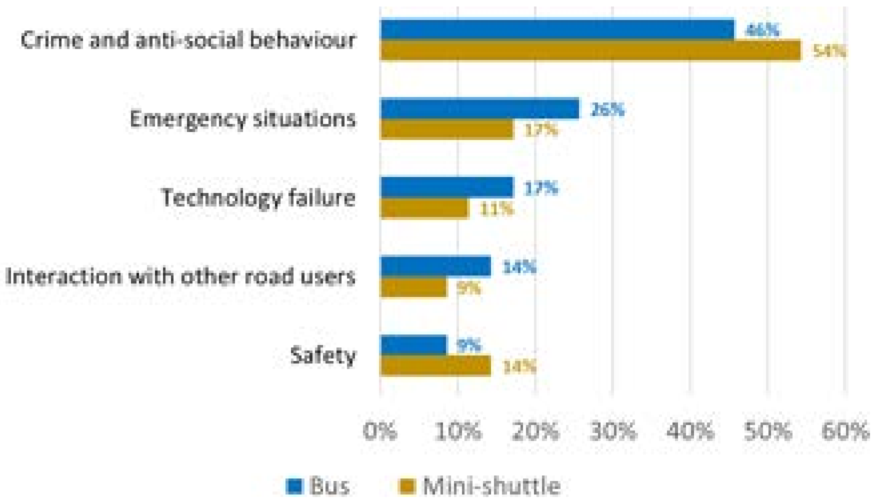

Figure 26. Main concerns about buses and mini-shuttles, after experiencing them

The main concern about the delivery robot (Figure 27) is also related to crime: the fact that goods can be stolen from the vehicle (mentioned by 46% of the sample). The other major concerns are accessibility to front door, delivery time, vandalism, and delivery failures in general. Whether robots can deliver goods at people's front doors or not was a concern expressed mainly in terms of individuals who may have disabilities and cannot walk to the location where the robot stops.

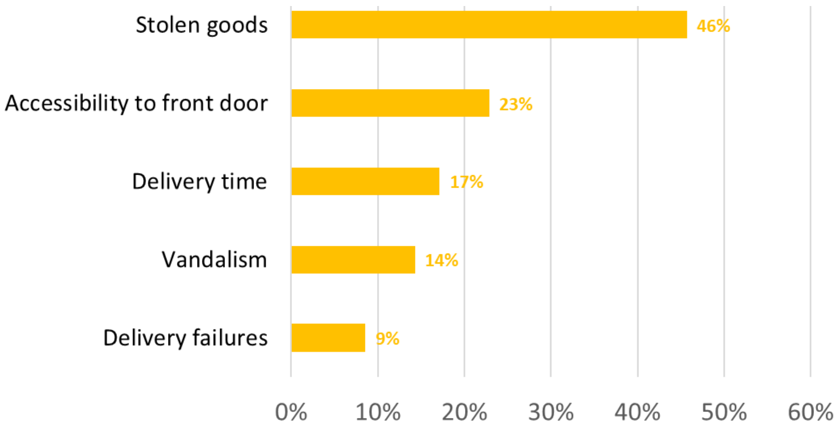

Figure 27. Main concerns about delivery robots, after experiencing them

A rough comparison is possible between the results above, which capture the concerns that participants expressed about the three vehicles after the demonstration, and their previous concerns. In the pre-event questionnaire, participants stated their concerns about self-driving vehicles in general, among a list of seven possible concerns. They could also add their own concerns. Full comparisons of proportions of the sample stating a given concern in the pre- and post-event questionnaires are not possible, as in the pre-event questionnaire participants had a list of concerns they could choose from, while in the post-event one there were no such list, i.e. the question was fully open-ended. However, it is possible to compare the rank of each concern.

As shown in Figure 28, safety (with regards to traffic collisions) was the main concern in the pre-event questionnaire. In the post-event questionnaire (as shown in the previous three figures), safety was only ranked fourth and fifth, in the case of the bus and mini-shuttle respectively, and not ranked among the top five concerns in the case of the delivery robot. However, technology

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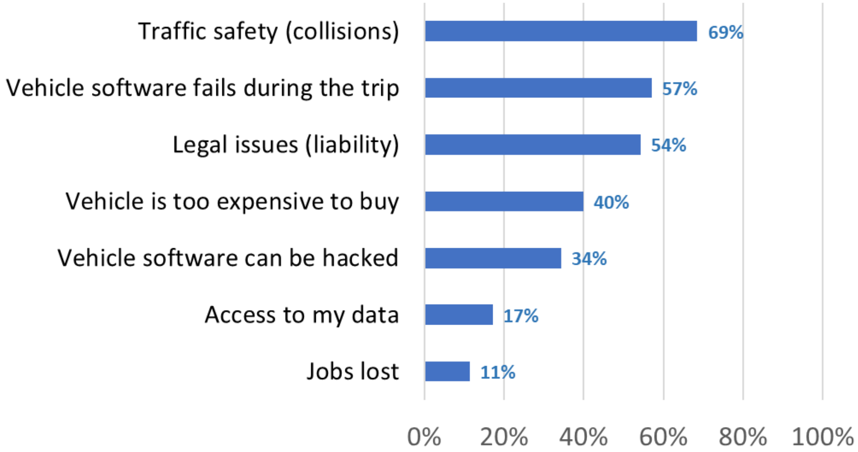
failures remained an important concern in both questionnaires. Price was a concerned stated by 40% of participants in the pre-event questionnaire. In the post-event questionnaire, almost no participant mentioned this as a concern. The main concern expressed in the post-event questionnaire (i.e. security issues related to crime and anti-social behaviour or stolen goods) was not mentioned by any participant in the open ended box of the pre-event questionnaire.

Overall, this rough comparison suggests that participants express different concerns before and after experiencing self-driving vehicles.



Note: participants could indicate up to three concerns

Figure 28. Main concerns about self-driving vehicles before experiencing them

3.4.6 Intention to use

At the end of each section of the post-event questionnaire, participants were asked if they would use the vehicles they have experienced. At the end of the questionnaire, they were also asked if they would buy a vehicle that was not a part of the demonstration: a self-driving car. These results can be compared with the ones from similar questions asked in the pre-event questionnaire. In that questionnaire, participants stated if they would use or buy a self-driving vehicle, with the question not specifying the type of vehicle.

Figure 29 shows the results. The majority of the sample said they would use the self-driving vehicles they experienced: 71% would use the bus, 62% the mini-shuttle, and 68% the delivery robot. The rest of the answers are “maybes”. Only two participants (6%) said they would not use the bus and only one would not use the mini-shuttle.

These intentions are more positive than the ones expressed before the demonstration, where only 29% stated they would use self-driving vehicles (in general) and 15% said they would not use them.

The intentions regarding using the vehicles experienced are also more positive than the intentions regarding buying a self-driving car (which was not part of the demonstration). Only 20% said they would buy the car, the same number who said they would not buy it. However, in this case, intentions also became more positive compared with the situation before the demonstration. In the pre-event questionnaire only one participant (3%) said they would buy a self-driving vehicle (in general) and 47% said they would not do it.

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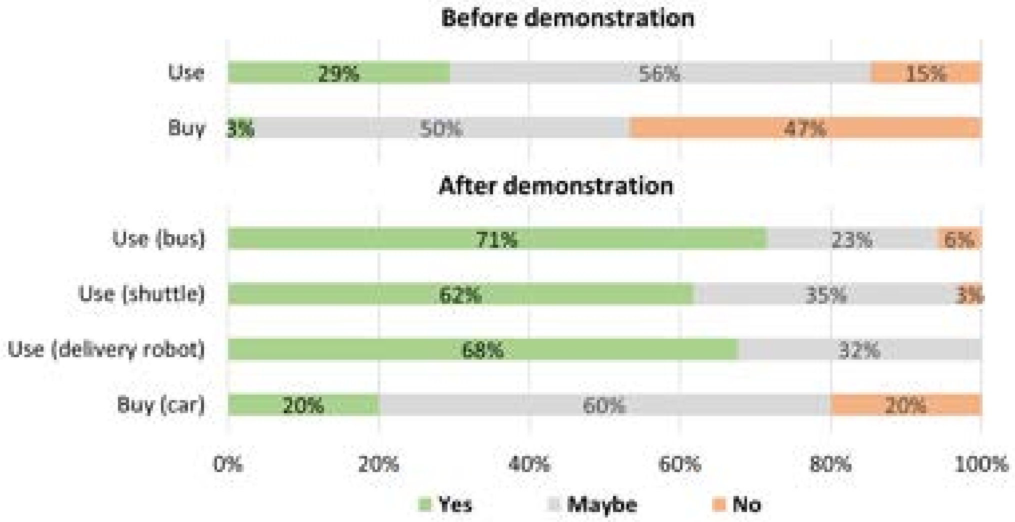

Figure 29. Intention to use or buy self-driving vehicles

3.4.7 Relationships between opinions and intentions

In this sub-section, we estimate how the participants' stated intentions to use the vehicles relate to their opinions about them. We do this by comparing the intentions among two groups: participants who have a certain opinion about the vehicle and those who do not have that opinion. The opinions examined, in the case of the bus and mini-shuttle, are thinking that the self-driving vehicle is:

- More interesting
- Slower (i.e., the human-driven bus is faster – as the question was about which vehicle was faster)
- Cheaper
- More insecure

In the case of the delivery robot, we only examine the opinion about insecurity.

We test whether the proportion of participants stating they will use the vehicle differs between the participants with the opinions above and those who do not hold these opinions. We use the chi-square test of proportions[2].

Opinions about whether self-driving vehicles are more stressful, more comfortable, or more dangerous are not examined. In the case of the delivery robot, opinions about whether the vehicle is slower, or cheaper are also not examined. This is because the chi-square test of proportions is not reliable for tabulating the intention variable versus variables measuring these opinions, due to the small sample. A common rule of thumb for this test is that sample size should allow for a minimum of five observations for each combination of values of the two variables. This rule could not be observed for the variables mentioned above, and so they were dropped from the analysis.

[2] Swinscow, T D V. (1997) *Statistics at Square One*. BMJ Publishing Group., https://www.bmj.com/about-bmj/resources-readers/publications/statistics-square-one, Chapter 8

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While perceived safety is an important variable, no suitable replacements were possible. Alternatives included: 1) the answers to the safety questions, 2) the proportion of participants who mentioned "safe" as one of their feelings, one of the things they liked in the vehicles, or one of their concerns about these vehicles, and 3) the concerns about self-driving-vehicles reported in the pre-event questionnaire. All these alternatives suffered from the same problem of small sample size.

As the sample is small even when the rule of thumb above is observed, in the results below we report differences in proportions that are significant at the usual significant levels of 5% and 10%, but also those significant at the 15% level. It should be emphasised that these are low levels of significance.

Table 31 shows the results. Only one variable is related to intention to use the vehicles at the 10% level: people who think the self-driving mini-shuttle is more secure that a human-driven mini-shuttle are more likely to say that they intend to use the self-driving one. At lower levels of significance, security is also related to intention to use the delivery robot. In addition, those who think that the self-driving bus is cheaper and those who think the self-driving mini-shuttle is faster are more likely to say they intend to use them.

Table 31. Proportion of sample intending to use vehicles, by opinion

	Intends to use vehicle		
	Bus	**Mini-shuttle**	**Delivery robot**
All	71	60	66
Less interesting	67	56	
More interesting	79	63	
Faster	77	70^{+}	
Slower	62	47	
More expensive	60	53	
Cheaper	80^{+}	67	
More secure	75	75*	76^{+}
Insecure	68	47	56

Note: Significance levels refer to the differences in intentions between a group and its counterpart. The proportion of the group identified with stars is significantly higher than the counterpart group. Levels of significance: **10%, $^{+}$20%.

3.4.8 Relationships between opinions, intentions, and participant characteristics

In this sub-section, we estimate how opinions and intentions to use the vehicles relate to the participant characteristics. We do this by comparing the opinions or intentions among two groups: participants with a given characteristic and those without it. The opinions examined are the same as those in the previous section, i.e. thinking that the self-driving vehicle is more interesting, slower, cheaper, and more insecure. Again, we test whether the opinions and intentions to use the vehicle differ among between groups of participants, using the chi-square test of proportions.

Given the need to have a sample size that follows the rule of thumb of having a minimum of five observations for each combination of opinions and participant groups, we reclassified the variables that measure participant characteristics as binary variables. The variables included in the analysis are:

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- **Gender**: men vs. women
- **Employment status**: not working vs. working
- **Education**: no university degree vs. university degree
- **Household composition**: no children in household vs. children in household
- **Residence location**: small town or village vs. city
- **Awareness of self-driving vehicles**: aware but not following developments vs. not aware vs. aware and following developments
- **Previous experience using self-driving vehicles**: no previous experience vs. previous experience
- **Activity done first on the day**: demonstration vs. virtual reality

Some variables were potentially relevant but could not be reclassified so that the rule of thumb could be observed. These include income, migration background, health issue affecting mobility, driving licence, attitude to driving, use of bus, use of car, and previous intentions to use self-driving vehicles (as expressed in the pre-event questionnaire).

Other variables met the rule of thumb but were always insignificantly related to opinions and intentions. These include frequency of travelling for shopping and leisure, and previous concerns with self-driving vehicles (as reported in the pre-event questionnaire). Results for these variables are not shown in the analysis that follows.

Again, we report differences in proportion that are significant at the usual significant levels of 5% and 10%, but also those significant at the 15% and 20% level, with the caveat that these two levels of significant are low.

Table 32 shows the proportions of the different groups holding each type of opinion about self-driving buses and intending to use those buses. The opinion that self-driving buses are more interesting is significantly higher for participants with no children in the household, and for those who first joined the virtual reality experiment. As it will be described in Chapter 4, the virtual reality experiment featured a virtual bus, with several events happening during the ride. The virtual reality can be regarded as interesting in itself. This could contribute to participants thinking a real self-driving bus is also more interesting than a conventional one.

The opinion that self-driving buses are slower than human-driven ones is not significantly related at the 10% level with any variable. At the 20% level, individuals with university degree, those who are not following developments of self-driving vehicles, who had no experience with these vehicles before the demonstration, and who joined the demonstration before the virtual reality experiment, had higher propensity to think that self-driving vehicles will be slower than human-driven ones. This last result will be discussed below, when examining the case of the mini-shuttle.

Men and individuals living in cities are significantly more likely to think self-driving buses will be cheaper, at the 5% significance level. At the 20% level, those who are aware of self-driving vehicles and following developments are also more likely to have this opinion.

Men and city residents think self-driving vehicles will be more insecure than human-driven ones. The result for individuals in cities is as expected, as crime in public transport tends to be more of a problem in cities. The result for men is unexpected, as women tend to express more concerns about personal security in public transport. However, this could be related to the type of vehicle. As it will be seen below, women show higher propensity to think that self-driving mini-shuttles will be more insecure than human-driven ones.

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Intention to use self-driving buses is not related to any sample segment at the 10% level. At lower levels of significance, intention is higher for people with university degrees, without children in the household, aware and following developments in self-driving vehicles, and with previous experience of using these vehicles.

Table 32. Opinions and intention to use self-driving bus, by sample segments (%)

	Opinion about self-driving bus				Intends to use self-driving bus
	More Interesting	Slower	Cheaper	More insecure	
ALL	40	37	57	54	71
Man	45	35	70**	65*	70
Woman	36	43	36	36	71
Not working	40	27	60	60	67
Working	40	45	50	50	75
No university degree	29	21	50	57	57
University degree	48	48+	62	52	81++
No children in household	52*	38	57	57	81++
Children in household	21	36	57	50	57
Small town or village	33	33	33	33	75
City	43	39	70**	65*	70
Not following or not aware	33	50+	44	44	61
Aware and following	47	24	71++	65	82+
No previous experience	40	53+	47	40	67
Previous experience	40	25	65	65	75+
First: demonstration	24	47+	65	53	65
First: virtual reality	59**	24	47	53	76

Note: Significance levels refer to the differences in opinions or intentions between a group and its counterpart. The proportion of the group identified with stars is significantly higher than the counterpart group. Levels of significance: **5%, *10%, ++15%, +20%

Table 33 shows the proportions of the different sample segment holding each type of opinion about self-driving mini-shuttles and intending to use those mini-shuttles.

The opinion that self-driving mini-shuttles are more interesting is not related to any variable. The opinion that self-driving mini-shuttles are slower is significantly higher, at the 5% or 10% level, for individuals who are working, had no previous experience in using self-driving vehicles, and first joined the demonstration (not the virtual reality experiment). In the latter case, this could be because the self-driving bus that the participants experienced in virtual reality moved faster than self-driving cars, using dedicated road lanes, so they may think that self-driving buses will be faster in general. This result was also obtained above in the case of the bus, although only significant at the 20% level.

At lower levels of significance, individuals with university degree and those that are not following developments in self-driving vehicles also have higher propensity to think that self-driving mini-shuttles are slower.

The opinion that self-driving mini-shuttles are cheaper is only related to other variables at the 20% level. Men and individuals who are following developments and had previous experience think they will be cheaper.

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Individuals with children in the household think self-driving mini-shuttles will be more insecure. While not statistically significant, even at 20% level, it is worth noting that women have a higher propensity than men to say these vehicles will be more insecure, unlike in the previous case of self-driving buses.

Intention to use self-driving mini-shuttles is significantly related, at 5% or 10% level with individuals with university degree, and those who are following developments and had previous experience.

Table 33. Opinions and intention to use self-driving mini-shuttle, by sample segments (%)

	Opinion about self-driving mini-shuttle				Intends to use self-driving mini-shuttle
	More Interesting	Slower	Cheaper	More insecure	
ALL	54	43	51	54	60
Man	65	40	60^{+}	45	65
Woman	43	50	36	64	50
Not Working	47	27	47	53	60
Working	60	55*	50	55	60
No university degree	43	29	43	64	43
University degree	62	52^{+}	57	48	71*
No children in household	57	43	52	43	62
Children in household	50	43	50	71*	57
Small town or village	42	50	50	58	58
City	61	39	52	52	61
Not following or not aware	50	56^{++}	39	61	44
Aware and following	59	29	65^{++}	47	76**
No previous experience	60	60*	27	40	53
Previous experience	50	30	70^{++}	65	65**
First: demonstration	53	59**	41	53	59
First: virtual reality	59	24	59	53	59

Note: Significance levels refer to the differences in opinions or intentions between a group and its counterpart. The proportion of the group identified with stars is significantly higher than the counterpart group. Levels of significance: **5%, *10%, $^{++}$15%, $^{+}$20%.

Table 34 shows the results for the delivery robot. The only variable related to the opinion that this type of vehicles is more insecure than conventional distribution vehicles is gender: men are more likely to have this opinion. At lower levels of significance, having a university degree is also related to this opinion. No variables are related to the intention to use the delivery robot.

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Table 34. Opinions and intention to use delivery robot, by sample segments (%)

	Opinion about delivery robot	Intends to use delivery robot
	More insecure	
ALL	51	66
Man	65*	60
Woman	36	71
Not Working	53	67
Working	50	65
No university degree	36	71
University degree	62++	62
No children in household	57	62
Children in household	43	71
Small town or village	50	75
City	52	61
Not following or not aware	44	72
Aware and following	59	59
No previous experience	47	53
Previous experience	55	75
First: demonstration	47	71
First: virtual reality	53	59

Note: Significance levels refer to the differences in opinions or intentions between a group and its counterpart. The proportion of the group identified with stars is significantly higher than the counterpart group. Levels of significance: **5%, *10%, ++15%, +20%.

3.5 Conclusions

This section collects the key conclusions from the demonstration, organised of terms of the five objectives stated in the introduction to the chapter.

The demonstration was done in a middle-size city. The sample aligned with the population in terms of age and gender, but had an under-representation of people with migration background, not working, or without university degrees. Almost none of the participants regularly use buses. Cycling is the dominant mode but car travel is also important. Participants had a good level of prior awareness of self-driving vehicles and even experience using them.

3.5.1 Feelings and opinions about self-driving vehicles after using them

There was a general positive feeling among participants when using the vehicles, with most reporting feeling safe, both when asked specifically about safety and in open-ended questions probing for aspects they liked. Most participants felt safe in all situations when riding the vehicles. They also tended to report that the vehicles will be safer for other road users (pedestrians and cyclists). On average, the view is that self-driving vehicles will be safer than human-driven ones. Participants also liked that the self-driving vehicles are quiet and that the ride was smooth. Using self-driving vehicles is also expected to be cheaper than human-driven ones. The majority of participants intends to use the three vehicles. However, intention to use the mini-shuttle is significantly related to perceptions of personal security when using them.

The main negative aspects are the perception that vehicles can be dangerous in terms of exposure to crime and anti-social behaviour from other passengers, vandalism, and, in the case

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of the delivery robot, stolen goods. The general view was that the vehicles are slow – this is related to the design of the experiment, as vehicles were programmed to move slowly. There were also concerns about the design of the vehicles. While the bus felt familiar, the large majority thought the mini-shuttle was too narrow, with not enough seating space.

Table 35 maps the key results of the demonstration onto the nine Move2CCAM impact dimensions.

Table 35. Conclusions of demonstration: feelings and opinions

Mobility	• The vehicles were regarded as something that could enhance mobility, and participants thought about several possible uses • The majority think that using self-driving vehicles will be cheaper than human-driven ones • General view that riding in self-driving vehicles was smooth but that the vehicles were too slow • A few people were happy that the bus is comfortable, but there were many negative views about the self-driving shuttle being narrow
Transport network	• Almost no participant expressed opinions about impacts on congestion or other transport network indicators
Land use	• Almost no participant expressed opinions about impacts on land use
Environment	• General view that the vehicles are quiet and environmentally-friendly
Economy	• Almost no participant expressed opinions about economic aspects
Equity	• Some participants expressed concerns that delivery robots may not be a good solution for people with disabilities, if they do not stop at people's front doors.
Public health	• Slight tendency to think that self-driving vehicles will reduce stress
Safety	• The majority thought that all three vehicles were safe, in terms of traffic collisions • The vehicles were regarded as safe in all situations, and both for vehicle users and for other road users (pedestrians and cyclists) • Some concern about what can happen in emergency situations
Security	• Strong concern that self-driving passenger vehicles can create situations when passengers fear about crime and anti-social behaviour from other passengers • Strong concern that delivery vehicles will be vandalised or have goods stolen

3.5.2 Feelings and opinions about different types of vehicles

Participants were generally happy with the self-driving bus, one of the reasons being that the vehicle felt familiar. The other vehicles had much different designs, compared with that participants are used to see on the road, which raised some concerns (Table 36).

Table 36. Conclusions of demonstration: comparison of different vehicles

Bus vs. mini-shuttle	• Participants reported more things they liked for the bus than for the mini-shuttle (2.5 vs. 1.9 per person respectively), but more things they disliked for the mini-shuttle (1.5 per person, compared with 0.8 for the bus) • More people reported feeling safe and comfortable in the bus than in the mini-shuttle • Participants were less happy with the mini-shuttle than the bus due to its narrow space or to innovative features such as movement in both directions (as this implied seating backwards to the vehicle movement) • Slightly stronger intention to use the bus
Passenger vehicles vs.	• The delivery robot gathered more opinions regarding its possible uses • Stronger belief that delivery robots will be cheaper and safer than human-

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delivery robot	driven vehicles, when comparing with the bus and mini-shuttle • Similar intentions to use self-driving passenger and delivery vehicles

3.5.3 Change in concerns and intention to use

Changes in participants' views can be assessed for two variables, collected in questionnaires before and after the event: the concerns expressed about using self-driving vehicles, and the intention to use them. Both point to a general improvement in participants' views about self-driving vehicles (Table 37). However, crime and anti-social behaviour emerged after the demonstration as people's main concern, while before the demonstration the main concern was safety.

Table 37. Conclusions of demonstration: change in concerns and intentions

Concerns	• Safety was the main concern expressed before the event, but after the demonstration most participants thought self-driving vehicles are safe and expressed fewer concerns, expect about what happens in emergency situations • Crime and anti-social behaviour emerged as the main concern after the demonstration • Cost was a major prior concern but was hardly mentioned after the demonstration
Intentions	• Intention to use self-driving vehicles was 29% before the event but 62%-71% after the event • Intention to buy a self-driving car (a vehicle not featured in the demonstration) also increased

3.5.4 Comparison between self-driving and human-driven vehicles

Self-driving vehicles tend to compare well with human-driven ones. Table 38 shows the main tendency among the sample when comparing the two types of vehicles. The table does not imply that all participants have the opinions shown, but only that more participants have these opinions than those who have opposite ones. In this assessment, the opinions that both types of vehicles are similar, and lack of opinion, are not accounted for. However, the table identifies opinions held by the majority of all participants, accounting for those who think both vehicles will be similar and those who have no opinion. The results show that self-driving vehicles are judged to be better than human-driven ones in all aspects expect speed and security in terms of crime.

Table 38. Conclusions of demonstration: comparison with human-driven vehicles

	Self-driving vehicles	Human-driven vehicles
Positive	• More interesting[+] • Cheaper* • Less stressful • More comfortable • Safer (accidents)	• Faster • More secure (crime)*
Negative	• Slower • Less secure (crime)	• Less interesting • More expensive • More stressful • Less comfortable • More dangerous (accidents)

Note: *: opinion held by more than 50% of participants for all three vehicles, [+]: opinion held by more than 50% of participants in the case of the mini-shuttle only.

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3.5.5 Variations in opinions and intentions among sample

Opinions and intentions were significantly related to several characteristics of the participants, as synthesized in Table 39. All demographic characteristics were relevant. There were also some significant different between participants who joined the demonstration before vs. after the other project event happening on the same day, involving virtual reality.

Table 39. Conclusions of demonstration: variations among sample

Gender	• Men more likely to think self-driving vehicles will be cheaper than human-driven ones, compared with women • Men more likely to think self-driving buses and delivery robots will be more insecure in terms of crime
Employment status	• Workers more likely to think the self-driving mini-shuttles will be slower than human-driven ones
Education	• Individuals with university degree more likely to use self-driving vehicles even though they think they will be slower
Household composition	• Individuals in households with children more likely to think the self-driving bus is more interesting and to use it • Those in households without children more likely to think the self-driving shuttle will be more insecure
Residence location	• City residents more likely to think the self-driving bus will be cheaper and more insecure
Awareness	• Participants who were more aware of self-driving vehicles before the demonstration more likely to think they will be cheaper and to use them • Those less aware are more likely to think self-driving vehicles will be slower
Previous experience	• Participants who had used a self-driving vehicle before the demonstration more likely to think they will be cheaper and to use them • Those without that previous experience are more likely to think self-driving vehicles will be slower
Order of activities	• Participants who joined the demonstration before the virtual reality experiment more likely to think self-driving vehicles will be slower • Those who joined the demonstration after the virtual reality experiment more likely to think self-driving vehicles will be more interesting

3.5.6 Final remarks

This chapter showed that although safety is a major concern about self-driving vehicles, the experience of using them tends to mitigate these concerns. In general, the participants in the demonstration think self-driving vehicles will be safe. These vehicles also compare well with human-driven ones in terms of other aspects, although there is some variation across the types of vehicles and different groups in the sample.

However, the demonstration also raised concerns among participants about the implications of self-driving vehicles for security in terms of crime, both for passenger and delivery vehicles. Slow speed was also a concern, although this is related to the experimental nature of the demonstration, where speed was programmed to be slow. Other concerns relate specifically to the narrow space provided by the self-driving shuttle.

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4. Virtual reality experiments

4.1 Overview

Virtual reality experiments were organised in Helmond (Netherlands), Katowice (Poland), and Mitylene (Greece), involving a total of 92 citizens. The three sites provide a variety of geographic, economic, and social contexts. As mentioned in Chapter 3, Helmond is a mid-sized city in the Netherlands (population=95,940). Katowice is a larger city (population=286,960), part of Metropolis GZM, a metropolitan area. Mytilene is a smaller city (population=33,523), the largest settlement in the island of Lesbos.

The overall aims of the virtual reality experiments were to collect information on citizen needs and requirements when using self-driving private and public transport, and to assess their feelings when using these vehicles, both as stated in questionnaires and group discussions, and revealed in physiological measurements.

The experiments had five specific objectives:

- To compare citizens' perceptions and preferences about different aspects of travelling in self-driving private and public transport vehicles
- To assess physiological reactions to different aspects of travelling in self-driving private and public transport vehicles, using electroencephalogram data (EEG)
- To capture perceptions about the possible impact of self-driving vehicles on several dimensions of the lives of citizens
- To assess whether perceptions, preferences, physiological reactions, and perceived impacts are related to the characteristics of participants, or if they differ across the three countries studied
- To gather feedback on the effectiveness of virtual reality as a research method to study perceptions, preferences, and physiological reactions to self-driving vehicles

Virtual reality provides an immersive experience that can realistically replicate realities that not yet exist, such as trips on self-driving vehicle in a context where all vehicles on the road are also self-driving. At the same time, virtual reality can introduce variations in the conditions of those trips. This method is relevant to study self-driving vehicles, as these vehicles have mainly been deployed in temporary trials in small areas. Self-driving vehicles are not yet the main mode of road transport and citizens may find it hard to imagine how they will operate with only images or videos. While demonstrations such as the one described in Chapter 3 help citizens to better understand these vehicles, they are usually done in off-road sites, not accounting for the new types of infrastructure and travel environments that will exist in the future. Virtual reality provides citizens with experiences of these new infrastructures and environments in a realistic way.

Previous virtual reality studies have usually involved participants using headsets showing a road, other vehicles, and the road surroundings. The interior of the vehicle is shown less often. In addition, most previous studies featured only one type of vehicle, not allowing for comparison between different types of vehicles. In most cases, the vehicle was a private car, not a public transport vehicle. However, in the future, the choice between private and public transport will have different determinants, if both vehicles are self-driving, compared with the case when both vehicles are human driven. For example, not having to drive opens up possibilities for using travel time for other purposes, even in private cars, which may affect the choice between car and bus.

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For this reason, the experiments described in this chapter feature both a private and a public transport vehicle.

The virtual reality experiment is complemented with the collection of physiological data (electroencephalogram, or EEG), which assess the individuals' mental states when using self-driving cars and buses. These mental states are important in themselves, as they are related to the individuals' wellbeing and satisfaction using the two modes. They can also provide insights on the individuals' preferences for the two modes, and thus on the possible choices they would make if both modes were available in the real world.

Virtual reality is an underexplored method in transport research. These experiments are an opportunity to gather data on the effectiveness of the method for collecting transport passenger user data. Previous studies have been limited by the small samples used, and even more by using unbalanced samples, almost exclusively of younger participants (mostly students), and with a predominance of males. The experiments reported in this chapter address these gaps by using samples that are balanced in terms of gender and age, including participants aged over 65 – a group forgotten in most of previous studies. This allows us to understand possible inequalities in how different groups perceive and react to self-driving vehicles and the impact in their mobility and other aspects of their lives.

Finally, both virtual reality and physiological measure collection methods have potential ethical issues, such as concerns about data privacy, apprehension or embarrassing related to using headsets, motion sickness, and possible negative reactions to some of the scenarios represented in virtual reality. However, most published studies give only perfunctory information about how these issues were dealt with. The experiment reported in this chapter addresses and reports a comprehensive set of possible ethical issues.

The rest of this chapter is organised as follows

- Section 4.2 describes the **general design** of the experiment
- Section 4.3 describes the two **virtual reality scenarios** (bus and car)
- Section 4.4 describes the **data collection methods**
- Section 4.5 describes the methods to **recruit participants** and to address **ethics** considerations.
- Section 4.6 describes the **characteristics** of participants and their travel context and behaviour
- Section 4.7 and 4.8 analyse participant **choices** and **EEG** data
- Section 4.9 analyses the results of the post**-experiment questionnaire**
- Section 4.10 analyses the results of the **group discussions**
- Section 4.11 synthesises the key **conclusions** of the demonstration

4.2 General design of the experiment

The experiments were designed by University College London and organised by project partners in the three regions: City of Helmond (Netherlands), the GZM government (Poland), and Eloris (Greece). These partners also conducted the group discussions at the end of the experiment. All data collection materials were designed in the local languages. All results were translated into English.

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Data was collected in five stages (Table 40). Participants provided demographic data and answered a questionnaire before the event. During the event, they first engaged in the virtual reality experiment, then answered a questionnaire, and finally participated in group discussions (Table 40).

Table 40: Data collection stages

Stage	Description	Timing	Duration
1	Provision of demographic data	Before the event	-
2	Pre-questionnaire	Before the event	-
3	Virtual reality experiment	-	20 minutes
4	Post-experiment questionnaire	-	10 minutes
5	Discussion groups	-	20 minutes

The events in each site were held over a day, in December 2023 (Greece and Poland) and January 2024 (The Netherlands). Figure 30 shows aspects of the events.

The day was divided into eight slots. In Poland and Greece, each time slot had four participants. In the Netherlands, as mentioned in the previous chapter, the event coincided with the demonstration of self-driving vehicles, which had the same participants. Here, the day was divided into eight 2-hour slots, each with two groups of four participants, one engaged in the virtual reality experiment and the other in the demonstration, each lasting for one hour. In the second hour, the groups swapped. Participants were briefed at the beginning of the day and before each of the activities (experiment, post-questionnaire, and discussion groups)

Figure 30. Aspects of the event: virtual reality experiment and group discussions

4.3 Virtual reality scenarios

4.3.1 Overview

A 6-minute virtual reality game was designed for Meta Quest Pro headsets (https://www.meta.com/gb/quest/quest-pro). The literature shows that longer durations may induce boredom or even motion sickness among participants. All text interacting with the user was translated into the local languages (Dutch, Poland, Greek). Monetary values were also shown in the local currencies. Participants were briefed before the game, with information explaining the rules of the game and the nature of the choices they had to make.

The game represents a future reality where self-driving vehicles are widely available. The game includes two scenarios: a trip on a car and a trip on a bus, both self-driving. Participants can

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choose between them at the start of the game (Figure 176Figure 31). At the beginning, a screen was presented with information about the two modes. The car and bus trips both start at the city centre and end at the participants' home, travelling along the same route. The participant is informed that they will be alone in the car and the trip is expected to take 18 minutes. The bus takes 15 minutes, which is shorter than the car because the bus uses a dedicated road lane. The car is paid per use and costs four times more than the bus (with the bus fare set as the current fare for a 15-minute ride in each of three experiment sites).

Participants could choose to switch from bus to car or from car to bus on eight occasions during the trip. This en-route mode switch is something that is plausible in the future, if both cars and buses are self-driving. Only one switch was allowed in the game. When participants switched to the other mode, they could not switch back to the original mode. The possibility of switching, and the restriction to only one switch, was mentioned in the participants briefing and also on the initial screen seen in the game, showing the two options.

Immediately after the trip starts, in both the car and the bus, participants were asked to choose what they would do during the trip (use a device to work, use a device for entertainment, or just look around). This was just to record their preference – the chosen time use was not represented in the virtual scenes that follow.

Figure 31. Virtual reality experiment: initial choice between self-driving bus and car

The scenarios change during the trip. Table 41 shows a list of the attributes that change in the car and bus scenarios. These attributes were selected on the basis of being potential determinants of mode choice or mode switch in the future. In the game, it is expected that some changes would trigger a mode switch and/or certain physiological reactions measured by EEG. Each stage of the car and bus scenario is thus defined by a combination of attributes level (for example "*city centre, daytime, uncrowded, human supervision, passengers minding their own business*").

Table 41: Attributes of the virtual reality scenarios

Attribute	Values	Car	Bus
Landscape	City centre, industrial, residential	Yes	Yes
Time of day	Daytime, getting darker, night-time	Yes	Yes

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Congestion	No, getting worse, easing up	Yes	
Passenger number	None, fee, many		Yes
Passenger behaviour	Mind their own business, acting in an anti-social manner		Yes
Human assistant	Present, absent		Yes

In the car scenario, the landscape (e.g., what the car passenger can see from the window) is an attribute because in the future driving will no longer be required, so passengers can enjoy the scenery, which becomes more important for trip quality. Travelling at night-time, or in congested conditions, also prevents people from seeing the landscape. Congestion is also an attribute because it is a major determinant of travel mode choice and of traveller stress. We test a situation where buses always move faster than cars, by using dedicated (and uncongested) lanes.

In the bus scenario, emphasis was put on personal security issues of travelling in unsupervised public transport, one of main concerns found in previous literature. This is tested by several attributes: landscape (industrial wasteland with derelict industrial buildings); crowding; time of day (dusk and night-time); and behaviour of other passengers (some acting in an anti-social manner, talking loudly, playing music, and putting their feet on the seats). The presence of a human assistance is important because people are concerned with the risk of collision if no human is present to take over vehicle if needed. Crowding and landscape are part of the trip's perceived quality and can cause stress, regardless of personal security. Time of day and crowding also interact with landscape: it is more difficult to see the landscape at night and in a crowded bus.

The game was designed as an immersive virtual reality, with 3D scenes and sounds corresponding to each scenario stage (e.g., city sounds, bus doors opening and close, bus passengers chatting or making loud noise). The traffic featured mostly self-driving vehicles, but a few conventional ones. Self-driving vehicles were designed without a steering wheel or any other feature associated with human drivers. No pedestrians or cyclists were featured in the scenarios (this was to reduce the cost of building the scenario). Bus passengers were portrayed as simplified silhouettes rather than human-like characters, to avoid associations with any age, gender, ethnic, or socio-economic group. However, these silhouettes can immediately be identified as humans due to their shape, gestures, and sounds.

4.3.2 Self-driving car scenario

The participant enters the vehicle, which starts moving (Figure 32). The scenario changes, following nine stages (Table 42). The landscape changes regularly and it gets progressively dark. The participant can see self-driving buses moving faster in the bus lane. The traffic becomes progressively denser.

The scenario stages start and end at bus stops. At each bus stop, the participant is shown the current delay and expected arrival time. Delays build up during each stage, up to 6.5 minutes at the end of Stage 7. When shown this information, participants are asked if they want to switch mode, i.e., to get off the car and get on a bus. This carries an additional cost, equal to the full-trip bus fare (from origin to destination). If the participant decides to get off, the experiment continues with the bus. If not, the car continues.

At the end of Stage 9, the car stops. The participant's home is just opposite. The participant is asked to choose between: a) send the vehicle to a nearby parking area to reuse the following day (which has a cost), and b) send the vehicle back to the city centre.

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Table 42. Virtual reality experiment: car scenario

Attribute	**Stages**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Landscape	City centre			Industrial	City centre	Industrial	City centre	Industrial	Residential
Time of day	Daytime		Gradually getting darker					Night-time	
Congestion	No	Gets progressively worse						Eases up	No

Note: Attribute levels represented: city centre, daytime, starting to be congested

Figure 32. Virtual reality: scene from car scenario

4.3.3 Self-driving bus scenario

The participant boards the bus and sits in a vacant seat at the back of the bus (Figure 33). The scenario changes, following nine stages (Table 43). The landscape and time of day attribute levels are identical to the ones in the car scenario, as the vehicles are using the same road. Landscape thus changes regularly, and it gets progressively dark. The bus uses a dedicated lane and moves faster than the private cars in the general lanes. At each bus stop, new passengers join, and others leave the bus.

The scenario stages start and end at bus stops. At each bus stop, participants are shown the expected arrival time (which decreases linearly in each stage). When shown this information, participants are also asked if they want to switch mode, i.e., to get off the bus and get on a car. This carries an additional cost, equal to the full-trip car cost (from origin to destination). If they decide to get off, the experiment continues with the car. If not, the bus continues. At the end of Stage 9, the bus stops. The participant's home is just opposite.

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Table 43. Virtual reality experiment: bus scenario attributes

<table>
<tr><th rowspan="2">Attribute</th><th colspan="9">Stages</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th></tr>
<tr><td>Landscape</td><td colspan="3">City centre</td><td>Industrial</td><td>City centre</td><td>Industrial</td><td>City centre</td><td>Industrial</td><td>Residential</td></tr>
<tr><td>Time of day</td><td colspan="2">Daytime</td><td colspan="5">Gradually getting darker</td><td colspan="2">Night-time</td></tr>
<tr><td>Passenger number</td><td>Few</td><td colspan="2">Many</td><td colspan="5">Few</td><td>None</td></tr>
<tr><td>Passenger behaviour</td><td colspan="5">Mind their own business</td><td colspan="3">Anti-social</td><td>No other passenger</td></tr>
<tr><td>Human assistant</td><td colspan="4">Present</td><td colspan="5">Absent</td></tr>
</table>

Note: Attribute levels represented: city centre, not crowded, no human assistant, starting to get dark, passengers mind their own business

Figure 33. Virtual reality: scene from bus scenario

4.4 Data capture

4.4.1 Demographic data

In Greece and Poland, participants provided information about their demographic characteristics when they were originally recruited by market research companies to join the Move2CCAM project network of “satellites” in 2023. In the Netherlands, demographic information was collected in a questionnaire distributed days before the event (see next sub-section).

Demographic variables collected included age, gender, ethnic group (in Poland and Greece only) or migration background (in Netherlands only), employment status, income (in Netherlands only), qualifications, educational background, driving licence, household type, and type of residence location (urban vs rural). These questions were included as appendix in a previous report of this project (Deliverable 3.3., Appendix 1).

4.4.2 Pre-event questionnaire

Participants answered a questionnaire before the event. This was done online, through the Qualtrics platform. Participants who had joined previous activities of the project filled this

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questionnaire before they joined their first activity, in 2023. In the Netherlands, participants whose first activity was the virtual reality experiment filled this questionnaire in advance to the event.

The questionnaire was identical to the one used in the demonstration of self-driving vehicles described in Chapter 3. Appendix 2 contains the English version of this questionnaire. It includes questions to capture travel context (residential area characteristics, mobility problems), travel behaviour (travel frequency and main mode, feelings about driving, use of travel time in public transport), and attitudes towards self-driving vehicles (awareness and concerns about self-driving vehicles, intention to use them, and use of travel time when using them).

4.4.3 Virtual reality game data

The virtual reality headset recorded the choices made by participants in the game, and the time when they were made. This included the initial choice of car or bus, if/when participants switched from one mode to another, what they chose to do during the trip and, if they end the game in the car, what they decide to do with the car (park it nearby or send it back to the city centre).

The headset also captured the times when participants started and ended each stage of the scenarios, both when the stage started after a switch choice, and when switching was no longer possible and the stages followed each other without prompts to make further choices.

4.4.4 EEG data

Brain activity was recorded using non-invasive electroencephalography (EEG) earbuds (EMOTIV MN8 - https://www.emotiv.com/mn8-eeg-headset-with-contour-app. Electroencephalography records electrical activity in the brain. The EMOTIV MN8 device has two sensors and records electric activity into five frequency bands: theta (4-8Hz), alpha (8-12Hz), low beta (12-16Hz), high beta (16-25Hz) and gamma (25-45Hz).

Low frequencies tend to be more present in relaxed states of mind, while high frequencies are more present in stressed states of mind. As such, the ratio between high and low frequencies is often used as an indicator of stress. We used as our main indicator the ratio between the high beta and alpha frequencies, as previous studies have shown that this ratio is associated with arousal or stress. The high beta and alpha frequencies were averaged across the two device sensors. We then calculated their ratio, for each EEG reading. The ratios were then averaged for each second, then for each combination of participants and scenario stages, and finally for each scenario stage.

The application associated with the EMOTIV MN8 device produces two indicators, based on an algorithm classifying the frequency bands. These indicators are labelled “cognitive stress” and “attention”. We did not use data for these indicators because the details of this algorithm are not clear in the EMOTIV documentation. As such, it is not possible to know with certainty what the two indicators are measuring.

EEG data was recorded during the virtual reality game. Before the game started, a baseline reading was taken. For this reading, participants were asked to relax for 15 seconds with their eyes open, and after a 5-second break, to relax for another 15 seconds with their eyes closed.

4.4.5 Post-experiment questionnaire

Participants filled a questionnaire after the experiment (Appendix 5). The first section of this questionnaire is about the choices people made during the game: which vehicle they chose in the

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beginning (and why), if they switched to the other vehicle during the trip (and why), and if yes, if they regret switching (and why).

Two sets of questions then ask for opinions about the car and bus scenarios. Participants only answered the questions about the scenario(s) they have experienced (car, bus, or both). The set of questions were similar for the car and bus scenario and covered:

- **Feelings** during the experience. Participants could choose all that applied from a list of 18 possibilities. The list was similar to the one used in the vehicle demonstration in the Netherlands described in Chapter 3, to allow comparisons of real-world and virtual experiences.
- The three things the participant **remembered** the most from the scenario
- Which **changes participants noticed** in the scenarios. The question probed for all attributes of the scenarios described in Section 4.3: landscape (type of buildings), time of day, speed of the vehicle, speed of the vehicles in the other lane, and, in the case of the bus only, the number and behaviour of other passengers and the presence of a human assistant. Participants could also indicate other aspects, as free text.
- How **realistic** the scenario was (on a 5-point scale), and what was not realistic (open ended question).
- How self-driving cars/buses will **compare** with cars/buses with a human driver: which trips will be more interesting, faster, cheaper, more stressful, more comfortable, more dangerous (in terms of accidents), and more insecure (in terms of crime). Again, this question is similar to the one asked in the vehicle demonstration described in Chapter 3, to allow comparisons.

The section about the virtual bus trip had two extra questions, answered only by participants in the Netherlands site who had already joined the self-driving vehicle demonstration on that day. The questions are whether there was anything they liked in the virtual bus that they had previously disliked in the real bus, or the opposite.

The final section of the questionnaire is about travel intentions:

- Whether the participant **would use** a self-driving car and bus in the future. These questions are similar to questions asked in the pre-activity questionnaire, to allow comparisons.
- Whether **travel behaviour would change**, in terms of productive or leisure uses of travel time; worry about parking; and car, bus, and overall trip frequency.

4.4.6 Post-experiment group discussions

After filling the post-experiment questionnaire, participants joined discussions with the other three participants in the group. They were presented with eight slides (Appendix 6) containing images from the two scenarios and probed to give their views on different aspects of their experience.

Participants were first asked about their opinion of:

- The **external design** of the two vehicles
- The **internal design** of the two vehicles
- The **scenery outside** the vehicle (showing images of both the city centre and industrial areas, both at daytime and night-time).

Participants were then asked, if they were in the car when it happened, about their opinion about buses travelling faster in the other lane.

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Finally, they are asked, if they were in the bus when it happened:

- How they felt when the bus became **crowded** with passengers
- What they thought about the **human assistant** and how they felt when the assistant left
- How they felt when some passengers started having **anti-social behaviour**
- How they felt when the bus became **empty** of other passengers

4.4.7 Other data

We recorded the games played by each participant, to attempt to extract information about which parts of the virtual scenarios they looked at. However, this information was difficult to be objectively identified and was not used in the analysis.

4.5 Participant recruitment and ethics

4.5.1 Participant recruitment

Participants were recruited from the Move2CCAM network of "satellites", i.e., citizens who were invited to previous activities organised by the project. The aim was to recruit a balance of men and women, and proportions of participants in three age groups (18-34, 35-64, and 65+) that are aligned with the population of each region. As noted before, a balance between different genders and ages is important because many studies have been limited by using unbalanced samples.

A sample of 30 in each region was deemed necessary to balance the need to simplify planning and save costs (experiments with more than 30 participants would require several days), while still generating enough data to derive robust results and compare them across gender and age groups.

4.5.2 Ethics

The study received ethical approval from the Bartlett School of Environment, Energy and Resources at University College of London (ID: 20231120_EI_ST_ETH_ Move2CCAM). The event addressed several potential ethical issues, as it involved participants wearing two devices (virtual reality headsets and EEG earbuds) that they may be unfamiliar with. As noted before, this aspect has been insufficiently covered in previous studies. The equipment and scenarios were thoroughly tested before the experiment to gauge their suitability and any possible ethical issues. Table 44 lists the ethical issues and the strategies implemented to address them in this study.

Table 44: Virtual reality experiment – ethics issues

Ethics issue	Strategy to address the issue
General concerns about what will happen and how data is collected and treated	• Participants were provided with an information sheet and consent form before the event and only started the experiment upon confirmation the form had been signed • Participants were briefed at the beginning of the event and before every single activity during the event
Discomfort or embarrassment wearing the virtual reality headset and the EEG earbuds	Participants were informed before the experiment about these issues and reassured that they could opt-out at any moment, before or after they started wearing the headset
Motion sickness, headache, skin irritation, or other discomforts while using the virtual reality	

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headset Red marks on the forehead for a few minutes after the experiment	
Risks of transmittable diseases through wearing equipment used by others before	The virtual reality headset and EEG earbuds were disinfected after every use.
Discomfort if a researcher of another gender helps participants wearing the headset and EEG earbud.	• Participants were provided with clear instructions on how they could wear and calibrate the headset and wear the EEG earbuds. • Male and female researchers were both present to guide participants on how to wear the two devices
Use of participants' time	Participants received a small monetary compensation for their participation
Risks of fatigue (especially in the Netherlands site, where participants also join a vehicle demonstration)	Participants were provided with food and drinks, and the schedule of the experiment had frequent breaks
Uneasiness with some of the scenarios seen in the virtual reality game (congestion, bus overcrowding, passengers acting in an anti-social manner)	• Participants were informed before the experiment about these issues and reassured that they could opt-out at any moment • The scenarios ended on a positive note, with all situations resolved and the car and bus arriving at the destination.
Identification of virtual figures with specific age, gender, ethnic, or socio-economic groups	Human figures were portrayed as simplified silhouettes

Participants were provided with an information sheet and an informed consent form, which they filled before joining the event. The information sheet contained:

- Details about the event, funder, organisers, and nature and duration of each activity
- Information about the devices that participants would wear during the experiments, including photos and links to the manufacturers' web pages, and reassurance that the devices are standard commercial products and are used by many people, to play games, or monitor their concentration or other types of brain activity
- Reassurance that the devices would be disinfected and that researchers can help them to wear or remove the devices
- A brief description of the virtual reality game (including a screenshot) and the post-experiment activities (questionnaire and group discussions
- Information about use of personal data collected at all stages and of photos and video recordings of the event
- Possible discomforts, and what to do if they do happen
- Advice that participants with certain conditions should not take part in the research

Participants gave they consent by confirming (by ticking a box) that they understand what the research involves and what is expected of them. The information sheet and consent form were included in a previous report of this project (Deliverable 3.3., Appendix 19).

The pre- and post- event questionnaires did not capture any information that could identify individuals. Participants were identified through an ID number. The data was analysed by University College London, which did not have access to the file matching ID numbers with

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participant contact details. Only the event organisers (Eloris, GZM government, and City of Helmond) had access to this file.

4.6 Participant characteristics

A total of 92 participants completed all data collection activities in the virtual reality experiment: 34 in the Netherlands, 30 in Poland, and 28 in Greece. In the Netherlands, half of participants completed the experiments after riding in the real self-driving bus, as part of the demonstration reported in Chapter 3. The other half completed the virtual reality experiments before riding in the real self-driving bus.

4.6.1 Demographic and socio-economic characteristics

The following tables show the key characteristics of the samples. A good gender balance was achieved in Poland and Greece. In the Netherlands, there were 61% of men and 39% of women (Figure 34). The age distribution was reasonably aligned with the population of the three sites (Figure 35). Sites differed in terms of urbanisation levels (Figure 36). There were higher proportions of city centre residents in Greece, village residents in Poland, and city (but not city centre) residents in the Netherlands.

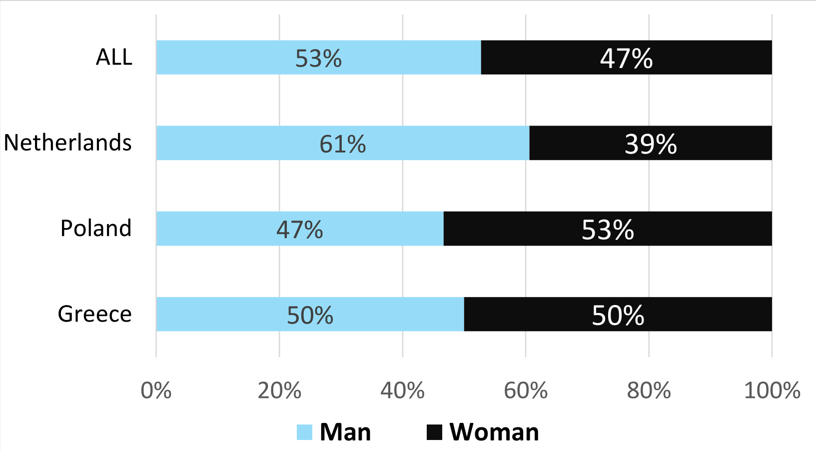

Figure 34. Virtual reality experiment participants – gender

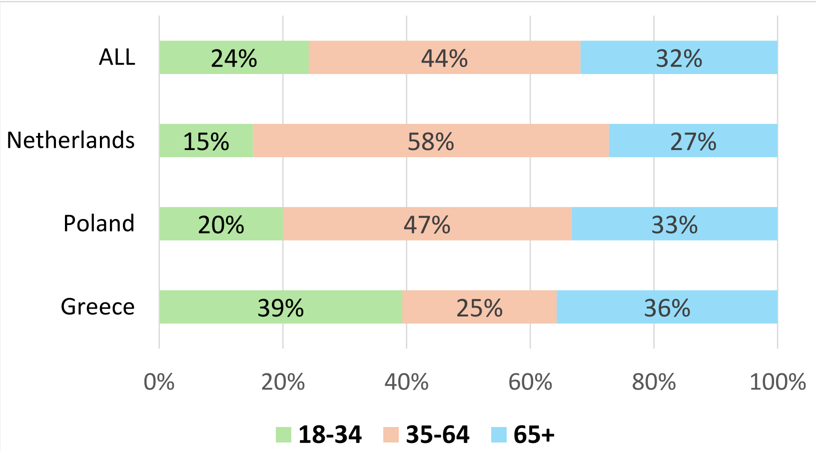

Figure 35. Virtual reality experiment participants – age

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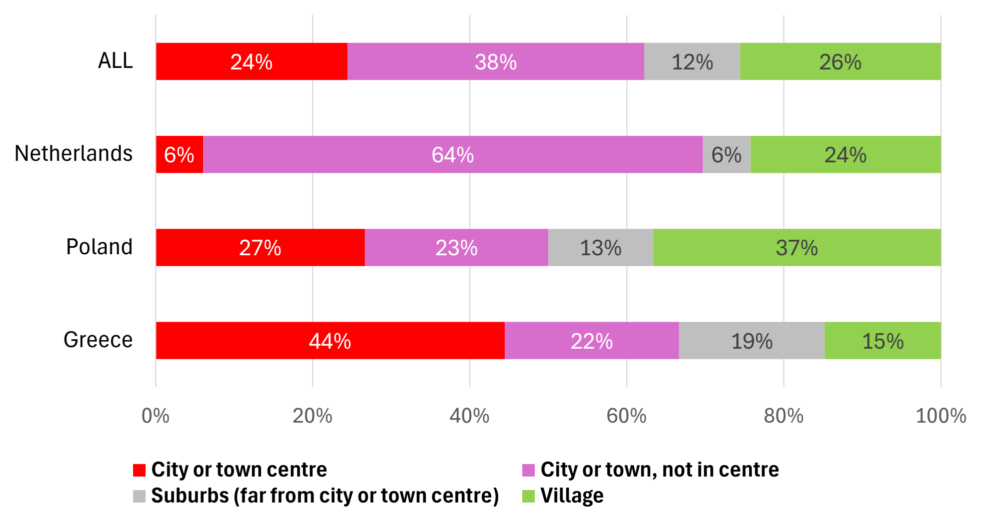

Figure 36. Virtual reality experiment participants – type of residence area

In Greece and Poland, all participants identified themselves as "white" in terms of ethnicity. In the Netherlands, the question was whether at least one of the parents of the participant was born abroad. Six participants (19% of the 32 who answered this question) answered yes. As mentioned in Chapter 3, this is below the proportion in the population of the municipality. Income was only collected in the Netherlands. Data was previously included in Chapter 3 (Figure 12) and shows there is a slight predominance of higher-income groups.

Table 45 shows other characteristics. Most participants are working. In all three countries, the proportions of the sample having a university degree or higher degree are slightly above the population proportions. Most participants live with their partner and/or children.

Table 45: Virtual reality experiment participants - other participant characteristics (%)

	ALL	Netherlands	Poland	Greece
Employment				
Work (full or part time)	58	58	63	54
Student	10	6	10	14
Other (retired, not working, homemaker)	32	36	27	32
Education				
Primary or secondary school (inc. vocational)	43	36	40	56
University degree	33	45	27	26
Higher university degree	20	15	27	19
Still in full-time education	3	3	7	0
Household type				
Lives alone	17	9	23	19
Lives with friends	4	12	0	0
Lives with family	7	3	10	8
Lives with partner	36	36	43	27
Lives with children (and with/without partner)	36	39	23	46

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4.6.2 Current travel context and behaviour

Table 46 shows the participants' travel context. Relatively high proportions stated they had a disability or health problem affecting mobility (although in most cases they stated it only affects them a little. The large majority has a driving licence. Only about half of participants in the Netherlands and Poland and one third in Greece drive and enjoy doing it. Shopping trips have different frequency patterns in the three countries.

Figure 37 shows the proportion of participants reporting using each mode for at last one of four possible purposes (work, shopping, leisure, or go to health centre). Car (driving alone) and cycling are more prevalent in the Netherlands site. Bus and walking are more prevalent in Poland.

Table 46: Virtual reality experiment participants - travel behaviour and context (%)

	ALL	Netherlands	Poland	Greece
Disability or health problem affecting mobility				
Yes	17	18	33	0
No	79	76	67	96
Prefer not to say	3	6	0	4
Driving licence				
Have license, is able to drive	78	88	67	79
Have licence, no car	7	9	7	4
Have licence, can not drive because of health	4	0	13	0
No licence	11	3	13	18
Attitude to driving				
Enjoy driving, do not mind doing it	43	50	47	32
Prefer to use time for something else	14	21	10	11
Does not drive	42	29	43	57
Travel for shopping				
Never or less than once a month	8	0	10	15
1-3 times a month	32	18	50	30
1-3 times a week	49	74	37	33
4+ times a week	11	9	3	22

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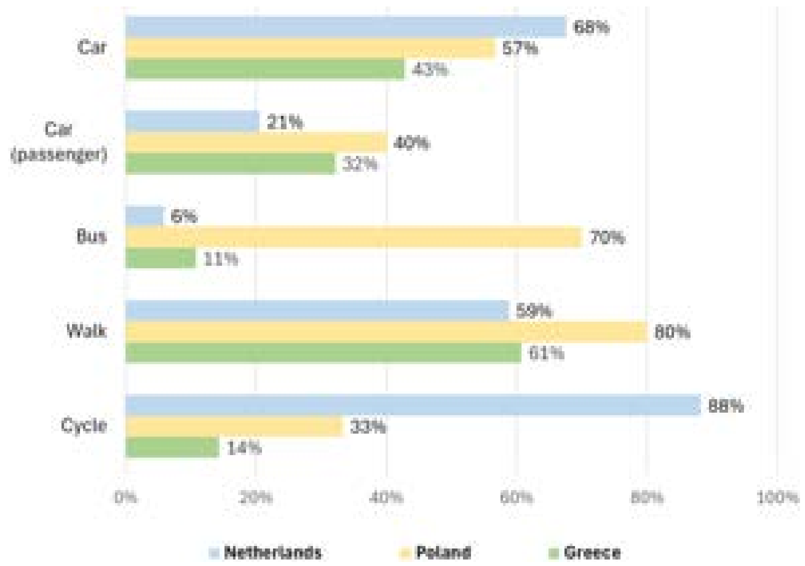

Notes: Numbers for whole sample: car (driver)=57%, car (passenger)=30%, bus=28%, walk=66%, cycle=48%. Other modes: train only in Netherlands (18%), taxi only in Poland (3%) and Greece (3%)

Figure 37. Virtual reality experiment participants – use of travel modes

4.6.3 Prior awareness and concerns about self-driving vehicles

There was some awareness of self-driving vehicles among the sample (Figure 38). Overall, 46% said they were aware of self-driving vehicles and following developments, and another 47% said they were aware but did not know much. Only 8% were not aware of these vehicles. In Greece, 61% said they were aware and following developments, and none said they were not aware.

The main concerns about these vehicles (Figure 39) were traffic safety and vehicle software failing during the trip. Legal issues were also a concern of the majority of the sample in the Netherlands.

The main use participants in all three countries reported for their travel time if they could use self-driving vehicles was “look outside the window” (Figure 40). Other activities include talking to other passengers, listen to music, other activities on a device, and think. Work was mentioned by only 29% of participants in Netherlands and 7% in the other two countries.

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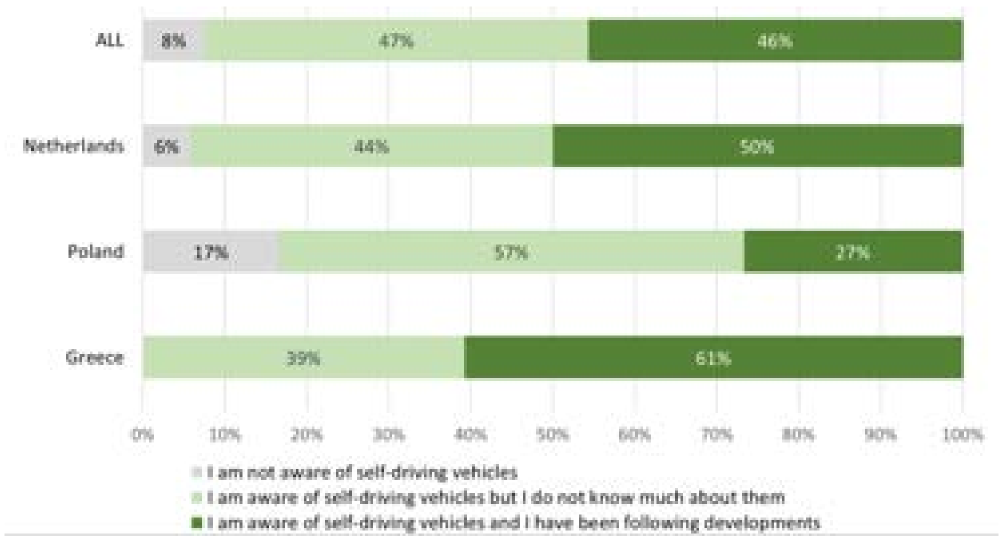

Figure 38. Virtual reality experiment – previous awareness of self-driving vehicles

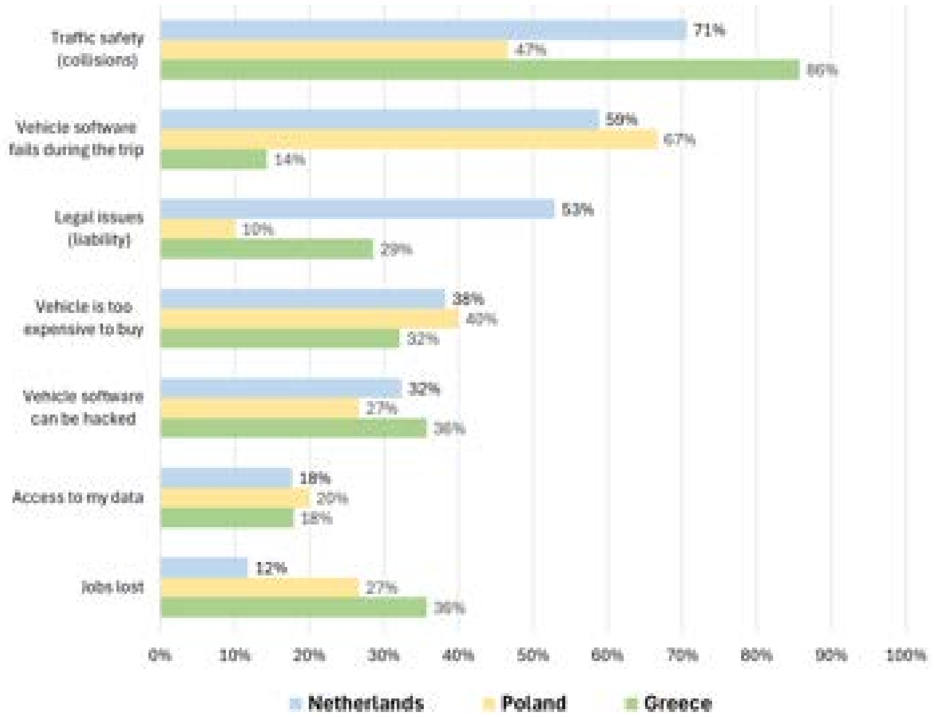

Figure 39. Virtual reality experiment – previous concerns about self-driving vehicles

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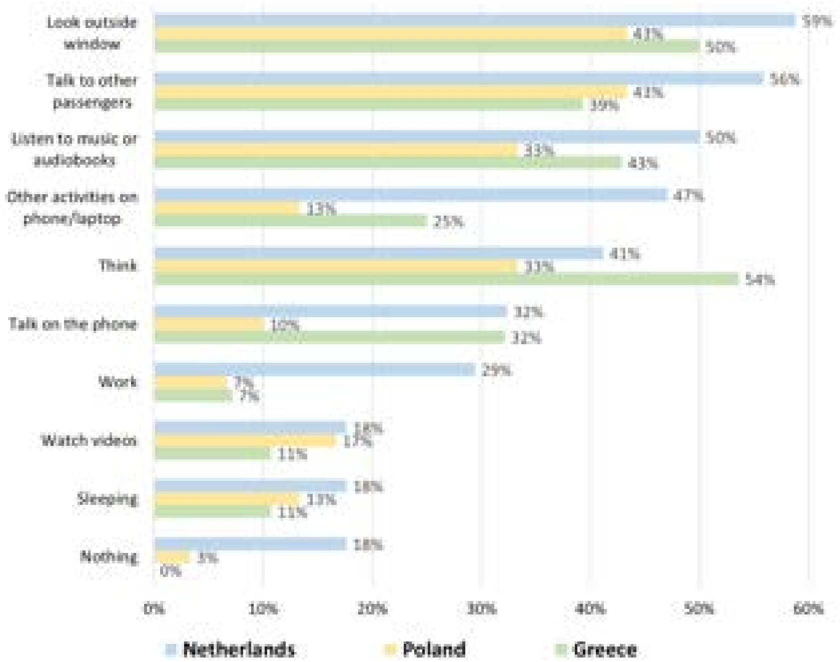

Figure 40. Virtual reality experiment – intended use of travel time in self-driving vehicles

4.7 Choices

4.7.1 Mode choice

Figure 41 shows the participants' initial choices of travel mode in the virtual reality game. Overall, 43% chose the car and 57% chose the bus. The proportion of participants choosing the bus was considerably higher in the Netherlands (71%), and slightly smaller among the younger age group (45%).

We coded all the reasons for the choices, which were provided by participants in an open-ended question. The main reasons for choosing the car (left side of Figure 42) were that is the usual mode participants use, it is more private, and seemed more curious than the bus. The main reasons for choosing the bus (right side of the figure) were that it seemed more curious, followed by two of the trip attributes shown in the game: the bus was cheaper and faster than the car.

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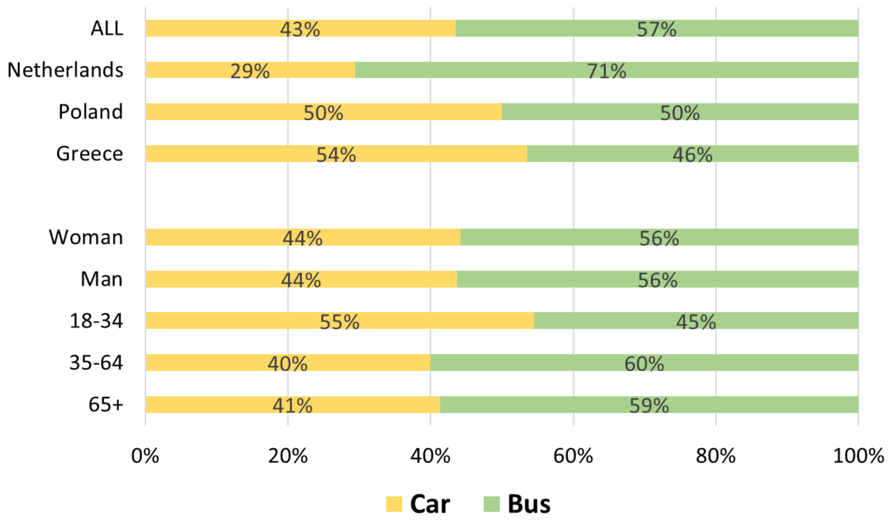
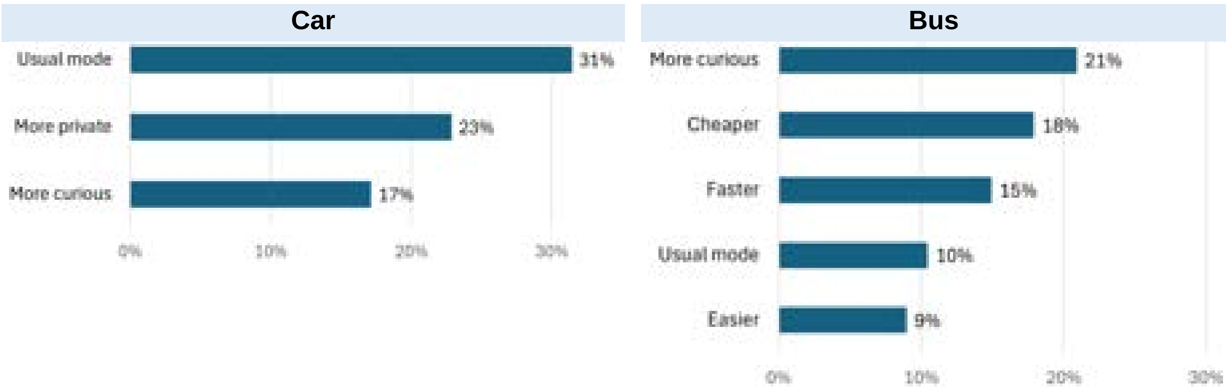


Figure 41. Virtual reality experiment – initial choices



Note: Base is number of different reasons given by participants who chose bus (67) and car (35). Charts show only reasons given by more than 5 participants, i.e. 7% of bus choices and 14% of car choices

Figure 42. Reasons for initial choices

4.7.2 Mode switch

It was expected that most participants switched from one mode to another during the game, as it was likely that they were curious to try both modes in virtual reality. Figure 43 shows the proportions who did not switch.

Only 5% of participants who started in the car did not switch to the bus during the trip. All participants in Poland, women, aged 18-34, or 65+ switched from car to bus. In contrast, the proportion of participants who did not switch from the bus to the car was much larger: 27%. This proportion was even larger among participants aged above 65, at 47%.

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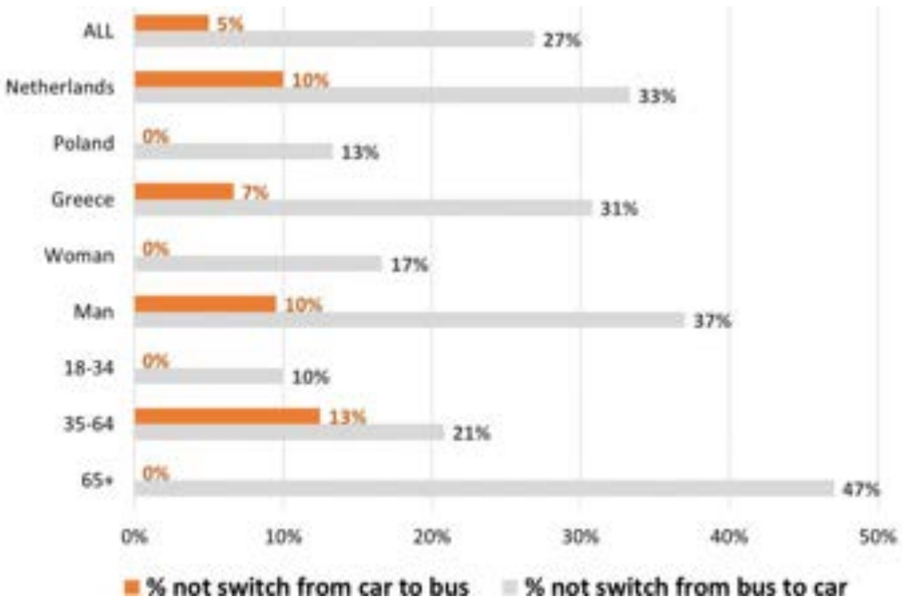

Figure 43. Virtual reality experiment – mode switch

Figure 44 shows the proportion of participants who started in the car and were still in the car at the end of each stage of the bus scenario. Most participants (70%) switched in the first two occasions they could switch (i.e., at the start of stages 2 or 3). This was a general behaviour, with no large differences across countries, genders, or age groups.

Figure 45 shows the proportion of participants who started in the bus and were still in the bus at each stage of the bus scenario. Again, there was a drop in the first two stages, but not as pronounced as in the case of the car. After this, there not many participants switching, until the start of Stage 7, when there was another drop. This coincided with the arrival in the bus (in Stage 6) of the passengers with anti-social behaviour. In the Netherlands and Greece, the drop continued at the start of Stage 8 (as the anti-social passengers were still in the bus in Stage 7). This shift from bus to car after the arrival of these passengers in the bus was considerably more pronounced for women than men.

We coded the reasons that participants gave for switching. The main reasons were curiosity to see what the other mode looked like (78% of reasons to switch from bus to car and 84% of reasons to switch from car to bus). Three participants (i.e. 8% of those who switched from the bus) mentioned the unruly passengers with anti-social behaviour as a reason to switch. Four participants (i.e. 13% of those who switched from the car) mentioned slow speed as a reason.

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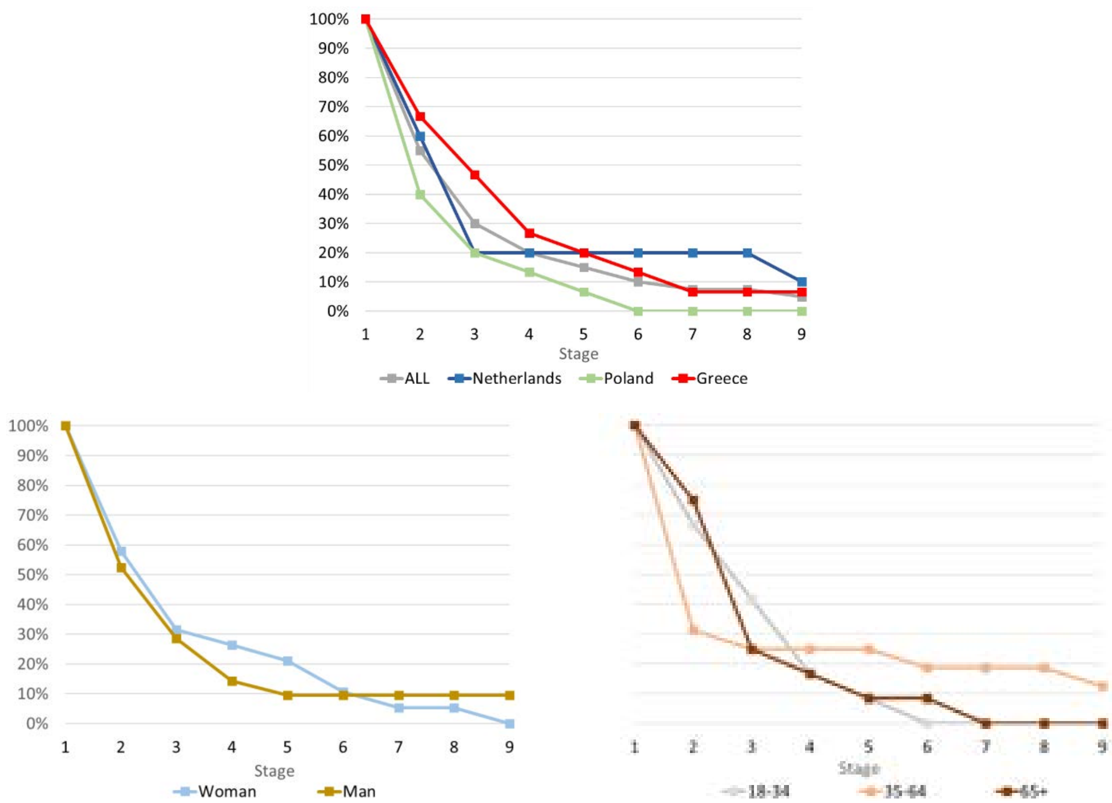

Figure 44. Virtual reality experiment – proportion of participants remaining in the car scenario, by stage, country, gender, and age

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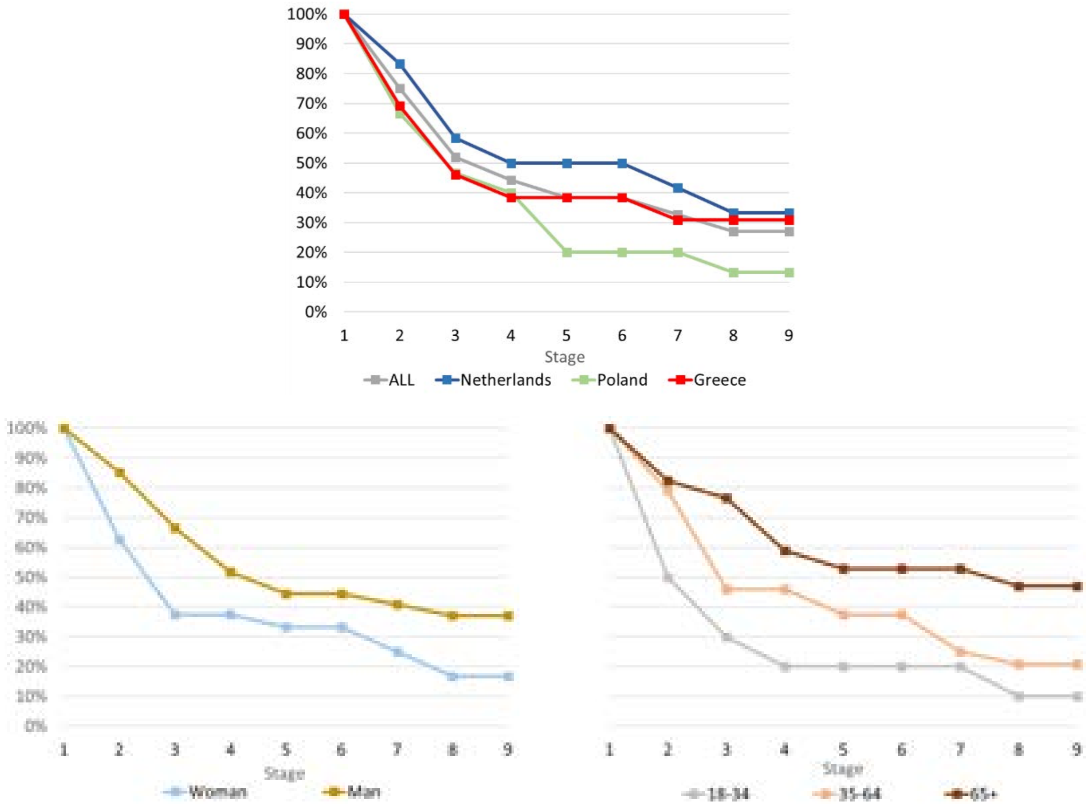

Figure 45. Virtual reality experiment – proportion of participants remaining in the bus scenario, by stage, country, gender, and age

4.7.3 Regret

28% of participants who switched regretted doing so, both in the case of the car and the bus (Figure 46). The proportion of those who regretted switching from bus to car was higher in Poland and among the 18-34 and 65+ age groups. The proportion who regretted switching from car to bus was zero in the Netherlands and lower than average among men and those aged above 65.

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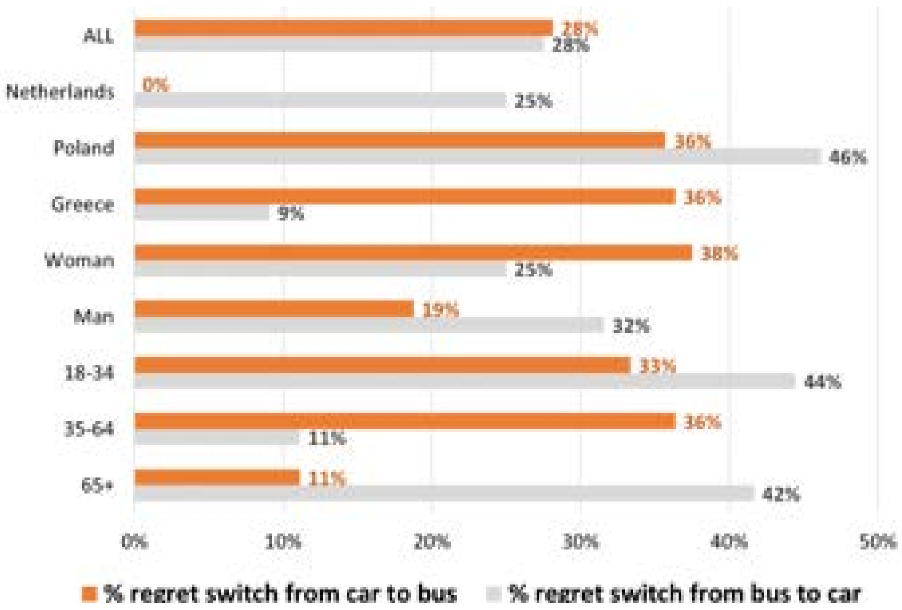

Figure 46. Virtual reality experiment – regret

We coded the reasons given for regretting. The main reasons to regret having switched from car to bus was that the car was slow (eight participants, i.e., 53% of those who regretted) and the ride was boring (three participants, i.e., 20%). The main reasons to regret having switched from bus to car were the unruly passenger behaviour (five participants, i.e., 42% of those who regretted) and the presence of other passengers in general (three participants, i.e., 25%)

4.7.4 Other choices

Figure 47 and Figure 48 show the choices participants made regarding the use of travel time, when prompted to do so immediately after the trip started. “Look around” was the most frequent choice. This is consistent with the responses participants gave in the pre-event questionnaire (compare with Figure 40). Choices were mostly consistent across the two modes and all genders and age groups. However, in the case of the bus, participants aged 18-34 had a considerably lower propensity to choose “look around” compared with others, instead choosing entertainment.

When prompted to choose what to do with the car at the end, two thirds of participants who ended the game in the car chose to send it back, and one third chose to park it nearby to use the following day. However, two thirds of participants aged 65+ chose to park nearby (in contrast with those aged 18-34 (89% chose to send the car back). The majority of Greek participants also chose to park nearby.

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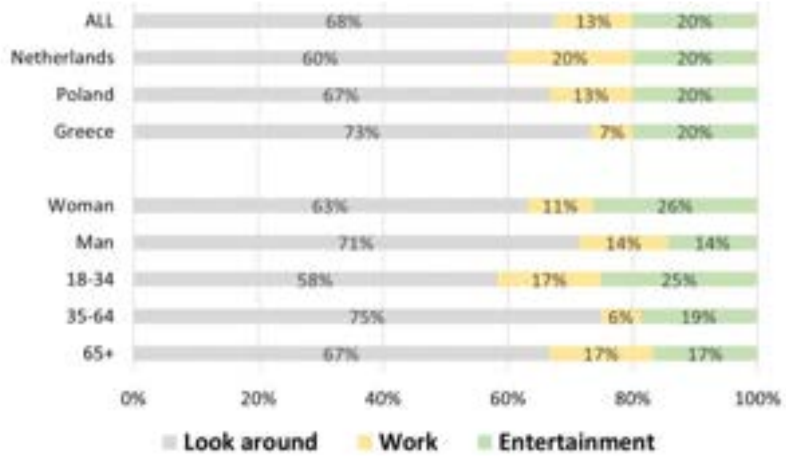

Figure 47. Choices for use of travel time (car)

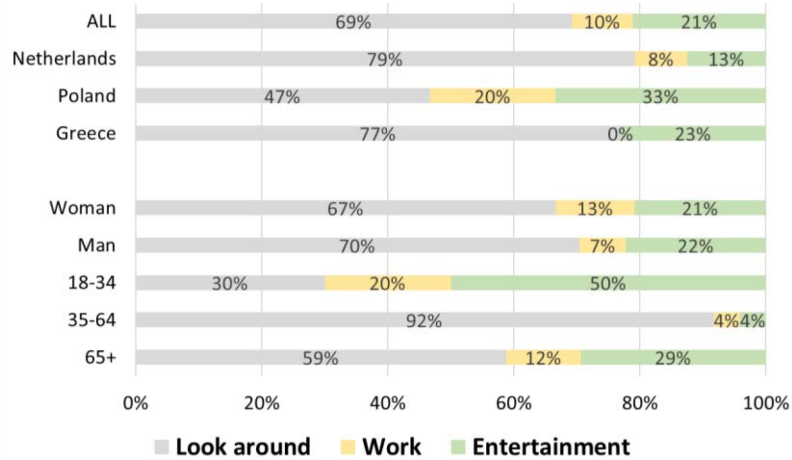

Figure 48. Choices for use of travel time (bus)

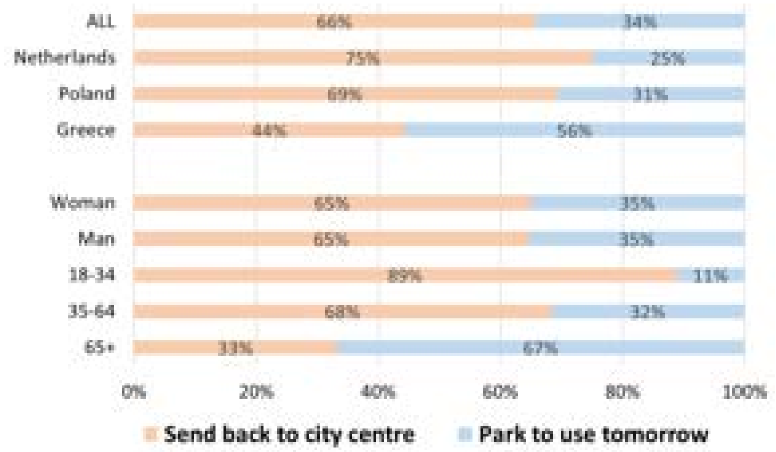

Figure 49. Choices for car return

4.8 EEG results

The following tables show the results of the analysis of EEG data, using the difference between the mean ratio between the beta high and alpha frequencies in each stage and in the baseline

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conditions (i.e. before the game). As mentioned, this is an indicator of arousal or stress. The tables show the differences of those mean ratios across the participants who experienced each stage of the car trip (Table 47) and each stage of the bus trip (Table 48). The stars in the tables identify the differences that are statistically significant, i.e. the cases when the mean ratios for a stage are significantly higher than the baseline ratios, based on t-tests. The analysis is split by gender and age.

In the car scenario (Table 47), only the Stage 7 difference is significant (at the 10% level), for the whole sample. This corresponds to the peak of congestion. No differences are significant for women, and the 35-64 age group. Men show significant differences in Stages 5 and 7 and the 18-34 group show significant differences in the last stage. The 65+ age group shows significant differences in all stages from Stage 2. This suggests a sustained state of stress/arousal. However, this result was based on data for less than 10 participants.

Table 47. EEG results: difference between beta-alpha ratio in car scenario stages and baseline, by gender and age

Attribute	**Stages**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Landscape	City centre			Industrial	Centre	Industrial	Centre	Industrial	Residential
Time of day	Daytime		Gradually getting darker					Night-time	
Congestion	No	Gets progressively worse						Eases up	No
Difference									
All	-0.03	-0.03	0.02	0.05	0.05	0.09	0.11*	0.03	0.08
Men	-0.08	0.00	0.05	0.08	0.08*	0.04	0.06*	0.02	0.06
Women	0.02	-0.05	-0.02	0.03	0.01	0.14	0.15	0.02	0.11
18-34	*-0.19*	*-0.15*	*-0.15*	*0.02*	*-0.02*	*0.08*	*0.08*	*0.07*	*0.09**
35-64	0.00	*-0.23*	-0.02	-0.11	-0.05	-0.07	0.00	-0.08	-0.03
65+	*0.09*	*0.33***	*0.41***	*0.41****	*0.27****	*0.36****	*0.33***	*0.16***	*0.29***

Notes: Values in *italics and smaller font* are based on less than 10 participants. Stars identify differences that are significantly positive, i.e. the ratio is significantly higher than the baseline ratio for the same group of participants, based on t-tests. Significance levels: ***: 1%, **: 5%, *:10%.

In the bus scenario, six of the nine stages show significant differences with the baseline, for the whole sample. In Stage 1, the difference is zero, i.e., the beta-alpha mean ratio is the same as in the baseline. The difference is statistically significant, and grows, during Stages 2-3 (when the bus is crowded) and Stage 4, when the bus crosses the derelict industrial area. It declines and becomes insignificant in Stage 5, when there are few passengers and the bus returns to the city centre. It then grows and becomes significant in Stages 6-8, when the anti-social passengers are in the bus. It reaches a peak in Stage 8, when the anti-social passengers have been in the bus for two stages and it is already night-time. It then decreases and becomes insignificant in the last stage, when the bus is quiet and there are no other passengers.

Men showed no significant differences with the baseline in any stage. In contrast, women show significant differences in all stages from Stage 2. The 35-64 age group shows no significant differences and the 18-34 group shows only one in Stage 2 (when the bus starts to be crowded). In contrast, the 65+ group show significant differences in all stages from Stage 3. For both women and the 65+ group, the differences grow when the bus is crowded (Stages 2-3) and then enters the derelict industrial area (Stage 4), decrease when the bus returns to the city centre

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(Stage 5), and then grow again when the anti-social passengers are in the bus (Stages 6-8), reaching a peak in Stage 8 when these passengers have been in the bus for two stages and is already night-time. The differences decline sharply when these passengers leave, and the bus is quiet, but remain significant (Stage 9).

Table 48. EEG results: difference between beta-alpha ratio in bus scenario stages and baseline, by gender and age

Attribute	Stages								
	1	2	3	4	5	6	7	8	9
Landscape	City centre			Industrial	City Centre	Industrial	City centre	Industrial	Residential
Time of day	Daytime		Gradually getting darker					Night-time	
Passengers	Few	Many		Few					None
Passenger behaviour	Mind their own business					Anti-social			No other passenger
Assistant	Present				Absent				
Difference									
All	0.00	0.07*	0.16**	0.19**	0.12	0.16*	0.15*	0.20*	0.09
Men	-0.01	0.00	0.13	0.15	0.09	0.12	0.08	0.08	0.06
Women	0.01	0.16**	0.22**	0.26**	0.18*	0.22**	0.28*	0.43**	0.15*
18-34	-0.02	0.13**	0.15	0.12	0.13	0.05	0.09	0.11	-0.05
35-64	-0.06	0.01	0.12	0.12	0.07	0.15*	-0.03	-0.03	0.03
65+	0.09	0.11	0.22**	0.31**	0.17	0.24**	0.37**	0.47**	0.21*

Notes: Stars identify differences that are significantly positive, i.e. the ratio is significantly higher than the baseline ratio for the same group of participants, based on a t-test. Significance levels: ***: 1%, **: 5%, *:10%.

4.9 Post-experiment questionnaire results

This section reports the main results of the post-experiment questionnaire, including the feelings stated by participants (Section 4.9.1), aspects they remembered or noticed in the scenarios (4.9.2), assessment of the realism of the scenarios (4.9.3), comparison between self-driving and human-driven cars and buses (4.9.4), intentions to use self-driving cars and buses (4.9.5) and intended changes in travel behaviour (4.9.6).

4.9.1 Feelings

Figure 50 compares the feelings reported by participants about their experience using the virtual bus and car. Most feelings were positive. More participants reported positive feelings regarding the bus and the car. The main feelings were of being content, safe, amused, and pleased. The main negative feeling was boredom in the car scenario, reported by 27% of those who tried that scenario.

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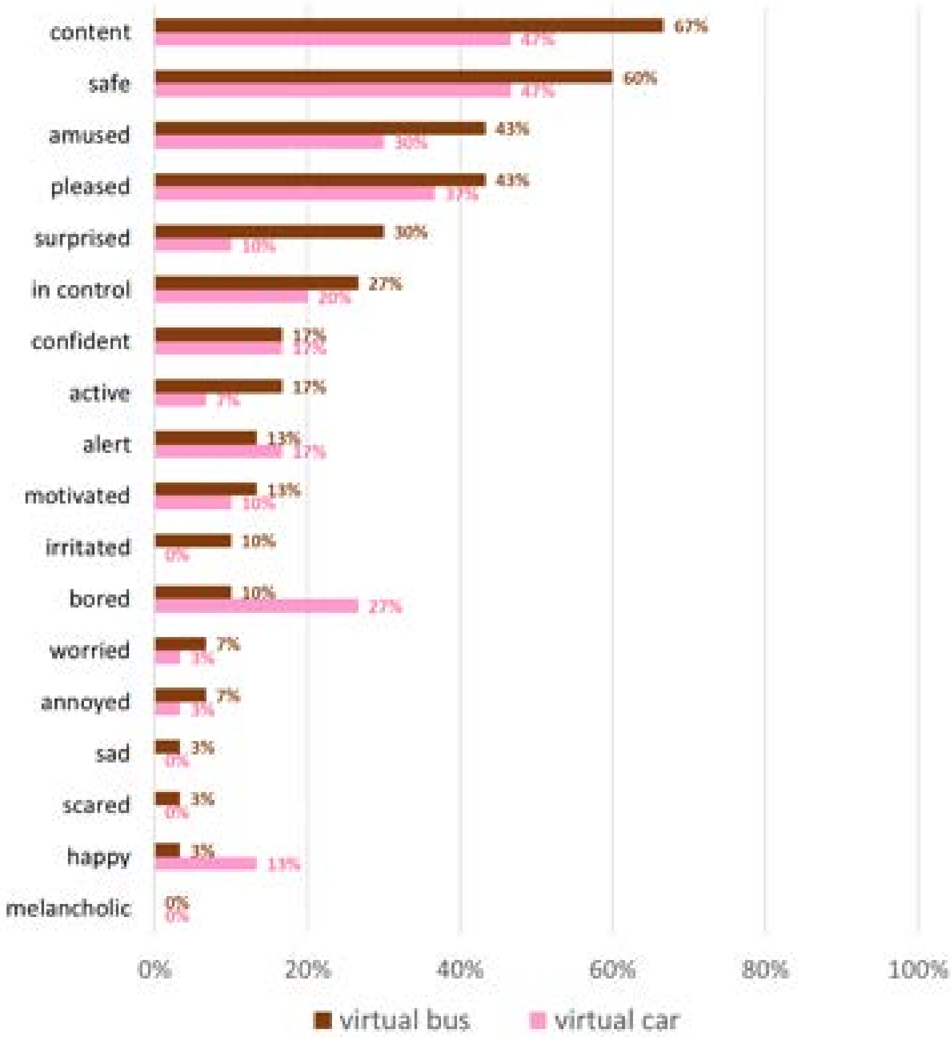

Figure 50. Feelings while riding in the virtual vs. real self-driving bus

4.9.2 Aspects participants remembered and noticed in scenarios

Participants stated, in open-ended questions, the three things they remembered about each trip. We coded all the answers. Figure 51 shows the results. The main things they remembered from the virtual car trip was that the car was slow (and slower than the bus), the view from the window, the internal design of the car, the absence of other passengers, being safe, the other vehicles on the road, and the fact that the car was quiet and comfortable.

The main things they remembered about the virtual bus trip were the view from the window, the fact that the bus was fast (and faster than the car), the presence of other passengers in general, the specific situation of the unruly passengers, and that the bus was quiet, safe, and spacious.

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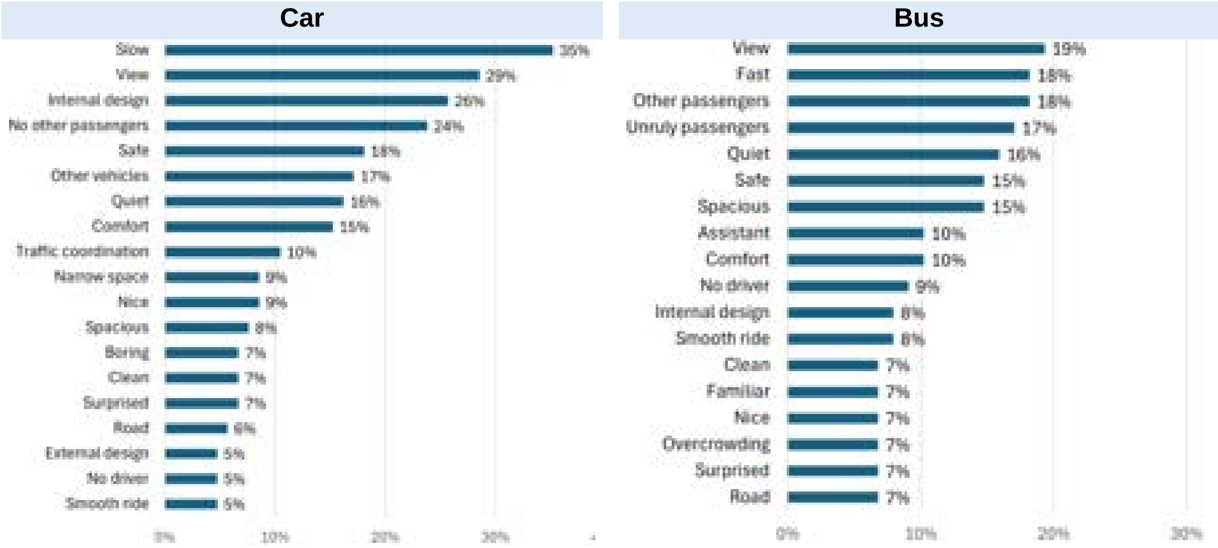

Note: Base is number of different aspects participants remembered about the bus (88) and car (105). Charts show only reasons given by more than 5 participants, i.e. 6% of bus aspects and 5% of car choices

Figure 51. Aspects participants remember from the scenarios

These results can be compared with those in Figure 52 and Figure 53, which show the changes that participants stated they noticed in the scenarios, after being shown a list of these changes. The majority or almost majority of participants stated that they noticed the changes listed for the car (Figure 52). About the same proportion noticed the changes in the speed of the vehicle they were in (i.e. the car) and those in the speed of the vehicle they were not (i.e. the bus). This is consistent with the results above (Figure 51), as speed (and its relationship with the bus) was the main aspect participants remembered about the car trip.

The majority or almost majority of participants stated that they noticed the changes listed for the bus (Figure 53). The main change noticed was in the number of passengers. Again, about the same proportion noticed the changes in the speed of the vehicle they were in (i.e. the bus) and those in the speed of the vehicle they were not (i.e. the car). More than half said that they noticed a change in the presence vs. absence of the human assistant. This compared with only 10% who said they remembered the assistant, as stated in the previous (open-ended) question (Figure 51).

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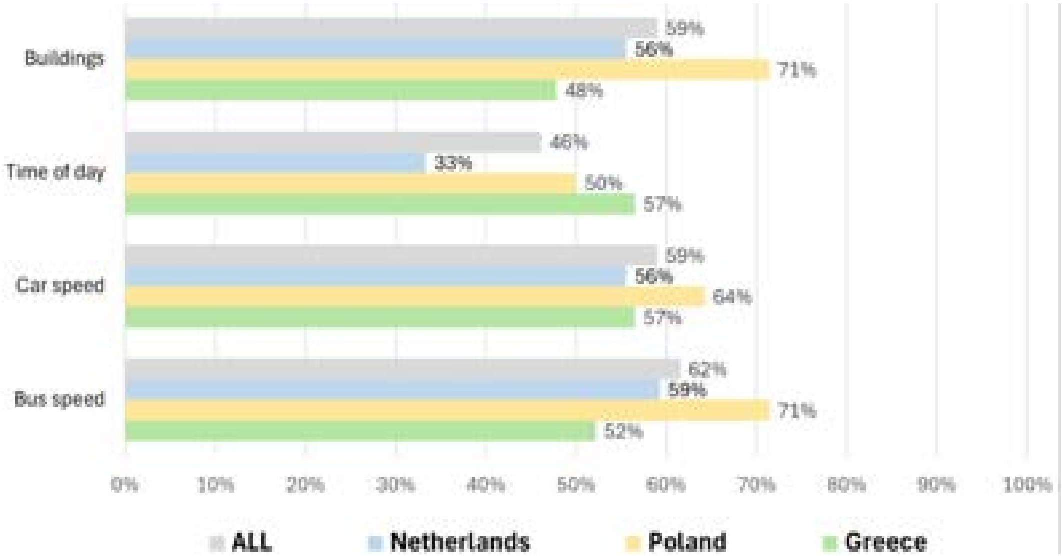

Figure 52. Aspects participants retained from virtual car

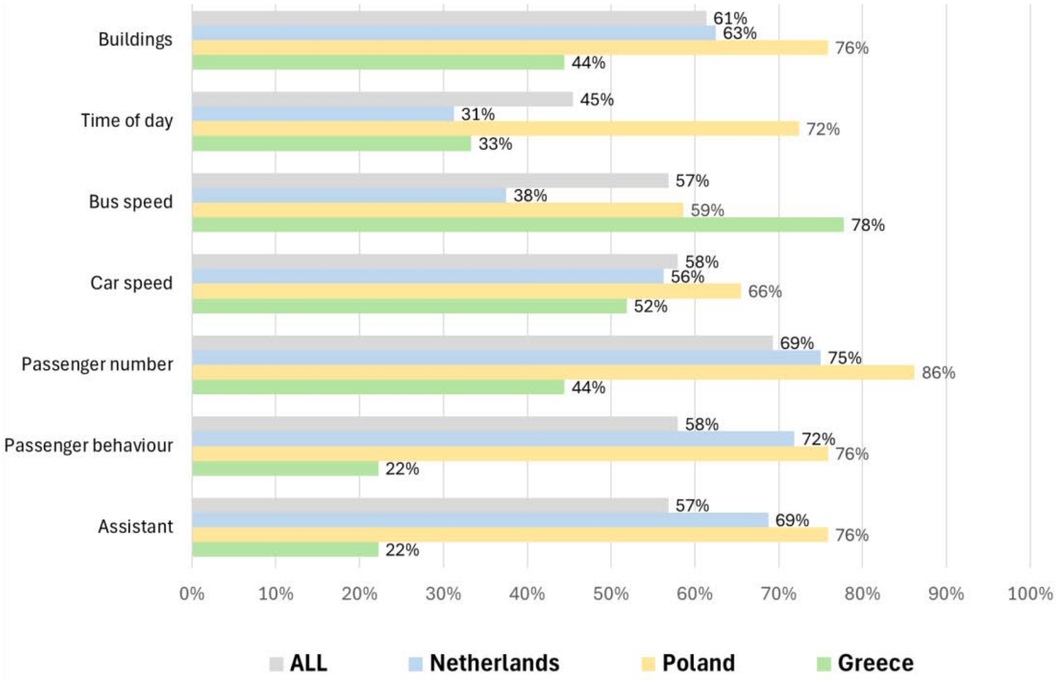

Figure 53. Aspects participants retained from virtual bus

4.9.3 Participant assessment on realism of scenarios

The majority of participants thought that both car and bus scenarios were realistic or very realistic (Figure 54). The main aspects people thought were not realistic (Figure 55) were, in the case of the car, the movement (e.g., slow, no lane change or overtaking, smooth movement and no breaking), the road (straight, with few intersections, and no potholes), the absence of pedestrians or cyclists, the buildings, and the ride (too short and quiet).

In the case of the bus, the main aspects thought to be unrealistic were the passengers (number, appearance, repetitive behaviour, and non-response), traffic (too harmonious, no unexpected

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situations, too many or too few vehicles), bus movement (fast and smooth), the ride (could not use phone, unclear if it was standing or seating), and the road (straight, signals always green).

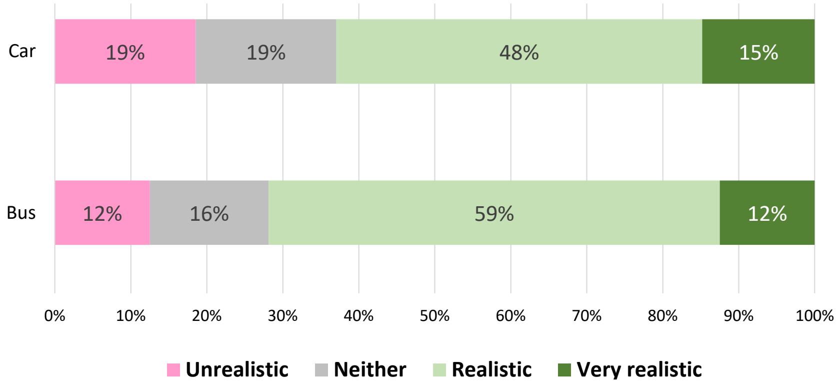
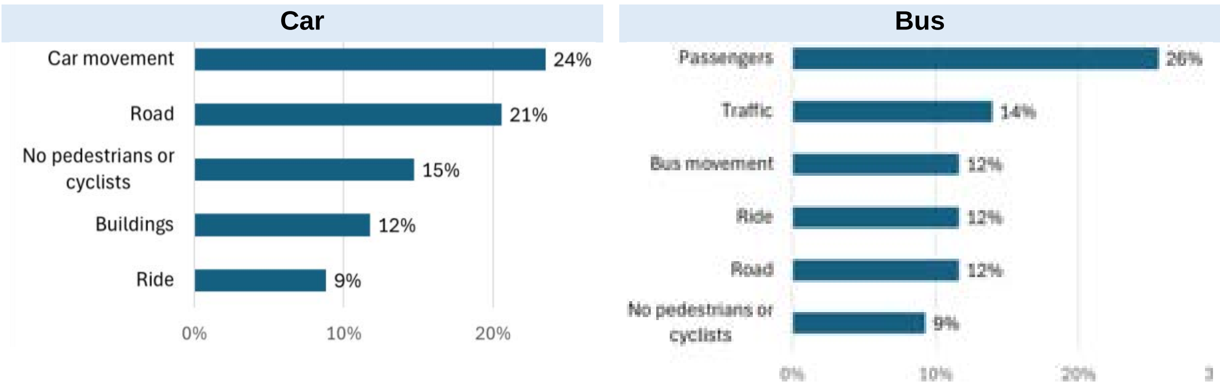


Figure 54. Participants' assessment of realism of virtual reality scenarios



Note: Base is number of different aspects participants thought were not realistic about the bus (43) and car (34). Charts show only reasons given by more than 3 participants, i.e. 7% of bus aspects and 9% of car choices

Figure 55. Aspects participants thought were not realistic

4.9.4 Assessment of self-driving vs. human-driven vehicles

Figure 56 shows how participants compare human and self-driven vehicles regarding interest, speed, cost, stress, comfort, safety (from collision) and security (from crime), after experiencing the two self-driving vehicles in virtual reality.

More participants thought that self-driving vehicles are more interesting (39%) than those who think that human-driven ones are more interesting (11%). This result is consistent across countries.

The sample is more balanced when it comes to speed, with a small advantage for self-driving (35% vs. 22%), but this is mostly derived from the opinion of the Greek participants. There is also a balance regarding which vehicles will be more stressful.

The majority of Poland and Netherlands participants think self-driving vehicles will be cheaper, safer, but also more insecure than human-driven ones. Opinions are different in Greece: the majority thinks human-driven vehicles are cheaper and is unsure about safety and security.

The majority of participants in Poland and Greece think self-driving vehicles are more comfortable, but most of those in the Netherlands are unsure.

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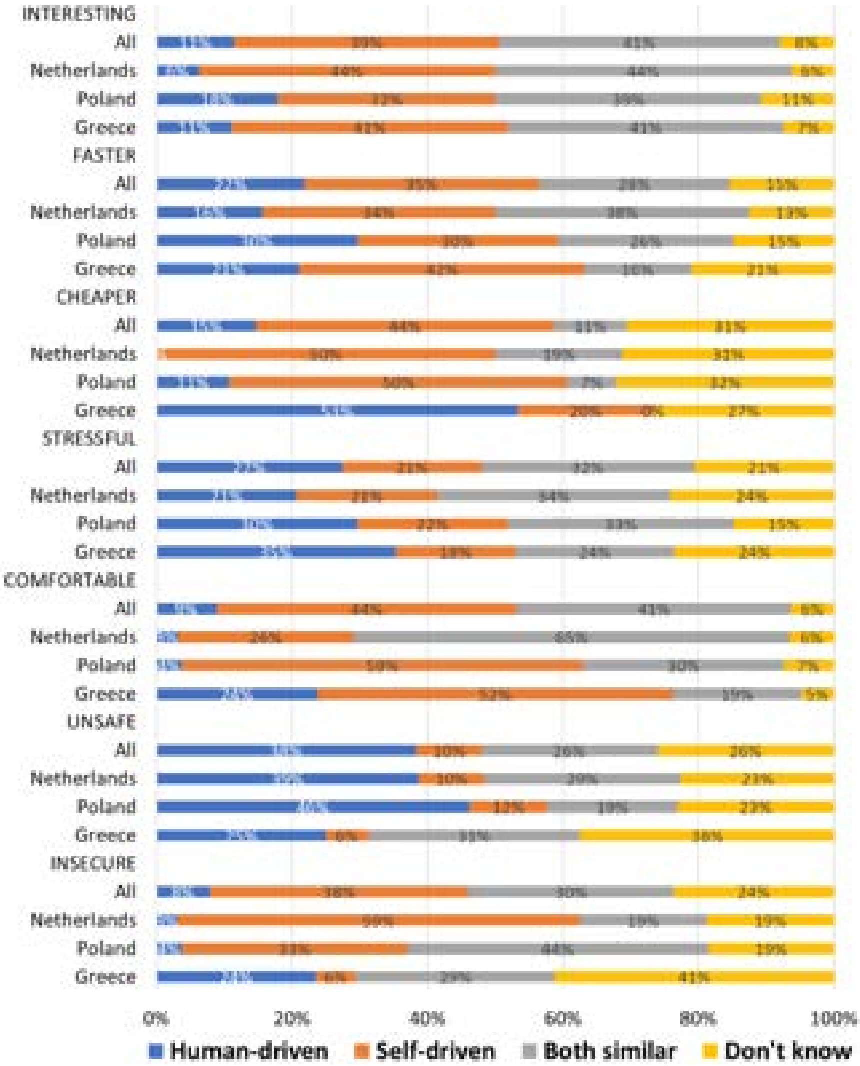

Figure 56. Comparison of self-driving and human-driven vehicles

4.9.5 Intention to use

Figure 57 compares the intentions to use self-driving cars and buses expressed after experiencing them in virtual reality and the previous intentions to use self-driving vehicles in general, expressed in the questionnaire answered before the event.

Overall, the intention to use self-driving vehicles increased markedly, from before the event (40% said they would use a self-driving vehicle) to after the event (58% said they would use a self-driving car and 70% said they would use a self-driving bus). The increase is higher in the Netherlands and Poland, as in Greece there was already a high proportion of positive intentions. In all countries, the stated propensity to use a self-driving bus is higher than the one to use a self-driving car. The increase in positive intentions comes mostly from the reduction of the number of participants who said they were unsure. The proportions who have negative intentions was residual before the event but remains residual (not eliminated).

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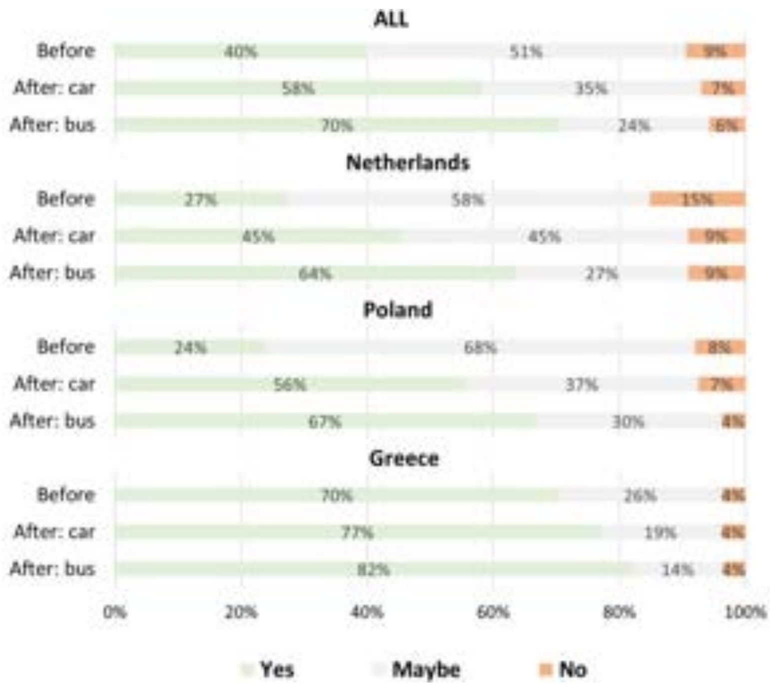

Figure 57. Intention to use self-driving vehicles before and after the experiment

4.9.6 Change in travel behaviour

Figure 58 shows participants' intentions to change travel behaviour after experiencing the self-driving car and bus in virtual reality. Overall, 46% and 51% said they would use the travel time for productive and leisure uses, respectively, if they could travel on a self-driving vehicle. The proportions for each county are in the same range as the proportions of participants reporting in the pre-event questionnaire that they would use travel time to work or for leisure uses such as watch videos (seen previously in Figure 40).

The majority in all countries said they would worry less about parking. One quarter of participants in all countries said they would travel by car more often, and 27% said they would travel by bus more often. 28% said they would travel more, regardless of mode.

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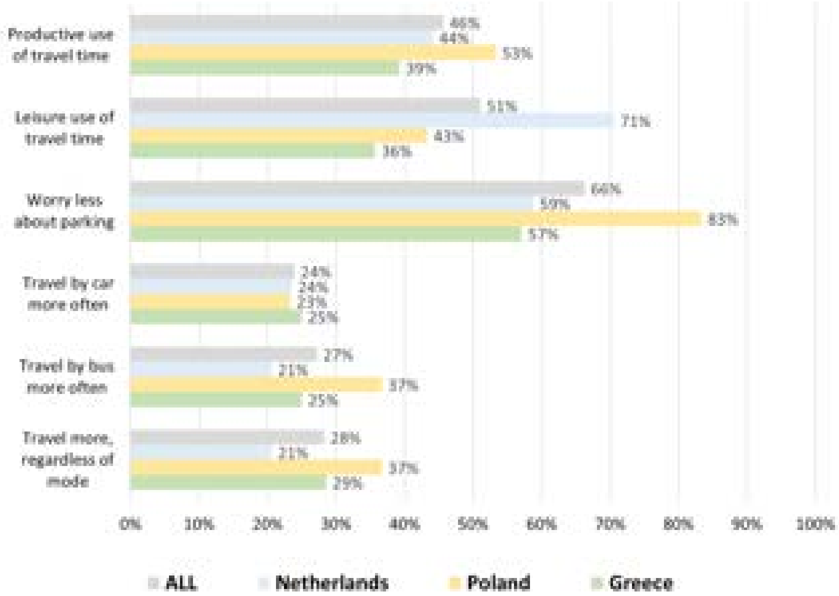

Figure 58. Intention to change travel behaviour

4.9.7 Relationships between opinions, intentions, choices, and participant characteristics

In this sub-section, we estimate how the participants' stated intentions to use self-driving cars and buses relate to their opinions about these vehicles, after experiencing them in virtual reality. We do this by comparing the intentions among participants who have a certain opinion and those who do not. The opinions examined are thinking that the self-driving vehicle is more interesting, slower, cheaper, more stressful, more comfortable, safer, and more insecure. We test whether the proportion of participants stating they will use the vehicle differs among the two groups of participants, using the chi-square test of proportions.

Table 31 shows the results. Intentions to use a self-driving car are significantly higher among those who think this vehicle is less stressful, more comfortable, and safer than a human-driven car. Intentions to use a self-driving bus are only significantly related to one opinion: thinking self-driving vehicles will be more secure.

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Table 49. Proportion of sample intending to use vehicles, by opinion

	Intends to use vehicle	
	Car	**Bus**
All	54	67
Less interesting	49	66
More interesting	64	71
Faster	54	68
Slower	55	65
More expensive	54	68
Cheaper	55	67
Less stressful	60**	70
More stressful	27	53
Less comfortable	45	61
More comfortable	64*	77
Less safe	48	66
Safer	70**	71
More secure	56	73**
Insecure	43	55

Notes: Significance levels refer to the differences in intentions, or opinions between a group and its counterpart. The proportion of the group identified with stars is significantly higher than the counterpart group. Levels of significance: ***%, **5%, *10

We now estimate how the stated opinions and intentions to use the vehicles relate to the participant characteristics and to the choices they make in the virtual reality game. We also estimate how the choices made in the game relate to participant characteristics.

To have reasonable sample sizes for each combination of opinions and participant groups, we reclassified the variables that measure participant characteristics as binary variables. The variables included in the analysis are:

- **Virtual reality choice** (initial choice): car vs. bus
- **Gender**: men vs. women
- **Age**: 18-34, 35-64, 65+
- **Education**: no university degree vs. university degree
- **Household composition**: no children in household vs. children in household
- **Disability affecting mobility*:*** no vs. yes
- **Situation regarding driving**: Can vs. cannot (because of no driving licence, no car, or a health problem)
- **Attitude towards driving*:*** Drives and enjoys it vs. does not drive or drives but does not enjoy it
- **Bus use:** no vs. yes
- **Awareness of self-driving vehicles**: aware but not following developments vs. not aware vs. aware and following developments
- **Previous intention to use self-driving vehicles** (expressed in the pre-event questionnaire): no vs. yes
- **Activity done first on the day** (for Netherlands participants only) demonstration vs. virtual reality

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Other variables were tested but proved to always be insignificantly related to opinions and intentions. These include employment status, residence location (urban vs rural), frequency of travelling for shopping and leisure, and previous concerns with self-driving vehicles (as reported in the pre-event questionnaire). Results for these variables are not shown in the analysis that follows.

Table 32 shows the results for the self-driving car. As expected, the propensity to choose the car in the initial choice of the virtual reality game is significantly higher for participants who drive and enjoy doing it, and the intention to use a self-driving car after the virtual reality experiment is higher for those who already had that intention before the event. The older age group and participants in the Netherlands who joined the virtual reality experiment before seeing the real self-driving vehicles in the demonstration also have more positive intentions to buy a self-driving car.

The propensity to think self-driving cars are more interesting than human-driven ones is higher for those who chose the car in the game, those more aware of self-driving vehicles, had a previous intention to use them, and joined the virtual reality experiment before the demonstration.

The propensity to think self-driving cars are slower is higher among participants with a university degree, who cannot drive, use buses, had no previous intentions to use self-driving vehicles, and joined the virtual reality experiment before the demonstration.

The propensity to think self-driving cars are cheaper is higher among participants with a disability affecting mobility and those who use buses. “More stressful” is related to the 25-64 age group and those who use buses and “more comfortable” is related to university degrees and disability. “Safer” is only related to university degrees and “more insecure” only to the use of buses.

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Table 50. Preferences and opinions about self-driving car, by sample segments (%)

	Car choice in game	Intends to use self-driving car in future	Opinion of self-driving car (vs. human-driven)						
			More Interesting	Slower	Cheaper	More stressful	More comfortable	Safer	More insecure
ALL	40	54	36	32	24	16	49	29	15
Car choice in game		59	57***	38	24	14	57	35	22
Bus choice in game		51	22	27	24	18	44	25	11
Man	40	52	35	25	23	15	48	29	15
Woman	42	56	37	37	23	19	49	28	14
Age:18-34	55	45	36	45	23	9	55	36	14
Age: 35-64	38	48	35	28	23	25**	48	25	18
Age: 65+	34	69*	38	24	24	10	45	28	10
No university degree	43	52	30	20	20	16	39	20	18
University degree	38	56	42	42**	27	17	58*	38*	13
No children in household	40	58	40	38*	27	18	52	32	12
Children in household	41	47	28	19	19	13	44	25	22
No disability	39	51	36	30	20	14	45	26	16
Disability	44	69	38	38	44**	25	69*	44	13
Can not drive	32	59	23	55***	32	9	45	27	5
Can drive	43	53	40	24	21	19	50	30	19
Does not drive or enjoy it	33	56	35	33	21	17	48	31	12
Drives and enjoy it	50*	53	38	30	28	15	50	28	20
Does not use bus	38	58	33	24	17	11	45	26	11
Uses bus	46	46	42	50**	42***	31**	58	38	27**
Not following or not aware	32	52	26	34	24	20	42	26	14
Aware and following	50	57	48**	29	24	12	57	33	17
No previous intention	43	43	29	38*	19	19	47	31	16
Previous intention to use	35	74***	47*	21	32	12	53	26	15
First: demonstration	18	35	24	35	29	18	41	35	24
First: virtual reality	41	53*	53*	12	18	6	59	29	6

Notes: Significance levels refer to the differences in preferences, intentions, or opinions between a group and its counterpart. The proportion of the group identified with stars is significantly higher than the counterpart group. Levels of significance: ***%, **5%, *10%

Table 51 shows the results for the self-driving bus. The propensity to choose the bus in the initial choice of the virtual reality game is significantly higher for participants who do not drive or do not enjoy doing it and those not following developments or not aware of self-driving vehicles. Intention to use a self-driving bus is only related to one variable: not having children in the household.

The propensity to think self-driving buses are more interesting is higher among those who chose the car as their initial choice in the game and those who use buses, and lower among the older age group. Participants who use buses are also more likely to think self-driving buses will be slower and more stressful than human-driven ones. Those who are more aware of self-driving vehicles are also more likely to think they will be more stressful.

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Participants with a disability and who drive and enjoy it are more likely to think self-driving buses will be more comfortable. Participants in the 65+ age group are less likely to think self-driving buses will be safer and more likely to think they will be more insecure. Those with previous intention to use a self-driving vehicle also think they are more insecure. There are no variables significant related to comparisons in terms of cost.

Table 51. Preferences and opinions about self-driving bus by sample segments (%)

	Bus choice in game	Intends to use self-driving car in future	Opinion of self-driving bus (vs. human-driven)						
			More Interesting	Slower	Cheaper	More stressful	More comfortable	Safer	More insecure
ALL	60	37	18	36	16	38	30	32	67
Car choice in game		41	27*	35	22	43	38	35	68
Bus choice in game		35	13	36	13	35	25	29	67
Man	60	38	19	42	15	31	31	31	65
Woman	58	37	16	28	16	47	28	30	70
Age:18-34	45	36	23	36	9	45	27	32	59
Age: 35-64	63	43	23	38	23	38	25	40	60
Age: 65+	66	31	7+	31	10	34	38	17+	83**
No university degree	57	41	16	27	23	30	27	34	64
University degree	63	33	21	44	10	46	33	29	71
No children in household	60	43*	20	38	18	38	33	27	68
Children in household	59	25	16	31	13	38	25	41	66
No disability	61	38	20	34	14	36	25	30	67
Disability	56	31	13	44	25	50	56**	38	69
Can not drive	68	23	23	50	14	45	23	27	77
Can drive	57	41	17	31	17	36	33	33	64
Does not drive or enjoy it	67*	42	21	37	19	42	21	27	69
Drives and enjoy it	50	30	15	35	13	33	43**	38	65
Does not use bus	62	32	14	29	17	32	30	32	70
Uses bus	54	50	31*	54**	15	54**	31	31	62
Not following or not aware	68*	38	18	36	18	28	28	26	62
Aware and following	50	36	19	36	14	50**	33	38	74
No previous intention	57	40	22	40	19	34	29	31	60
Previous intention to use	65	32	12	29	12	44	32	32	79*
First: demonstration	82	41	18	47	12	35	47	65	53
First: virtual reality	59	41	12	47	24	12	24	47	71

Note: Significance levels refer to the differences in preferences, opinions, or intentions between a group and its counterpart. The proportion of the group identified with stars is significantly higher than the counterpart group. Levels of significance: ***%, **5%, *10%. The proportion of the group identified with + is significantly lower than the counterpart group (at 10% level).

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4.9.8 Relationships between virtual reality and vehicle demonstration

The previous section showed that the order of the events for the participants in the Netherlands, (who joined both virtual reality and the vehicle demonstration) is significantly related to some of the results of the virtual reality questionnaire. Previously, the chapter on the demonstration (Section 3.4.8) also showed that the order of events was related to the results of the demonstration questionnaire.

This section compares results of the two events, for questions that were identical to both: “likes” and “dislikes”, reported feelings, comparisons between self-driving and human-driven vehicles, and intentions to use self-driving vehicles.

Participants were asked what they liked in one experience and disliked in the other. The main aspect participants liked in the virtual bus was the space inside the bus, mentioned by nine participants, i.e. 32% of the Netherlands sample. The main aspect they liked in the real bus was human interaction (four participants, i.e. 14%).

Figure 59 compares feelings participants reported for the two activities, focusing on the only vehicle common to both: a self-driving bus. In the demonstration (an experience of a real self-driving bus), higher proportions reported feeling surprised, in control, motivated and, to a lesser degree, safe). In the virtual reality experiment (an experience of a virtual self-driving bus), higher proportions reported feeling pleased.

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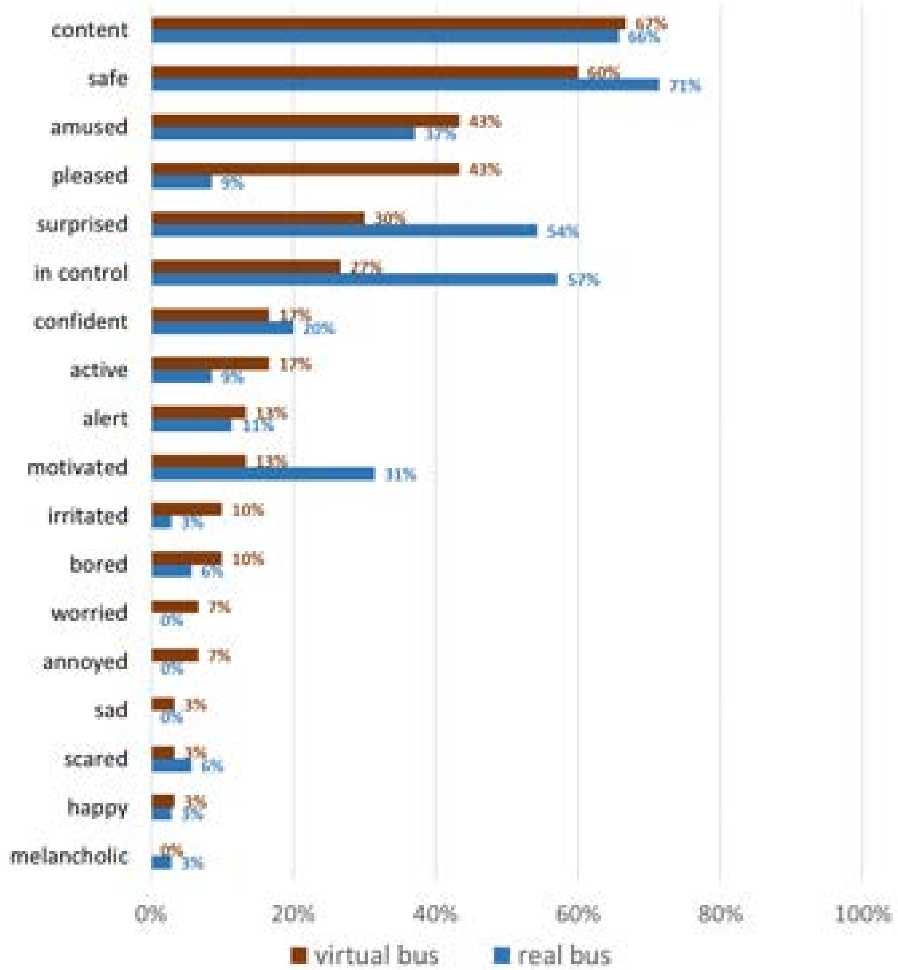

Figure 59. Virtual vs. real bus: feelings

Figure 60 compares the assessments of self-driving buses versus self-driven ones. The results are broadly similar. The main difference is that higher proportions thought that self-driving buses are faster when experiencing them in virtual reality. This result is as expected, since the virtual bus was designed to be faster than the virtual car, and the real self-driving bus moved slowly to reassure to participants that the vehicle was safe.

Higher proportions think the self-driving bus is more comfortable than a human-driven one when experiencing a self-driving bus, compared with experiencing it in virtual reality.

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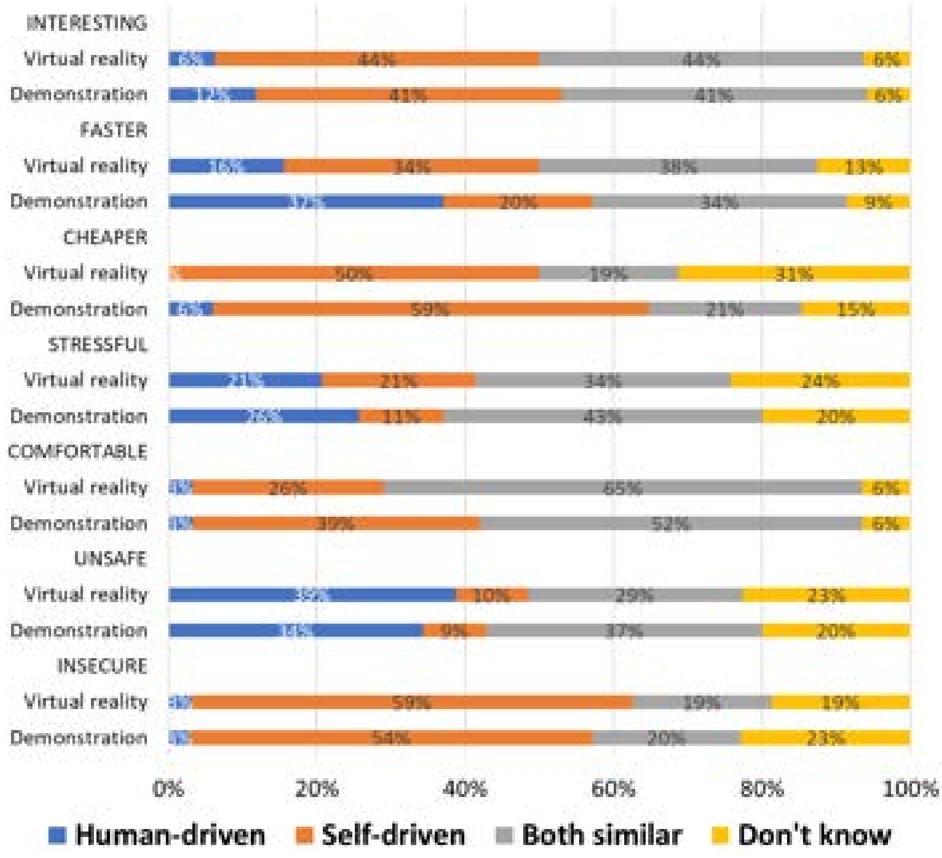

Figure 60. Virtual vs. real bus: vehicle comparison

Figure 61 compares intentions to use self-driving buses. Participants stated their intention before joining both events. They also stated their intention after the virtual reality and after the demonstration. In the last two cases, the results can be split according to sequence, i.e. which event participants joined first.

Positive intentions always grow, when compared with prior ones (i.e. before both events). Participation in the demonstration slightly reduce intentions because:

- Joining only the virtual reality produces slightly more positive intentions (71%) than joining only the demonstration (65%)
- Joining the virtual reality and then the demonstration produces more positive intentions (76%) than joining only the demonstration (65%)
- In contrast, joining the demonstration and then the virtual reality produces fewer positive intentions (56%) than joining only the virtual reality (71%)

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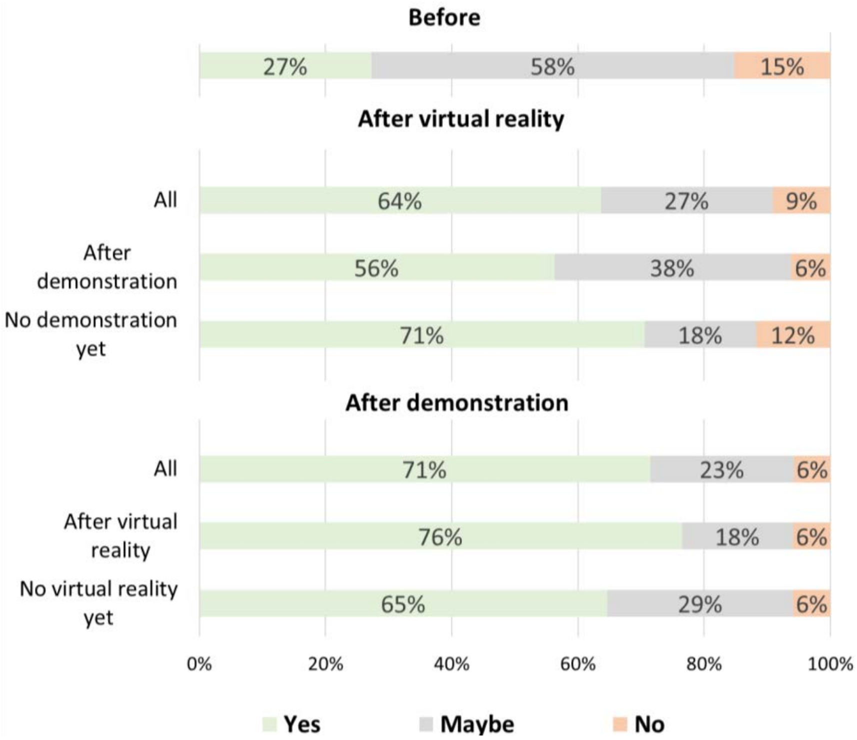

Figure 61. Virtual vs. real bus intentions to use bus

4.10 Group discussion results

4.10.1 Overview

24 group discussions were held, lasting about 20 minutes each, i.e., a total of eight hours of discussions. Twenty of the groups had four participants, four had three participants. Each discussion was structured into eight steps. At the start of each step, the moderator showed one image from the games. The images are described in sub-section 4.4.6 and shown in Appendix 6.

Notes were taken during the discussions on each participant intervention, also identifying their participant ID number. The discussion in all groups was translated into English by project partners in the three countries. ID numbers were then matched to the data on participant characteristics by researchers at University College London. Partners in the three countries did not have access to this file. This procedure ensured anonymity of participants. Two participant characteristics were retained for further analysis of the data from the discussion groups: gender and age.

The interventions of all participants were classified into a database of statements, identifying the main point made (standardized into general categories as the analysis proceeded) and also the vehicle they refer to, in the case of the discussions on external design, internal design, and view, as they were about comparisons of the two vehicles. Comments that applied to both vehicles or were more general (e.g. about the view, the road, or the overall realism of the scenarios) were coded separately. The left side of Table 52 shows statistics of the database of statements and the right side of Table 52 shows the total number of words. The discussions were longer in Poland, followed by Netherlands, and Greece. They focused more on the bus than on the car.

The translated noted from the discussion groups included a total of 15,361 words, i.e. an average of 179 words per participant. Table 53 shows the distribution of those words. The longest

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discussions were about the human assistant. In Poland there were also long discussions about the internal design of the bus and the unruly passengers with anti-social behaviour.

Table 52: Virtual reality post-experiment discussion – statements and words

Image		Statements			Words		
		Netherlands	Poland	Greece	Netherlands	Poland	Greece
1	External design	61	60	33	804	823	205
2	Internal design	35	89	30	522	1770	216
3	View	81	66	30	803	641	202
4	Car: slower than bus	40	38	23	662	522	230
4	Bus: crowded	30	41	23	487	667	142
6	Bus: Human assistant	50	71	34	1022	1118	212
7	Bus: Unruly passengers	27	49	22	377	1007	151
8	Bus: Empty	20	34	22	279	566	80
Final discussion		29	62	0	480	1373	0
Total car		93	111	39	1584	1958	376
Total bus		191	285	119	2973	5067	705
Total general		89	114	59	879	1462	357
Total		373	510	217	5436	8487	1438

Table 53: Virtual reality post-experiment discussion – words by participant

Image			Netherlands	Poland	Greece	Men	Women	18-34	35-64	65+
1	Car	External design	13	16	2	10	12	10	8	16
	Bus		10	9	3	8	6	5	10	5
2	Car	Internal design	9	15	4	10	10	5	12	10
	Bus		6	39	3	16	17	7	15	26
3	Car	View	1	2	0	1	1	0	1	1
	Bus		3	4	0	2	4	2	3	3
4	Car	Slower than bus	19	17	10	15	15	15	19	10
5	Bus	Crowded	14	22	6	11	19	10	13	21
6	Bus	Human assistant	30	37	10	25	28	24	28	26
7	Bus	Unruly passengers	11	34	7	17	16	11	19	17
8	Bus	Empty	8	19	4	8	13	9	10	12
General			36	69	16	41	41	29	43	47
All words per participant			**160**	**283**	**65**	**163**	**183**	**127**	**183**	**195**

Sub-sections 4.10.2 and 4.10.3 are an overview of all discussions about the car and the bus. The following eight sub-sections then analyse the results for each of the eight topics discussed. In these sections, we first show representative quotes from the participants' statements. We also use word clouds as a quick way to capture the main topics discussed. The word clouds show the 50 most common words in the discussion, after excluding the objects of discussion (e.g. “car”, “bus”) and words expressing an opinion (e.g., “think”, “feel”). We then show the most common statements made, the proportion they represent in all statements, and the group who made that

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statement more frequently (if the difference with the frequencies for other groups are considerable), by country, gender, and age. We show only statements made at least five times.

4.10.2 Virtual car

The discussions about the virtual car, across all eight topics are synthesised in Figure 62. A large part of the discussions was about speed, especially the fact that the bus was moving faster than the car ("faster", "speed") and associated intentions to switch or not to the bus ("switch", "change" "wanted", "reason"). There were also discussions about how vehicle looked like ("vehicle", "design", "minimalistic") and how comfortable it was ("comfortable", "sit", "seats"), as well as comparisons both with the virtual bus and with real-life conventional cars ("compared", "different", "better", "driver", "driving"). The absence of other passengers was also noticed ("passengers", "people"). Participants also reflected on their experience ("experience", "curiosity").

Figure 62. Word cloud of discussions about the virtual car

4.10.3 Virtual bus

The discussions about the virtual bus, across all eight topics, are synthesised in Figure 63. The main topics were about the other passengers ("passengers", "people", "person") and the human assistant ("assistant", "steward", "security"). Passengers also discussed how comfortable it was to use the bus ("seats", "sit", "stops") and what to do in case of unexpected events ("emergency", "situation", "someone"), and specific situations such as being alone in the bus at the end ("alone", "empty") Reasons to switch or not to the car were discussed ("switch", "change", "reason"), as well as comparisons with the virtual car and with real-life conventional buses ("difference", "driver").

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Figure 63. Word cloud of discussions about the virtual bus

4.10.4 External design

"*The car looks from the 90s (Back To the Future)*" – Poland, Man, 18-34

"*It looks like a normal bus, but without driver. I miss the place where the driver sits in the normal bus.*" – Netherlands, Man, 18-34

Figure 64 shows the most common words used to talk about the vehicles' external design. Participants compared both virtual vehicles and each of them with their conventional counterparts ("better", "compared", "difference", "driver"). They also gave their opinions about the vehicles ("vehicle", "design", "beautiful", "clean", "comfortable", "futuristic", "modern", "nice", "normal", "regular", "seats") and how virtual reality portrayed them ("realistic").

Table 54 shows the most common statements. The car was perceived as futuristic (or "modern") and minimalistic (i.e. with few noticeable features), while the bus was perceived as familiar, i.e., similar to the conventional buses participants use or see in their regions, only without a steering wheel. Both vehicles were assessed as having a "sleek design". All these statements were more common among men.

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Figure 64. Word cloud of discussions about the vehicles' external design

Table 54: Most common statements in discussions about the vehicles' external design

Statement	Frequency	% of discussions about vehicle(s)	Most common		
			Country	Gender	Age
CAR					
Futuristic	11	17%	Poland	Men	35-64 and 65+
Minimalistic	8	12%	Netherlands	Men	35-64 and 65+
BUS					
Familiar	24	38%	Poland	Men	35-64
Both					
Sleek design	7	28%	Greece	Men	18-34

4.10.5 Internal design

"Oddly enough, we sit facing each other [in the car]*, not just facing forward. Like in tour buses, around a table"* – Poland, Woman, 35-64

"A lot of standing places in the bus and just a few seats" – Netherlands, Man, 65+

Figure 65 shows the most common words used to talk about the vehicles' internal design. Participants assessed the quality of the vehicles ("nice", "clean", "pretty", "comfortable", "discomfort", "passengers", "people") and seating arrangements ("design", "arrangement", "placed", "seats", "sit", "small", "space", "spacious", "spaciousness"), including the fact that the car had seats in both directions ("backwards", "forward") and the bus had sideway seats in front of each other ("sideways", "front") . Participants noticed some aspects that were not realistic in the virtual reality, including the absence of some features (e.g., "lack", "missing", "minimalistic", "belts"). Participants also compared the two virtual self-driving vehicles, and each of these with their conventional counterparts in the real world ("different", "driver", "driving").

Table 55 shows the most common statements. The most frequent ones, for the car, were the seating arrangement (with some seats backwards to traffic) and the fact that the design was minimalistic, without features participants were expecting to find in a self-driving vehicle for passengers to use their time (e.g. devices). For the car, the most frequent statement was the lack of enough seats and the seating arrangement (with seats facing each other). A common

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statement for both vehicles was that they seemed comfortable. The statements about seating arrangement (both in the car and the bus) were more common among men.

Figure 65. Word cloud of discussions about the vehicles' internal design

Table 55: Most common statements in discussions about the vehicles' internal design

Statement	Frequency	% of discussions about vehicle	Most common		
			Country	Gender	Age
CAR					
Seats backwards to traffic	5	11%	Netherlands, Poland	Men	-
Minimalistic, no facilities	5	11%	Netherlands, Poland	-	35-64
BUS					
Few seats	10	14%	Poland	Women	-
Seats facing each other	6	8%	Poland	Men	35-64
BOTH					
Comfortable	9	24%	Greece, Poland	-	-

4.10.6 View

"It became darker outside very quickly" – Netherlands, Woman, 35-64

"*I was stressed that I was driving without a driver, I did not look around the sides (I did not see the factory, graffiti), I was even a little scared*", Poland, Woman, 35-64

"In the car, I looked little around, 40 years of driving experience causes one to look ahead of the road – Poland, Man, 65+

The discussions about the view from the vehicles (Figure 66) centred on whether participants looked outside or inside the vehicle and what they noticed outside ("around", "attention", "environment", "looked", "outside", "road", "street", "surroundings", "vehicle", "view"), compared with conventional vehicles ("driving"). Many talked about the changes ("changes", "different"), in land use ("urban", "city", "buildings"), traffic ("traffic") and time of day ("daytime", "lights", "night"). They also gave opinions about the scenes ("nice", "interesting", "boring"), identifying what they missed in them ("pedestrians", "people"), and assessing their realism ("realistic", "straight" (road)).

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The most common statement was that participants looked mostly outside, not inside (Table 56). Other common statements were that they noticed the change in time of day and that the road was straight (with mentions that this was not realistic), and that the view was monotonous (i.e., not enough diversity in buildings and road infrastructure). All these statements were more common among the 35-64 group.

Figure 66. Word cloud of discussions about the view

Table 56: Most common statements in discussions about the view

Statement	Frequency	% of discussions about vehicle	Most common		
			Country	Gender	Age
BOTH					
Looked mostly outside, not inside	20	13%	Netherlands	Men	35-64
Noticed change in time of day	10	8%	Netherlands, Poland	-	35-64
Road was straight	10	7%	Netherlands	Men	-
Monotonous view	9	7%	Netherlands	-	35-64

4.10.7 Car slower than bus

"Seeing the faster bus, I thought about taking the bus; I wanted to go faster from the beginning and even wanted to go faster by car" – Poland, Woman, 35-64

"The b*us was faster but not as fast as in everyday life; the thought of changing to a bus for this reason did not come up*" – Poland, Woman, 18-34

"*Time is less important. Work could be done during the ride. If you are focused on your work, you don't notice it is faster or slower*" Netherlands, Woman, 35-64

The discussion about congestion affecting the car trip (Figure 67) focused on whether participants noticed that the bus was faster or not ("faster", "slower", "speed", "schedule", "started", "ride"), and whether that was a reason to switch to the bus ("switch", "change", "wanted", "reason", "transfer", "important"). Opinions were split between those who noticed and those who did not, and those who wanted to switch and those who did not (Table 57). Some of those who wanted to switch mentioned time as the most important consideration for them. Some

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of those who did not want to switch noted that they could use time spent in a self-driving car to work or other activities.

Figure 67. Word cloud of discussions about the car speed

Table 57: Most common statements in discussions about the car speed

Statement	Frequency	% of discussions about vehicle	Most common		
			Country	Gender	Age
Noticed and wanted to switch or switched to car	18	18%	Greece	-	18-34, 35-64
Noticed	17	17%	Netherlands	Men	35-64
Did not notice	15	15%	Poland, Greece	-	35-64, 65+
Noticed but did not want to switch	11	11%	Poland	-	35-64

4.10.8 Bus overcrowding

"I felt no change in emotions, I did not consider switching and did not switch when more passengers started to come in" - Greece, Woman, 35-64

"I was reminded of the pandemic and one coughing passenger gave me discomfort travel" - Poland, Man, 65+

"Switch due to crowds and because of that, little view. This is for me the moment to switch to the car". – Netherlands, Man, 35-64

As expected, discussions about overcrowding in the bus mentioned "passengers" and "people" (Figure 68) and the fact that more of them arrived in the bus ("appear", "arrive", "coming", "boarding"). Some participants were not affected by the situation ("secure"), mentioning this is what they usually experience ("normal"). Others did not like it ("annoyed", "bothered", "discomfort", "disturbing", "noisy", "unsafe"). Discussion on whether overcrowding is a reason to switch usually followed ("switch", "wanted", "reason"). Some mentioned that situation becomes different in a self-driving vehicle without anyone to control the crowds ("driver", "help").

Statistically, the most common statement was that overcrowded was not a problem, followed by not wanting to switch, and feeling uncomfortable and insecure (Table 58).

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Figure 68. Word cloud of discussions about the bus overcrowding

Table 58: Most common statements in discussions about the bus overcrowding

Statement	Frequency	% of discussions about vehicle	Most common		
			Country	Gender	Age
No problem	27	29%	Poland	-	35-64
Noticed but did not want to switch	19	20%	Greece	Men	-
Felt uncomfortable or insecure	7	7%	Poland	-	-

4.10.9 Bus assistant

"A *steward is safe. When the steward was gone, I checked if there were cameras and if there was an emergency button. I couldn't see either*" – Netherlands, Woman, 35-64

"He *was a positive element, maybe he could help a person with a disability; he was unobtrusive, but he was there and it was important that he was there if he was needed by someone*" – Poland, Woman, 65+

"In my opinion it does not make sense, because it is supposed to be autonomous and yet instead of a driver there is an assistant" – Poland, Man, 18-34

There were lengthy discussions about the human assistant in the bus (Figure 69). The most common words were "assistant", "steward", and "person". The discussions were mainly about what could be the role, if any, of this assistant ("check", "control", "emergency", "happens", "help", "monitoring", "needed", "security", "situation", "someone", "something", "ticket"). The assistant could have some of the responsibilities now held by drivers ("driver"). Alternatives to ensure security were suggested ("button"). Participants noticed the assistant left ("disappeared") and noted their reactions ("feeling") or wishes to switch to the car ("reason", "switch").

The two most common statements (Table 59) present contrasting points of view: one is that the assistant offers security, and the other is that it was not a problem when the assistant left the virtual bus. The other common statements also show a mix of opinions, both in favour of having an assistant (who could play several roles) and opposed to it (on the basis that it is not necessary).

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Figure 69. Word cloud of discussions about the bus assistant

Table 59: Most common statements in discussions about the bus assistant

Statement	Frequency	%of discussions about vehicle	Most common		
			Country	Gender	Age
Assistant offers security	17	11	-	Women	-
No problem when assistant left	17	11	Greece	-	-
Did not know what assistant was doing	11	7	Poland	-	35-64, 65+
Did not want to switch when assistant left	11	7	Netherlands	-	-
Can offer support	11	7	Greece	Men	65+
Assistant is unnecessary	10	6	Netherlands, Poland	Men	-
Can react to situations	10	6	Netherlands, Poland	Women	35-64
Can check tickets	8	5	Netherlands, Poland	Men	-
Monitoring is an alternative to ensure security	7	5	Netherlands, Poland	-	35-64
Assistant did nothing	7	5	Poland	Women	-
Noticed the assistant	7	5	Poland, Greece	-	18-34

4.10.10 Unruly bus passengers

“*They annoyed me, irritated me, I honestly thought I could have driven the car because of them*” - Poland, Man, 35-64

“*You can't even see if there is a driver, despite the punks on board. I did not have the feeling that I could approach the driver and ask for intervention*” - Poland, Man, 35-64

“*As in a normal bus. It is irrelevant to such situations that these are autonomous vehicles or not*” – Poland, Woman, 18-34

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The discussion about the group of unruly bus passengers were also lengthy (Figure 70). Participants mentioned the group ("behaviour", "passengers", "people", "presence", "situation"). Some accepted the situation ("normal"), but others did not like it ("annoying", "anxiety", "bothered", "disturbing", "noise", "unsafe") and considered switching to the car ("change", "consider", "reason", "switch"). Some discussed the specific issues when this type of situations happens in a self-driving bus ("autonomous", "different", "drive", "driver"), and possible solutions to ensure security ("buttons", "cameras").

Statistically, statements that the situation was not a problem, or at least not a problem big enough to induce switching, were more common that those mentioning insecurity and annoyance (Table 60).

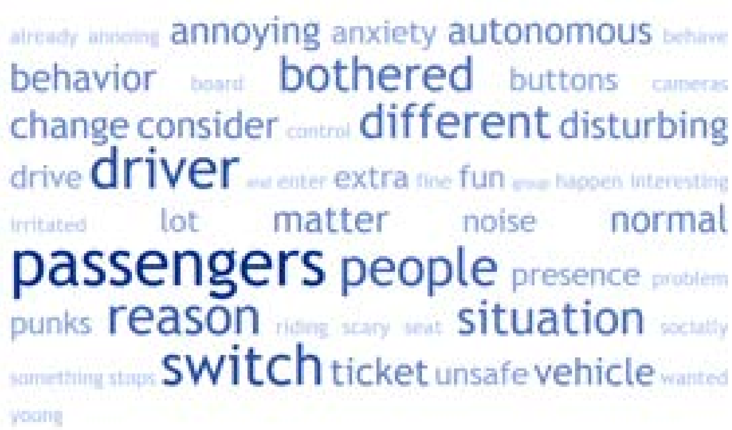

Figure 70. Word cloud of discussions about the unruly bus passengers

Table 60: Most common statements in discussions about the unruly bus passengers

Statement	Frequency	% of discussions about vehicle	Most common		
			Country	Gender	Age
No problem	13	13%	-	Men	18-34, 65+
Did not want to switch	9	9%	Netherlands	Men	35-64, 65+
Felt insecure	8	8%	Netherlands, Poland	Women	35-64, 65+
Annoying	8	8%	Netherlands, Greece	-	-

4.10.11 Empty bus

"T*he worst part was once everyone got off, it was the worst moment, because it was already dark*"- Poland, Woman, 35-64

"I*t was nice because it was empty, quiet, but it was strange because there was no driver. It was less comfortable than when there are more people*" – Poland, Woman, 35-64

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"It *improved my mood, I am an introvert and do not necessarily like contact with people*" – Poland, Man, 35-64

Finally, the discussions about the empty bus (Figure 71) acknowledged the situation ("alone", "empty", "passengers", "people", "quiet") and its effects on the participant. Some did not feel it was a problem ((does not) "matter", (did not) "mind", "nothing"). Others did perceive the situations as a problem ("anxiety", "strange", "unsafe") and discussed how it differs from similar situations in human-driven buses ("driver").

Statistically, the most commons statement was that it was not a problem (Table 61), followed by feeling insecure. Some participants said they prefer the bus when they are alone because they can have the bus all for themselves, sitting anywhere they want and not having to interact with other people.

Figure 71. Word cloud of discussions about the empty bus

Table 61: Most common statements in discussions about the empty bus

Statement	Frequency	% of discussions about vehicle	Most common		
			Country	Gender	Age
No problem	29	38%	Poland, Greece	-	35-64
Felt insecure	16	21%	Poland	Women	-
Better like this	12	16%	-	Men	35-64, 65+

4.11 Conclusions

This section collects the key conclusions from the virtual reality experiment, organised of terms of the five objectives stated in the introduction to the chapter.

The experiments captured a variety of data: choices made in a virtual reality game, physiological data, and results of a post-experiment questionnaire and group discussions. The experiments were done in three European countries, in sites with different geographic, economic, and social contexts. The sample was balanced in terms of gender and had an age distribution aligned with that of the populations of each site. However, it has a slight over-representation of people with university degrees. Participants had a good level of prior awareness of self-driving vehicles.

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4.11.1 Perceptions, preferences, and reactions to self-driving vehicles

Table 62 shows the results of the experiment regarding perceptions, preferences and physiological reactions, comparing the two self-driving vehicles that the participants experienced: car and bus. Participants had general positive views about both vehicles. This has contributed to the improvement in attitudes and intentions regarding the vehicles. However, there were concerns about comfort, speed, and, in the bus, also about personal security.

Table 62. Conclusions of virtual reality : perceptions, preferences, and reactions

Car	• General positive feelings when using the virtual car • Intention to use self-driving cars increased after the experiment • Speed is a determinant of participant's attitudes regarding self-driving cars: being stuck in congestion is perceived to be a major deterrent • Stress and arousal, as measured by EEG, was identified as congestion got worse and night-time approached, in the virtual car scenario • Importance of the car internal design as part of perceived trip quality: amount of space, seat arrangement, and possibility to see the view are major determinants • Intention to use a self-driving car is significantly higher when self-driving cars are perceived to be less stressful, more comfortable, and safer than human driven ones.
Bus	• General positive feelings when using the virtual bus • Intention to use self-driving buses increased after the experiment • Slight tendency to choose to use the bus when faced with the option between the two vehicles, either at the start or during the virtual trip • In some cases, this choice was motivated by the fact that the bus was faster and cheaper, in the experiment • Importance of bus internal design as part of perceived trip quality: amount of space, seat arrangement, and possibility to see the view outside are major determinants • Opinions split about the need for a human assistant. Those who said an assistant is needed listed several possible roles, such as ensuring safety and security, but also ticket checking • Personal security is a concern, when passenger number or behaviour is unpredictable. This may be a reason for not travelling by self-driving bus. • Increase in stress and arousal, as measured by EEG, was identified when participants were faced with anti-social behaviour of other passengers • Stress and arousal also recorded when the bus had few passengers and it crossed through derelict industrial areas • Intention to use a self-driving bus is significantly higher when self-driving buses are perceived to be more secure (in terms of crime) than human driven ones.

Table 38 shows how participants compared self-driving and human-driven vehicles. Self-driving ones are expected to be more interesting, cheaper, more comfortable, and safer. To a lesser extent, they are also thought to be faster. However, they are more secure in terms of crime. There is a balance of views on which type of vehicles will be more stressful to use.

There is also uncertainty among part of the sample. None of the opinions reported in Table 38 were held by 50% of the sample. They were simply held by more participants that the ones who had the opposite view. However, there were also reasonable proportions thinking that both vehicles will be similar, or being undecided.

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Table 63. Conclusions of virtual reality: comparison with human-driven vehicles

	Self-driving vehicles	Human-driven vehicles
Positive	• More interesting • Faster • Cheaper • More comfortable • Safer (accidents)	• More secure (crime)
Negative	• Less secure (crime)	• Less interesting • Slower • More expensive • Less comfortable • More dangerous (accidents)

4.11.2 Impacts of self-driving vehicles

Table 64 tabulates the conclusions of the experiment versus the nine Move2CCAM impact dimensions. Some impacts are positive (mobility, land use, safety). Deterioration of personal security is a major concern and can be a negative outcome of the deployment of self-driving vehicles. The impact on public health is uncertain. It could increase stress, especially among public transport users. The impact on the transport network is also uncertain: Congestion may increase if traffic levels increase. Equity may also be more difficult to achieve, as passengers with mobility restrictions may face challenges.

Table 64. Conclusions of demonstration: impacts

Mobility	• General positive feeling when using self-driving vehicles • Passenger satisfaction depends on vehicle comfort, speed, and personal security. • Self-driving vehicles are thought to be more interesting, cheaper, more comfortable, and safer than human-driven ones. • To some extent, they are also thought to be faster • Self-driving vehicles will allow for productive and leisure uses of travel time
Transport network	• Traffic levels can increase. 28% of participants said they would travel mode, regardless of the mode, if self-driving vehicles were available
Land use	• The view that participants can see from the vehicle window will be a determinant of passenger satisfaction and even of mode choice when vehicles are self-driving. “Looking around” was the main preference for using travel time. This may induce authorities to invest more in the aesthetical design of roads (e.g. green areas, attractive designs). • Most participants who used the car chose to send it back to the city centre at the end rather than parking it outside their homes. This suggests that parking needs in residential areas may decrease • The majority of participants also stated that they would worry less about parking, if they could use self-driving vehicles
Environment	• No information collected on this impact
Economy	• Half of sample said they would use travel time to work. This could improve productivity • At the same time, productivity may be negatively affected, if traffic levels increase and vehicles are stuck in congestion, causing delays to workers
Equity	• Concern that not having a human assistant in buses can reduce the accessibility of individuals with mobility restrictions
Public health	• Travel in self-driving cars and buses may increase stress, when passengers faced with unexpected situations, as revealed by EEG data • Balanced view on whether self-driving vehicles are more or less stressful than

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	human-driven ones, as revealed by questionnaire data
Safety	• Self-driving vehicles are thought to be safer, in terms of accidents, than human-driven ones
Security	• Self-driving vehicles are thought to be less secure, in terms of crime, than human-driven ones • Strong concern among some people that self-driving buses can create situations when passengers fear about crime and anti-social behaviour from other passengers

4.11.3 Variations among sample

Table 65 shows the aspects in which conclusions differ the most from the sample average, in each country, gender, and age group. Greece and the 65+ age group show the most differences.

Table 65: Conclusions of virtual reality experiment: variations among sample

Country	
Netherlands	• Higher propensity to use bus, compared to car, as seen both initially and during the game • Lower propensity to think self-driving vehicles will be more comfortable • Higher propensity to think they will be more insecure
Poland	• Lengthier group discussion about the role of the human assistant and the presence of unruly passengers
Greece	• Higher propensity to "look around" while travelling, rather than using time to work • Higher propensity to park the car nearby rather than sending it back to the city centre • Higher propensity to think self-driving vehicles will be more expensive • Higher propensity to think self-driving vehicles will be more secure • Stronger intention to use self-driving vehicles
Gender	
Men	• Higher propensity to use bus, compared to car, as seen in the participants' choices to switch modes in the game
Women	• More situations where EEG shows increased stress/arousal when using the virtual car
Age	
18-34	• Lower propensity to "look around" while travelling
35-65	• More likely to report self-driving cars will be more stressful than human-driven ones, as stated in questionnaire
65+	• Higher propensity to use bus, compared to car, as seen in the participants' choices to not switch from bus to car during the game and to regret switching • Much higher propensity to park the car nearby rather than sending it back to the city centre • More situations where EEG shows increased stress/arousal when using the virtual car • More likely to report that self-driving buses will be more insecure than human-driven ones

4.11.4 Effectiveness of virtual reality method

Table 66 synthesises the positive and negative points that participants mentioned regarding the virtual reality experiment and the scenarios they experienced. On balance, the experiment was successful. Minor improvements could be made to the representation of the scenarios, especially

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those outside the vehicle, again confirming the conclusion that the view from the vehicle windows will be an important aspect in a transport system based on self-driving vehicles.

Table 66: Conclusions of virtual reality experiment: effectiveness of virtual reality method

Positive	• Most participants expressed positive feelings about their experience in both scenarios • Experiencing virtual reality improve people's attitudes and intentions regarding self-driving vehicles • The improve these attitudes and intentions even over and above the improvement caused by experiencing a real self-driving vehicle (in a demonstration) • The scenarios were perceived as realistic or very realistic by the majority of participants • Participants noticed almost all of the changes in trip attributes, both in the car and bus
Negative	• Participants thought the environment outside the vehicles could be more realistic (e.g. road less straight and with more pedestrians and cyclists)

4.11.5 Final remarks

This chapter showed that citizens have general positive views about self-driving vehicles and the experience of using them in virtual reality mitigate previous concerns and raise the intention of using the vehicles in the future. However, the experiment also raised concerns about the implications of self-driving vehicles for security in terms of crime. This was evident not only in the participants' opinions in the questionnaire and group discussions, but also in measured physiological reactions to specific situations inside the self-driving bus. Slow speed due to congestion is also a possible problem. Other concerns relate to how comfortable the vehicles will be. Overall, the virtual reality experiment was also successful as a method to study passenger's reactions and views about self-driving vehicles.

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5. Pan-European survey

5.1 Overview

An online survey was implemented in eight European countries (Cyprus, France, Germany, Greece, The Netherlands, Poland, Spain, and United Kingdom), involving 7,941 citizens. The survey had six objectives:

- To assess citizens' current travel patterns across Europe.
- To assess citizens intentions, needs, and requirements regarding the purchase and use of self-driving vehicles.
- To capture perceptions about the possible impact of self-driving vehicles on several dimensions of the lives of individuals and on the regions where they lived. This used as a base the set of passenger and freight transport use cases created earlier in the project.
- To compare perceptions across countries, regions, age groups, and genders.
- To estimate the interrelationships between the different perceived impacts.
- To estimate the relationships between perceived impacts and demographics, current travel behaviour, and location.

A large international survey is needed because the possible impact of self-driving vehicles is still not fully understood. Previous studies have focused on specific impacts (e.g. safety, employment) but not on the full range of impacts that might arise at different levels (individual and regional) and on the inter-relations between those impacts. In addition, it is likely that the impacts will differ from country to country due to different economic, social, and cultural contexts.

While previous activities in the project, reported in previous chapters (e.g. demonstration of vehicles, virtual reality experiments) provided insights on impacts, they focused on specific experiences of using specific types of self-driving vehicles, using small samples of participants. A survey deployed widely across Europe was therefore needed to capture a wider range of vehicles and aspects beyond experiences, such as attitudes towards self-driving vehicles, intentions, and willingness to pay to use or buy these vehicles, possible changes in travel and online delivery ordering behaviour, and other ways in which self-driving vehicle will affect the individuals and their regions.

The survey includes several questions at the beginning to capture citizens' current travel patterns. While this is mostly to set the context for analyses of the possible impact of self-driving vehicles, it also provides useful information in itself, as it captures how citizens travel in a period that is both post-Covid but also when most of the travel behaviour adaptations to the post-Covid ways of living and working (e.g. flexible working patterns) are likely to have already taken place (as data was collected in 2024). This provides insights on wider transport and travel aspects, as most international travel behaviour surveys have captured either the pre-Covid period or the years immediately after Covid (2022-2023), when it was likely that citizens were still adjusting to new living and working circumstances.

The rest of this chapter is organised as follows.

- Section 5.2 describes the **methods** used in this survey.
- Section 5.3 and Section 5.4 describe the **characteristics** of participants and their individual behaviour (including travel, online delivery orders, and other behaviour).

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