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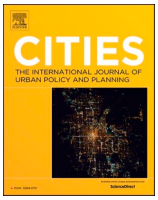

Envisioning the driverless city using backcasting and Q-methodology

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ABSTRACT

Despite the expected future introduction of autonomous vehicles in cities, very few studies have analysed the needs and challenges facing urban planning. This paper employs a combination of backcasting and Q-methodology to carry out participatory visioning for a future driverless city. This novel approach was used to elaborate shared visions of the desirable city among a group of 20 citizens and 10 practitioners. Views on 41 statements were analysed relating to urban design, society, environment, transport and mobility needs. Three main visions were identified. The first focuses on high-quality urban spaces and active mobility. The second vision is more futuristic and pro-social, consistent with the more imaginative and innovative stance of young people. The third vision is more conventional and closer to business-as-usual. The results suggest that there is some agreement on the future conditions and policies, especially on the need for environmentally friendly urban development and safe urban design. The article is premised on the belief that engaging stakeholders from different backgrounds, including citizens of various ages, can be enriching for urban planning since there is a wide variety of heterogeneous preferences across society. This requires a search for common ground when designing policy measures that satisfy multiple interests.

1. Introduction

In recent years, significant technological changes have directly affected the way cities are understood, planned, operated and managed. For example, the introduction and use of Information and Communications Technology (ICT), big data (Bibri & Krogstie, 2019), and various forms of artificial intelligence are significantly affecting urban transport systems (Cugurullo, 2020). One of the major changes that could be potentially very disruptive for cities is the introduction of autonomous vehicles (AVs), whose effects on urban form and land use may have direct impacts on the achievement of urban sustainable development goals and quality of life (González-González, Nogués, & Stead, 2019; Stead & Vaddadi, 2019).

Traditionally, when faced with the introduction of new means of transport, such as the automobile in the past, opinions of decision-makers and interest groups have had much greater influence on the development and implementation of technology in the urban environment than those of citizens, who were often more resistant to change (Norton, 2008). This dynamic may be repeated in the case of autonomous vehicles (especially automated cars) which often enjoy higher levels of support from governments and large technological companies than citizens. However, it is important to closely involve citizens in decisions that directly affect their environment and way of life if a common, sustainable and inclusive future for all is to be achieved (Yigitcanlar & Cugurullo, 2020).

In a context of uncertainty and transition, as in the case of AVs, most citizens (and many other stakeholders as well) do not have a clear opinion on the effects of the new disruptive elements on cities and regions. As such, their views are somewhat malleable (Cugurullo, Acheampong, Gueriau, & Dusparic, 2020), which can have both positive and negative implications. On one hand, pressures from large companies and governments to develop AVs to their full potential by campaigning only on their more optimistic side (Papa & Ferreira, 2018) can cause the negative impacts associated with the introduction of AVs to be overlooked, and thus the desired sustainability goals to be forgotten or underestimated as happened before with the automobile. On the other hand, future city goals can be approached more decisively from a citizen-centred perspective, with the citizens themselves defending these objectives and values over the AVs, choosing for schemes that enable the most positive to be drawn for both sides, conscious urban planning and a new, more comfortable and efficient mode of transport.

In this regard, it is therefore essential to implement planning

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processes that allow for the participation and involvement of different stakeholders, including citizens, in obtaining consensual and win-win future visions for the city, which also helps to support and embrace the decisions to be taken. Among current planning techniques, the participatory backcasting methodology presents a very useful approach to achieve this goal. This methodology, which has been developed since the 1970s, focuses on the elaboration of ideal future visions and allows the definition of the steps, decisions and measures needed to achieve them (Banister, Hickman, & Stead, 2007; Broman & Robèrt, 2017; Phdungsilp, 2011; Robinson, Burch, Talwar, O'Shea, & Walsh, 2011; Vergragt & Quist, 2011). Recent developments in this method allow participation to be incorporated into different stages of the process and involve different consultation groups. For example, stakeholders, social groups and citizens can participate in the definition of the ideal common future (visioning); and experts can be involved in both the identification of policy measures and paths (policy packaging) and their evaluation (appraisal) (Neuvonen & Ache, 2017; Phdungsilp, 2011; Robinson et al., 2011; Soria-Lara & Banister, 2017a, 2017b, 2018).

To date, studies using this methodology with the aim of planning the driverless city (i.e., a future city with a large or full implementation of autonomous mobility) are still scarce. These studies are mostly focused on the visioning phase, mainly under expert-led or think-tank schemes (González-González et al., 2019; González-González, Nogués, & Stead, 2020) or in specific cases applying a participatory approach using interviews with experts, surveys or focus groups techniques that generally provide qualitative analysis of the participants' responses (Nogués, González-González, & Cordera, 2020; Staricco, Rappazzo, Scudellari, & Vitale Brovarone, 2019). This study advances knowledge and understanding by using the participatory Q-methodology in the visioning phase of the backcasting. To the best of the authors' knowledge, this novel combination has not been used in this field so far. The Q-methodology lends statistical rigour to the process, while also making it possible to identify and clarify the heterogeneity of citizen and expert opinions (Curry, Barryb, & McClenaghanc, 2013; Krabbenborg, Molin, Annema, & van Wee, 2020).

The paper is divided into six main sections. Section 2 introduces the literature regarding planning methodologies, and more specifically the use of backcasting and Q-methodology in transport and urban planning fields, and visioning cities of the future. Sections 3 describes the combined participatory methodology proposed in the research, and its application to the case of the future vision of a middle-sized city. Section 4 summarises the statistical outcomes of the study, describing the frames or visions shared by groups of participants and highlighting the main differences between them. Section 5 discusses the results and finally Section 6 presents the main conclusions of the study.

2. Planning urban futures

2.1. Planning and participatory methodologies

There are three main types of planning methods that can be found in the literature on future studies, depending on whether they focus on predicting what will happen in the future (forecasting methods), what might happen (exploratory methods) and what planners want to happen (backcasting methods) (Banister & Hickman, 2013; Börjeson, Höjer, Dreborg, Ekvall, & Finnveden, 2006). Forecasting methods, which have a predictive character, try to identify general trends if no policy is implemented (Business-as-Usual) or under different scenarios or policies (what-if scenarios). In contrast, exploratory methods aim to identify the possible occurrence of different future scenarios, some of them being more or less unpredictable. Finally, backcasting methods have a more normative and proactive character, focusing on the construction of images of ideal futures and the possible policies that should be promoted to achieve them.

Both forecasting and exploratory methods have been extensively used in the field of urban and transport planning. Forecasting methods have relied in the use of simulation models of both transport (Ortúzar & Willumsen, 2011) and land use-transport interaction (LUTI) models to provide answers to questions about how the urban structure and the patterns of trip generation, trip distribution, modal choice and network assignment of transport demand will evolve. Meanwhile, exploratory planning has been used to generate an organised set of possible future scenarios, taking into account the main factors that may guide the system change, which may be both controllable and uncontrollable by the measures derived from the planning process (Hickman & Banister, 2014).

Due to the complexity of the issues at stake and the large-scale changes involved when considering urban transport futures, several authors have proposed methods which primarily focus on the desired outcome and on the multiple actions to be taken in combination (Banister & Hickman, 2013; Dreborg, 1996; Givoni, Macmillan, Banister, & Feitelson, 2013). In other words, they advocate a more proactive method with greater participation of different agents. Given these characteristics, many of the most recent studies in the urban and transport planning fields have turned to the use of backcasting methods (Banister et al., 2007; Bibri, 2018; Carlsson-Kanyama et al., 2003; Dixon, Montgomery, Horton-Baker, & Farrelly, 2018; Eames, Dixon, May, & Hunt, 2013; Höjer, Gullberg, & Pettersson, 2011; Neuvonen & Ache, 2017; Phdungsilp, 2011).

Within backcasting, different implementation techniques can be distinguished according to which actors are involved and the roles they have in the process. The content of the different parts of the planning process can be established by multidisciplinary teams of researchers and technicians (think-tank backcasting), by experts in the specific field being addressed (expert-led backcasting) or through broader consultations with experts, interest groups and the general public (participatory or collaborative backcasting) (Robinson et al., 2011). The use of participatory methods that include non-experts may be particularly appropriate in the phases of defining the desired future, especially when the current reality presents trends that need to be broken in order to achieve a qualitatively different target image.

Similarly, there are several participatory techniques that allow for the collection and analysis of the potential contributions of the different agents involved. These include the Delphi method (Hurmekoski, Pykäläinen, & Hetemäki, 2018; Soria-Lara & Banister, 2017a), focus groups (Hickman, Ashiru, & Banister, 2009; Soria-Lara & Banister, 2017b), workshops (Carlsson-Kanyama et al., 2003; Eames et al., 2013; Ortegón-Sánchez & Tyler, 2016), surveys (Nogués et al., 2020), and the Q-Method, among others.

Q-Method is a technique combining qualitative and quantitative approaches that allows the existence and characteristics of diverse points of view on a specific topic to be identified (Curry et al., 2013). Therefore, its aim is to detect subjective diverse statements rather than to demonstrate that these views are objectively present in the general public (Corr, 2001). Originally from the field of psychology (Stephenson, 1935; Watts & Stenner, 2005), this technique has now been applied to a multitude of fields, including urban and transport planning. One example is the work by Stapper, Van der Veen, and Janssen-Jansen (2020) in which the authors used the Q-method to obtain a typology of the ways in which planners involve citizens in the urban development process. The use of this method made it possible to determine the existence of three perspectives: more skeptical and focused on generating pre-development agreement with citizens; more optimistic and tending to involve citizens as much as possible in the process; and intermediate and trying to balance the interests of citizens and other stakeholders.

Brůhová Foltýnová, Vejchodská, Rybová, and Květoň (2020) have for example used the Q-method to clarify whether there were different views on sustainable urban mobility among different stakeholders. This allowed them to observe how under the same general idea of sustainable mobility there is some heterogeneity. One view is more focused on promoting public transport and restricting the use of cars, while another view is more oriented on promoting new transport infrastructure and

active mobility. A third view is focused on encouraging citizens to use public transport without restricting private transport. The method helped to identify that these views are not always wholly compatible.

These studies demonstrate how the application of the Q-Method to the visioning phase considering the existence of AVs can be useful to clarify whether there are several desired, compatible or even non-compatible, futures.

2.2. Planning AV futures

Despite the technological development of AVs, few studies have analysed the potential urban and spatial effects of AVs, especially the needs and challenges facing urban and spatial planning. Stead and Vaddadi (2019) conducted a review of the scientific literature in which they identified relatively few studies related to this particular topic, mostly focused on the use of exploratory methodologies, with only one using the backcasting method. Since then, a few other studies on backcasting and AVs have emerged, most of them focusing on the first phase — visioning. In one of these studies, González-González et al. (2019) carried out a theoretical visioning exercise consisting of a first identification of the most relevant and cited core goals for future cities as a result of the revision of international urban agendas, academic literature and participatory studies on city visions, and their contrast with the possible effects of AVs. By doing so, the study identifies the potential opportunities and conflicts that the introduction of AVs will entail.

In the same vein, Staricco et al. (2019) conducted an empirical visioning study for the city of Turin in the year 2050, assuming a full implementation of AVs. Three scenarios were developed, an optimistic one with little regulation of AVs, a pessimistic one associated with greater regulation of AVs and one related to Business as Usual (BAU). These three scenarios, elaborated by the research team comprising the consultation to urban and transport planners, transport engineers and sociologists, were validated by a focus group involving 7 local experts. The final selection phase of the vision involved the additional participation of 44 local stakeholders, through questionnaires and semi-structured interviews evaluating each of the 14 items selected by the researchers for the definition of the scenarios. The final chosen vision was the one with the highest regulation of AVs (45/51 consulted experts), which is also inspired by the superblock model (Rueda, 2019).

Regarding the second phase of the backcasting (i.e., policy packaging), González-González et al. (2020) developed an inventory of 34 regulatory, market-oriented, infrastructure-oriented and educational policy and planning measures to guide the transition and implementation of autonomous mobility in cities and territories. These measures are then organised into 8 packages and 3 policy paths in order to provide examples of actions for planners and policy makers to encourage them to start planning. These measures were subsequently evaluated in a new participative backcasting study (Nogués et al., 2020), focused on the third phase of the backcasting (i.e. appraisal), by means of a survey distributed to a group of 55 planning experts.

In another recent paper, the policy packaging phase is developed in a participative manner (Vitale Brovarone, Scudellari, & Staricco, 2021). At the same time as the local stakeholders were consulted to deliver the desirable vision (Staricco et al., 2019), they were questioned about possible planning measures to achieve it. From this consultation, the research team proposed a list of 18 measures that were subsequently discussed at a workshop with 8 of the consulted experts, resulting in a total of 33 key actions. These actions were grouped according to six themes and classified according to three main categories: policy, technology, and transformation of urban space, indicating the main actors involved and distributed along the 30-year timeline.

Very few studies can be found on the use of the Q-method in relation to AV studies. The most relevant ones are summarised below. First, a study by Milakis, Kroesen, and van Wee (2018) analysed the potential implications of AVs on accessibility and location choice. However, the Q-method was not applied in a classic way, since on the one hand the 38 statements were not obtained as opinions regarding the topic to be studied, but as possible effects of AVs on the chosen topic, drawn from the literature review of the expected AV impacts in various domains. Furthermore, the ranking and evaluation of the statements by the accessibility academics was not done on the basis of agreeing or disagreeing with them, but rather they were asked to rank certain assumptions (statements) in order of likelihood of occurrence. The academics were chosen from those researchers with at least 3 published articles on accessibility according to the Scopus database, of which 59 academics were identified and only 17 answered the questionnaire.

Second, a study by Zhou (2020) focused on views on the social effects of AVs in relation to four dimensions: economic development, energy consumption, social equity and public health. The author identified 43 statements from the revision of academic papers on the topic that were subsequently evaluated by 13 transport researchers at his university. Finally, three frames on the potential effects of AVs were identified: (1) the improved comfort and convenience generated by AVs will make people live further away from the urban centre, (2) AVs will increase social differences in the short term but will be accessible by all citizens in the long term, and (3) the improvements in terms of transport and environmental impacts generated by AVs will reinforce the economic dynamism of cities.

Third, a study by Lee and Ahn (2020) examined 34 statements from SAE Level-2 AV users with >3 months of experience. This consultation allowed the definition of 4 types of AV users: Active supporters, with high confidence on and willingness to purchase AVs; Technical acceptance type, that experience some anxiety but are satisfied with them; Dissatisfied with technology, users that are highly dissatisfied and find partially-AVs uncomfortable; and finally, Technology acceptance Anxiety type, a group that is particularly anxious about the possibility of the AV suddenly ceasing to operate while they are using it.

More recently, Ásványi, Miskolczi, Jászberényi, Kenesei, and Kökény (2022) aimed at knowing the opinions of tourism experts on the effects of AVs in the field. In this study the authors identified the existence of four groups of views among 21 tourist experts. These views ranged from an optimistic view about the future role of AVs on sightseeing services to a skeptical view on their deployment on this sector.

Finally, Tsigdinos, Tzouras, Bakogiannis, Kepaptsoglou, and Nikitas (2022), focusing on the design of future urban roads, identify four perspectives related to the transforming concepts pinpointed from a systematic literature review. Among the four groups of opinions, one alludes to AVs albeit skeptically about their potential to solve current transport problems. AV-sceptics prioritize active mobility, giving greater relevance to superblock-type schemes, and emphasize traffic segregation. In addition, the people-first techno-centrist group envisages AVs, although in this case it focuses on their shared use, and the opportunity they present to free up road space for people to use.

In summary, neither the backcasting planning technique nor the Q-method have been widely applied to the field of AVs. Moreover, their use together provides a novel contribution to scientific knowledge and an opportunity for the development and improvement of planning methods.

3. Participatory visioning using Q-methodology

In this study, the application of the Q-method within the visioning phase of the backcasting planning methodology aims to clarify the possible existence of different visions of the ideal future driverless city. Since reaching a consensual vision in the backcasting process can be difficult, the Q-method is primarily used to determine whether there are visions that may be conflicting or not consistent with each other. The application of the combined methodology was developed in five stages: definition of the key statements (Q-set); selection of the participants (P-set); ranking of the statements (Q-sort); factor analysis, in which the viewpoints are obtained and analysed; and, finally, the elaboration of the frames or visions of the future city.

3.1. Definition of key Q-set

The first step consisted of the identification of all possible statements that may reflect existing opinions on the research topic (Krabbenborg et al., 2020). This so-called 'concourse' (i.e., collection or set of statements) should contain many more statements than will eventually be presented to the selected participants. To this end, statements can be collected from sources on public debates on the topic, such as social media, or previous participation processes carried out for other studies. It is usually recommended in the methodological guidelines that the concourse presents three to four times more statements than those that will be finally selected in the so-called Q-set (Stainton Rogers, 1995).

The Q-set typically contains between 30 and 60 statements in such a way that it is manageable for participants to evaluate. These statements can be chosen from the concourse by various procedures, either randomly or by selecting statements that cover all aspects of the research topic (Průhová Foltýnová et al., 2020).

The main topic of this consultation was about envisioning an ideal city in 2050, concerning its urban form, the quality and attractiveness of its urban environment, the type of society, nature of activities, shopping, leisure activities, and the preferred transport mode and mobility. So, the Q-set was organised around three main categories to which were associated a set of questions that should be covered (Table 1) in order to guide the statement selection process.

Several sources were consulted for the elaboration of the first draft list of statements. An important group of these sources related to studies on strategic visions of cities, such as the works by Carlsson-Kanyama et al. (2003); Höjer et al. (2011); Mont et al., 2014; Joffe and Smith (2016); Ortegón-Sánchez and Tyler (2016); González-González et al. (2019) and Soria-Lara et al. (2021). Next, we also consulted research works that include visions of cities with the implementation of AVs, such as the ones by Staricco, Brovarone, and Scudellari (2020); Begg (2014) and DuPuis et al. (2015).

From this first review a total of 97 statements were collected, representing existing opinions and arguments on the topic. These were then reduced to a final number of 41 (Tables 2, 3 and 4), a more manageable figure for the inclusion in the Q-set. This number was chosen so as to have a sufficient number of statements to reflect the full spectrum of opinions and perspectives of the participants, while at the same time avoiding overloading them with an excessive number of statements to sort.

Table 1
Categories of the Q statements.

Statement category	Main questions to cover
Urban form and design	• What the urban design and land use of the future driverless city should look like? • Is it a more compact and mixed city or a mainly dispersed one? • How open and green areas look like in your city in 2050?
Society, economy and environment	• Is it an inclusive an equitable city? • How healthy are the citizens? • How attractive urban centres are for business and commerce activity? • How has public safety changed with the implementation of the autonomous vehicles?
Transport and mobility	• How the mobility of the future driverless city should be? • What is the priority transport mode in the city? • How much access is given to AVs in the city (especially urban centres)? • What is the used of motorised transport in the driverless city relative to other modes (walking, cycling, public transport, etc.)?

Table 2
Q sort statements on urban form and design (1–11).

N	Statements on the urban form and design of my desired future city
1	In every street there is enough space to walk safely, with safe social distance to other people, for cafés, cultural mini-spaces (e.g. parklets) due to the elimination of old curbs
2	In every neighbourhood, including those in the city centre, there are many open areas, such as squares, playgrounds, parks, sport and resting/meeting areas for children and the elderly, in spaces that have been freed from vehicle transit
3	The city has large open areas and green spaces, but they are located in some specific neighbourhoods and/or on the outskirts where there used to be large car parks, to which people can access by public or public transport
4	There are not many physical meeting areas and open spaces in the city, most interactions are online so there are virtual spaces and facilities
5	It is a compact city with a clear mix of land uses, housing has retail and basic services that can be reached by walking, cycling or public transport in <15 min
6	The population has grown enormously and most live in small dwellings in high-rise buildings (skyscrapers)
7	Most of the streets are green, naturalised, with trees, gardens…
8	There are specific pick-up and drop-off points for AV travelers, usually in the old bus shelters and in very important buildings/landmarks
9	AV users can get on and get off at any point, so there is plenty space for AVs, especially in the city centre where there is more vehicle transit
10	In every residential neighbourhood, within the city centre or on the outskirts, there are spaces or buildings reserved for parking private vehicles
11	AVs can only park and recharge on the outskirts of the city and neighbourhoods

Table 3
Q sort statements on society (12–26).

N	Statements of the society, economy and environment of my desired future city
12	Most of the shopping, leisure, facilities and working areas are located on the outskirts of the city, people do their shopping or pick up their orders on their way to work or home, and have to use a motorised mode of transport to access them
13	The city has new shopping and office areas in some inner-city neighbourhoods where there used to be large car parks
14	There are many mobile retail stores, inside AVs which can serve anywhere without the need for a physical store
15	The city has reserved downtown areas for agricultural activity, urban gardens, where there used to be large car parks
16	There is little commuting, no large office areas or buildings, because most citizens work at home (homeworking)
17	Delivery of goods is done on an individual basis to each citizen and house
18	Delivery of goods is made to collection points located in each neighbourhood that can reached on foot or by bicycle
19	As there is almost no vehicle traffic in the city centre and inside neighbourhoods, and AVs are connected and do not make mistakes, there are no traffic accidents and children can go on their own to school, their extracurricular activities…
20	Citizens are in very good health because they do most of their journeys on foot or by bicycle
21	There are many opportunities for door-to-door travel which has increased sedentary lifestyles, and consequently health problems
22	The city is equitable and inclusive, all citizens, including disabled, elderly, minorities or young people have the same accessibility opportunities to public services
23	Only a few citizens, the wealthiest, can afford private AVs, the rest can only access shared and active mobility (walking, cycling)
24	Many attractive peripheral residential areas have been developed, because the houses are individual and cheaper (further away) and have green space, even though they have to daily commute to the city centre by car and pay for the construction of infrastructures through green taxes
25	The cultural diversity of the neighbourhoods has been enhanced through the regeneration of spaces freed from car parking and transit, and the urban identity has been reinforced, creating a cultural richer city
26	As there are many private vehicles energy consumption is enormous and there are energy supply problems and cuts

3.2. Selection of the P-set

The P-set refers to the people chosen to assess the Q-set statements. The selection of this group depends on the objectives of the study, although a large number of participants is not necessary, since the Q-

Table 4
Q sort statements on transport and mobility (27–41).

N	Statements on the transport and mobility of my desired future city
27	In the city, pedestrians have priority over other modes of transport
28	Streets have a large number of spaces for bicycle transit and parking, and bicycles have priority when sharing the road with motorised vehicles
29	Goods delivery is mainly made on foot and by bicycle
30	Autonomous public transport is the priority mode, with a wide range of means (bus light rail, tram, etc.) and services, and is easily accessible in all neighbourhoods
31	Intermodality between public transport and private modes in user-friendly
32	Automobiles have priority in their journeys and the streets and roads are adapted to allow motorised traffic to flow as smoothly as possible
33	Any vehicle can circulate regardless of the pollutant emissions it produces
34	As there are many private vehicles, there are serious traffic and congestion problems
35	The mobility of electric vehicles is a priority and there are facilities and equipment adapted for their charging and use
36	Fully AVs coexist with vehicles that still allow driving
37	There are a large number of facilities and equipment adapted to the circulation and use of AVs
38	AVs have priority over other, non-autonomous modes
39	Private motorised mobility is restricted in some parts of the city (e.g., downtown area)
40	AVs are mainly shared, with several users on the same journey
41	Aerial mobility by drones for passengers and goods is widespread while streets are used for walking and cycling mobility

method seeks to establish the different views on a topic rather than the weight of these views among different segments of the population. A number of between 10 and 40 is usually recommended (Dryzek, 2005; Milakis et al., 2018; Zhou, 2020), although Q-method can be effective with a smaller number of individuals (Van Exel & de Graaf, 2005) as a different point of view can be pointed out even by a single individual (Watts & Stenner, 2005). It is still advisable that any view is supported by more than one individual to demonstrate that the view is not merely subjective but is therefore relevant from a social and planning standpoint.

As regards the typology of participants, some authors argue that participants should be involved or familiar with the topic, in order to provide well-informed opinions (Kougias, Nikitas, Thiel, & Szabó, 2020). However, given that the main goal is to develop city visions that can be embraced by the population, this study focuses on the consultation to both citizens and experts, although with greater proportion of the former. This was done also in order to capture other city visions besides those conditioned by the views of current trends in academic or practical urbanism and transport planning. Furthermore, as mentioned before, the studies on backcasting driverless cities carried out to date have focused participation on experts and stakeholders' consultation, and we believe that including also citizen participation is essential in this first planning phase.

In this study the desired number of participants was set at 30 people, including 20 citizens and 10 experts in urban and transport planning from the Autonomous Community of Cantabria, in North Spain. It is a region whose capital, Santander, is a medium-sized city with a total population of 173,375 inhabitants in 2020 (INE, 2020). In conducting the study, it was not indicated that the vision was to be carried out specifically for this city, but for a generic city with similar characteristics to this one. This implies a compact and mixed city that basically develops tertiary functions, given its role as a regional capital, and which is undergoing a process of urban dispersion that may be affected by the arrival of autonomous vehicles. The majority of daily trips are made on foot, with >47 % of the modal split, although work-related trips are mainly made by car (SUM^{+}Lab, 2015).

The survey was conducted in a participatory session on mid-July 2021. The P-set sought to include as diverge a range of people as possible, selecting potential participants on the basis of gender (-50 % male; -50 % female), socio-economic status, age and affiliation (Table 5), which could provide a broad spectrum of public opinion on the topic. A representation of people younger than 20 years (35 %) was specifically selected given that younger people have more of an interest in 2050 than older people and because previous studies highlight their suitability to imagine more creative and disruptive futures (Soria-Lara et al., 2021; Tuominen, Tapio, Varho, Järvi, & Banister, 2014). In order to capture other views of people whose commuting is related to work, having children, etc., we have also included other population cohorts with a maximum age of 65 years-old, given that by 2050 these people would outlive their life expectancy.

The experts were evenly split between the two main fields of work: urban/spatial planning and transport planning. As regards the professional profile, 40 % come from academia and 60 % from the public and private sectors. All experts and most citizens (80 %) had some prior familiarity with this subject.

3.3. Q-sorting, interpreting viewpoints and visioning

In any Q-sorting phase, the participants are asked to sort the selected statements of the Q-set according to their degree of approval or opposition (Krabbenborg et al., 2020). A common practice to facilitate this sorting task by individuals is to perform a partial sorting using a forced pyramid-type distribution (Curry et al., 2013). It has been shown that this sorting technique, easier for participants, in a quasi-normal distribution, does not influence the elicitation of the different views and is no more restrictive than an unforced distribution (Brown, 1980). After this process, each selected individual will be represented by a Q-sort (i.e., a complete ordering of the Q-set statements).

In this study, each participant was asked to place the 41 statements across boxes in a pyramid-type chart (Fig. 1) according to a scale ranging from strongly agree (+5) to strongly disagree (−5).

In the next phase, the correlation between the Q-sorts is performed and Principal Component Analysis (PCA) is applied to extract the components that group similar response configurations made by the participants. Thus, each component will reflect different item configurations that are shared by different individuals. The matrix is then rotated, usually using the Varimax method, to obtain orthogonal factors that are easier to interpret. In this case the coefficients indicate the degree to which each individual/Q-sort can fit into each viewpoint but minimising the number of viewpoints with high loadings for the same individual. Finally, the scores of each statement in each component are

Table 5
Characteristic of the people surveyed.

Experts (n = 10)			Citizens (n = 20)			All (n = 30)
Field of work	Urban/spatial planning	50 %	Gender	Male	40 %	50 %
	Transportation planning	50 %		Female	60 %	50 %
Professional profile	Academic world	40 %	Age	≤20	35 %	23.30 %
				21–35	35 %	33.30 %
	Public and private sector	60 %		36–50	15 %	30 %
				51–65	15 %	13.30 %
Degree of knowledge about AVs	I have heard about the subject	100 %	Degree of knowledge about AVs	I have heard about the subject	80 %	86.70 %
	I have worked on it	0 %		I have worked on it	0 %	0 %
	I know nothing about it	0 %		I know nothing about it	20 %	13.30 %

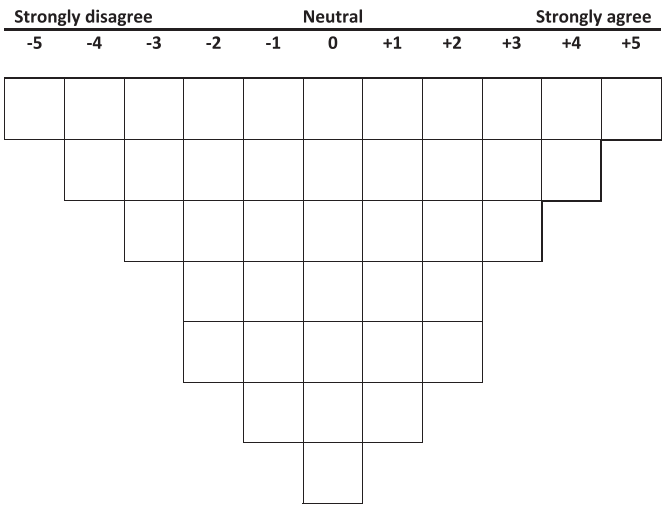

Fig. 1. Forced distribution to partial sorting the 41 statements.

calculated, so that the meaning of each viewpoint can be interpreted according to the statements to which it is most related. All this process was carried out using the software KADE v1.2 (Banasick, 2019).

In the last phase, the final visions are elaborated. The obtained z scores give an idea of which statements were most relevant and then what to call each perspective (frame). The frame is not the result of a single view but rather an idealised view shared by a group of participants (Kougias et al., 2020). The aim is to structure the variety of individual perspectives into common discourses in order to compare the differences and similarities between groups. In this way, a typology of opinions can be constructed, analysing the main statements that characterize their ideal city.

4. Results

4.1. Statistical results

The PCA showed eight factors among the responses with eigenvalues >1 and a total explained variance of 81 % (Table 6). The first factor presented the highest explained variance with 45 % of the total and an eigenvalue of 13.4. After factor rotation using the Varimax method, a total of eleven individuals were loaded on Factor 1, of which nine were purely and significantly loaded (p-value < 0.05). Factor 2 presented eight individuals with three of them loading purely and significantly. Factor 4 grouped two individuals, in both cases with statistically significant pure loadings. Factors 3 and 5, on the other hand, presented only one individual with a pure and significant loading. Finally, factor 6 presented two individuals, although only one of them was purely and significantly loaded, while factors 7 and 8 did not present any purely loaded individual. Since Q studies generally apply the criterion that for a factor to be accepted as a valid frame it must have two or more significantly fully loaded individuals (Rajé, 2007), factors 1, 2 and 4 were considered to represent frames to be analysed, while factors 3, 5, 6, 7 and 8 were excluded from the subsequent analysis.

4.2. Visions of the future driverless city

4.2.1. Frame 1: factor 1 — citizen-centred urban regeneration, open spaces and sustainable mobility

This frame is the one with the highest variance as in all Q-method analyses. In other words, it is the most common view among participants. As shown in the factors loading table (Table 6), 11 participants belong to this group (37 % of the respondents), of which a total of 9 were

Table 6
Factor loadings matrix.

Respondents/sorts	Factors							
	1	2	3	4	5	6	7	8
1	0.46	0.56	−0.04	0.34	0.07	0.04	−0.01	0.31
2	0.43	0.20	0.09	−0.10	−0.05	0.42	0.34	0.43
3	0.49	0.48	0.03	0.45	−0.05	0.04	−0.11	−0.10
4	0.52	0.67*	0.21	−0.04	0.00	0.17	0.14	0.09
5	0.80*	0.20	−0.14	0.08	−0.06	0.10	−0.06	0.16
6	0.20	0.57	0.04	0.39	0.36	0.05	0.37	0.08
7	0.78*	0.28	0.01	0.10	−0.11	0.15	0.12	0.14
8	0.32	0.79*	0.08	0.16	0.13	0.19	0.15	0.11
9	0.55	0.33	−0.12	0.30	0.17	0.06	0.10	0.37
10	0.23	0.12	0.16	0.30	−0.13	−0.03	0.80*	−0.05
11	0.03	0.59*	−0.39	−0.08	0.06	0.32	−0.05	−0.03
12	0.86*	0.04	−0.10	0.10	0.01	0.13	0.25	−0.09
13	0.30	0.33	−0.14	0.73*	−0.08	0.21	0.19	0.01
14	0.18	0.40	0.24	0.42	0.14	0.33	0.49	−0.01
15	0.21	−0.14	0.30	0.73*	0.08	−0.07	0.05	0.22
16	0.66*	0.04	−0.23	0.18	0.48	0.10	0.26	−0.15
17	0.76*	0.32	0.16	0.24	−0.13	−0.11	0.25	0.13
18	0.72*	0.31	−0.12	0.21	0.13	−0.23	0.22	0.23
19	0.11	0.18	−0.45	0.42	0.09	0.46	0.17	0.29
20	0.78*	0.26	0.21	0.26	0.24	0.08	0.19	0.02
21	0.53	0.56	−0.17	0.20	0.15	−0.05	0.21	0.12
22	0.41	0.64	−0.07	−0.12	0.16	0.20	0.43	0.10
23	0.14	0.23	−0.01	0.08	0.12	0.85*	0.06	0.05
24	0.38	0.44	−0.43	0.05	0.30	0.14	0.22	0.33
25	−0.04	0.17	0.06	0.00	0.85*	0.09	−0.01	0.10
26	0.36	0.13	−0.13	−0.18	0.35	0.18	0.62	0.16
27	−0.05	0.05	0.85*	0.12	0.06	0.04	0.12	−0.07
28	0.17	0.08	−0.11	0.14	0.10	0.06	−0.02	0.85*
29	0.77*	0.32	−0.10	0.05	0.01	0.18	0.28	0.24
30	0.73*	0.09	0.04	0.14	0.34	0.37	−0.01	0.23
Eigenvalue	13.41	2.30	1.97	1.53	1.37	1.14	1.11	1.01
% exp. variance	45	8	7	5	5	4	4	3

* Statistically significant (p-value < 0.05).

purely loaded on this factor. This group, which includes 50 % of the experts and 30 % of the citizens, was made up mainly of people in the 36–50 age group, women predominate over men and most of them loaded significantly on this factor. In contrast to the participants who have somewhat extreme views (agree or disagree), those who have a neutral or almost neutral attitude towards the group's distinctive statements prevail, with the most neutral being those of the experts.

The desired city is very focused on the citizen, especially on pedestrians (statement 27 — ST27), space for individuals (ST1) and the naturalisation of streets and urban spaces in each neighbourhood through open and green spaces obtained from former large on-street car parks and curbs (ST2) (Table 7). In addition, sustainable mobility is promoted through cycling (ST28) and the circulation of private vehicles is restricted in the city centre (ST39). In fact, the prioritisation of motorised and private vehicles is one of the most penalised aspects in this frame (ST32), not allowing the circulation of polluting vehicles (ST33), avoiding reserving spaces in neighbourhoods and in the centre for car parking (ST10) and not allowing AVs to pick-up and drop-off passengers everywhere (ST9). Peripheral residential development in sprawl (ST24) is viewed negatively, as is the fact that most work is done by homeworking (ST16).

Participants in this group are neutral on electric mobility and its facilities/parking areas (ST35), on AV facilities (ST11), on air mobility (ST41) and on agricultural activity in the city centre (ST15).

In summary, this group's vision of the city of the future is one of a greener, citizen-centred city, in which public space is very important and the individual is the focus of all policies.

4.2.2. *Frame 2: factor 2 — future-oriented but with social conscience*

This view is shared by 27 % of the P-set (8 participants), although most of the participants' sorts were mixed with significant loadings on more than one factor, especially factor 2. Most of the participants belonging to this future oriented group are non-expert men aged 35 or below, which supports the idea that this type of people can provide more radical views on the future. In general, both male and female respondents gave answers closer to neutral views, although the most categorical opinions on the statements were given by women, especially on the side of disagreement with the circulation of vehicles regardless of their level of pollution.

The desired city is based on innovations such as air mobility for passengers and goods (ST41) (Table 8) and itinerant shops (ST17), although at the same time, those who are classified in this frame do not like the idea of virtual spaces being the majority for social interaction (ST4). These innovations are welcome, but they maintain the importance of equity and inclusivity for all citizens (ST22), as well as public health through active mobility (ST20) and, to a lesser extent, cultural diversity (ST25). The development of open and green spaces in each neighbourhood (ST2) is preferred, and there is a commitment to safety by restricting access of motorised traffic in the neighbourhoods (ST19). Even so, there are some features linked to private vehicles that are seen as positive, such as the individualised delivery of goods to households (ST17) and the freedom to get on and off of AV at any point in the city (ST9).

In this frame, people are very critical of the circulation of any vehicle regardless of its pollutant emissions (ST33), of too many private vehicles (ST34) and, to a lesser extent, of the priority given to electric mobility (ST35), although they do not like carsharing (ST40) or the allocation of space for bicycles (ST28).

They are neutral on sustainable freight delivery (ST18), as well as on the creation of green spaces and parking in the suburbs (ST3), and agricultural activity in the city centre (ST15).

This group therefore presents the most ground-breaking view with the current situation, seeing several technological innovations in a positive light. However, this does not mean that this vision renounces aspects of social equity, public health and the environment, although they do not advocate sharing journeys in the same vehicle with other users, an aspect that has been considered fundamental in the literature on AV in order to foster their potential positive effects.

Table 7
Standardized scores of the statements of factor 1 ranked higher and lower than in other factors.

N	Statement	Factor 1
Positive statements ranked higher than in other factors		
27	In the city, pedestrians have priority over other modes of transport	1.8**
1	In every street there is enough space to walk safely, with safe social distance to other people, for cafés, cultural mini-spaces (i.e., parklets) due to the elimination of old curbs	1.51
2	In every neighbourhood, including those in the city centre, there are many open areas, such as squares, playgrounds, parks, sport and resting/meeting areas for children and the elderly, in spaces that have been freed from vehicle transit	1.48
7	Most of the streets are green, naturalised, with trees, gardens…	1.43
28	Streets have a large number of spaces for bicycle transit and parking, and bicycles have priority when sharing the road with motorised vehicles	1.37**
39	Private motorised mobility is restricted in some parts of the city (e.g., downtown area)	1.34**
19	As there is almost no vehicle traffic in the city centre and inside neighbourhoods, and AVs are connected and do not make mistakes, there are no traffic accidents and children can go on their own to school, their extracurricular activities…	0.97
25	The cultural diversity of the neighbourhoods has been enhanced through the regeneration of spaces freed from car parking and transit, and the urban identity has been reinforced, creating a cultural richer city	0.67
13	The city has new shopping and office areas in some inner-city neighbourhoods where there used to be large car parks	0.66
35	The mobility of electric vehicles is a priority and there are facilities and equipment adapted for their charging and use	0.22
29	Goods delivery is mainly made on foot and by bicycle	0.06
37	There are a large number of facilities and equipment adapted to the circulation and use of AVs	−0.21
Negative statements ranked lower than in other factors		
15	The city has reserved downtown areas for agricultural activity, urban gardens, where there used to be large car parks	0.17
11	AVs can only park and recharge on the outskirts of the city and neighbourhoods	−0.11
41	Aerial mobility by drones for passengers and goods is widespread while streets are used for walking and cycling mobility	−0.15
24	Many attractive peripheral residential areas have been developed, because the houses are individual and cheaper (further away) and have green space, even though they have to daily commute to the city centre by car and pay for the construction of infrastructures through green taxes	−0.62
10	In every residential neighbourhood, within the city centre or on the outskirts, there are spaces or buildings reserved for parking private vehicles	−0.62**
16	There is little commuting, no large office areas or buildings, because most citizens work at home (homeworking)	−0.96**
9	AV users can get on and get off at any point, so there is plenty space for AVs, especially in the city centre where there is more vehicle transit	−1.04**
23	Only a few citizens, the wealthiest, can afford private AVs, the rest can only access shared and active mobility (walking, cycling)	−1.16
26	As there are many private vehicles energy consumption is enormous and there are energy supply problems and cuts	−1.48
32	Automobiles have priority in their journeys and the streets and roads are adapted to allow motorised traffic to flow as smoothly as possible	−1.62*
33	Any vehicle can circulate regardless of the pollutant emissions it produces	−1.66

* Statistically significant distinguish factor ($p < 0.05$).
** Statistically significant distinguish factor ($p < 0.01$).

4.2.3. *Frame 3: factor 4 — intermodality and pro status quo*

This final viewpoint is shared by the lower number of participants, in particular 2 respondents representing 7 % of the P-set, being represented

Table 8
Standardized scores of the statements of factor 2 ranked higher and lower than in other factors.

N	Statement	Factor 2
Positive statements ranked higher than in other factors		
41	Aerial mobility by drones for passengers and goods is widespread while streets are used for walking and cycling mobility	2.06**
22	The city is equitable and inclusive, all citizens, including disabled, elderly, minorities or young people have the same accessibility opportunities to public services	1.99*
2	In every neighbourhood, including those in the city centre, there are many open areas, such as squares, playgrounds, parks, sport and resting/meeting areas for children and the elderly, in spaces that have been freed from vehicle transit	1.52
20	Citizens are in very good health because they do most of their journeys on foot or by bicycle	1.09
17	Delivery of goods is done on an individual basis to each citizen and house	0.97**
19	As there is almost no vehicle traffic in the city centre and inside neighbourhoods, and AVs are connected and do not make mistakes, there are no traffic accidents and children can go on their own to school, their extracurricular activities…	0.88
25	The cultural diversity of the neighbourhoods has been enhanced through the regeneration of spaces freed from car parking and transit, and the urban identity has been reinforced, creating a cultural richer city	0.73
13	The city has new shopping and office areas in some inner-city neighbourhoods where there used to be large car parks	0.65
14	There are many mobile retail stores, inside AVs which can serve anywhere without the need for a physical store	0.65**
9	AV users can get on and get off at any point, so there is plenty space for AVs, especially in the city centre where there is more vehicle transit	0.26
3	The city has large open areas and green spaces, but they are located in some specific neighbourhoods and/or on the outskirts where there used to be large car parks, to which people can access by public or public transport	0.15*
29	Goods delivery is mainly made on foot and by bicycle	0.1
Negative statements ranked lower than in other factors		
31	Intermodality between public transport and private modes in user-friendly	0.18
15	The city has reserved downtown areas for agricultural activity, urban gardens, where there used to be large car parks	−0.04
8	There are specific pick-up and drop-off points for AV travelers, usually in the old bus shelters and in very important buildings/ landmarks	−0.1
18	Delivery of goods is made to collection points located in each neighbourhood that can reached on foot or by bicycle	−0.12*
11	AVs can only park and recharge on the outskirts of the city and neighbourhoods	−0.25
35	The mobility of electric vehicles is a priority and there are facilities and equipment adapted for their charging and use	−0.26
37	There are a large number of facilities and equipment adapted to the circulation and use of AVs	−0.4
24	Many attractive peripheral residential areas have been developed, because the houses are individual and cheaper (further away) and have green space, even though they have to daily commute to the city centre by car and pay for the construction of infrastructures through green taxes	−0.51
28	Streets have a large number of spaces for bicycle transit and parking, and bicycles have priority when sharing the road with motorised vehicles	−0.61*
36	Fully AVs coexist with vehicles that still allow driving	−0.76*
39	Private motorised mobility is restricted in some parts of the city (e.g., downtown area)	−0.83
38	AVs have priority over other, non-autonomous modes	−0.87
40	AVs are mainly shared, with several users on the same journey	−0.98**
21	There are many opportunities for door-to-door travel which has increased sedentary lifestyles, and consequently health problems	−1.2
23	Only a few citizens, the wealthiest, can afford private AVs, the rest can only access shared and active mobility (walking, cycling)	−1.29
4	There are not many physical meeting areas and open spaces in the city, most interactions are online so there are virtual spaces and facilities	−1.53
34	As there are many private vehicles, there are serious traffic and congestion problems	−1.66
33	Any vehicle can circulate regardless of the pollutant emissions it produces	−2.17

* Statistically significant distinguish factor ($p < 0.05$).
** Statistically significant distinguish factor ($p < 0.01$).

by people of both sexes between 35 and 40 years of age, both purely loaded on factor 4.

The desired city is compact and with a mix of land uses (ST5) (Table 9), although it also has some peripheral urban development that is restricted by means of green taxes (ST24). Most of the population work from home (ST16) and when they need to move around, they do so by public transport (ST30) or shared transport (ST40), in an efficient and easy intermodal system for the population (ST31) (negative in terms of many private vehicles due to energy issues). There are specific areas for boarding and alighting AVs (ST8), and dedicated spaces in neighbourhoods for these vehicles (ST10). AVs share road infrastructure with manually-driven vehicles (ST36). Goods are collected at specific points in the neighbourhoods that are accessible on foot or by bicycle (ST18), and door-to-door deliveries are limited. Leisure spaces, facilities and green spaces are spread throughout the urban core but are not necessarily located in every neighbourhood.

They are neutral on AVs facilities and priority (ST37, ST38) and electric mobility (ST35), but also on pedestrian mobility (ST27). Also, in relation to technological and social innovations such as air mobility (ST41) and allowing parking only in the suburbs (ST11).

This group has to some extent a predominant transport perspective, and a conventional and business-as-usual vision of the desired city, neutral views predominate among the members of the group, which is why they have been referred to as *Intermodality and pro status quo*.

5. Discussion

This paper has explored the visions of the future driverless city desired by different stakeholders, including citizens and urban and transport planning experts at the same time, using a novel combination of two techniques, backcasting planning and the Q-method.

Recent research on urban planning in the context of AVs has started to draw on backcasting approaches (González-González et al., 2019, 2020; Nogués et al., 2020; Staricco et al., 2019; Vitale Brovarone et al., 2021). This methodology has mostly been applied in the first phase of visioning and has sometimes considered participation, but usually with the involvement of experts or academics. This article adds the consultation of citizens during this first stage, promoting public participation in planning, in line with the achievement of sustainable development goals adopted by the United Nations.

The inclusion of diverse stakeholders with different interests makes the backcasting planning objective of obtaining an agreed ideal future vision very complex. The combination with the Q-method allows part of this problem to be solved, while giving statistical rigour to the process. The aim of the method is to identifying the different perspectives present in the groups of people consulted (Corr, 2001; Curry et al., 2013). During the process incompatible or conflicting perspectives can be found (Ásványi et al., 2022; Brůhová Foltýnová et al., 2020; Lee and Ahn, 2020; Stapper et al., 2020; Zhou, 2020), as well as inconsistencies within the groups themselves and common points of agreement (Brůhová Foltýnová et al., 2020; Curry et al., 2013; Milakis et al., 2018).

The analysis conducted in this study identified three main views on the desired city of the future with autonomous vehicles. The majority of respondents opted for visions 1 and 2, with only a very small number opting for the third vision, which is considered the business-as-usual, the most conventional one.

Table 9
Standardized scores of the statements of factor 4 ranked higher and lower than in other factors.

N	Statement	Factor 4
Positive statements ranked higher than in other factors		
5	It is a compact city with a clear mix of land uses, housing has retail and basic services that can be reached by walking, cycling or public transport in <15 min	1.99
8	There are specific pick-up and drop-off points for AV travelers, usually in the old bus shelters and in very important buildings/ landmarks	1.98**
16	There is little commuting, no large office areas or buildings, because most citizens work at home (homeworking)	1.49**
40	AVs are mainly shared, with several users on the same journey	1.49**
30	Autonomous public transport is the priority mode, with a wide range of means (bus light rail, tram, etc.) and services, and is easily accessible in all neighbourhoods	1.25
18	Delivery of goods is made to collection points located in each neighbourhood that can reached on foot or by bicycle	0.99
24	Many attractive peripheral residential areas have been developed, because the houses are individual and cheaper (further away) and have green space, even though they have to daily commute to the city centre by car and pay for the construction of infrastructures through green taxes	0.99**
10	In every residential neighbourhood, within the city centre or on the outskirts, there are spaces or buildings reserved for parking private vehicles	0.99
31	Intermodality between public transport and private modes in user-friendly	0.75
15	The city has reserved downtown areas for agricultural activity, urban gardens, where there used to be large car parks	0.5
9	AV users can get on and get off at any point, so there is plenty space for AVs, especially in the city centre where there is more vehicle transit	0.49
36	Fully AVs coexist with vehicles that still allow driving	0.25
37	There are a large number of facilities and equipment adapted to the circulation and use of AVs	0.25
35	The mobility of electric vehicles is a priority and there are facilities and equipment adapted for their charging and use	0
38	AVs have priority over other, non-autonomous modes	−0.25
Negative statements ranked lower than in other factors		
27	In the city, pedestrians have priority over other modes of transport	0.24
41	Aerial mobility by drones for passengers and goods is widespread while streets are used for walking and cycling mobility	0
11	AVs can only park and recharge on the outskirts of the city and neighbourhoods	0
25	The cultural diversity of the neighbourhoods has been enhanced through the regeneration of spaces freed from car parking and transit, and the urban identity has been reinforced, creating a cultural richer city	−0.74**
2	In every neighbourhood, including those in the city centre, there are many open areas, such as squares, playgrounds, parks, sport and resting/meeting areas for children and the elderly, in spaces that have been freed from vehicle transit	−0.74**
29	Goods delivery is mainly made on foot and by bicycle	−0.74
13	The city has new shopping and office areas in some inner-city neighbourhoods where there used to be large car parks	−0.75**
14	There are many mobile retail stores, inside AVs which can serve anywhere without the need for a physical store	−0.99
3	The city has large open areas and green spaces, but they are located in some specific neighbourhoods and/or on the outskirts where there used to be large car parks, to which people can access by public or public transport	−1.23*
12	Most of the shopping, leisure, facilities and working areas are located on the outskirts of the city, people do their shopping or pick up their orders on their way to work or home, and have to use a motorised mode of transport to access them	−1.24
17	Delivery of goods is done on an individual basis to each citizen and house	−1.49*
26	As there are many private vehicles energy consumption is enormous and there are energy supply problems and cuts	−1.49
6	The population has grown enormously and most live in small dwellings in high-rise buildings (skyscrapers)	−1.74

* Statistically significant distinguish factor ($p < 0.05$).

** Statistically significant distinguish factor ($p < 0.01$).

Vision 1, which has a predominant women perspective and is the one chosen by the majority of experts and a relevant part of the citizens (30 %), is committed to a people-centre city with high-quality urban open spaces and active and sustainable mobility, as well as to restrict access to vehicle circulation, proving to be the option most in line with the visions and sustainable goals currently advocated by the scientific literature (Carlsson-Kanyama et al., 2003; González-González et al., 2019, 2020; Vitale Brovarone et al., 2021). This perspective reinforces the one identified by Tsigdinos et al. (2022), in which *People-first techno-centrists* see technology, such as AVs, as an engine to help achieve a more anthropocentric and liveable cities.

Vision 2 has a more pro-social content and futuristic perspective than the others, which is consistent with the most disruptive stance of young people, who are assumed to have a greater capacity to imagine disruptive visions of the future (Tuominen et al., 2014; Soria-Lara et al., 2021). This group shows some incongruities, such as being very critical of the existence of too many private cars, but at the same time advocating the freedom to get on and off of an AV at any point in the city and declaring themselves against car sharing. The latter issue seems to be contrary to studies that claim that younger people are more likely and more clearly supportive of shared mobility (Krueger, Rashidi, & Rose, 2016). This may be due, on one hand, to the recent *SARS*-CoV-2 (Covid-19) pandemic, which has affected the perception of car sharing and public transport use (Shokouhyar, Shokoohyar, Sobhani, & Gorizi, 2021) and, on the other hand, to the fact that the focus of the study is on medium-sized cities, where shared services are not as present as in large cities.

Finally, Vision 3, whose supporters show attitudes oriented towards maintaining the '*status quo*'. This group focuses the most on the transportation statements than on social or urban design aspects. These participants desire a compact and land use diverse city, while also allowing for peripheral development. They advocate for the use of shared transportation, including AVs, in contrast with group 2, and envisage the compatibility of driving with conventional, manually-driven vehicles.

The results suggest that, although differences in the viewpoints are conditioned by diverse factors, such as age, gender and degree of knowledge, there is also considerable room for possible agreement on the future. In general, there is more consensus on the side of disagreement (i.e., on what is not desired for the city of the future), which has important implications in the formulation of planning policies. In particular, it seems that respondents are aware of the importance of protecting the environment and its resources, and their opinions lend support for sustainable oriented urban development policy.

Regarding the consensus on the side of agreement, there is concern about the design of urban spaces liberated by the arrival of autonomous vehicles, a design that configures wide and safe spaces, allowing for social distancing. This is consistent with recent studies that point to the importance of urban design and the need to allocate more space to active transport modes and open spaces, especially in pandemic situations such as the Covid-19 one (Sharifi & Khavarian-Garmsir, 2020). In this sense, sharing AVs could be fundamental, as claimed by several studies giving their enormous potential (Axsen & Sovacool, 2019; Sperling, 2018), including freeing up road space. However, it seems that these opportunities might not be clear for society or experts, as can be seen from the incongruencies of group 2 and the *AV-sceptics* group in the study by Tsigdinos et al. (2022). This illustrates the need for better communication of the results of studies on the expected impacts of AVs in their different options (private, shared, restricted areas…) so that society is better informed and aware of the relationships between the different decisions to be taken, and also their potential consequences.

6. Conclusions

This article advances knowledge and understanding by identifying the desired visions of citizens and experts together in order to provide a broad legitimacy to the decision-making process. To this end, a combination of the backcasting planning methodology and participatory Q-method technique is used for the first time in this field, to the best of the author's knowledge.

In a context of a Spanish middle-sized city, 30 people aged between 17 and 65 years-old, 20 citizens and 10 experts from the urban and transport planning fields, defined their ideal driverless city according to their preferences on 41 statements on urban design, society, environment, transport and mobility. We have seen how divergences emerge between experts and middle-age citizens, more focused on high-quality public spaces and active mobility, and younger citizens more concern on social aspects while supporting futuristic mobility, but with a common ground on supporting sustainability and environmentally-friendly cities.

This study provides an insight into the different perspectives on the desired city within society. Clearly, the acceptance of a consensual vision among the different actors increases the chance of a plan being approved and implemented but it is no panacea. A better understanding of the compatible and conflicting key aspects or clear points of rejection is essential in the formulation of policies that favour the transition towards more sustainable urban and mobility systems broadly supported by all stakeholders. In fact, the formulation of such policies also requires consensus and public consultation. As we have seen, these processes usually only involve groups of experts (Nogués et al., 2020; Soria-Lara and Banister, 2017a, b, 2018; Vitale Brovarone et al., 2021) but given that policies can often be controversial and contested when put into practice (Nogués et al., 2020), consultation of other stakeholders or those affected by them, such as citizens, can also play an important role in their acceptance.

CRediT authorship contribution statement

Esther González-González: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft preparation, Writing - reviewing and editing, Visualization. Rubén Cordera: Methodology, Formal analysis, Investigation, Writing -original draft preparation, Writing - reviewing and editing, Visualization. Dominic Stead: Conceptualization, Writing - reviewing and editing. Soledad Nogués: Conceptualization, Formal analysis, Investigation, Writing - original draft preparation, Writing - reviewing and editing, Funding acquisition.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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