# Autonomous vehicle: attitude, activities, and feelings

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Between myth and reality, the concept of autonomous vehicle (AV) is becoming a credible alternative for the coming decades. The objective of this paper is to improve our knowledge about attitudes towards autonomous vehicles (AV). The first challenge is to identify the activities which could be performed in the AV. The second challenge is to characterise emotions towards the AV while the third is to better understand the link between the socio-demographic characteristics and attitudes towards the AV. The analysis is based on an online survey with a representative panel in France (1 100 respondents). The results show that car users are those who are the most interested in the autonomous vehicle. Also, they will not be ready to use the full potential of AV because 70% of them declare "watching the road" as their main activity. This can be explained by the fact that AV is associated with feelings of stress, being afraid and apprehension, even for people who already use driving assistance systems. Of the people questioned, those between 46 to 65 years old have a more positive attitude toward AV than others. Finally, the possibility of working inside an AV acts negatively on AV use through the risk of the added workload anticipated by individuals and by the fact that individuals do not perceive the interest of working inside a vehicle rather than at home or in the workplace.

*Keywords: Autonomous Vehicle, Value of Time, Activity non related to driving task (NDRT), emotion*

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# **Title**: Autonomous vehicles: attitudes, activities, and feelings

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**Summary:**

Between myth and reality, the concept of the autonomous vehicle (AV) is becoming a credible alternative for the coming decades. Thanks to the development of assisted driving, the amount of time dedicated to the driving activity in a car during a trip should decrease to the benefit of other activities, leading to a major question: what could we do with the extra time in our private vehicles? The objective of this paper is to improve our knowledge about attitudes towards autonomous vehicles (AV). The first challenge is to identify the activities which could be performed in an AV. The second challenge is to characterise emotions towards AVs while the third is to better understand the link between the socio-demographic characteristics and attitudes towards them. The analysis is based on an online survey with a representative panel in France (1 100 respondents). The method is split between a descriptive data analysis and a linear regression model. The results show that car users are those who are the most interested in the autonomous vehicle. Also, they will not be ready to use the full potential of AVs because 70% of them declare that “watching the road” is their main activity. Other activities would be under-represented. This can be explained by the fact that AVs are associated with feelings of stress, fear and apprehension, even for people who already use assisted driving systems. People are not ready to place their trust in artificial intelligence to drive a car. Of the people questioned, those between 46 to 65 years old have a more positive attitude toward AVs than others. Finally, the possibility of working inside an AV acts negatively on AV use due to the risk of the added workload anticipated by individuals and by the fact that individuals do not perceive the interest of working inside a vehicle rather than at home or in the workplace.

**Keywords:**

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## 1. Introduction

Between myth and reality, the concept of the autonomous vehicle is becoming a credible alternative for the coming decades. Thanks to the development of assisted driving and the first autopilot system proposed by Tesla, the amount of time dedicated to the driving activity in a car during a trip should decrease to the benefit of other activities, leading to a major question: what could we do with the extra time in our private vehicles?

The question is controversial in the economic literature, seen through the concept of value of time (VOT). As defined by Horowitz (1978), the value of time is a "surrogate measure of the comfort, convenience, and reliability of the travel experience" (p.385). The determinants of VOT are multiple. They depend on the mode of transport, travel leisure, individual characteristics, etc. Considering the private car, it is possible to consider that an equilibrium exists between the comfort of having one's own mode of transport and the discomfort of driving. This can determine the decision to make a trip or a modal choice. It is interesting to consider what the new equilibrium might be if the constraint of the driving activity were removed. Debate in the literature is ongoing (Pudane *et al.*, 2018; Rashidi *et al.*, 2020). Many of the studies consider that VOT could decrease, leading to more intensive car use (Singleton, 2018; Steck *et al.*, 2018; Rashidi *et al.*, 2020; Szimba&Hartmann, 2020). Kolarova *et al.* (2019) assessed that VOT could decrease by 40%, especially for commuting trips. However, some studies criticised these results and questioned the gain achieved by autonomous vehicles. The first criticism concerned the method used to assess the value of time. Based on surveys and declared preferences, reality could prove to be less optimistic. Wadud and Huda (2021) showed that drivers could be less ready than expected to do activities other than driving. The second limit was psychological. Several studies highlighted that the acceptability of the autonomous vehicle was far from obvious (Hohenberger *et al.*, 2017; Molnar *et al.*, 2018; Walker *et al.*, 2019). Gaining trust in artificial intelligence is a considerable challenge. De Almeida Correia *et al.* (2019) showed that many respondents to a survey were not ready to place their trust in artificial intelligence used to drive a car. Also, the analysis of emotion related to autonomous vehicles highlighted counterintuitive results such as increased stress in autonomous vehicles in comparison to manual driving (Walker *et al.*, 2019).

To our knowledge, the literature lacks studies that explore behaviours regarding autonomous vehicles from the perspective of attitudes, activities and feelings. The objective of this paper is to improve our knowledge about attitudes to autonomous vehicles (AV). The first challenge is to identify the activities which could be performed in an AV. The second challenge is to characterise emotions towards AVs while the third is to better understand the link between sociodemographic characteristics and attitudes regarding AVs.

The analysis is based on an online survey conducted with a representative panel in France (1100 respondents). The method is split between a descriptive data analysis and a linear regression model to identify the main determinants of attitudes towards autonomous vehicles.

The main results show that car users are those who are the most interested in the autonomous vehicle. Also, they will not be ready to use the full potential of AV because 70% of them declared "watching the road" as their main activity. Other activities would be under-represented. This can be explained by the fact that AV is associated with feelings of stress, fear and apprehension, even for people who already use driving assistance systems. People are not ready to place their trust in artificial intelligence to drive a car. Drivers aged between 46 to 65 years old have a more positive attitude toward AVs than others. Finally, the possibility of working inside an AV is seen negatively due to the risk of the added workload anticipated by drivers and by the fact that they do not consider working inside a car as an alternative to working at home or in the workplace.

Section 2 provides a review of the academic literature concerning the analysis of activities in an AV. Section 3 provides a description of the survey method after which the results are presented in section 4.

## 2. Review of the literature

The academic literature on autonomous vehicles is split into three main fields: engineering, psychology and economics. In this paper, the engineering aspect is not taken into account. The two other fields have for common target the assessment of users' attitudes to AVs. For the economist, the focus depends on the effect of AVs on the VOT. If automatic driving allows reducing the time related to the driving task during a trip to benefit other tasks, then the VOT should decrease and AVs should be more attractive (Pudane *et al.*, 2018). Otherwise, for psychologists, they assume that the possibility to do other tasks is not enough to determine the attractiveness of AVs. The emotions aroused by, and the initial attitude to, a new technology can have a strong effect on the adoption of AVs (Walker *et al.*, 2019). Considering this, this part provides an overview of the main lessons and limits obtained from the academic literature with respect to psychology and economics.

The first lesson concerns the consensus among economists about the benefit of AVs on the VOT. Theoretically, the reduction of driving time should increase the time for other activities and the utility time (Singleton, 2018; Steck *et al.*, 2018; Rashidi *et al.*, 2020; Szimba & Hartmann, 2020). Based on surveys, several studies quantified that the effect of automatic driving on VOT was from 30% (Steck *et al.*, 2018; De Almeida Correia *et al.*, 2019; Zhong *et al.*, 2020) to 40% (Kolarova *et al.*, 2019) in comparison with a conventional car. The benefits can vary according to several factors like age (Herrenkind *et al.*, 2019; Zoellick *et al.*, 2019), residence (Zhong *et al.*, 2020) or the purpose of the trip (De Almeida Correia *et al.*, 2019; Kolarova *et al.*, 2019). Regarding this last point, the authors showed that the VOT should be less impacted in the case of leisure trips than for commuting or professional trips. The main explanation concerns the higher utility of time in case of professional trips than for leisure or shopping trips. However, there is a debate on the empirical application of these results. The main limit is still the difficulty of obtaining data from real experiences due to the lack of operational AVs. Consequently, research has been based on theoretical models and surveys which can be far from the reality perceived between declared preference and revealed behaviour. Indeed, some authors question the effect of automatic driving on the VOT and assume that it could be more modest than expected and even, in specific cases, lower (Rashidi *et al.*, 2020; Singleton, 2018). Singleton (2018) moderated the benefit because of several reasons. First of all, the vehicle design could limit activities during a trip. Also, it is not sure that the sensations of users in the vehicle will be similar to those of train passengers. They conclude that the main effect would be on the welfare of the users during a trip with reduced stress and apprehension related to driving tasks. Likewise, Rashidi *et al.* (2020) reported six papers in which the effects of AVs on the VOT are unclear. Three papers found an increase in VOT: +9.83% (Krueger *et al.*, 2019), +14.54% for Gao *et al.* (2019) and +29.03% (Yap *et al.*., 2016). Furthermore, three papers found a difference between professional and leisure trips (De Loof *et al.*, 2018; De Almeida Correia *et al.*, 2019; Kolarova *et al.*, 2019). The first explanation given by the authors concerned the methodology. Many studies are based on a limited panel and bias can occur (Krueger *et al.*, 2019). The second explanation concerns the subject itself. The AV is a disruptive innovation. The lack of familiarity with new technologies can lead to feelings of unease about AVs (Gao *et al*., 2019). Finally, the differences observed between leisure and commuting trips highlighted the effect of activities and emotions on the VOT. The authors assumed that professional activities (work in the vehicle) have a higher utility than leisure activities (game playing, etc.). Also, they assumed that users would be more willing to spend time in the vehicle used as a substitute office than for leisure.

The second lesson highlights the diversity of factors to explain attitudes towards AVs. First of all, psychologists identified a conflict between two motivations (Choi & Ji, 2015; Keszey *et al.*, 2020), one related to a utilitarian motivation (based on the rationality: usefulness) and the other to a hedonic motivation (based on emotions: anxiety, pleasure, etc.). These two aspects can also be interpreted as a conflict between perceived usefulness and trust (Choi & Ji, 2015). Xu *et al.* (2018) added perceived safety to understand the intention to use an AV. Regarding the emotional aspect, trust was considered as a major determinant (Choi & Ji, 2015; Hohenberger *et al.*, 2017; Molnar *et al.*, 2018; Xu *et al.*, 2018). Zhang *et al.* (2019) showed that initial trust is a critical factor for using an AV. Nevertheless, according to the authors this concept can be difficult to define. It can be perceived safety (Xu *et al.*, 2018), anxiety, pleasure, etc. (Hohenberger *et al.*, 2016; Hohenberger *et al.*, 2017). From a general point of view, Choi & Ji, (2015) showed that trust can reduce perceived risk and increase the intention to use an AV. Also, Molnar *et al.* (2018) found that using an AV, even in a simulator, can increase trust. However, Hohenberger *et al.* (2017) highlighted the complexity of the issue as anxiety-related feelings can diminish the positive assessment of the benefits. Consequently, it is necessary to balance usefulness with emotions. Secondly, the literature showed that attitudes can be variable according to several factors such as the socio-demographic characteristics of the users, their travel behaviour and the driving style of the AV. On the basis of an extensive literature review, Adnan *et al.* (2018) showed that the level of trust was strongly dependant on the socio-demographic profile of users. Hohenberger *et al.* (2016) found that age and gender can be determinants. Nevertheless, Keszey *et al.* (2020) recommended improving research in the field. They obtained a counterintuitive result as anxiety can be more pronounced between genders in young people and decrease with age. Sener *et al.* (2019) found that the younger participants, in this case males and participants with driving disabilities, had a higher likelihood of intent to use. Also, they found that travel behaviour characteristics could be important. For example, participants owning a vehicle with highly automated features had a higher probability of using an AV. Finally, the AV driving style can have a significant impact on trust. Ekman *et al.* (2019) tested two types of driving: “defensive” and “aggressive. They found that the “defensive” driving style was perceived as more trustworthy than the “aggressive” one, in part because it was deemed more predictable. Last but not least, Walker *et al.* (2019) studied the effect of trust on activities not related to the driving task in an AV. They used a simulator for this experiment and showed that the more the participants self-reported trust, the less they controlled the road and the more they paid attention to a non-driving task. Their experiment highlighted two major lessons: firstly, a relationship can be established between the emotions and the ability of users to practise activities in the AV; secondly, a process of self-enhancement can be identified. Consequently, mixing the literature from the field of economics and that of psychology shows that the effect of AVs on the VOT should be moderated and explored in greater depth, especially concerning activities other than driving tasks. Whereas economists are optimistic and imagine that time will be fully reassigned to other tasks, psychologists show that acceptance depends on several factors that are not always rational and which can have a strong influence on their use and the VOT.

Finally, a considerable portion of the literature discussed the effect of new non-driving activities in relation to penalties traditionally associated with conventional cars. Nevertheless, it is interesting to observe that little research has focused specifically on activities in an AV. Most studies have considered activities as a step in their analysis. In the field of engineering, different secondary activities were tested to estimate the capacity of users to take control of an AV (Wandtner *et al.*, 2018; Dogan *et al.*, 2019; Jarosch *et al.*, 2019). Some papers in economics included questions in their survey about secondary tasks more to give examples to the respondent than to develop an in-depth analysis of the possible activities. For example, Zhong *et al.* (2020) proposed a short list of five activities (communicating, recreation, formal, personal, information search) with no difference between work

and leisure or other activities. The activities were just one step in a model of declared preference and VOT estimation. Also, some theoretical time-use models have been developed to assess the usefulness of the extra time available in an AV (Pudane *et al.*, 2018; De Almeida Correia *et al.*, 2019). They mainly distinguished two types of activities: activities that require a specific place or not, and activities that can be performed or not in an AV. They assumed that different activities will be possible in an AV but they did not take their analysis further. Consequently, only four papers took the the analysis further (Schoettle & sivak, 2014; Kyriakidis *et al.*, 2015; Bansal & Kockelman, 2017; Wadud & Huda, 2021). They identified a wide variety of activities, between 6 and 12 for the most exhaustive. Table 1 highlights some core activities quoted by all the studies, such as sleeping, mobile phone use, watching movies/playing games, and reading. Also, it showed some confusion. For example, watching a movie and playing games are totally different in terms of intensity and concentration. They should be split into two items. Watching a movie can be defined as a passive activity whereas playing games is a dynamic activity. According to the trust in the AV, it is not sure that users would be ready to practise the two activities with the same intensity. A similar comment can be made about the activities resting and sleeping. It is obvious that sleeping needs a level of trust in the system considerably higher than simply relaxing. Finally, the results showed that users could have a strong preference for listening to the radio / music, interaction with other passengers, window gazing, eating / drinking or making telephone calls / messaging. It is interesting to observe that these activities are similar to practises in conventional cars. Also, Schoettle & Sivak (2014) showed that 40% of their respondents were not ready to do other activities during a trip and 22% would not ride in an AV. We noted that users would be more willing to practise passive activities than active ones. Also, the relationship between trust and activities must be studied further.

**Table 1:** Overview of non-driving activities proposed in the academic literature during a trip in an AV (see Wadud & Huda, 2021)

| Secondary tasks | Schoettle & sivak, 2014 | Kyriakidis *et al.*, 2015 | Bansal & Kockelman, 2017 | Wadud & Huda, 2021 |
|---|---|---|---|---|
| Resting/sleeping | X | X | X | X |
| Mobile phone use – Calls, texting | X | X | X | X |
| Watching movies / Playing games | X | X | X | X |
| Reading | X | X | X | X |
| Working | X | | X | X |
| Email/internet surfing | | X | X | X |
| Eating / Drinking | | X | X | X |
| Interaction with other passengers | | X | X | X |
| Window gazing | | X | X | X |
| Watching the roadway | X | | | X |
| Listening to radio/music | | X | | X |
| Doing nothing/thinking | | X | | X |
| Online social media | | | | X |

To conclude, two limits in this literature review support our research question concerning attitudes towards AVs.

The first limit is that of imperfect knowledge of users' characteristics considering their attitudes towards AVs. This paper proposes to go further by extending the scope of the characteristics.

The second limit concerns the lack of mixing between rational approach and emotions. The economic literature assumes that users will be rational. Nevertheless, psychologists highlight the importance of emotion in users' behaviour. Considering this fact, it is important to go further in the analysis of emotions, crossing them with the attitudes of the users.

## 3. Data collection

In this section, we present the survey and the descriptive statistics.

- Data collection

Data were collected through an online survey during April 2021 in France. Web-surveys are often used in the transport field, especially for the topic of AV (Hohenberger *et al.*, 2016; Bennett *et al.*, 2019; De Almeida Correia *et al.*, 2019; Kolarova *et al.*, 2019). Their biases and limitations are therefore well-known (see, for example, Bonnel *et al.*, 2009; Groves, 2011; Monzon *et al.,* 2020). To limit them, we mandated a specialized survey company (www.inkidata.fr) to administer the survey and supply the sample from which we selected a representative panel of the French population according to different criteria (gender, age, education, see **Annex 3**). The participants were remunerated after completing the survey. In total, a sample of 1 100 respondents was collected (the survey elements are included in **Annex 1** and **2)**. The survey can also be obtained from the authors).

The survey contained 26 questions divided into four sections. The objective of the first section was to obtain information on the transport habits and attitudes of the respondents. The questions concerned the description of the main daily trip before the Covid 19 pandemic, such as the pattern (leisure, shopping, work, etc.), frequency (daily, between two and three times per week, less, etc.), average travel time and distance, the main mode of transportation and the itinerary (municipality of residence and municipality of employment). The second part focused on the activities practised during the trip (depending on the mode of transportation) with two discriminating questions for people travelling by train for more than 30 minutes for work and/or leisure. The objective was to characterize the different activities performed during a trip according to the mode of transportation and the type of travelling pattern (leisure, work, etc.). The activities were given to the respondents although they could add activities through a category "other". The 16 activities were given and were identified in the literature review (Wadud & Huda, 2021). The list is given in **Annex 1**. The third section was specific to the AV. A short text introduced the section and the concept of AV. It was completed by a video lasting 20 seconds shot on a French high-speed road in an electric car equipped with a semi-autonomous driving system (type Tesla). In this section, the questions concerned the emotions provoked by the AV (stress, fear, pleasure, etc.), the activities that could be performed in the AV and the attitudes towards the AV based on 13 affirmative sentences like "I do not like the idea of automatic driving", "I am afraid by the risk of dysfunction", "I am afraid to get sick in an AV", etc. The sentences were based on the list proposed by De Almeida Correia *et al.* (2019) and the full list is given in the annex. Also, one question addressed the economic aspect of AVs concerning the willingness of people to buy an AV if prices were similar to those of traditional cars. The last question concerned the percentage of work that could be performed by people in an AV (from working all the time to not at all). Finally, the last section dealt with household socio-economic characteristics (education, gender, age, professional category, household size, trip motivation, etc.). Some specific questions for car owners were asked to assess their attitudes towards driving assistance systems (speed regulator, speed limiter, adaptive cruise control, Tesla autopilot,

etc.). In this question, we distinguished several possibilities: system knowledge, appropriation of the system in the car, effective use of the system.

- Descriptive statistics

The sample was selected to be representative of the French population for gender, age, education and professional category. As can be seen in **Table 2**, 52% are women and 48% are men. The results are in line with the French population in 2021 according to the National Institute of Statistics (INSEE, 2021[1]) with respectively 51.7% and 48.3%. Regarding age, we considered only people of driving age (18 years old in France). The distribution in our sample was 32.8% for 18 to 35 years, 35.7% for 36 to 55 years and 31.4% for older than 56 years. In comparison to the French population, the first class (23% according to the INSEE) of our sample was more over-represented than the second one (25%) but the last one (35%) was more in phase. In terms of education, the panel matched the national distribution with 49% having a least a degree in our panel versus 46% in France in 2018 (INSEE). Finally, the socio-professional categories were close to the national distribution. Farmers represented 1.1% of the sample versus 1.4% in France, employee-workers made up 29.8% of the sample versus 31.5% in France. Also, 24% of the French population is retired versus 21.8% in our sample, while 4% of the French population are students versus 7.7% in the study.

**Table 2:** Survey data (N = 1 100 respondents)

| | | Number | % | | | Number | % |
|---|---|---|---|---|---|---|---|
| Gender | Women | 572 | 52.0 | Education | No | 47 | 4.3 |
| | Men | 528 | 48.0 | | Certificate | 230 | 20.9 |
| Age | 18 to 25 years | 151 | 13.7 | | A-level | 282 | 25.6 |
| | 26 to 35 years | 210 | 19.1 | | Degree | 312 | 28.4 |
| | 36 to 45 years | 188 | 17.1 | | Higher than degree | 229 | 20.8 |
| | 46 to 55 years | 205 | 18.6 | Income per month | Less than 2000 euros | 325 | 29.5 |
| | 56 to 65 years | 150 | 13.6 | | 2000-4000 euros | 440 | 40.0 |
| | Older than 65 years | 196 | 17.8 | | 4000-6000 euros | 169 | 15.4 |
| Travail time | Full time | 560 | 50.9 | | 6000-8000 euros | 33 | 3.0 |
| | Part-time more than 50% | 73 | 6.6 | | More than 8000 euros | 17 | 1.5 |
| | Part-time less than 50% | 36 | 3.3 | | NA | 116 | 10.5 |
| | NC | 431 | 39.2 | License | Yes | 1001 | 91.0 |
| Household size | 1 person | 207 | 18.8 | | No | 99 | 9.0 |
| | 2 people | 450 | 40.9 | Public transport ticket | Yes | 283 | 25.7 |
| | 3 people | 199 | 18.1 | | No | 817 | 74.3 |
| | 4 people | 151 | 13.7 | Socio-professional category | Retailed | 240 | 21.8 |
| | 5 people | 71 | 6.5 | | Student | 85 | 7.7 |
| | | 16 | 1.5 | | Employee-Workers | 328 | 29.8 |

[1] https://www.insee.fr/fr/statistiques

| | | | | | | |
|---|---|---|---|---|---|---|
| | More than 5 people | | | | | |
| | NA | 6 | 0.5 | Intermediary Prof. | 163 | 14.8 |
| | | | | Executives | 117 | 10.6 |
| | | | | Craftsman-Manager | 49 | 4.5 |
| | | | | Farmer | 12 | 1.1 |
| | | | | Inactive | 106 | 9.6 |

## 4. Methodology

In the absence of any such analysis, to analyse the data we first used a statistical descriptive analysis to obtain a general framework of attitudes toward autonomous vehicles. This step was necessary for establishing a state of knowledge of attitudes and feelings regarding autonomous vehicles by an analysis of attitudes and feelings towards technology and also to know the activities people practise during car-sharing travel.

Then we wanted to find determinants of autonomous vehicle behaviour. Consequently, we analysed attitudes toward autonomous vehicle through a detailed approach, in particular by identifying significant correlations between attitudes to autonomous vehicles and feelings, technology use, activities, and socioeconomic variables. We used the generalized least squares (GLS) method to carry out this more precise analysis of the determinants of attitudes to autonomous vehicles. This method is well-known and standard (Green, 1993; Maddala, 2001). We considered that the well-established robustness of the GLS method in transport (Souche, 2010) was useful in this first step of exploring behaviours to autonomous vehicles from the perspective of attitudes, activities and feelings.

In the model, the variable to be explained is the use of autonomous vehicles and corresponds to the following question in our survey: Are you ready to use an autonomous vehicle if its price were equivalent to that of a standard car? The attitude to autonomous vehicles was a binomial variable taking 1 if the response was yes and 2 if the response was no. In the model, the explanatory variables corresponded to answers to question on the assistance system (see **Figure 3**), on activities (see **Figure 4**), on feelings (see **Figure 5**), and to the socioeconomic data contained in the survey database (**Table 2**) taken as control variables. We tested two models, the first model was without control variables and the second one with control variables. A sub-category of each variable was taken as a reference variable (for example, for gender the reference variable was “Female”, see details of reference sub-category in **Table 4**). We checked the satisfaction of the model properties. To interpret the variable coefficients, the *t*-value coefficient is significant when the *t*-value exceeds an absolute value of 1.96 with a level of significance of 0.05, and that a positive sign means a positive action of the variable compared to its reference category.

## 5. Results

We first present a general overview of the survey results on attitudes toward autonomous vehicles and on the feelings and activities declared inside an AV. Then we estimate a model for identifying significant variables for understanding AV behaviours.

- Overview of results

Data analysis provided initial information on mobility behaviours. We wanted to check how close our sample was close to standard French mobility behaviour. The objective was to avoid mobility behaviour bias before analysing attitudes toward autonomous vehicles.

The sample mobility behaviour is presented in **Table 3**. We formulated questions considering the "main daily travel (before Covid 19)".

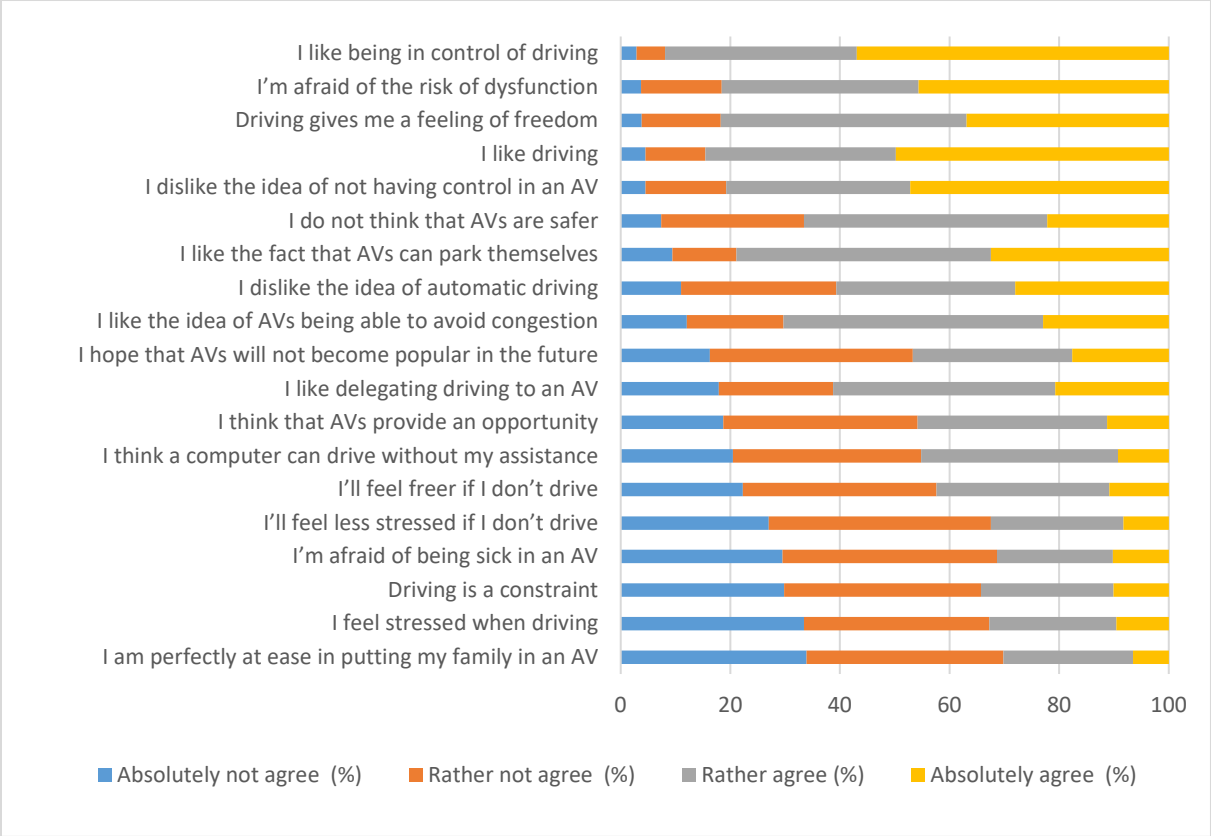
The results appear quite consistent with French mobility behaviour, as with 72% the car is the transport mode used most (see Personal Mobility Survey 2018–2019 by INSEE). The majority of this sample population holds a driving licence and owns a car (more than 90% in both cases), and a small number travelled by public transport (25%). Quite logically, the sample population travels mainly for work or study motives (almost 60%), for 52% less than 10 km and 75% have a travel time of less than 30 minutes.

**Table 3:** Travel data in the sample.

| | | Number | % | | | Number | % |
|---|---|---|---|---|---|---|---|
| Travel time | | | | Transport mode | | | |
| | Less than 5 minutes | 45 | 4.1 | | Car driver | 749 | 68.1 |
| | 5 to 15 minutes | 410 | 37.3 | | Car passenger | 52 | 4.7 |
| | 16 to 30 minutes | 383 | 34.8 | | Tramway/Subways | 75 | 6.8 |
| | 31 to 60 minutes | 185 | 16.8 | | Bus | 56 | 5.1 |
| | More than 60 minutes | 77 | 7 | | Train | 48 | 4.4 |
| Travel distance | | | | | Bicycle | 30 | 2.7 |
| | Less than 5 km | 225 | 20.5 | | Feet | 83 | 7.5 |
| | 5 to 10 km | 355 | 32.3 | | other | 7 | 0.6 |
| | 11 to 30 km | 373 | 33.9 | License | | | |
| | 31 to 50 km | 91 | 8.3 | | Yes | 1001 | 91 |
| | More than 50 km | 56 | 5.1 | | No | 99 | 9 |
| Car number | | | | Travel motive | | | |
| | No | 107 | 9.7 | | Work | 576 | 52.4 |
| | One car | 513 | 46.6 | | Studies | 76 | 6.9 |
| | Two cars | 375 | 34.1 | | Purchase | 270 | 24.5 |
| | Three cars and more | 105 | 9.5 | | Leisure | 143 | 13 |
| Public transport ticket | | | | | NA | 35 | 3.2 |
| | Yes | 283 | 25.7 | | | | |
| | No | 817 | 74.3 | | | | |

In the second step, we present results regarding attitudes to autonomous vehicles (**Figure 1**). First, they show that more than 82% of the respondents have already heard about autonomous vehicles. The topic is therefore known. However, this number falls to 48%, when we asked individuals if they would use an autonomous vehicle with a price quite similar to that of a standard vehicle. Between knowing and using, the difference is considerable. Moreover, it seems that a large majority of the respondents liked to drive and the feeling of freedom and 'disliked the idea of not having control over the AV' (for more than 80%), but at the same time they also would appreciate the possibility of avoiding congestion with an AV (70%).

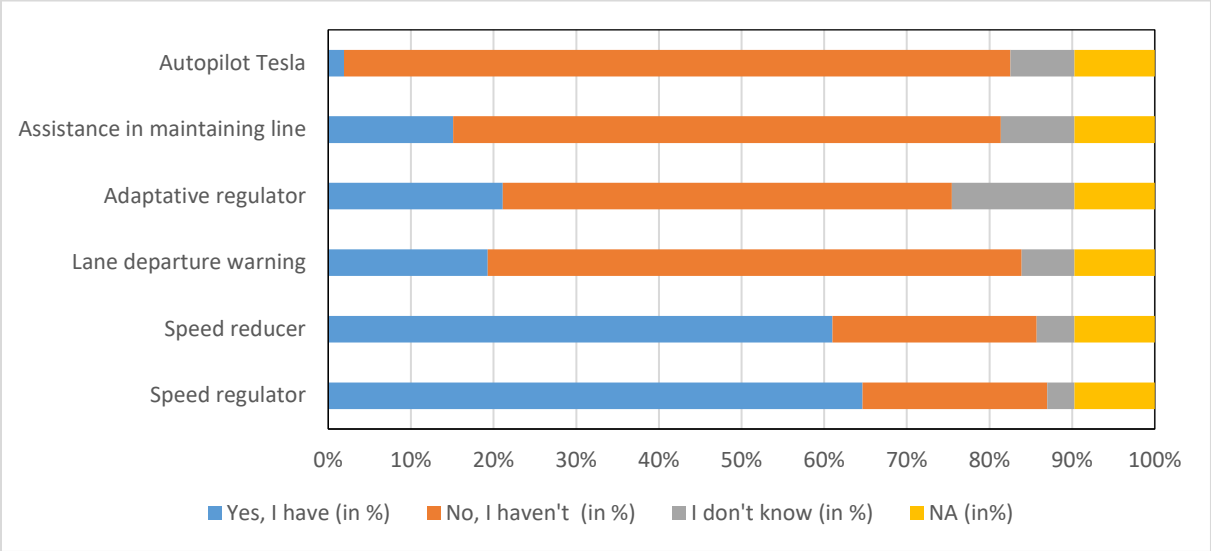
**Figure 1 :** Attitudes toward autonomous vehicles (in %).




In the third step, we provide elements for completing knowledge on attitudes toward autonomous vehicles (Keszey *et al.*, 2020). We detail individual attitudes in taking into account both technological innovation for assisted driving, feelings during automated driving experiments, and activities already experienced during car-sharing experiences.

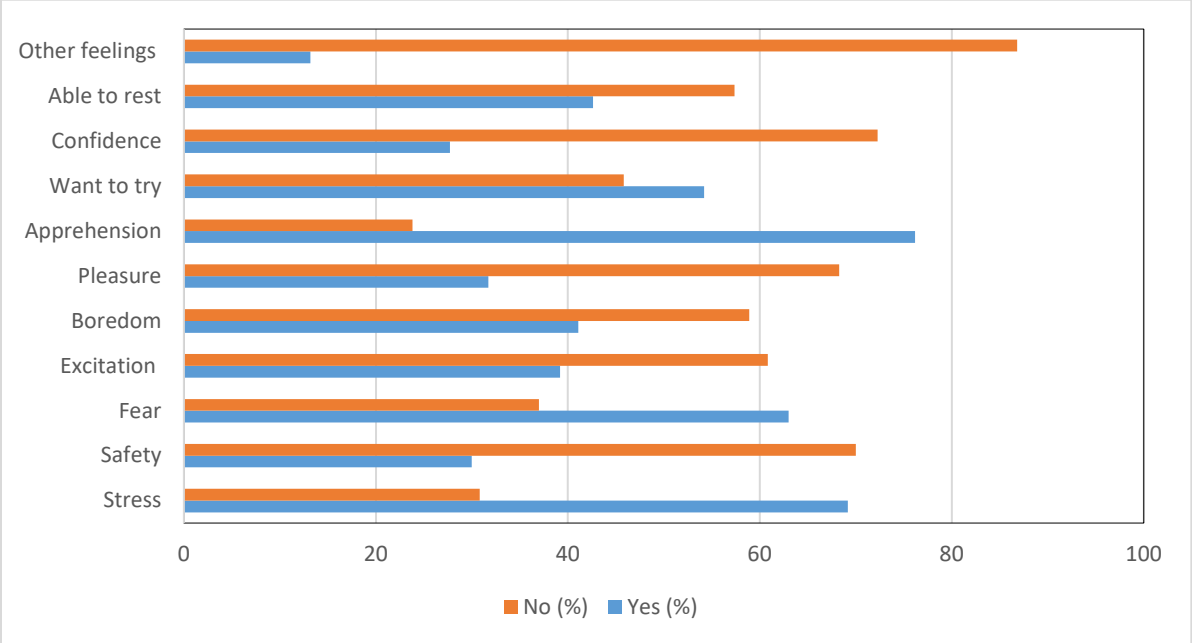
Concerning attitudes to technological innovations for assisted driving (**Figure 2**), we first observe that technological innovation concerned only a small percentage of the sample (around 20%) except for speed reducers and regulators (60%). We note that respondents were equipped only with speed reduction and speed cruise control although we cannot be sure whether they used them effectively.

**Figure 2 :** Assisted driving system for cars



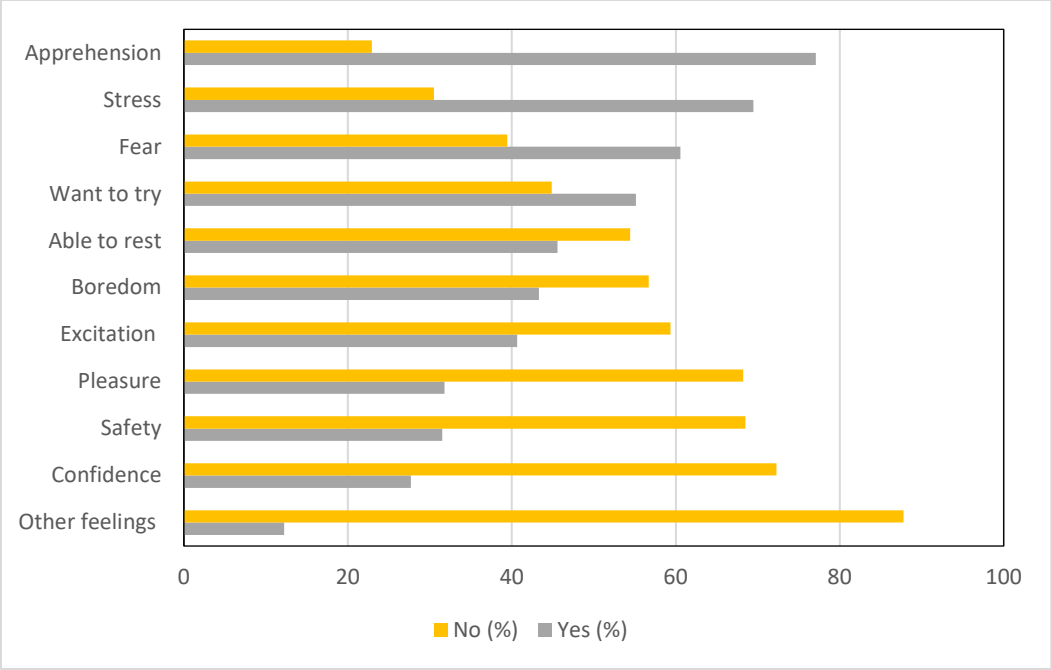

During an automated driving experiment with an autopilot (**Figure 3**), stress, fear and apprehension are feelings which clearly dominate these experiences. We can reasonably expect the same negative feelings when individuals are faced with autonomous vehicle experiences.

**Figure 3 :** Feelings generated by auto-conduct experience



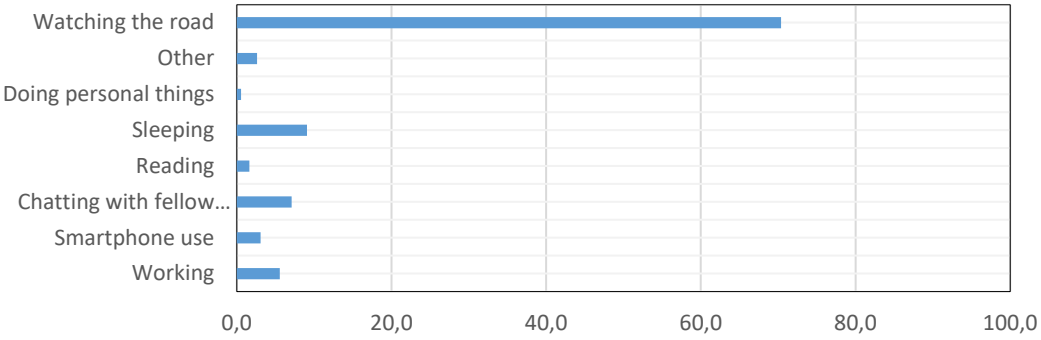

What feelings are linked to the speed regulator (**Figure 4**)? While the speed regulator is in use, it generates dominant feelings of apprehension, stress, fear and, surprisingly, no positive feelings such as pleasure, safety or confidence. These rather counter-intuitive results appear to be an illustration of user behaviour complexity that has already been pointed out by Ajzen (1991) in his theory of planned behaviour.

**Figure 4:** Feelings generated by speed regulator




Lastly, activities performed during a trip in an AV can be useful for understanding autonomous vehicle behaviour (**Figure 5**). However, road watching reaches a score of 70% of the answers followed by "passive" activities like "sleeping" or "chatting with fellow passengers". This result underlines the difficulties of understanding activities for a mode which cannot be used and pleads in favour of experiments in real situations.

**Figure 5:** Declared activities inside an AV




## 6. Discussion

We present the GLS estimation first with attitudes to technology, feelings and activities (Model 1 in **Table 4**), then we add socioeconomic variables as control variables to all the database variables (Model 2 in **Table 4**). The estimation model properties are satisfied as the first models show no problem of convergence, and there are no problems of multicollinearity between variables or autocorrelation problems. The presentation of the results is completed by a discussion.

The estimation results showed that several explanatory variables were significant for explaining autonomous vehicle behaviour (see *t-value*). In particular, almost all the feeling variables were

significant. As anticipated, feelings of pleasure, excitation and wanting to try an AV showed a positive attitude towards autonomous vehicle use. On the contrary, feelings of apprehension, stress and fear demonstrated a negative attitude towards AV. This result confirmed the idea that AV seems to increase stress in comparison to manual driving (see Walker *et al.*, 2019). Concerning experience of innovative technology, only not having experience of automated driving seemed to be correlated to a positive attitude to AV. This result contradicted the hypothesis that people who had already experimented with innovative technology would be in favour of VAs. However, this result appears to be more in line with the idea that people are not ready to place their trust in artificial intelligence to drive a car, as identified by de Almeida Correia *et al.* (2019). One explanation is the limited number of respondents who were familiar with innovative technology, except for speed reduction and regulation.

Nonetheless, the model showed no correlation between attitudes to AVs and the activities the person declared doing inside the vehicle. The absence of link between attitudes to AVs and activities inside them can probably be explained by the fact that more than 70% of the respondents declared that the first activity they would want to do in the AV would be to watch the road. This result is in line with that of Wadud and Huda (2021) who showed that drivers could be less ready than expected to do activities other than driving. As we explained previously, it seems difficult to anticipate activities in a context with which people are not familiar, thus underlining the need for real experiments using AVs.

However, as anticipated, controlling the model with socio-economic variables (see Model 2) slightly increased the level of Multiple R-squared, meaning better model adjustment. Age, level of income, household size and the ability to work inside the AV were significantly correlated with the variable to be explained. Belonging to an average household size (3-4 persons), earning a medium to high income, and the possibility of working inside an autonomous vehicle acted negatively on autonomous vehicle use, contrary to respondents aged between 46 and 65 years old. The role of age has already been underlined in the literature (Herrenkind et al., 2019; Zoellick et al., 2019) but, to our knowledge, this is not the case for the role of income. Medium and mostly high income earners are both categories who use cars a great deal and have a high value of time with emphasis placed on saving it. Therefore, it is logical to expect that they would be more in favour of AVs. As the result shows, it was not the case. We can postulate that this result reflects the scientific debate of the advantage or not of AV in terms of the VOT explained previously. For these categories, the advantages of AVs appear to be both unclear and insufficient. Moreover, standard transport variables like being a car user, travel time and travel distance do not seem to affect attitudes to AVs whereas some of the literature presents autonomous vehicles as a means of shortening travel time. This advantage appeared to be underestimated by the respondents.

Concerning the negative effect of the possibility of work inside autonomous vehicles, it can be explained by the risk of added workload anticipated by the respondents or by the fact that they did not perceive the interest of working inside a vehicle as being greater than working at home or in the workplace.

Lastly, the 46 to 65 year-old group showed a positive attitude towards autonomous vehicle use. Concerning the result for age, this result was unexpected as we presumed that the younger group would prefer the autonomous vehicle but this was not the case (Sener *et al.*, 2019; Keszey *et al.*, 2020).

1 **Table 4:** General Model

| | Model 1 | | Model 2 (with control variables) | |
|---|---|---|---|---|
| | coef. | t-value | coef. | t-value |
| **Autopilot** | | | | |
| AutopilotexperiencyNo | 0.108999 | *(2.198)* | 0.095958 | *(1.906)* |
| SpeedregulatorNo | -0.017206 | *(-0.387)* | -0.023797 | *(-0.539)* |
| SpeedregulatorNA | 0.052548 | *(0.653)* | 0.073607 | *(0.775)* |
| SpeedreducerNo | 0.057310 | *(1.328)* | 0.037902 | *(0.881)* |
| SpeedreducerNA | 0.049145 | *(0.662)* | 0.058740 | *(0.774)* |
| AlertNo | 0.039249 | *(0.865)* | 0.062068 | *(1.368)* |
| AlertNA | -0.149516 | *(-2.033)* | -0.108169 | *(-1.458)* |
| AdaptativeregulatorNo | 0.014008 | *(0.382)* | 0.009081 | *(0.250)* |
| AdaptativeregulatorNA | -0.007058 | *(-0.154)* | -0.028611 | *(-0.632)* |
| LanewarningNo | -0.076100 | *(-1.575)* | -0.082096 | *(-1.705)* |
| LanewarningNA | 0.082814 | *(1.277)* | 0.057186 | *(0.880)* |
| AutopilotTeslaNo | 0.091580 | *(0.937)* | -0.028197 | *(-0.284)* |
| AutopilotTeslaNA | 0.070997 | *(0.650)* | -0.074703 | *(-0.669)* |
| **Feelings** | | | | |
| StressNo | -0.111012 | *(-2.956)* | -0.092845 | *(-2.458)* |
| SecurityNo | 0.045752 | *(1.328)* | 0.064212 | *(1.876)* |
| AfraidNo | -0.071520 | *(-2.064)* | -0.094692 | *(-2.703)* |
| ExcitationNo | 0.094411 | *(3.059)* | 0.076588 | *(2.488)* |
| BoredomNo | -0.098796 | *(-3.684)* | -0.082299 | *(-3.041)* |
| PleasureNo | 0.095107 | *(2.714)* | 0.083126 | *(2.356)* |
| ApprehensionNo | -0.088142 | *(-2.404)* | -0.072249 | *(-1.977)* |
| WanttotryNo | 0.326939 | *(10.035)* | 0.302236 | *(9.261)* |
| TorestNo | 0.087788 | *(3.179)* | 0.079079 | *(2.859)* |
| OtherfeelingsNo | 0.026792 | *(0.756)* | 0.026543 | *(0.755)* |
| **Activities** | | | | |
| ActivitiesinAVDiscuss | -0.020396 | *(-0.304)* | -0.076272 | *(-1.133)* |
| ActivitiesinAVWatch road | 0.037305 | *(0.692)* | -0.029727 | *(-0.543)* |
| ActivitiesinAVSleep | 0.006692 | *(0.101)* | -0.049699 | *(-0.740)* |
| ActivitiesinAVOther | 0.058480 | *(0.835)* | 0.021436 | *(0.305)* |
| **Socioeconomics** | | | | |
| GenderMan | | | -0.026370 | *(-0.999)* |
| Age26-45 years | | | 0.042298 | *(0.941)* |
| Age46-65 years | | | 0.097170 | *(2.085)* |
| AgeMore than 65 years | | | 0.120289 | *(1.565)* |
| ProfcategoryInactive-student | | | -0.008584 | *(-0.125)* |
| ProfcategoryMiddle category | | | 0.048735 | *(0.519)* |
| ProfcategoryExecutive-Craftsman | | | 0.103876 | *(1.063)* |
| WorktimePart time 50% | | | -0.014390 | *(-0.283)* |
| WorktimeLess part time 50% | | | 0.071421 | *(0.885)* |
| DiplomaLower than degree | | | -0.005505 | *(-0.077)* |
| EducationDegree and higher | | | -0.012245 | *(-0.168)* |
| Income2000-6000 euros | | | -0.105516 | *(-2.548)* |
| IncomeMore than 6000 euros | | | -0.121255 | *(-2.522)* |
| IncomeNA | | | -0.037000 | *(-0.359)* |
| Householdsize2-4 people | | | -0.069168 | *(-2.025)* |
| HouseholdsizeFive people and more | | | -0.064230 | *(-1.113)* |
| HouseholdsizeNA | | | -0.288254 | *(-1.516)* |

| | | | | |
|---|---|---|---|---|
| LicenseNo | | | -0.095013 | *(-1.704)* |
| PublictransportticketNo | | | -0.033547 | *(-0.872)* |
| CarnberOne car | | | -0.050113 | *(-0.504)* |
| CarnberTwo or more cars | | | -0.036353 | *(-0.358)* |
| CarillNo | | | -0.017891 | *(-0.494)* |
| Traveltime5-30 mn | | | 0.085046 | *(1.255)* |
| Traveltime30 mn or more | | | 0.097758 | *(1.298)* |
| Traveldistance5-30 km | | | -0.036730 | *(-1.024)* |
| Traveldistance30 km or more | | | 0.009258 | *(0.168)* |
| ModePublic transport | | | -0.068543 | *(-1.526)* |
| ModeOther | | | -0.033656 | *(-0.726)* |
| WorkinsideAVNo | | | 0.016597 | *(0.522)* |
| WorkinsideAVYes | | | -0.108742 | *(-3.071)* |
| *(intercept)* | 1.024710 | *(9.571)* | 1.333210 | *(6.009)* |
| Multiple R-squared | 0.512 | | 0.5507 | |
| Log-Likelihood | -331.1945 | df=30 | 294.1114 | df=60 |
| Residual standard error | 0.3549 | df=874 | 0.3466 | df=844 |
| F-statistic: | 32.79 | df=28 and df=874 ; p-value: < 2.2e-16 | 17.84 | df=58 and df=844 ; p-value: < 2.2e-16 |
| Durbin-Watson | 2.036387 | p-value = 0.59 | 2.015169 | p-value = 0.786 |

## 7. Conclusion

The objective of this paper was to improve knowledge about attitudes towards autonomous vehicles (AV). The first challenge was to identify the activities which could be performed in the AV. The second challenge was to characterise the emotions instilled by AVs while the third was to better understand the link between socio-demographic characteristics and attitudes towards AVs.

It was significant that the results showed that car users were those most interested in the autonomous vehicle. Also, although 82% of the respondents had already heard about autonomous vehicles, only 48% of them were ready to use an AV having a price similar to that of a standard vehicle. This highlighted a real difference between knowledge and utilisation. Regarding emotions, the results showed that during an auto-driving experience with an autopilot, stress, fear and apprehension were feelings which clearly dominated these experiences. We can reasonably expect the same negative feelings when individuals are confronted with autonomous vehicle experiences. We also found a negative effect of the possibility of working inside the autonomous vehicle. This contradicted the literature, but can be explained by the risk of added workload expected by the respondents or by the fact that they did not perceive the advantage of working inside a vehicle as being better than at home or at in the workplace. Finally, we showed no correlation between attitudes to AV and the activities the respondents declared doing inside the vehicle. Although one of the limitations of the paper is that we could not measure the time assigned to each activity inside the AV, the absence of a link between attitudes to AVs and activities inside them is probably due to the fact that more than 70% of the respondents declared that the first activity they would want to do in an AV would be to watch the road while travelling. This result is in line with that of Wadud and Huda (2021).

As in the studies of Hohenberger *et al.* (2017), Molnar *et al.* (2018); Walker *et al.* (2019), we confirm that the acceptability of the autonomous vehicle is far from being obvious. Our results point out the need to test attitudes to AVs through real experiments using this type of vehicle.

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## 9. Annex

**Annex 1**: List of activities

| | |
|---|---|
| □ Driving/walking/ pedalling | □ Talking with other travellers |
| □ Working (reading, writing) | □ Game playing |
| □ Professional phone calling | □ Personal phone calling |
| □ Reading professional email | □ Reading personal email |
| □ Sleeping/ lazing | □ Watching through window |
| □ Listening music, watching movies, reading | □ Browsing social networks |
| □ Online shopping | □ Getting ready (make up, styling, etc.) |
| □ Eating/ Drinking | □ Reading newspapers |
| □ Other: ….. | |

**Annex 2:** List of affirmative sentences

□ I like driving by myself.
□ I do not like the concept of automatic driving.
□ I think that a computer can drive without my assistance.
□ I do not like the idea of not having control over my vehicle.
□ I like the possibility of taking over driving if I do not like the driving style of an AV.
□ I will not worry about putting my close family in an AV.
□ I am afraid by the risk of dysfunctions.
□ I think that an AV is an opportunity to be more productive.
□ I am afraid to be sick in an AV.
□ I would like an AV if it can avoid traffic jams.
□ I would like an AV if it can find a cheaper parking place alone.
□ I would like an AV if I can delegate the driving when I cannot drive by myself (alcohol, tiredness, etc.)
□ I do not think that an AV is safer than manual driving.
□ I hope that AVs will not happen in the future.

**Annex 3:** Survey Quotas (%)

| | | 2017 | 2018 |
|---|---|---|---|
| Gender | Men | 49 | |
| | Women | 51 | |
| Age | 18 to 29 years | 24 | |
| | 30 to 44 years | 26 | |
| | 45 to 59 years | 27 | |
| | 60 to 74 years | 22 | |
| Modal share | Car | | 63 |
| | Public transport | | 9.1 |
| | Bicycle | | 2.7 |
| | Walking | | 23.5 |
| Degree | No | 22.8 | |
| | Certificate | 30.4 | |
| | A-level | 16.9 | |
| | Degree | 19.8 | |
| | Higher than degree | 10.1 | |