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25th Euro Working Group on Transportation Meeting (EWGT 2023)

# Ride experience in automated minibuses: measuring users' transport mode preferences before and after a test ride

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## Abstract

In the present study, we explored the influence of ride experience in automated minibuses (AmBs) on transport mode choice that includes the automated shuttles as well as conventional transport options (car, bus and bicycle) on the first-/ last-mile stage of rail trips. We used the case study of the connection between Brandevoort train station and the newly developing working and living area in Helmond (the Netherlands) where an AmB was tested in the February-March period of 2021. We conducted a two-wave stated preference experiment wherein data was gathered both before and after the participants had a test ride in the AmB. The results of the joint hybrid mixed logit model indicate a clear preference towards flexible-service AmBs, particularly in relation to travel time and costs. While preferences for less favoured regular-service AmBs experienced a noteworthy shift in travel time and costs, waiting and walking time parameters influenced by participants' ride experience in this pilot and by prior ride experience from other pilots. This reinforces the idea that the ride experience in AmBs even in a short pilot trial like the one conducted in Helmond has a significant impact on preferences for AmBs in comparison with car, bus and bicycle alternatives. Hence, panel studies can provide a more comprehensive understanding of how attitudes and preferences of potential users evolve over time.

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*Keywords:* automated minibus; stated choice experiment; ride experience

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## 1. Introduction

The introduction of automated driving technology is associated with high uncertainty. Without a reference technology to rely on, making realistic predictions about the adoption of automated driving becomes challenging.

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Additionally, not only is the technology not ready, but also the potential users might have higher expectations of automated transport modes than what they are currently able to deliver.

One particular type of automated transport mode is the automated minibus (AmB) which is being tested in short trials across Europe and around the world (Hagenzieker et al., 2021). AmBs have the potential to serve as a viable alternative for short-distance transportation, particularly for connecting transit lines with rapidly growing urban areas that lack sufficient public transport coverage. Presenting this transport innovation and providing ride experience in trials at different stages of the automated driving development process allows not only to test the advancements of technology but also to capture the process of users' formation of attitudes and preferences for these solutions over time. Understanding these changes in attitudes and preferences can contribute to better predictions regarding the future deployment of AmBs.

According to the Diffusion of Innovation theory (Rogers, 2003), the process of formation of attitudes and preferences encompasses five stages that ultimately lead to the final decision of adopting or rejecting the innovation, AmBs in this study. From acquiring knowledge about AmBs at the knowledge stage, and forming initial attitudes and preferences towards them at the persuasion stage, potential users may decide to participate in pilot trials to get their first ride experience in AmBs marking the decision stage. Afterwards, they reassess their attitudes and preferences towards AmBs and may continue to monitor the progress of the innovation during implementation in other pilot trials until it loses its novelty and becomes like a conventional transport mode (implementation stage). Lastly, during the confirmation stage, potential users seek validation and support for their decision, which can lead to the final adoption or rejection of AmBs based on their satisfaction and perceived advantage of this new transport mode. Following this process, individuals may change their opinions in favour of or against the use of AmBs.

Through pilot trials of AmBs, we can observe the transition from individuals' knowledge-persuasion stages to decision-implementation-confirmation stages. However, trying to capture the process of the formation of potential users' attitudes and preferences towards innovations is not an easy task due to the difficulties associated with recruiting the participants before the trials and the drop-off rates at the later stages of research. Consequently, there are limited longitudinal studies available.

Among the few studies on relatively recent innovations, there are longitudinal studies on electric vehicles (Jensen et al., 2013, 2014; Hinnüber et al., 2019), vehicle-to-grid charging for electric vehicles (Ghotge et al., 2022), and hydrogen buses (Loria Rebolledo et al., 2019). The results from these studies demonstrate that even a first-time ride experience in an electric vehicle (Hinnüber et al., 2019) or a short experience with vehicle-to-grid charging by current electric vehicle drivers (Ghotge et al., 2022) can influence participants' attitudes and evaluations of these innovations. In a longer 3-month trial, experience with an electric vehicle significantly impacted participants' preferences regarding driving range, top speed, fuel cost, battery life, and charging locations (Jensen et al., 2013, 2014). Comparing frequent, occasional, and non-users of hydrogen buses, the more experienced frequent users were willing to pay more for comfort and emission reductions provided by an environmentally friendly fleet of buses (Loria Rebolledo et al., 2019).

Regarding automated transport, several longitudinal studies have focused on the formation of attitudes as predictors of behavioural intention to use such technology. The combination of a real ride experience and a ride experience in a simulator was used in two studies by Hartwich et al. (2019) and Classen et al. (2021). Younger and older participants' trust and acceptance of automated vehicles were positively influenced by initial system experience in a driving simulator and remained stable for young drivers after test rides in a BMW i3 vehicle equipped with automated longitudinal control (Hartwich et al., 2019). For older drivers, exposure to automated vehicle technology in both a simulator as drivers and an AmB as passengers increased their perceptions of safety, trust, and perceived usefulness (Classen et al., 2021). Two other studies by Chee et al. (2021) and Guo et al. (2022) took place in Stockholm, Sweden where an AmB provided public transport services in two areas of the city. The results indicated that users' intentions to use AmBs were positively influenced when the users' needs were met and they received favourable recommendations from others (Guo et al., 2022). While the participants who were satisfied with the safety and travel time reliability of the bus service continued to use it and valued its comfort, in contrast to those who chose to discontinue its use (Chee et al., 2021).

While these few longitudinal studies with varying experimental setups provide clear evidence of changes in potential users' attitudes towards AmBs over time, there is still a lack of research on transport mode preferences that include both AmBs and conventional modes of transportation (cars, public transport (tram, bus), and bicycles) and the process of preference formation under the influence of ride experience in close-to-realistic traffic conditions.

To address this research gap, our study aims to answer the following research questions: a) Do potential users exhibit a preference for AmBs over traditional transportation options (cars, buses, or bicycles) when considering the first- and last-mile segments of their public transport trips? b) Does this preference remain stable under the influence of ride experience in AmBs in close-to-realistic traffic conditions?

We use the case study of the connection between the Brandevoort train station and the newly developing working and living area in Helmond (the Netherlands) in which an AmB followed a route on public roads in mixed traffic. This case study represents an application case of the first-/last-mile connection between a transit line and rapidly growing urban areas that lack sufficient public transport coverage. Presently, there is no public transport service operating on this specific route. We consider buses as a conventional mode of public transport service that is currently used in Helmond. We define the ride experience as a first ride experience and a consecutive ride experience in an AmB.

The remainder of the paper is structured as follows. We describe the pilot trial in the city of Helmond and our research setup in Section 2. Then, in Section 3, we apply discrete choice modelling to analyze the data, followed by a discussion of the results in Section 4. Finally, we summarize the main conclusions in Section 5.

## 2. Pilot in Helmond and research setup

The pilot trial of an AmB that we study in this paper took place in Helmond, the Netherlands, in February-March 2021. The Navya Arma minibus operated along a 3.1 km route connecting the Brandevoort train station and the Automotive Campus (Fig. 1). The route included four stops, two roundabouts and an overpass over a highway. The AmB's maximum speed was 16 km/h. To ensure safety and smooth operation, road signs were used to alert other traffic users, and parking and overtaking were prohibited along the route.

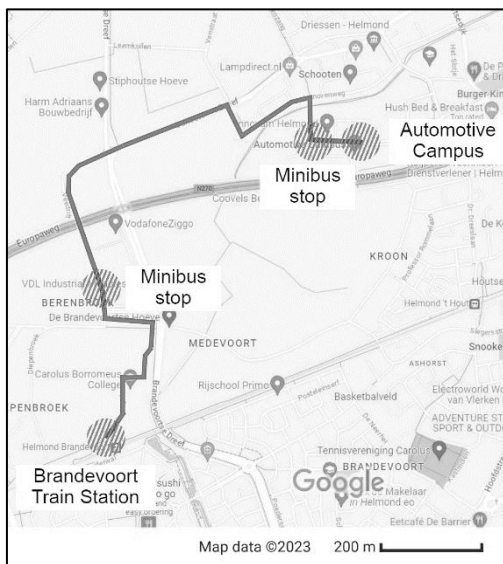


Fig. 1. The route of the automated minibus between the Brandevoort train station and the Automotive Campus in Helmond, the Netherlands (Google Maps, n.d.).

The AmB's operation in this pilot was not entirely smooth as it experienced some interruptions and challenges. During the trial's second week, the minibus was unable to operate due to icy road conditions caused by snow. Additionally, there were a few days when the rides had to be cancelled due to a malfunction in the software. The timing of the pilot trial coincided with the COVID-19 pandemic and the lockdown measures implemented in the Netherlands. As a result, only two passengers, next to the host and steward, were permitted to ride in the AmB despite its normal capacity of accommodating 11 seated passengers. To manage the limited capacity, participants were required to reserve a time slot for their ride.

The experiment conducted with a sample of system users consisted of three parts: an online stated choice survey administered before the test ride, the actual test ride, and a follow-up online survey conducted after the test ride. This experimental design allows us to track the influence of the ride experience gained during the pilot trial by comparing the survey responses before and after the test ride. Also, (it's important to understand at which stage of the adoption process the user is) participants could have a previous ride experience in an AmB in other pilot trials. To get this information, a question is also included in the first survey.

The first survey before the test ride included (a) questions about respondents' current travel behaviour, (b) a stated mode choice experiment, (c) indicator statements measuring attitudes towards AmBs and (d) questions about respondents' socio-economic background. While in the second survey after the test ride, the participants were asked to repeat the stated choice experiment and to give scores on the indicator statements once again. The participants who booked a test ride received the survey links by email before and after their test ride.

The starting section of the first survey included questions about respondents' current travel behaviour such as their current transport mode, frequency and duration of travel, and changes in their travel due to the pandemic.

In the stated choice experiment section, a conventional bus, a private car, a bicycle, an AmB providing regular service, and an AmB providing flexible service were the alternatives whose attributes were orthogonally combined to form choice sets using Ngene software (Choice Metrics, 2018). Each survey (before and after a test ride) included six choice sets for respondents to evaluate. In this context, regular service refers to a service with a fixed route and schedule, while flexible service represents an on-demand service following a flexible route. Classical attributes in the choice sets are in-vehicle travel time, travel costs, waiting time at the bus stop or the doorstep and walking time to the stop (Table 1). The attribute levels were selected based on the data from trip-planning apps.

The subsequent section consisted of 13 indicator statements used to assess attitudes towards the AmB itself such as perceived usefulness, ease of use, and safety and to evaluate the overall experience of the test ride (Table 2).

The final section of the first survey included inquiries regarding participants' socioeconomic background such as gender, age, educational attainment, occupation, and annual gross household income. Additionally, we asked them to indicate their affiliation with a specific group, i.e., residents of Helmond, individuals with a professional interest in participating, or individuals working in the Automotive Campus. We also sought to understand their preference for the type of supervision that would replace a human driver (steward, remote supervision, or a combination of both).

Table 1. Alternatives, their attributes and attribute levels in the stated choice experiment

Attributes and attribute levels	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
	Auto	Bus	Bicycle	Automated minibus (regular)	Automated minibus (flexible)
In-vehicle travel time (min)	10 / 15 / 20	6 / 11 / 16	15 / 20 / 25	6 / 11 / 16	10 / 15 / 20
Travel costs (€)	3.0 / 4.0 / 5.0	1.1/1.6/2.1	-	1.1 / 1.6 / 2.1	2.0 / 2.5 / 3.0
Waiting time at the bus stop or doorstep (min)	-	2 / 5 / 8	-	2 / 5 / 8	2 / 5 / 8
Walking time to the bus stop (min)	-	4 / 7 / 10	-	4 / 7 / 10	-

### 3. Data analysis and discrete choice modelling

Despite the challenges posed by the pandemic COVID-19, interruptions due to weather conditions and software malfunction, a total of 112 individuals participated in the pilot trial. Among them, 78 participants completed either the first or second survey, with 45 individuals responding to both surveys, which are the focus of further analysis.

The final sample comprises 47.8% residents of Helmond, 46.7% participants with a professional interest in automated driving, and 5.5% transport professionals residing in Helmond. Notably, 40% of the participants had prior ride experience in an AmB. The distribution in the sample is positively skewed towards the male gender (77.8%), age above 50 (64.1%), and those with a higher education level (74.3%). While the percentage of employed participants (69.2%) is representative of the population in the Netherlands. 25.8% of participants did not provide information about their annual gross household income, leading us to exclude this variable from the analysis.

Analysing the responses to the attitudinal statements (Table 2), we performed an initial check on whether there was a significant difference between the scores given before and after the test ride. To do so, we employed a nonparametric Wilcoxon Signed-Ranks test suitable for Likert scale data using SPSS (IBM, 2017). Then, the potential model structure was extracted using maximum likelihood estimation and tested using confirmatory factor analysis. Its fit to both waves of responses was verified with multi-group confirmatory factor analysis (Rosseel, 2012). The final model consists of three latent variables: the benefits and usefulness of AmBs, enjoyment of rides in AmBs, and ease of use and safety of AmBs. Lastly, the structural equation models were pre-estimated before these latent variables sequentially entered the choice model.

Table 2. Attitudinal indicators: mean scores and model structure based on multi-group confirmatory factor analysis

Indicator statements <sup>1</sup>	Scores (mean / standard deviation)	
	Before test ride	After test ride
<b>Factor 1. Benefits and Usefulness of AmBs</b>		
S1 <sup>2</sup> I think that in 30 years only self-driving vehicles will be on the roads	4.02 (1.889)	4.22 (1.704)
S2 <sup>2</sup> Thanks to self-driving vehicles, there will be fewer fatal road accidents in the future	4.98 (1.5)	5.2 (1.531)
S3 <sup>3</sup> In the future, I will use self-driving transportation for my daily trips	4.11 (1.787)	4.44 (1.645)
S4 <sup>4</sup> A ride on a self-driving bus is better for the environment	5.15 (1.762)	5.19 (1.45)
S5 <sup>4</sup> A ride on a self-driving bus is flexible	4.43 (1.536)	4.62 (1.346)
S6 <sup>4</sup> A ride on a self-driving bus saves time	3.78 (1.304)	3.73 (1.178)
<b>Factor 2. Enjoyment of Rides in AmBs</b>		
S7 <sup>5</sup> Do you like self-driving transport?	5.73 (1.0282)	5.68 (1.132)
S8 <sup>4</sup> A ride on a self-driving bus is fun	5.41 (0.999)	5.32 (1.258)
S9 <sup>4</sup> A ride on a self-driving bus is relaxing	4.7* (1.348)	4.99* (1.24)
<b>Factor 3. Ease of Use and Safety of AmBs</b>		
S10 <sup>3</sup> Self-driving buses without a driver are safe	4.78 (1.363)	5.04 (1.551)
S11 <sup>3</sup> The use of a self-driving bus is comparable to the use of current public transport (bus, tram, and metro)	5.16 (1.492)	5.09 (1.607)
S12 <sup>6</sup> I think it takes a lot of time to learn how a self-driving bus works (reversed)	4.82 (1.898)	4.71 (1.829)
S13 <sup>5</sup> Riding backwards in a self-driving bus (seats facing the opposite direction of travel) is not an option for me (reversed)	4.8** (1.841)	5.24** (1.773)

The difference between the two scores is significant: \*\* at a 95% level based on Wilcoxon signed-rank test statistics ( $Z = -2.512$ ,  $p = 0.012$ ); \* at a 90% level based on Wilcoxon signed-rank test statistics ( $Z = -1.886$ ,  $p = 0.059$ )

<sup>1</sup> Statement S7 is on a Likert scale from 1 = dislike extremely to 7 = like extremely. All other statements are on a Likert scale from 1 = strongly disagree to 7 = strongly agree. <sup>2</sup> Adapted from Jian et al. (2000); <sup>3</sup> Adapted from Nordhoff et al. (2018); <sup>4</sup> Adapted from Kyriakidis et al. (2015); <sup>5</sup> Adapted from Öztürker et al. (2022); <sup>6</sup> Adapted from Madigan et al. (2016).

Results of confirmatory factor analysis. Model fit: for wave 1 before the test ride (RMSEA – 0.14, CFI – 0.969, TLI – 0.97) and for wave 2 after the test ride (RMSEA – 0.123, CFI – 0.976, TLI – 0.961).

Multi-group confirmatory factor analysis confirmed weak (restricted factor loadings) and strong (restricted factor loadings and intercepts) model structure invariance against the configural model.

We estimated a hybrid mixed logit model with panel effects jointly on the data collected in the two waves (before and after a test ride) in Biogeme (Table 3) (Bierlaire, 2023). The difference in the data variance between the two waves is accounted for by the scale parameter. Examples of this approach can be found in the studies by Jensen et al. (2013) and González et al. (2016). It allows us to assess the significance of the variations in attitudes and preferences influenced by the ride experience in the Helmond pilot trial. Additionally, the participants' previous ride experience in other trials was incorporated into the model as an interaction term.

#### 4. Discussion of results

From the estimated choice model (Table 3), we discuss the results from the perspective of the relative changes in the preferences for AmBs in comparison to conventional transport modes (car, bus, or bicycle) under the influence of ride experience in the Helmond pilot and previous ride experience in other pilots. We go through the outcomes based on each component of the utility functions starting with instrumental variables and subsequently exploring latent and socio-economic variables.

Table 3. Modelling results of joint hybrid mixed logit model with panel effects

Parameter	Corresponding variable	Parameters		
		Specific for wave 1	Specific for wave 2	Generic
<b><math>\beta_{ik}</math></b>	<b>Instrumental variables</b>			
$\beta_{busreg\_TT}$	In-vehicle travel time (min)	-	-0.144***	-
$\beta_{busflex\_TT}$		-	-	-0.0889***
$\beta_{bus\_TT}$		-	-	-0.186***
$\beta_{car\_TT}$		-0.097*	-	-
$\beta_{car\_TT} * exp$		-	-0.203***	-
$\beta_{bike\_TT}$		-	-	-0.137***
$\beta_{busreg\_TC}$	Travel costs (€)	-1.26***	-	-
$\beta_{busflex\_TC}$		-	-	-0.626***
$\beta_{bus\_TC}$		-	-	-0.757***
$\beta_{car\_TC}$		-	-	-1.17***
$\beta_{car\_TC} * exp$		-	0.916***	-
$\beta_{busreg\_waitT}$	Waiting time at a stop or a doorstep (min)	-	-0.106**	-
$\beta_{busreg\_walkT}$		Walking time to a stop (min)	-	-0.0945*
$\beta_{busreg\_walkT} * ride\_exp$		-0.129**	-	-
$\beta_{bus\_walkT}$		-	-0.25***	-
<b><math>\beta_{is}</math></b>	<b>Socio-economic variables</b>			
$\beta_{busflex\_gender}$	Female (ref. - Male)	-	1.85***	-
$\beta_{busflex\_gender} * ride\_exp$		-	-2.67***	-
$\beta_{bus\_age}$	Old (above 50)	-	0.78**	-
$\beta_{car\_age}$	(ref. – Young (below 50))	1.83***	-	-
$\beta_{bike\_age}$		1.13***	-	-
$\beta_{bike\_age} * ride\_exp$		-1.62***	-	-
$\beta_{busreg\_occupation}$	Employed	-	-1.71***	-
$\beta_{busflex\_occupation}$	(ref. – Student, retired, unemployed and others):	-	-2.68***	-
$\beta_{busflex\_ocu} * ride\_exp$		-	1.16*	-
$\beta_{car\_occupation}$		4.04***	-	-
$\beta_{car\_ocu} * ride\_exp$		-3.02**	-	-
$\beta_{bike\_occupation}$		2.54***	-	-
$\beta_{busreg\_steward}$	Steward in the minibus	-	0.558*	-
$\beta_{busflex\_steward} * ride\_exp$	(ref. – No supervision)	-	1.44***	-
$\beta_{bus\_steward} * ride\_exp$		2.27***	-	-
$\beta_{bike\_steward}$		-1.54***	-	-
$\beta_{busreg\_operator}$	Remotely by operator	1.12***	-	-
$\beta_{busflex\_operator}$	(ref. – No supervision)	1.98***	-	-
$\beta_{bus\_operator}$		1.09**	-	-
$\beta_{car\_part}$	Participants with a professional interest	-2.72**	-	-
$\beta_{car\_part} * ride\_exp$		4.4***	-	-

$\beta_{\text{bike\_part}}$	(ref. – Residents of Helmond)	0.911*	-	-
$\beta_{ii}$	<b>Latent variables</b>			
$\beta_{\text{busreg\_F2}}$	Enjoyment of rides in AmBs	-	0.375*	-
$\beta_{\text{bike\_F2}}$		-	-0.732***	-
$\beta_{\text{car\_F3}}$	Ease of use and safety of AmBs	1.54*	-	-
$\beta_{\text{bike\_F3}}$		-1.12*	-	-
$\mu$	<b>Scale between waves</b>			
$\mu_{\text{wave2}}$	Scale parameter	1	1.19 <sup>a</sup>	-
$\sigma$	<b>Panel effects</b>			
$\sigma_{\mu}$	Standard deviation for panel effects	-	-	1.01***
Number of parameters		59 <sup>b</sup>		
Sample size / Number of observations		45 / 540		
Initial log-likelihood / Final log-likelihood		-869.0965 / -577.6521		
Rho-square / Adjusted Rho-square		0.335 / 0.29		
Akaike / Bayesian Information Criterion		1233.304 / 1303.764		
Number of Halton draws from a normal distribution		1000		
<sup>a</sup> t-test against 1; <sup>b</sup> parameters from structural equations for latent variables are not shown in this table; *** significant at a 99% confidence interval; ** significant at a 95%; * significant at a 90%				

*Instrumental variables.* In terms of perception of in-vehicle travel time in AmBs compared to conventional modes of transportation such as cars, buses, or bicycles, participants in this pilot show a clear preference for spending their travel time in AmBs that offer flexible service. This preference remains consistent even after the participants have experienced the test ride indicating that the ride experience does not significantly alter their choice. Moreover, participants perceive the travel time in AmBs (flexible service) as similar to the travel time in a car before the test ride (the travel time perception in a car loses its significance after riding in the AmB).

On the other hand, participants show a lower preference towards in-vehicle travel time in AmBs providing regular service. Notably, the ride experience in the Helmond pilot influences their perception, as the travel time parameter gains its significance after the test ride. Furthermore, participants perceive their travel time in regular-service AmBs as comparable to that of bus and bicycle alternatives.

These similarities in the perception of travel time between an AmB (flexible service) and a car, and between an AmB (regular service), a bus and a bicycle might indicate that an AmB with flexible service is associated with higher convenience and comfort, akin to a private car, as it offers doorstep pick-up and drop-off for passengers. While an AmB with regular service is considered alike to conventional public transport and, surprisingly, the use of active modes. This unexpected association with active modes could be attributed to the physical effort involved in riding a bike, which can be linked to the effort of walking to and from the bus stop when taking an AmB (regular service).

Considering the travel costs, participants consistently express a preference for AmBs offering flexible service regardless of the ride experience. The travel costs for AmBs providing regular service are less favoured. Yet, this parameter loses its significance once participants gain ride experience in the pilot. However, in contrast to the similarities in the perceptions of travel time parameters between the travel options in this experiment, participants prefer paying for AmBs (flexible service) similar to the bus alternative and evaluate the travel costs for AmBs (regular service) as negative as the travel costs of using a car alternative.

One potential explanation could be that participants perceive flexible-service AmBs as being similarly affordable as conventional public transport options, at the same time offering greater convenience and travel comfort. As a result, the perception of paying for regular-service AmBs, which do not possess these advantages, is akin to the perception of paying for using cars. Here, the benefits of flexibility provided by cars are counterbalanced by their generally higher travel costs particularly in the presence of flexible-service AmBs as an alternative option.



As for AmBs providing regular service, the disutilities associated with waiting time at a bus stop and walking time to the bus stop gain significance after participants have experienced a ride in this pilot. Moreover, those participants who have previous ride experience in an AmB perceive walking time to the bus stop more negatively, but only before the test ride in the Helmond trial. Additionally, participants prefer to walk to the bus stop to board an AmB with regular service rather than a conventional bus.

The more negative perception of walking time among participants with prior AmB experience may be attributed to their higher expectations for the service. They might anticipate a more seamless and efficient experience when selecting AmBs with regular service, leading them to view walking time as a more significant drawback. However, regardless of previous ride experience, all participants become more aware of the negative impact that both walking and waiting time have on their preferences for this travel option after experiencing a ride.

The preference for walking to the bus stop to take an AmB rather than a conventional bus could be attributed to the excitement surrounding automated driving technology. Participants might be drawn to the novelty of AmBs.

Consistent with the current study, the studies conducted by Dekker (2017) and Öztürker et al. (2022) also demonstrated a higher value placed on flexible service compared to regular one, particularly among current public transportation users in the latter study. However, these findings contrast with the results of the study by Winter et al. (2019) where regular service was preferred over hybrid service (on-demand, following a fixed route).

*Latent variables.* Two out of three latent attitudinal variables have a significant impact on the preferences in this experiment, namely enjoyment of rides in AmBs, and ease of use and safety of AmBs. Yet, only the enjoyment of the rides in AmBs directly and positively affects the preferences for AmBs with regular service. As for the other alternatives, choosing a bicycle before the test ride in the Helmond pilot happens with a lower probability on average for participants who envision AmBs as safe and easy to use. On the contrary, participants opt for a private car even though they recognize AmB's safety and ease of use features. While after a test ride, those who enjoyed their ride experience in the AmB expressed their preference against a bicycle alternative.

AmBs could be viewed as a safe and effortless alternative to cycling, and this perception is supported by having an enjoyable ride experience in this trial. However, even though participants recognize the safety and ease of use offered by AmBs, the convenience provided by cars is hard to outweigh due to the comfort and freedom associated with them.

*Socio-economic variables.* The participants' choices as explained by their socio-economic characteristics undergo a significant change from the pre-ride wave to the post-ride wave. Female participants demonstrate a preference for AmBs with flexible service after a test ride in the Helmond pilot. However, this preference is negatively affected by prior ride experience in AmBs. In the case of older participants (aged 50 and above), their initial choice favours car and bicycle travel options before a test ride. However, their preference changes when selecting a bicycle influenced by their previous ride experience. After a test ride, older participants opt for a bus travel option.

Employed participants, before gaining ride experience in the pilot, tend to choose a car and bicycle. However, those with prior ride experience hold an opposing opinion on the car alternative. After a test ride, employed participants do not enjoy AmBs with regular or flexible service. Nevertheless, previous ride experience softens their negative preference for AmBs providing flexible service. This dislike of AmBs is not surprising as employed participants have higher time pressure to reach their work destinations while the travel is not that efficient with the current speed of AmBs in test conditions (the max speed was 16 km/h).

Participants who have a professional interest in joining the pilot trial tend to dislike the car alternative and prefer a bicycle before a test ride. However, those with previous ride experience in AmBs reverse their perception and return to their choice of car alternative. The explanation of this pattern could be that the participants who experience the AmB for the first time might feel excited because of trying it in reality whereas the experienced participants may feel disappointed with the slow progress from their previous experience to the current one.

The preference for supervision in AmBs, regular or flexible, shifts from remote supervision by an operator before the test ride to supervision by a steward inside the AmB after the ride. Witnessing the current state of technology could explain this change. Apart from that, participants without prior ride experience in AmBs who opt for supervision by a steward in the minibus dislike a bicycle. On the other hand, participants with previous ride experience in AmBs who select steward supervision show a positive inclination towards a bus alternative. Additionally, participants who choose remote supervision by an operator before the test ride, regardless of previous experience, show a preference for a bus.

In summary, the aforementioned findings revealed participants' strong inclination towards flexible-service AmBs, specifically regarding travel time and costs. The preferences for less popular regular-service AmBs underwent a

significant change in the perception of all instrumental variables due to participants' ride experience in the Helmond pilot as well as their previous experiences from other trials.

Finally, it's important to highlight some limitations of this study. The first one arises from the hypothetical scenario presented in the SC experiment. While the provided ride experience aimed to mitigate this limitation, participants still had to imagine their commutes using AmB alternatives as the case study in Helmond and the SC experiment design did not fully mirror their current travel patterns. The second constraint is due to the modest sample size, with nearly half of the participants having a professional interest in AmBs. This makes it challenging to generalize the results to the population. The third limitation stems from the low speed of the AmB in the Helmond pilot trial which could have influenced participants' perceptions of safety during the test rides. This limitation remains consistent across various pilot studies, reflecting ongoing concerns about the safety of automated driving until the technology proves itself.

While taking into account these limitations, the findings of this study can be seen as the initial phase in exploring how participants' real ride experiences (initial and consecutive) with AmBs influence their preferences for this mode of transportation in comparison to conventional transport options (in the case of this study, car, bus, and bicycle).

## 5. Conclusions

In a pilot trial conducted in Helmond, the Netherlands, we examined how the ride experience in AmBs influenced users' attitudes and preferences for this transport solution compared to traditional transport options (car, bus, and bicycle). Participants took a test ride in an AmB on a public road with mixed traffic, and we collected data from pre- and post-ride surveys. Our analysis using a joint hybrid mixed logit model revealed that participants exhibited a clear preference for flexible-service AmBs in terms of travel time and costs. Moreover, they perceived travel time to be analogous to that of cars while their willingness to allocate travel costs for flexible-service AmBs resembled that of choosing a bus. Notably, preferences for less favoured regular-service AmBs underwent a shift in the perception of travel time and travel costs and waiting and walking time parameters influenced by participants' ride experience. After the test ride, the disutility of travel time in regular-service AmBs gained significance opposite to the travel costs. Additionally, participants perceived the travel time to be on par with both buses and bicycles while viewing the travel costs with the same unfavourable perspective as those associated with car usage. The inconveniences related to the waiting time at a bus stop and walking time to the bus stop became significant for participants after they had experienced a ride in this pilot. Those participants with prior ride experience demonstrated a propensity for walking to the bus stop when considering regular-service AmBs favouring it over conventional buses. As for underlying psychological attitudes, having an enjoyable ride experience in this pilot reinforced the preference for AmBs with regular service. While preference for supervision in AmBs, whether with regular or flexible service, transitions from remote operator supervision before the test ride to onboard steward supervision inside the AmB after the ride.

These findings highlight the significant impact of ride experience (initial and consecutive) in AmBs on participants' preferences for this transport mode. This emphasizes the importance of panel studies in understanding changes in attitudes and preferences for AmBs over time. However, it is important to acknowledge that our conclusions are specific to this particular case study in Helmond. Expanding this research to encompass a wider geographical and demographic context will be crucial for establishing the broader applicability of our results.

It is important to note that there is still a long way from the full-scale implementation of AmBs. Therefore, it is recommended to adopt an iterative monitoring process that closely tracks the advancements in automated driving technology and its perception among potential users. Additionally, longer pilot trials are needed to give potential users more time to form their opinions while using AmBs as a daily transport option. Moreover, engaging potential users in participatory studies during these trials can steer the development and deployment of AmBs towards a transport solution that is specifically designed to meet their needs.

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