric. The aim of the paper is to test the validity of the obtained classifications. As shown by the results obtained, e.g. the Rand index, there is high similarity, despite the different number of groups in each segmentation; the validity of the proposed expert segmentation is therefore confirmed.

Keywords Seniors · Transport preferences of the elderly · Mobility types of seniors · Cluster analysis · Classification agreement

1 Introduction

Two processes: the ageing society and increasing urbanization mean that more and more seniors live in cities and use the cities' transport systems to meet their needs. Among the means of transport available to seniors, the car was already identified as the most suitable one in the OECD report (2001) on Ageing and Transport. A lot of the research and activities carried out so far have been focused on ensuring the

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longest possible use of cars by seniors (Coughlin and D'Ambrosio 2012; Haustein et al. 2013). The possible measures to extend the elderly car-use include: driving assistance systems, adapting the road infrastructure to the needs of seniors, changes in regulations regarding the verification of driving licences, special training courses and others. Such a strong focus on the car as the preferred means of transport does not change the fact that not all seniors have access to one and some have to use other available means of transport, usually public or active transport (i.e. walking or cycling). The following issues, differing from one mode of transport to another, can be perceived as barriers to the use of alternatives to cars: service provision, health, safety and personal security, comfort, information and awareness, attitude, affordability, built environment (Luiu et al. 2018).

The issue of transport needs and ensuring mobility of the elderly is not only an interesting and current research problem but also a significant issue from the point of view of various decision-makers responsible for undertaking activities aimed at ensuring the social inclusion of seniors. Most studies dealing with the transport needs of seniors indicate differences depending not only on age or gender, but also on the place of residence, the availability of transport infrastructure, accessibility of various transport means and other factors.

This paper presents two classifications of the elderly in terms of their preferences regarding means of transport:

- one prepared on the basis of literature research and expert knowledge,
- the other with the use of a selected taxonomic method.

The aim of the article is to test the agreement between the obtained classifications and thus to verify the validity of the proposed expert segmentation.

A brief review of the literature on the segmentation of seniors according to their transport behaviour will be presented first. Next, the primary research providing the data for the grouping, both the methodology and the results, will be discussed followed by the methodology of preparing both segmentations. The obtained results, their comparison, and summary, together with the conclusions drawn, will be presented last.

2 Literature Review: Seniors and Their Transport Needs. Attempts at Segmentation

Attempts at segmentation relating to transport behaviour can be performed using different types of variables. The following variables may be used in studies related to transport behaviour: variables describing transport behaviour (such as the means of transport used, frequency of their use, preferences and attitudes towards particular transport options), socio-demographic characteristics of individuals and households (such as age, sex, place of residence, education, household size and others), spatial factors (e.g. spatial availability of individual transport options,

quality of transport infrastructure, distribution of the most popular destinations and others), individuals' attitudes (e.g. pro-ecological proclivities, perceived status, independence, etc.) or significant life events (Haustein and Hunecke 2013). Segmentation can be carried out in two ways, preparing a description of segments and a set of rules, based on which individual units will be assigned to a given segment, before conducting the study ("a priori") and "a posteriori", when segmentation is carried on the basis of the obtained data, most often using clustering methods (Sagan 2009).

Studies on the segmentation of seniors in terms of their transport behaviour related to various types of travel can be found in the literature. The Boksberger and Laesser (2008) study on Swiss seniors, which considered Switzerland specifically as a mature market, identified, using cluster analysis, three segments (Grizzled Explorers, Time-honoured Bon Vivants, Retro Travellers) based on the motivation of seniors to undertake travel (and selection of travel means) for touristic purposes. On the one hand, this study indicated some shortcomings of previous segmentations in this area, but also confirmed the existence of previously identified motivations, with the tendency to change depending on the stage of the senior's life. An example of a different approach to such segmentation is the study by Lee and Bowes (2016) who divided seniors according to age into four segments (pre-seniors: younger than 65; the young-old: 65–74; the old-old: 75–84; and the oldest-old: 85+) and investigated the influence of age and transport needs on the perceived barriers in making decisions about tourist travels. Both the above-mentioned studies were aimed at obtaining information that could be helpful in adjusting offers by travel agencies to better suit the preferences of the elderly, who are an important and increasingly more active group of consumers.

Transport behaviour of seniors related to their daily travels, e.g. shopping, commuting, etc., is the main interest for the segmentations prepared and presented in this paper. This type of segmentation can be useful for spatial planning or for the preparation of policies and activities aimed at meeting various transport needs (Elmore-Yalch 1998) (including those of the seniors) (Załoga and Kłos-Adamkiewicz 2019). In the literature on the subject, several examples of such segmentations concerning seniors and their transport behaviour may be found. An overview of the previous segmentations made using both of the above-mentioned approaches ("a priori" and "a posteriori") and based on a number of variables relating to various aspects potentially influencing their behaviour has been presented in Table 1.

Previous attempts at the segmentation of seniors, taking into account their transport behaviour, available in the literature, show a certain similarity in terms of the identified segments. A synthetic review and comparison of the existing segmentations relating to the transport behaviour of seniors carried out by Haustein and Siren (2015) allowed for the grouping of individual segments from the existing segmentations, based on their common aspects (car orientation, activity level, socio-economic economic resources, health and gender), under so-called metasegments (see Table 2).

Table 1 Segmentation studies concerning seniors and their transport choices

Study (project acronym)	Segmentation method	Variables used for segmentation	Segments
Hildebrand (2003)	Cluster analysis	Socio-demographic and household variables	1. Disabled drivers 2. Affluent males 3. Mobile widows 4. Mobility impaired 5. Workers 6. Granny flats
Mollenkopf et al. (2004)—MOBILATE	Cluster analysis	Mobility and satisfaction from mobility	1. Subgroup 1 2. Subgroup 2 3. Subgroup 3 4. Subgroup 4
Haustein et al. (2008)—MOBILANZ	Cluster analysis	Socio-demographic, infrastructure, mobility-related attitudes	1. Restricted mobiles 2. Mobile car-oriented 3. Self-determined mobiles 4. Pragmatic PT-oriented 5. Bike-oriented 6. Eco-friendly PT–oriented
Aigner-Breuss et al. (2010)—MOTION 55+	A priori segmentation	Focus on car use	1. Predominant car user 2. Selective car users 3. Persons without a car
Bell et al. (2010)—SZENAMO	Cluster analysis	Socio-demographic and household variables	1. Mobile person 2. Slightly restricted mobiles 3. Highly restricted mobiles
Haustein (2012)	Cluster analysis	Socio-demographic, infrastructure, mobility-related attitudes	1. Captive car users 2. Affluent mobiles 3. Self-determined mobiles 4. Captive public transport users
Mandl et al. (2013)—GOAL	Cluster analysis	Demographic and health variables	1. Fit as fiddle 2. Happily connected 3. Hole in the heart 4. An oldie but a goodie 5. The car-full
Siren and Haustein (2013)	Cluster analysis	Transport and mobility-related variables	1. Independents 2. Flexibles 3. Restricted

Source Based on Luiu et al. (2018); Haustein and Siren (2015)

The metasegments identified in the study differed significantly from each other in terms of all the included variables, but they indicated some general trends important from the perspective of means of transport used: the high importance of the car (two metasegments: affluent mobile drivers and car-dependent seniors), the perception of public transport as an alternative to the car (transport service-dependent seniors) and large differentiation in relation to the use of other potential means of transport. It should be noted that the segmentation proposed in this paper differs from the ones presented, as it is based on the declared preferences

Table 2 Group of segments/metasegments identified by Haustein and Siren (2015)

Segments	Group of segments	Mobility patterns
Affluent mobiles Mobile car–oriented Workers Affluent males Fit as fiddle Happily connected Independents Fully mobile seniors Subgroup 1	Affluent mobile drivers[1]	Predominant car use, high activity engagement
Captive car users Mobility impaired Hole in the heart Disabled drivers	Car-dependent seniors	Predominant car use, low activity engagement
Subgroup 2 Self–determined mobiles Flexibles Selective car users An oldie but a goodie Self-determined mobiles Bike-oriented Ecology-minded PT–users Slightly impaired seniors	Mobile multi-model seniors[2]	Use of all modes; high/ medium activity engagement
Granny flats Subgroup 3 Persons without a car Highly impaired seniors Mobility impaired The car-full Subgroup 4 Restricted	Transport service-dependent seniors	Walking, public transport and car use as passenger; low activity engagement

[1]Two segments, predominant car users and mobile widows, were classified as transitory ones between metasegments affluent mobile drivers and car-dependent seniors

[2]Two segments, pragmatic PT-oriented and captive PT users, were classified as transitory ones between metasegments mobile multi-model seniors and transport service-dependent seniors

Source Based on Haustein and Siren (2015)

of seniors in relation to individual means of transport, taking into account various travel destinations—that is, it is oriented towards transport behaviour.

3 Methodology: Segmentations Rationale and Data Collection

In this study, primary data collected with the use of an auditorium survey on a sample of 400 students from the Universities of the Third Age (U3A) from the Silesian region will be used. The survey was conducted from December 2018 to

February 2019 in the following cities in Silesia: Bieruń, Dąbrowa Górnicza, Katowice, Rybnik, Sosnowiec. The accessibility of U3A participants and the fact that they are considered active seniors, willing to acquire new skills and expand their knowledge (shown by their enrolling and participation in Long Life Learning —LLL classes), were the main reasons for choosing this demographic for the study. The research addressed two issues: the transport preferences of seniors in relation to various travel destinations and the use of various types of information and communication technologies (ICTs) that could be beneficial for fulfilling the seniors' transport needs. In order to make sure that the questions would be easy to understand and answer, the questionnaire was trialled before starting the research, and during the research an experienced interviewer was present to provided support if needed. The distribution of respondents in terms of their characteristics is presented in Table 3.

The overwhelming majority of respondents participating in the study were female, with secondary or higher education, not working and living in one or two-person households, belonging to the so-called young old age category (60/65–74 years old) (Solecka 2018). More than half of the respondents do not own a car but have a driving licence, the majority declared a monthly income per person in the range of PLN 1500–3000 and assessed their health condition as good. It should be noted that the sample is not representative of the general population of seniors

Table 3 Characteristics of the surveyed group of respondents

Variable	Categories and values of variables						
Gender	Female				Male		
	340				60		
Owns a car	Yes				No		
	164				226		
Has a driving licence	Yes				No		
	238				147		
Education	Primary		Vocational		Secondary		Higher
	2		24		205		154
Employment status	Professionally active		Pensioner		Annuitant		Volunteer
	10		350		28		7
Health	Very good		Good		So–so		Bad
	23		222		103		17
Monthly income per person [PLN]	Up to 1500		1500–3000		3000–5000		Above 5000
	72		252		56		5
Number of people in the household	1		2		3		4 or more
	197		170		16		12
Age	51–55	56–60	61–65	66–70	71–75	76–80	81 and more
	4	18	82	111	93	65	22

(overrepresentation of women and young seniors), but is representative of the total population of Polish U3A students (GUS 2020).

As enrolment at U3A is possible at the age of 50, there was a small group of people younger than 60 years in the sample. Taking into account that different studies vary in defining seniors' age (mostly it is 60+ or 65+, but also at times it can be 50+ or 55+), it was decided to leave in the data on those respondents for the purposes of the analysis. Since some of the questions about respondents' characteristics could relate to sensitive issues (e.g. questions about income, health or the number of people in the household), answers to all questions were voluntary. It turned out to be a good decision: all respondents participating in the survey answered questions about transport preferences, but a small group did not answer particular questions (about 9% did not provide answers regarding the assessment of their health).

Regarding the study of the means of transport preferred by seniors, respondents were asked to indicate the most frequently used means of transport for particular destinations. In order to obtain the most detailed information, it was decided to extend the category of journeys beyond the most frequently used ones, that is necessary (work, school) and optional (other) trips (Hebel 2014), or a more detailed one, where necessary travel also includes shopping and accessing health care. Using that distinction would require either an explanation of the concepts (necessary versus optional travel) or questions about health issues (a potentially sensitive topic). The category depending on fulfilling the mobility needs of different levels (first degree: moving from A to B as quickly, cheaply and effectively as possible; second degree: ensuring a sense of independence, freedom, emphasizing the assumed social roles and status; third degree: enjoying the act of travelling without any particular goal) was also considered, but it was deemed too abstract for the purpose of the study (Curl and Musselwhite 2018). Finally, in order to obtain detailed information about the travel preferences of the elderly, the following seven travel agendas were specified:

- work/school,
- shopping,
- personal errands,
- social meetings,
- recreation/sport,
- culture/entertainment,
- care provided to a family member.

In terms of available means of transport, respondents could choose one of following seven options: car (as a driver), car (as a passenger), public transport, taxi, motorcycle, bicycle, walking. Considering that not every respondent will feel the need to travel in order to fulfil a certain goal (e.g. a given respondent may not provide care services to another family member, or they may live with a family member under their care and do not need to travel for that purpose), it was possible to indicate that the given purpose for travelling did not apply. Additionally, to

provide for the possibility of using various means of transport for a given destination due to changing conditions (e.g. everyday small shopping done on foot, but for larger purchases going by car), the respondents were asked to indicate the most frequently used means of travel. Different types of public transport were not included individually (in the case of cities in the Silesian region it is usually a bus or tram), and the motorcycle, despite some doubts, was added following questionnaire feedback.

As was already mentioned, two attempts to classify the elderly in terms of their preferences regarding their means of transport were made. The first (referred to as expert segmentation) is "a priori" segmentation, where the segments have been defined on the basis of a literature review, taking into account both existing segmentations and indicated preferences of seniors towards individual means of transport. The second, "a posteriori" segmentation will be prepared with the use of cluster analysis. Both methods will be presented in the following sections.

3.1 Expert Segmentation

In the case of the first segmentation, the in-depth literature studies on the transport preferences of seniors as well as earlier segmentation of seniors using various indicators were used for describing the transport types of the elderly. The synthetic overview of existing segmentations by Haustein and Siren (2015), that indicated four metasegments (affluent mobile drivers, car-dependent seniors, mobile multi-model seniors, transport service-dependent seniors) was also taken into consideration but with certain modifications. All the segmentations included in that overview were carried out for more developed countries with different socio-cultural background; Polish seniors display certain characteristics that distinguish them from other EU countries (Okólski 2018). Taking into account the expected differences identified in the literature, resulting for example from gender (fewer female drivers, more frequent use of public transport and walking by women) (Böcker et al. 2017), the frequency of using a given means of transport (bicycles generally make a minor contribution to the modal breakdown regardless of age; taxis are used more as a special case or an exception and not as a rule; the same goes for motorcycles, although there is no reference to this mode of transport in the literature) (Hebel and Wyszomirski 2018; Ryan 2020) and after some deliberation and considering several possibilities, the authors decided to include six different segments. The segments were defined on the basis of the preferences declared by the respondents regarding the most frequently used means of transport in relation to various travel destinations, namely:

- active drivers, i.e. those mainly declaring the use of a car as a driver,
- passengers or driver's partners, i.e. those mainly declaring the use of a car as a passenger,

- public transport users, i.e. those declaring that they travel mainly using public transport,
- those who most often declare the use of active transport, i.e. walking or cycling,
- those who declare using both active and public transport, the so-called hybrid segment,
- those using various means of transport, indicating at least three different means without clear preference.

Three of the specified segments are similar to metasegments identified by Haustein and Siren (2015), but it should be emphasized that they were largely based on transport preferences and not on other socio-demographic indicators that were considered in that study. Hence in the proposed segmentation, an active driver is a person who, for the vast majority of travel purposes (destinations), declares the use of a car as a driver without taking into account other factors (high activity, high income or being predominantly male) indicated for the affluent mobile drivers metasegment. The indication of this segment (active drivers) and the second segment referring to the use of the car (as a passenger) results from the great importance of the car for the mobility of the elderly, whether as a driver or a passenger. The segment of PT (Public transport) users results from several factors identified in the literature, such as the inability to use a car (whether due to lack of access, age restrictions for drivers, deteriorating health), or the increasing emphasis on changing the modal division with regard to means of transport used in the city that results in incentives for seniors to use PT (e.g. free rides) and others (Mifsud et al. 2017; Raczyńska-Buława 2017). The segment of mobile seniors using various means of transport depending on their needs and individual travel goals, without indicating a predominant one (e.g. shopping on foot, entertainment by taxi, personal errands by car), was also included. In addition, the authors decided to add two segments, the first one to include seniors using mainly active transport (i.e. walking or cycling), and the second (the hybrid segment) to include respondents using both public and active transport. This was decided partly due to the predominance of women expected in the sample, who use this type of transport (public and active) more often than men (Haustein et al. 2013) and also the fact that most seniors' travels (especially daily ones) are usually confined to areas closest to their place of residence.

3.2 Segmentation Using Taxonomic Methodology

Parallel to the segmentation conducted using the expert method, the respondents were classified into groups with statistical methods, in particular, cluster analysis.

Based on the same data concerning the means of transport indicated by the respondents, it was assumed that each destination which the questionnaire enquired about would be represented by a separate variable:

- X_1—work/school,
- X_2—shopping,
- X_3—personal errands,
- X_4—social meetings,
- X_5—recreation/sport,
- X_6—culture/entertainment,
- X_7—care provided to a family member.

Each question concerning the means of transport asked the respondents to choose one of the options: 1—car (as a driver), 2—car (as a passenger), 3—public transport, 4—taxi, 5—motorcycle, 6—bicycle, 7—walking or indicate that a given destination did not apply to them (8). This means that the variables used in cluster analysis are nominal variables, the realizations of which are the respondents' choices coded numerically.

Clustering methods include hierarchical and iterative optimization methods. In this case, we applied one of the hierarchical methods—Ward's method, which is recognized for its strong formal properties, as some researchers posit (Fisher and Van Ness 1973; Trzęsiok 2009). Another argument in favour of the application of the method was the fact that it could be easily implemented to the analysis performed on nominal variables. Ward's method, in particular the ward.D function in **R** used in the study, allows for the use of any metric that can measure the distance between the objects under examination. In this case, the Sokal–Michener metric for nominal variables was used (Rogers and Tanimoto 1960; Walesiak 2011).

The key element of cluster analysis involves determining the optimal number of classes. The Silhouette index was used to validate this number (Kaufman and Rousseeuw 2009). The validation was conducted in the process of dividing the respondents into a few series of clusters, each time the number of clusters was different and the Silhouette index was calculated (I_S). The highest values of the index indicate the best cluster validity. It is also possible to interpret the I_S index in relation to the evaluation of the class structure obtained as a result of clustering. In their study, Kaufman and Rousseeuw (2009) argue that the highest values of $I_S \in (0.7, 1)$ reveal a strong structure of classes, while $I_S \in (0.5, 0.7)$ indicate that a reasonable structure has been found, but $I_S \in (0.25, 0.5)$ mean that the structure is weak and could be artificial. If $I_S \leq 0.25$, no substantial structure has been found.

The final stage of the study involved the comparison of the two segmentations: one performed by the expert and the other obtained as the result of cluster analysis. First, we needed to check whether the two classifications tallied, so we used the Rand index (Rand 1971), which measures the similarity between two clusterings of the same set of objects. The closer the value of the Rand measure is to 1, the more similar the results of two clusterings are. Additionally, we performed the analysis of correspondence to show the relationships between the classes of the two segmentations.

4 Results and Discussion

Based on the survey data on the most frequently used means of transport for different destinations, two segmentations were performed: expert and cluster analysis. The results, i.e. the clustering of respondents into appropriate classes, as well as the characteristics of these classes, are presented further in this part of the paper. In line with the aim of the paper, the two classifications were compared and discussed against the background of the results of research conducted by other researchers.

4.1 Main Findings of the Expert Segmentation

Following the assumptions of the expert segmentation presented earlier in the paper, the respondents were included in a given class according to their preference for a particular means of transport. Based on the means of transport declared as the most frequently used by the respondents for different destinations, the seniors were clustered into six classes:

- active drivers,
- passengers or, in other words, driver's partners,
- public transport users,
- active seniors (travelling mainly on foot or by bike),
- a hybrid segment including the respondents declaring the use of both public and active transport without any clear preference for either,
- the respondents declaring at least three different means of transport, without a clearly defined dominant.

When individual respondents were assigned to predefined segments, it turned out that it was necessary to create one more segment for a group of seniors who chose the answer "not applicable" so often that it prevented their inclusion in any of the original six segments. The absence of information on whether the choice of the "not applicable" option was caused by unrealized (or unconscious) transportation needs or by the lack of need to travel for a specific purpose made it difficult to name a new segment—the final version of the expert segmentation labelled it as "other".

The distribution of the respondents based on their inclusion in the groups proposed in the expert segmentation is presented in Table 4.

Table 4 Distribution of the respondents based on their inclusion in the groups proposed in the expert segmentation

Class	Drivers	Passengers	Public transport	Active seniors	Hybrid segment	Different means of transport	Other
Percentage share	23	9	22.5	5	26.5	3.25	10.75

The largest group (26.5% of respondents) consists of respondents classified in the hybrid segment. They declare the use of public transport as well as active transport. The most numerous subgroup go shopping on foot (56.6%), while using public transport for social meetings (53.8%) and cultural events (66%).

In terms of size, the second largest group includes active drivers. They account for 23% of the respondents. In general, they tend to choose the option of using a car as a driver: when going shopping (87% of the group), for personal errands (87%), for cultural and entertainment events (68.5%), for social meetings (67.4%) or to reach a family member they provide care to (64.1%).

The next group, similar in size (22.5%), includes people who mainly use public transport. They tend to choose this particular means of transport for personal errands (87.8%), cultural and entertainment events (87.8%), social meetings (85.6%) and shopping (73.3%).

In the group of passengers (9% of the total number of respondents), the respondents declared most frequently that they travelled by car as a passenger for shopping (77.8%), social meetings (66.7%), cultural and entertainment events (63.9%) and personal errands (58.3%).

On the other hand, active seniors (5% of the total) generally declare to travel on foot: for personal errands (75% of the respondents in this group), social meetings (75%) and shopping (70%). The respondent seniors did not declare the bicycle as their frequent choice as a means of transport, but the vast majority of respondents who use a bicycle to travel are classified in this group.

As mentioned above, we also identified the segment of the respondents who use different means of transport, without a clear preference for one mode. The means that were indicated most frequently were the car (as a driver or a passenger), public transport and active transport.

As many as 10.75% of the respondents declared no transport needs in the majority of the analysed situations: either for shopping (62.85% of this group), or for personal errands (65.1%), not to mention sport and recreation (93%), culture and entertainment (79.1%) or social meetings (79.1%).

4.2 Main Findings of the Segmentation Using Taxonomic Methodology

As mentioned above, we performed cluster analysis on the same data set using Ward's hierarchical method. In this case, it is crucial to determine the optimal number of classes. This was done as a simulation, which involved clustering the respondents into k classes, where the values $k = 2, \ldots, 9$ were checked. Each time the Silhouette index was calculated and the results are presented in Table 5.

The calculated values of the I_S index allowed for the determination of the optimal number of classes. Although the highest value of the index was obtained for $k = 2$, the clustering of respondents into two classes only was considered

Table 5 Silhouette index I_S calculated for clustering the respondents into k classes

k	2	3	4	5	6	7	8	9
I_S	0.255	0.243	0.241	*0.251*	0.184	0.157	0.140	0.135

uninteresting and hindering further research. Preliminary analysis of the data set and the expert segmentation revealed a diversity of behaviours and preferences of elderly respondents when they were asked about their choice of the means of transport. The classification of the seniors into two groups meant that only a group of people travelling by car was separate from all the others. This would significantly reduce the possibility of discovering the real class structure and make it impossible to conduct further research (e.g. analysis of correspondence). Based on expert knowledge, the authors decided that the optimal solution would involve dividing the respondents into five groups, because the value of the Silhouette index for $k = 5$ was only slightly lower from its highest value (it was the second highest value).

Both in this case and in the case of $k = 2$, we can only say that a weak class structure has been found (Kaufman and Rousseeuw 2009), but it is typical of clustering objects described by variables measured on weak scales.

The distribution of the respondents into five groups using Ward's method is presented in Table 6.

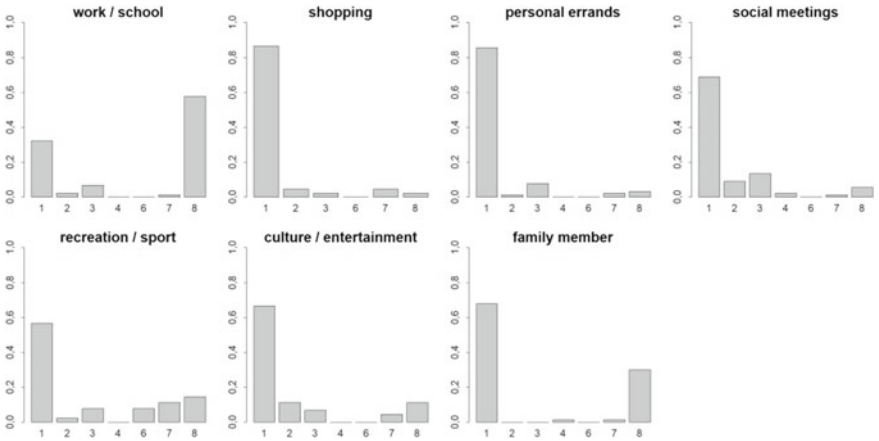
The first group consists of 22.5% of the respondents. The analysis of the answers of the respondents in this particular class to the questions used in the segmentation shows that the majority chose travelling by car as a driver (Fig. 1). This applies to most of their destinations: shopping (86.7%), personal errands (85.6%), social meetings (68.9%), visiting a family member they provide care to (67.8%), cultural and entertainment events (66.7%), sport and recreation (56.7%) and work or school (32.2%). Therefore, similarly to the expert segmentation, this group was labelled *active drivers*.

The second group includes only 6.25% of the respondents. The closer analysis of the distributions of their responses to the segmentation questions reveals that they mainly declare travelling by car, but as a passenger (Fig. 2). This way of travelling concerns mainly the following destinations: shopping (84%), social meetings (80%), personal errands (76%), cultural and entertainment events (72%), sport and recreation (48%). In the case of work- or school-related travels as well as when visiting a family member they provide care to, the dominant group of the respondents in this segment declared that those destinations did not apply to them.

The group was labelled *passengers* (*driver's partners*), similarly to the expert segmentation.

Table 6 Distribution of the respondents into five groups created using Ward's method

Class	1	2	3	4	5
Percentage share	22.5	6.25	43.25	13.75	14.25



(1 – car (as a driver), 2 – car (as a passenger), 3 – public transport, 4 – taxi, 5 – motorcycle, 6 – bicycle, 7 – walking, 8 – this destination do not apply)

Fig. 1 Distribution of the Class I respondents' answers to segmentation questions

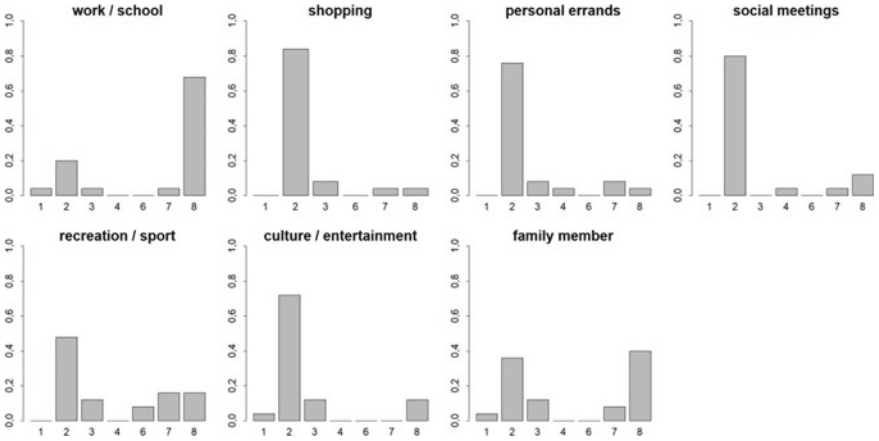


Fig. 2 Distribution of the Class II respondents' answers to segmentation questions

The third largest class includes 43.25% of the seniors participating in the survey. In this group, public transport is declared as the most frequently used means of transport for cultural and entertainment events (85.5%), social meetings (76.3%) and personal errands (68.2%). The respondents in this group usually go shopping by public transport (46.8%) or on foot (35.8%). Similarly, in the case of destinations related to sport and recreation, the most numerous subgroup includes those who declare using public transport (37%), but who also walk (21.4%). Notably, this

segment includes a large group of respondents declaring that the following destinations do not apply to them: work or school (52.6%), visits to a family member in need of care (53.8%), or sport and recreation (26%) (Fig. 3).

Given that the means of transport most frequently declared by the respondents classified in this segment is, nonetheless, public transport, we decided to label this group *public transport users*.

The next group includes 13.75% of the respondents. These are the seniors who, to a large extent, use active transport (Fig. 4). They walk mainly to social meetings (67.3%), personal errands (41.8%) or shopping destinations (40%). They declare to travel on foot (52.7%) and by bicycle (27.3%) to sport or recreation destinations.

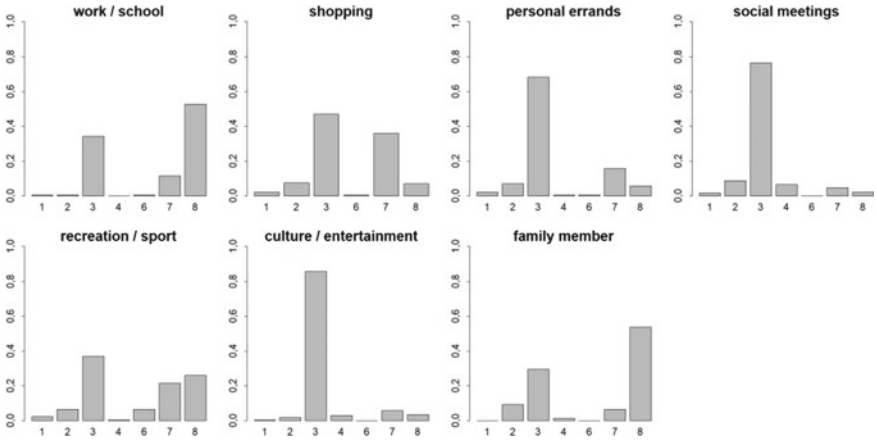


Fig. 3 Distribution of the Class III respondents' answers to segmentation questions

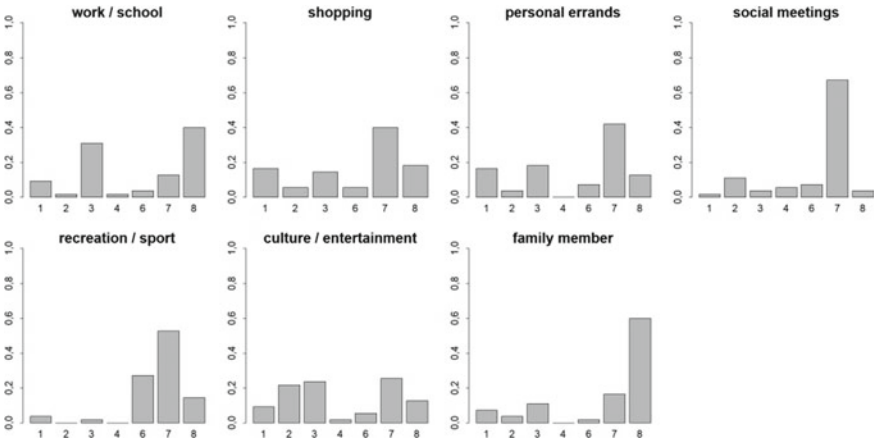


Fig. 4 Distribution of the Class IV respondents' answers to segmentation questions

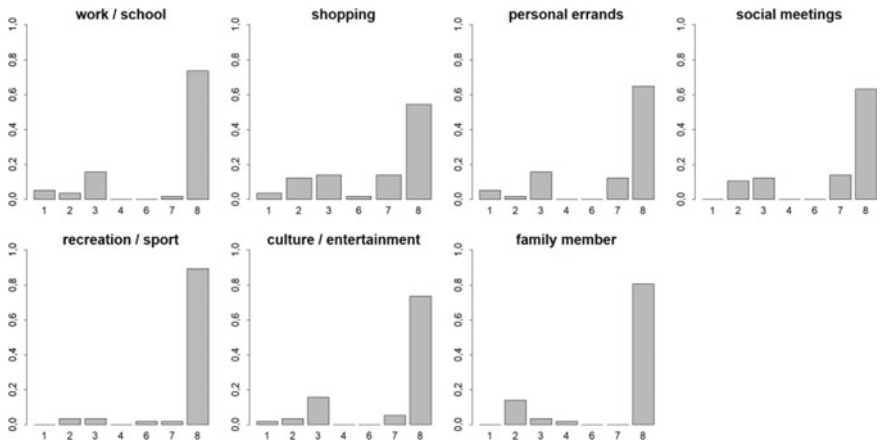


Fig. 5 Distribution of the Class V respondents' answers to segmentation questions

They usually get to work by public transport (30.9%), while in the case cultural and entertainment events, they tend to travel on foot (25.5%), by public transport (23.6%) or as a car passenger (21.8%). Nevertheless, these seniors are labelled *active*, also by analogy to the expert segmentation.

The last group includes 14.25% of the respondents. These are generally the seniors who declared no interest in travels related to sport and recreation (89.5%), visits to a family member they provide care to (80.7%), cultural and entertainment events (73.7%), personal errands (64.9%) or even shopping (54.5%) (Fig. 5). The respondents in this group claim that the destinations listed in the survey usually do not apply to them.

4.3 Comparison of the Two Segmentations

The aim of the analysis performed in the paper was to compare the two segmentations: expert and taxonomic.

The first step involved using the `classAgreement` function from the `e1071` package in **R** to calculate the value of the Rand index

$$R = 0.811. \tag{1}$$

It determines the similarity of two segmentations, which in this case can be interpreted as 81.1% of the pairs of objects classified to the same groups in both classifications. This value is at a satisfactory level.

In addition, the relationship between the results of the two segmentations was examined with the chi-squared test, and then the strength of the relationship was

measured using *V*–Cramer's coefficient (which is a normalized measure). The following results were obtained:

$$\chi^2(24) = 906.87;\ p - \text{value} = 0 \tag{2}$$

and

$$V = 0.753. \tag{3}$$

This means that a significant relationship exists between the classes obtained in the expert segmentation and the classes created by the algorithm in Ward's method. As a result, further examination is performed using analysis of correspondence, which will determine the relationships between particular classes of the two segmentations.

Analysis of correspondence is an exploratory technique used to examine the contingency table. It allows for the creation of the perception map, which illustrates relationships between categories of the variables under examination, which, in this case, are classes obtained as a result of the prior segmentation (Fig. 6).

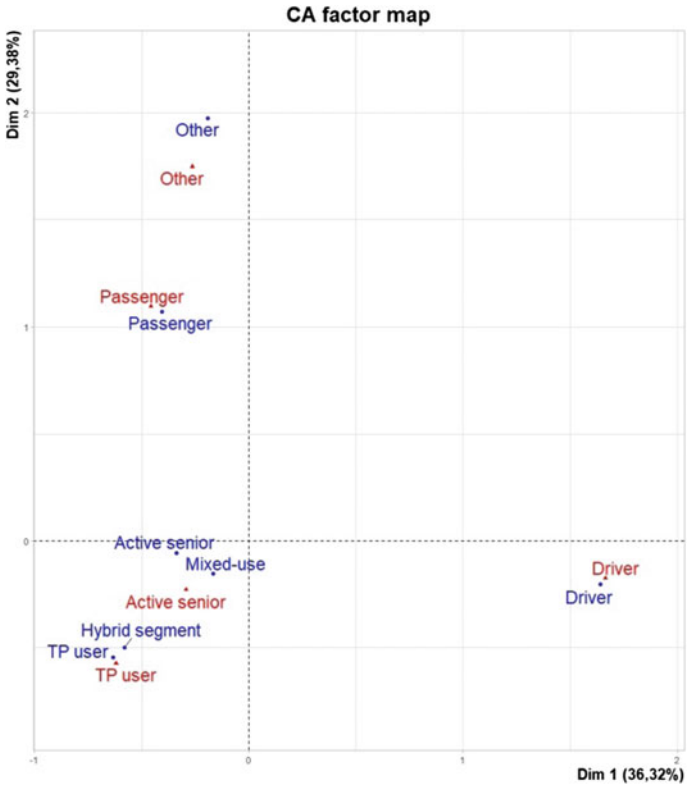


Fig. 6 Perception map illustrating the relationships between classes obtained as a result of the expert segmentation (blue labels) and classes obtained using the Ward's method (red labels)

Objects that are located close to each other on the perception map represent related categories of the variables under examination, in this case segments. It is clear that the classes of drivers are very similar to each other. Thus, it can be inferred that both the expert segmentation and cluster analysis classified the same seniors as drivers. The same applies to passengers (driver's partners). The classes of passengers, created as a result of two different segmentations, also tend to include the same respondents (70%).

The situation is slightly different in the case of the respondents who travel by public transport. The expert segmentation created two groups of respondents: one whose members declared that they chose this particular means of transport on a predominant basis and the other whose members travelled by public transport as often as on foot. The algorithm used in the Ward's method identified the respondents from the two groups as one class; therefore, the points representing these segments are located close to each other on the perception map. This can be treated as a recommendation for expert segmentation to combine those travelling by public transport and those belonging to the hybrid segment. This was considered in the process of analysis, but we decided not to combine the two classes due to the research assumptions that had been adopted.

A similar situation concerns the respondents using active transport. In this case, the perception map shows the links between the classes of the seniors travelling actively, identified as a result of the two segmentations, and the group of seniors classified by the expert as persons travelling by different means of transport. This group is the smallest in size, but it manifests a great variety of transport preferences. Despite the results of analysis of correspondence, the authors argue there are no grounds for including the group of highly mobile seniors, travelling by different means of transport, in the class of the respondents declaring to use mainly public transport.

The two groups including the respondents declaring that most travel destinations in the survey did not apply to them are also similar. Both segmentations classified most of such respondents into these two clusters (75%).

Despite some differences, discussed in the paper, the results of the two segmentations can be regarded as consistent and linked with each other to a relatively strong degree.

5 Conclusions

In the paper, two methods of segmentation of seniors in terms of their preferences for different means of transport were presented. The first called (for the purpose of this study) the expert one was based upon a simple assumption that the respondents should be divided according to the most frequently chosen means of transport for travelling to work, for shopping, pursing personal matters, social meetings and other purposes. Despite its simplicity, this may be considered to be an innovative approach, as the segmentations considered previously used various factors but

mostly focused on the car as the preferred means of transport. The second method was made using cluster analysis, using Ward's method and the Sokal–Michener metric, which is based on nominal variables. The aim of the study was to show that the results of both methods are consistent, which would support the validity of the proposed expert segmentation. For this purpose the Rand index was used, and this confirmed the good agreement between the two methods.

The analysis of the correspondence of the classes obtained in both cases showed a clear similarity; in both methods, drivers and passengers are the most separated groups. The study showed that in both approaches used, these two groups are very similar to each other.

Some differences are also noticeable, due to the different number of segments used by each method. Those differences related mainly to the group of people who travelled by public transport. Ward's method identified only one such group, while in the expert approach, people who mainly travel by public transport are separated from those who combine this way of travelling with active transport. The research, the results from which served as an input for the segmentation, was conducted on a sample of U3A students from several cities in the Silesian region. Depending on the spatial planning and development of a given area, not all of the indicated travel destinations may be present in the immediate vicinity of the respondent's place of residence. A compact and mix-used neighbourhood allows for the fulfilment of many needs using only pedestrian (or other types of active) transport, but in the case of less compact or single-use areas (i.e. only residential buildings in the near vicinity), it may be necessary to combine it with another mode of transport like car or public transport. Due to the study's anticipated higher number of women, who, according to the literature on the subject, are less often drivers than men and more often use public transport and walking, it was decided to include such a segment and referred to it in the paper as a hybrid one.

In the case of active transport, despite the different classification of this type of transport in each method (in the expert analysis, both walking and cycling were considered as means of active transport, while for Ward's method these were two separate categories), a certain similarity can be noticed.

The results obtained using Ward's method are closer to the classification in the form of four metasegments used by Haustein and Siren (2015). As already mentioned, according to the authors, this synthetic division is too general, and it would be advisable to break down some of these metagroups. Such an approach may result in potentially greater possibilities of using the proposed segmentation in practice (e.g. in facilitating the preparation of proposals and activities for specific groups of seniors interested in using a given means of transport).

It should be noted that this article is the first approach to the proposed expert segmentation. Expanding the research is possible by taking into account a more representative group of seniors, the most frequently used means of transport and relevant socio-demographic factors.

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