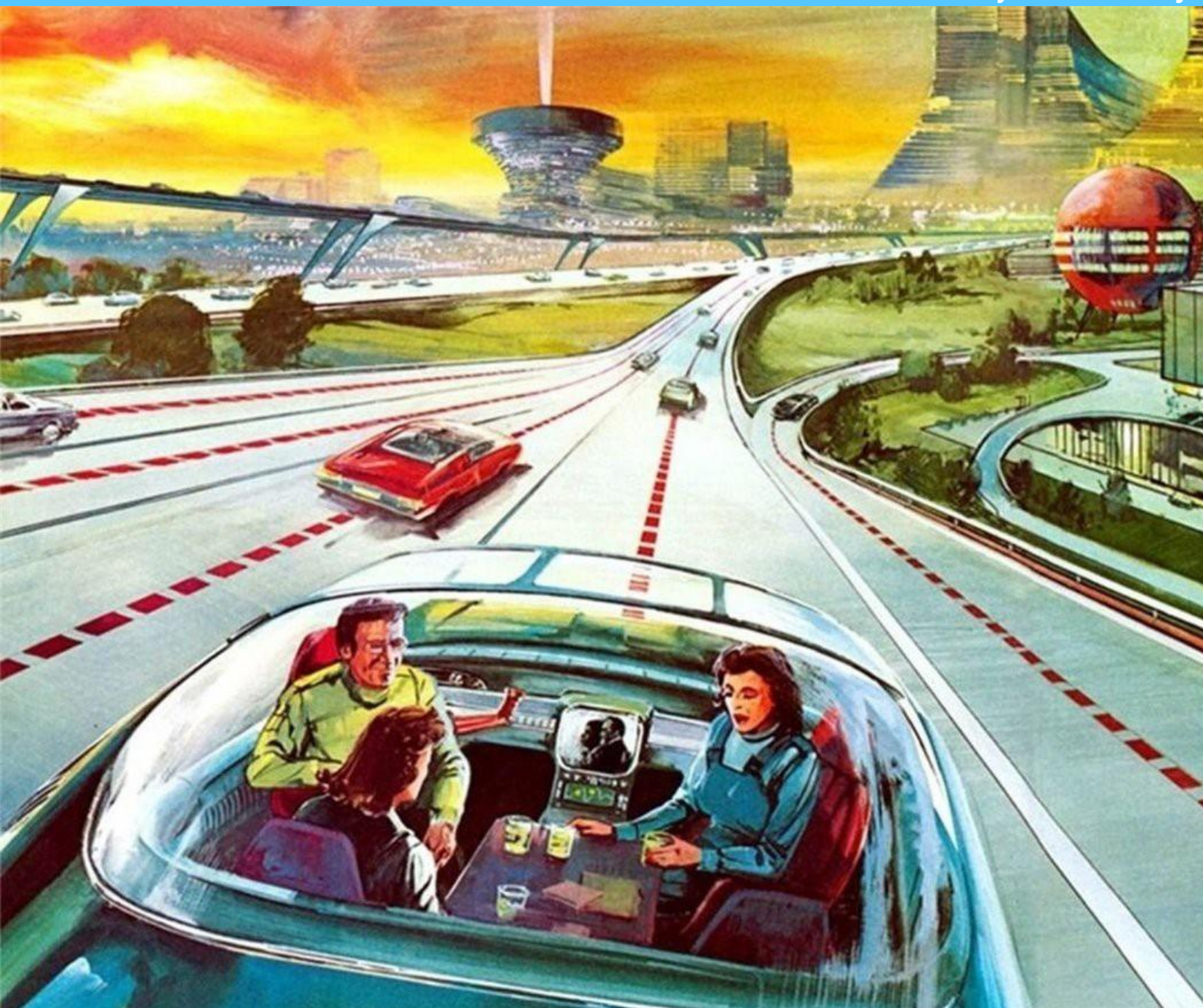


Behavioural response to automated vehicles

By Michał Rataj



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Abbreviations

AV – Automated vehicle

FAV – Fully-automated vehicle

FG – Focus group

PT – Public transport

VMT - Vehicle Miles Travelled

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Summary

Although fully-automated vehicles (FAVs) are not yet allowed on public roads and are barely present in people's daily lives, according to experts their wide implementation will happen within the next few decades. The technology is expected to bring major benefits in terms of safety, traffic flow efficiency and environmental impact. Furthermore, by eliminating the necessity of actively steering the vehicle, automated vehicles (AVs) are expected to bring extra free time during the day to perform activities, as well as increase mobility of some excluded societal groups (e.g. elderly).

However, taking away the burden of driving might also bring negative results. The convenience of the technology might encourage people to travel further and more often. Moreover, AVs users might transfer some of the activities from the traditional environments into the vehicle (e.g. work). The associated rearrangement of daily activity plans might have an impact on travel and residential location choices, possibly leading to further increase in overall travel distance. In such way, the expected positive impact of the technology could be compromised.

For that reason, it is necessary to examine behavioural response to AVs, namely the way travel time will be used in the vehicle and its consequences for daily activity plans, travel patterns and residential location choices. In order to fill in this scientific gap five focus groups were conducted. The participants were confronted with a simplified scenario of the future after broad AVs implementation and were asked a set of questions regarding the aforementioned topics.

It was found that, in contrary to the current modes, time inside AVs will be perceived not in terms of burden or opportunity, but rather in terms of pure opportunity. The participants perceive AV time as an extension of either work or private time. In context of daily activity plans it brings about a number of possible behavioral adaptations. In case of regular commuters, a willingness to use the in-vehicle time to release pressure from daily life was often identified, whereas people with less stationary jobs claim that the AV would allow them to bring more flexibility into their daily plans, or move their actual office or even the entire business into the vehicle.

However, the findings regarding daily activity plans do not provide a clear answer on their impact on travel and location decisions. At the same time, a number of advantages of AVs for irregular, long travels was identified, and many participants explicitly expressed their willingness to increase the amount of such travels. The impact of AVs on residential location choices appears to be limited: although people are not willing to move because of the AV, they claim it would still play a significant role in their relocation decisions if it was necessary for other reasons.

Moreover, some AV-specific phenomena were discovered, which might have an important significance on the actual AV use: namely increased pressure to perform onboard activities and feeling of "being trapped" in the vehicle. Furthermore, the participants pointed at the striking easiness of making travel decisions in case of AVs, compared to other modes.

Although the results bring a valuable indication of possible behavioral adaptation to the technology, one must also take into account limitations of the study. The most important of them is the speculative, imaginary character of the focus groups discussions, simplified future scenario and subjective character of qualitative analysis. Therefore, in the future studies on behavioural adaptation to AVs it is suggested to take a more experimental path, aiming at emulating the actual AV experience as far as possible. In that way the credibility of the findings from the present study could be further validated and extended.

1. Background of the study

Despite an immense technological advancement in all areas of life over the last century, the basic design of a car has not been a subject of any major change. For the driver it still means the same set of activities as fifty or more years ago: step inside, turn the key and get from point A to B, meanwhile paying attention to traffic, unpredictable behaviour of other car users, congestion, following the right route and finding a parking place. In such circumstances, the time spent on travelling is usually treated as disutility. This seems to be justified since the driver has to bear the opportunity cost of other activities that could be carried out during the time spent on driving.

However, this way of treating travel time is likely to change soon, due to a major new car technology that has appeared on the horizon in recent years: the concept of automated vehicles (AVs). In general, the notion of AVs encompasses vehicles that are capable of sensing its environment and navigating without (or with limited) human input. In the following three subchapters, the technology will be shortly introduced, including its current state of development, prospects and expected benefits.

1.1. AV definition and levels of automation

The automation of driving process can be realised to various extent. A few taxonomies have been developed to classify AVs, distinguishing the possible automation levels. The most commonly used is the one proposed by the Society of Automotive Engineers. According to this classification, a vehicle can be categorized into one of five levels of automation: the first being simple driver assistance (e.g. braking assistance), and the fifth meaning fully automated vehicles (FAVs) without any input required from a human driver (SAE, 2016).

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
Human driver monitors the driving environment						
0	No Automation	The full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	The driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	The driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task	System	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene	System	System	Human driver	Some driving modes
4	High Automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene	System	System	System	Some driving modes
5	Full Automation	The full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver	System	System	System	All driving modes

Table 1. Levels of vehicle automation (SAE, 2016)

1.2. Prospects of AVs

Currently, FAVs are not yet present on public roads (neither are allowed by law) and for someone used to the way the transport system currently works, the technology might seem to be a futuristic dream rather than a real option in any near future. To show the relevance of the study, the AVs state-of-art and development prospects are briefly discussed in this section. This is followed by a short discussion of the most praised benefits of the technology.

1.2.1. Predictions of car manufacturers

Over the last decade, a significant advancement has been made in development of various automated driving technologies. This trend can be exemplified by testing of Google autonomous car on public roads, or by large investments and research efforts made by more and more actors in the automotive industry. Most of the companies involved in developing AVs announce their introduction by year 2020 or sooner, while some of them claim to be ready for mass production by 2030 (Chan, 2017). In the table below the latest AVs developments and the predicted market introduction dates are presented for the major automotive companies. However, it has to be noted that most of them do not specify the exact level of automation.

Organization	Confirmed and predicted product introduction	Predictions of readiness for autonomous vehicles
Audi/VW	2016 – Piloted Driving	Full AV by 2021
BMW	2014 – traffic jam assist 2014 – automated parking	Available by 2021
Bosch	2017 – Integrated Highway Assist 2020 – Highway Pilot	Auto Pilot by 2025
Continental		Available by 2020
Daimler-Benz	2014 – Intelligent Drive	Available by 2020
Ford	2015 – fully assisted parking	To mass produce AV in 2021
GM	2017 – Super cruise	
Google	2015 – Driverless Pod prototype	Available by 2018
Honda		Available by 2020
Hyundai		Available by 2030
Mobile Eye	2016 – technology ready for OEMs	
Nissan	2016 – traffic jam pilot 2018 – multiple lane control	Available by 2020
Tesla	2015 – Lane Assist + ACC 2016 – highly autonomous	Self-driving 2020–2025
Toyota	Mid 2010s – highly autonomous	
Volvo	2015 – traffic jam assist 2017 – Drive Me FOT in Sweden	Zero fatality cars by 2020

Table 2. Current AV technology and introduction predictions for major automotive companies (Chan, 2017)

1.2.2. Predictions from scientific literature

Although the car manufacturers do not provide extensive information about the automation level, predictions regarding this aspect can be found in scientific literature. As concluded by Underwood (2014), the first market introduction of FAVs will happen not earlier than 2025. Using Delphi

methodology, he engaged twenty experts in robotics, transport and automotive engineering to predict the most probable date of introducing AVs with various levels of automation to the market. The results are shown in the figure below.

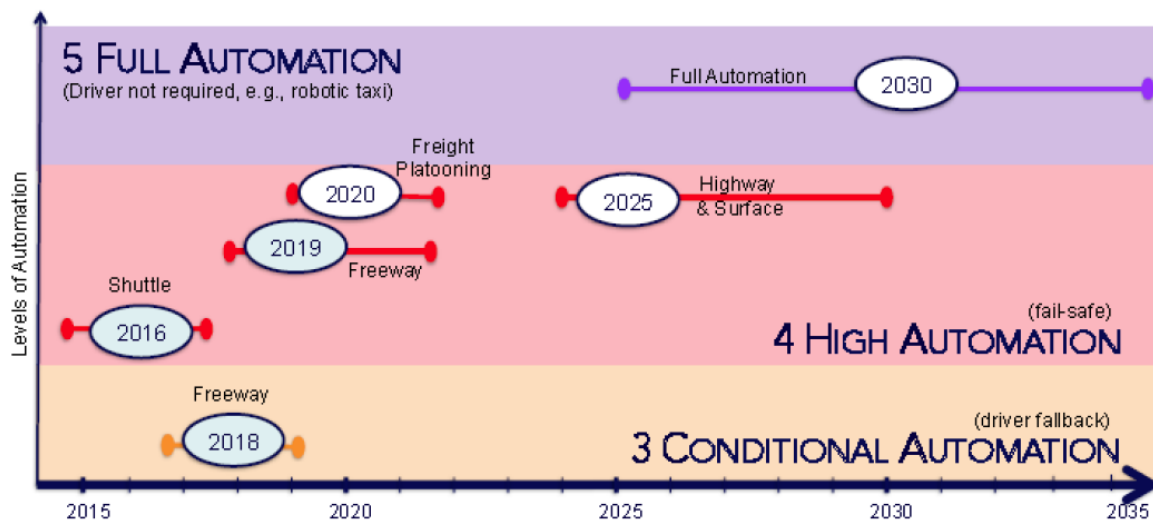


Figure 1. AVs market introduction predictions from experts in the field (Underwood, 2014)

The median response is presented for each kind of automation together with the interquartile range. As it can be seen, for FAVs the discrepancy among the experts is quite high, resulting in 10 years range for the implementation year (most optimistic predictions for year 2025). Despite lack of consensus among the experts about the exact date, it is important to note that eventually only one of the respondents claimed that FAVs would never be introduced to the market. It shows growing confidence in the technology, legislation and users acceptance and proves that FAVs have to be treated as a realistic option on public roads within next decades.

1.3. Expected benefits of AVs

Thanks to technological advancement offered by AVs, their introduction is expected to bring a number of benefits. Below, the most prominent advantages raised by AVs advocates are shortly discussed.

Traffic flow

Perhaps the most researched benefit so far is the impact of AVs on traffic capacity. Automated driving will be able to reduce congestion by predicting traffic conditions downstream, lowering the chance of a traffic breakdown and increasing the outflow of a queue (thus reducing time of congestion clearance). The most optimistic predictions forecast that the reduction of congestion might reach up to 50% (Hoogendoorn et al., 2014). This percentage might be even higher as the level of vehicle-to-vehicle and vehicle-to-infrastructure communication increases. Further improvements of traffic flow might be obtained by implementing innovative solutions, e.g. multiplatooning or smoothing traffic at the intersections. Thanks to communication between vehicles and infrastructure it will be possible to either merge AVs into very tight platoons right after green light appears (Clement et al., 2004) or even completely eliminate the need for traffic lights (Kamal et al., 2015).

Energy consumption and air pollution

The aspect strongly related to the enhanced traffic flow is fuel efficiency and energy consumption. Milakis et al. (2017) state that AVs might bring large improvement in this respect thanks to more homogenous traffic flows, reduced congestion, less idling time due to less congestion, and reduced air resistance due to shorter headways and multiplatooning. Furthermore, energy consumption might

also decrease thanks to improvement in safety. It would allow producing less heavy and solid vehicles, consuming less energy.

Safety

Currently, more than 90% of traffic accidents are caused by human factors (National Highway Traffic Safety Administration, 2008). For that reason, some of the advocates of automated driving state that it will reduce crashes by 90% (Fagnant & Kockelman, 2015). AVs will be equipped with a number of safety systems predicted to literally eliminate the risk of a crash. They include technologies like collision avoidance, lane keeping and lane change assistance, longitudinal speed assistance and intersection assistance (Milakis et al., 2017).

Social equity

Currently, some vulnerable groups in society, like children, disabled and elderly might suffer social exclusion due to lower access to mobility services (Lucas & Jones, 2012). AVs are expected to increase mobility of these groups. Eby et al. (2016) conducted a review of a number of various AVs technologies under development with the potential to increase mobility of older people. It was concluded that it is indeed very likely that thanks to these technological advancements elderly will maintain high mobility up to a very advanced age, despite of declining functional abilities.

Removing the burden of driving

Perhaps the most obvious, but also one of the most attractive benefits of AVs is taking away (at least to certain extent) the necessity of actively controlling the vehicle. In case of FAVs this element of car travel will be completely eliminated, giving the user freedom to perform a broad range of activities on-board. The advocates of the technology claim it will allow people to spend travel time more productively or will simply bring more free time during the day, improving the overall quality of life.

2. Introduction to the research problem

The problem being at the core of the present study is behavioural response to AVs. The central question regarding this topic is how the future AVs users will spend time inside their vehicles. Individual decisions in this matter might have significant consequences on the high level.

In the present chapter, this possible impact is explained in two steps. First, the question of aggregated impact of AVs is addressed. In this context, the importance of behavioural adaptation of individuals is highlighted. In the second step, the focus is narrowed down to a single AV user. A few examples of possible AV-driven rearrangements in an individual daily activity schedule are discussed, and the way they might impact travel and location decisions. Moreover, a short discussion of relevant literature is conducted. In such way the introduction arrives at the research problem, which is then formalised in a separate subsection.

2.1. High-level impact of AVs

Considering the relatively soon implementation of AVs, the question requiring an urgent answer is “What will be their influence on our life?”. The impact of AVs has to be analysed on multiple levels, depending on the scope and time horizon. To structure the discussion on the effects of this technology, Milakis et al. (2017) proposed a ripple model showing first-, second- and third-order effects of automated driving. The model is meant to conceptualize the way automated driving effects can sequentially diffuse from directly affecting traffic conditions and travel cost and choices, to a wide range of societal implications on economy, land-use or energy consumption.

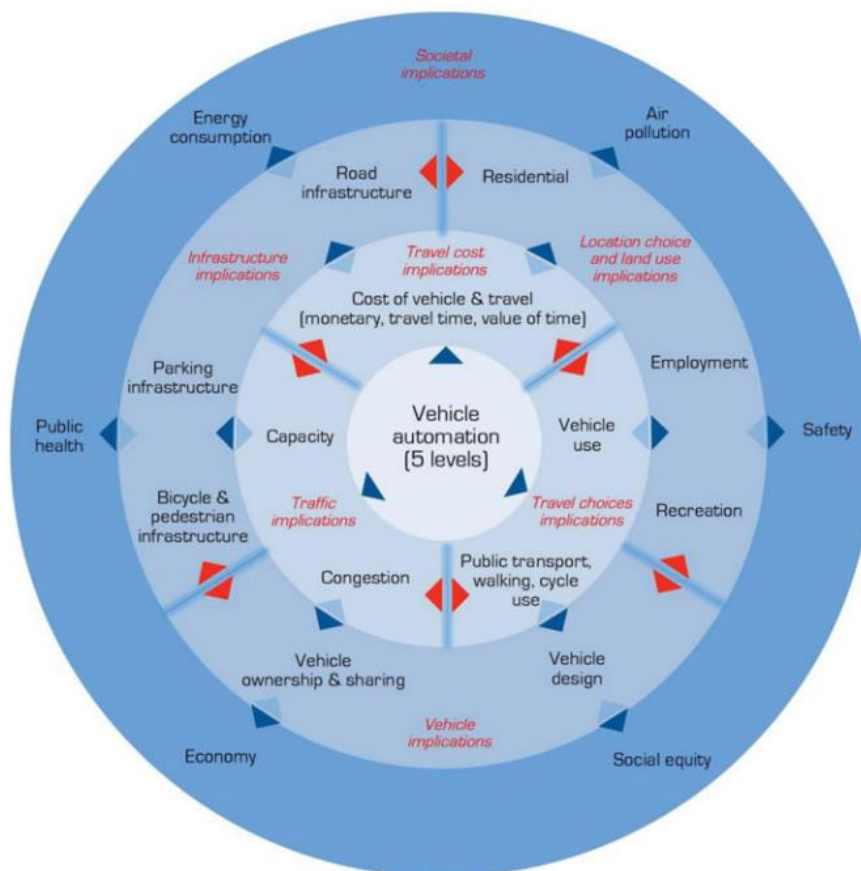


Figure 2. Ripple effect of automated driving (Milakis et al., 2017)

There is a rather strong consensus about the AVs benefits presented in chapter 1.3 in engineering terms – the technological advancement provided by AVs is indeed very likely to have a positive impact on traffic flow, energy consumption, safety etc.. However, the aggregate impact of AVs is still a matter of scientific dispute. The reason for that is the fact that any predictions about broad, long-term effects are impossible to make in isolation from the human factor. One of the major advantages of AVs for an individual user might also be the greatest problem of the technology on a large scale, namely the unprecedented freedom to perform activities on-board. The diagram below shows how the choice of activities performed inside AVs can manifest itself on the aggregate level.

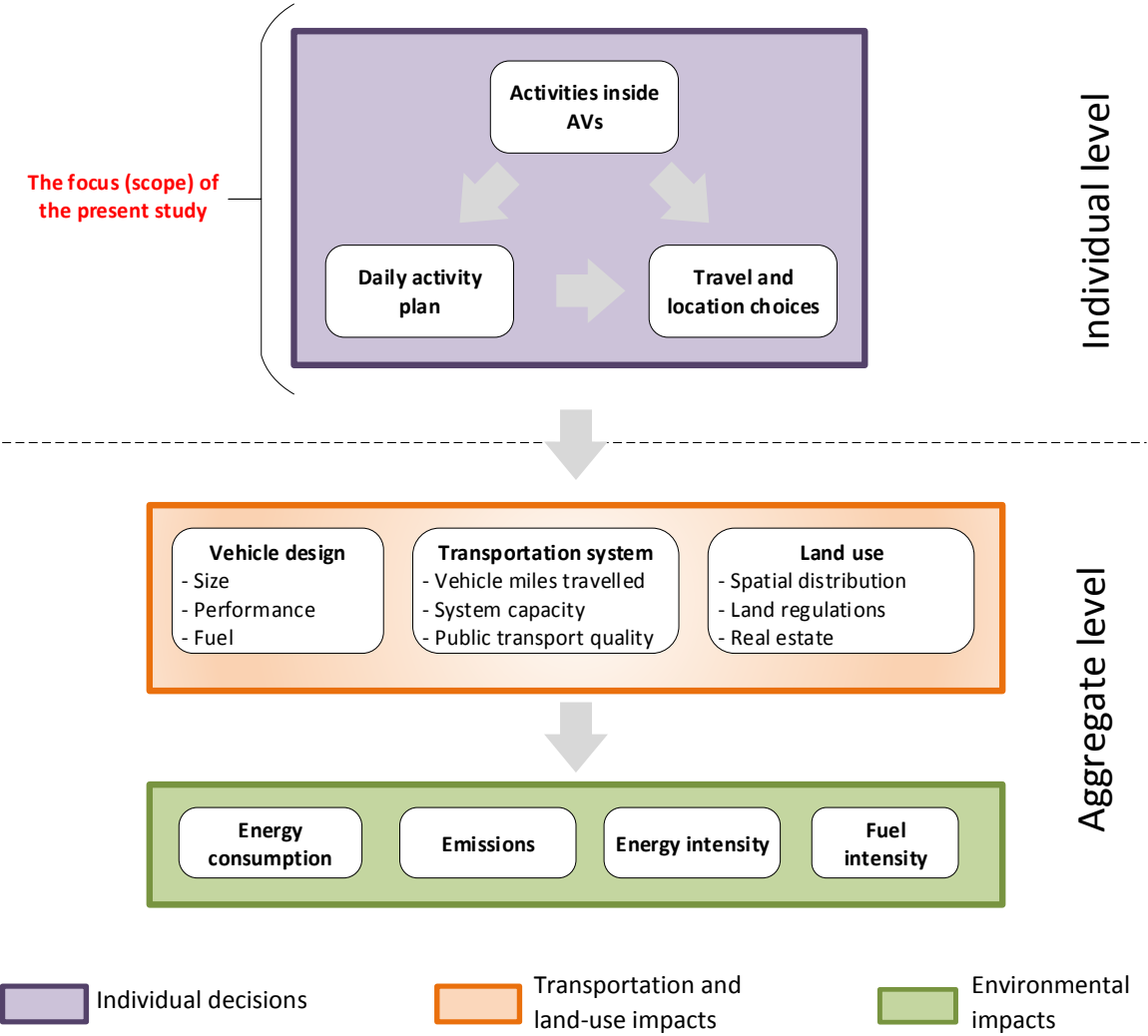


Figure 3. Relation of activities inside AVs and long-term AVs impact. Based on Gucwa (2014)

As it is shown in the figure, the activities performed inside AVs influence travel and (residential) location choices, both directly and by affecting daily activity plans. This relation is the focal point of the study and the diagram above allows to see its location in the broad context. Its exact nature will be discussed in more detail in the next subchapter, when zooming in on behavioural adaptation to AVs on the individual level. At this point, for the sake of research problem introduction, it is more important to focus on the impact of these individual decisions on the aggregate level: transportation system, land-use and environment.

The orange rectangle represents the aggregate impact of AVs on transportation and land-use. It consists of three smaller subcategories: impact on vehicle design, transportation system and land-use. Regarding the vehicle design, it is expected to be determined by the user's purpose. For example, installing a desk inside the AV might be the wish of a person willing to work inside the vehicle, whereas someone who is planning to use the AV for long, overnight trips might want to have a bed available. Thus, the choice of interior depends on travel decision, e.g. travel distance or time of day. Design of the AV interior has further impact on the **size** of the vehicle. Moreover, installing certain kinds of facilities might have impact on the actual vehicle operations. For instance, an AV with a massage chair or a fridge will require more energy. In such way **performance** of the vehicle can be affected, and consequently its **fuel** consumption.

Another transport-related aspect is the impact of AVs on the transportation system itself. It is likely that releasing (or alleviating) the burden of driving and providing unprecedented freedom to perform activities will make AVs more attractive than traditional cars. In such way the generalised cost of travel by AVs will be reduced compared to conventional cars and might convince people to travel more frequently and to more distant locations. Next to this direct impact of AV activities on travel decisions, this influence might also manifest itself via changes in daily activity plans: rearrangements of daily schedules might lead to more travel on everyday basis. On aggregate level, it could manifest as increase of the system-wide amount of **vehicle miles travelled** (VMT). This aspect was already addressed in multiple studies. Depending on the assumed penetration rate, value of time for AVs, vehicle-sharing, and capacity of public transport (PT) network, the increase of VMT is predicted to be from 4% (Childress et al., 2015) up to even 27% (Milakis et al., 2015). Obviously, such drastic increase poses the question whether the current **capacity or transport system** is able to handle AVs implementation. This issue becomes even more urgent considering possible mass exodus of current PT users to AVs. Such modal shift is likely to happen if the freedom and convenience offered by AVs to the users will prevail over the advantages of PT. In case such shift happens, deterioration of **PT quality** is likely to follow.

The last remaining transport-related impact covers possible changes in land-use. If travelling by AVs will bring little to no disutility to the users, they might choose residential locations further from their workplace, in order to reduce living costs and improve life quality. Commuting time could be then spent in a more productive way, consequently increasing the acceptable commuting duration. This would have impact on long-term **spatial distribution** of residential areas. The attractiveness of suburban areas could increase, possibly intensifying urban sprawl. Such tendency would be further manifested by increase in VMT and could require preventive actions in form of new **land regulations**. Moreover, the growing demand for **real estate** in remote areas might bring increase of prices, having impact on the housing market.

The aggregated effects of AVs on transportation and land-use find further manifestation in aggregated environmental impact, represented by the green rectangle. Most importantly, **energy consumption** is strongly affected by the value of VMT. More frequent and longer travels would also increase **emissions**. This environmental impact is a result of the influence of AVs on transportation system and land use. Furthermore, also the AV design has environmental impact: it affects **energy intensity**, namely Energy/VMT. Another environmental factor reflects the kind of resources used to supply the transport system, and is expressed by **fuel intensity** (Liquids/Energy). If AVs will not be electric, people switching from PT to AVs might cause an increase in use of fossil fuels. The direction and magnitude of the energy impacts is difficult to assess. Brown et al. (2013) estimated possible impacts range from nearly 90% fuel savings (if only energy benefits occur) to more than 250% increase in energy use (if only energy increases are considered).

The above relation between individual decisions and broad AVs impacts provokes to ask the question whether the technology with so many potential benefits will eventually be indeed beneficial for the society as a whole, or maybe quite the opposite. It is impossible to give a reliable answer to this question at this stage, it is however possible to imagine how the positive scenario might turn into a quite pessimistic one. In the table below, some of the expected benefits of AVs are juxtaposed with the way the aggregated behavioural adaptations of individual users might in fact transform them into negative high-level impacts.

Predicted positive impact	Behavioural adaptation	Possible negative impact
Increased safety will allow to produce less heavy vehicles, leading to less energy consumption	Users design the interior according to the activities they would like to perform inside	The size of the vehicles might increase, causing more energy consumption
Possibility of using AV as a courier saves people’s time	People send AVs for carrying out extra tasks, located further away	A lot of empty AVs on the roads: increase of VMT
AVs provide more flexibility and better accessibility	People use AVs instead of PT and active modes (e.g. for egress trips)	Decrease of PT service quality, increase of VMT, possible health deterioration
AVs provide better comfort and privacy than current modes	People switch to AVs from PT or car sharing	
Providing elderly, disabled and children better access to mobility	The groups in society with limited access to mobility use AVs instead of PT	
Possibility to spend travel time inside AV more productively	People decide to do some share of their work in the AV so they can live further from the workplace	Urban sprawl with all its negative consequences (e.g. increased VMT, energy use)
	People travel more frequently and to further destinations	Increase of VMT
No need for searching parking place – AV drives away and parks automatically	People travelling more frequently to destinations with parking problems	Congestion in city centers
AVs improve efficiency of traffic flow, thus reducing travel time	Induced travel demand for AVs, reinforced by the freedom to perform activities in the vehicle	Exceeding road infrastructure capacity

Table 3. Possible influence of behavioural change on AVs impacts

To know whether such transition from positive to negative impact might occur in reality it is necessary to explore behavioural adaptation on individual level, represented by the purple rectangle at the top of Figure 3. In the next section, the focus is narrowed down to this level to explain more elaborately how this adaptation might proceed.

2.2. Behavioural adaptation to AVs on individual level

As already indicated, the impact of AVs might be twofold: either realized directly, or indirectly - through rearrangements of daily activity plans. These two ways will be now addressed separately in more detail.

2.2.1. Direct impact of AVs on travel and location choices

This kind of impact is represented by the highlighted relation in the below diagram representing the research scope:

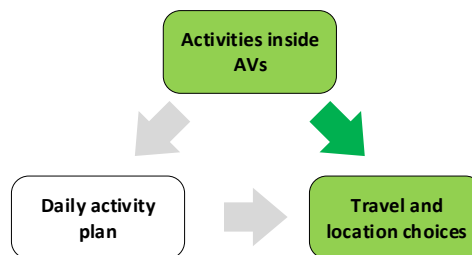


Figure 4. Direct impact of AVs on travel and location choices

In case of direct impact, the influence of AVs activities concerns single and rather irregular travel decisions. Thereby, it refers to situations when daily activity plans are less rigid, e.g. weekends or holidays. An example could be leisure trips, for instance a day trip to a distant theme park. Whereas now the frequency of visiting such place might be limited by the burden associated with travel, it can increase when an AV is available. Similarly, travel distance might increase: perhaps a better, more attractive theme park is available even further, entailing extra two or three hours of travel. Whereas currently the travel might be too burdensome to choose this destination, with an AV it could be made thanks to the possibility of spending the in-vehicle time on desired activities (e.g. sleeping). Moreover, due to such convenience, living very close to “civilisation” does no longer bring a very apparent benefit, especially for people who do not commute: they might then choose to live in more distant and desolate areas.

2.2.2. Impact of AVs on travel and location choices through daily activity plans

The indirect impact of AVs on travel and location choices is covered by the highlighted part of the diagram:

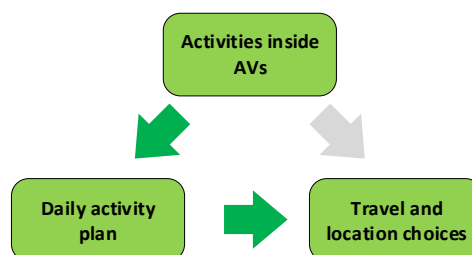


Figure 5. Indirect impact of AVs on travel and location choices

In case of AVs it is also possible that the time spent inside the vehicle might be treated as extra, “neutral” time available during the day. In that case the AV could serve as a sort of extension of traditional environments, e.g. a house or an office. Consequently, some of the activities traditionally performed in these environments could be transferred into the vehicle, thereby affecting daily activity plans of AVs users. Apart from moving activities completely from the “normal” environments into the AV, it is also possible to extend their duration. An example of activity transfer is shown in the picture below.

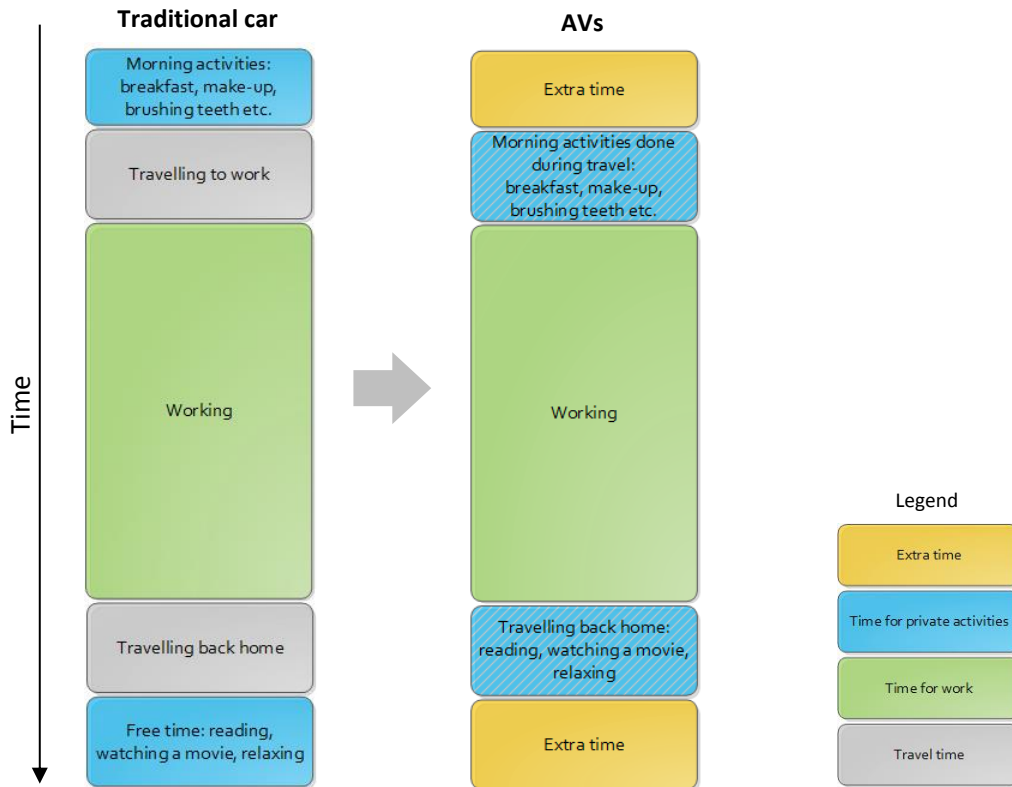


Figure 6. Example of a daily activity plan rearrangement (1)

The diagram shows an exemplary daily activity plan. In this example, some part of daily activities (morning routine and afternoon leisure) is transferred into the AV, which creates extra time during the day for performing other actions. For example, it could be utilized for extending other activities, e.g. longer sleep in the morning, or for performing extra activities, e.g. socialising or pursuing hobbies in the evening. Thus, the time would be then used to improve life quality. A variation of the above daily activity plan could include working in the AV. If the time spent in the vehicle would be accounted as working hours, the time spent daily in the office could be reduced. This concept is presented in the diagram below.

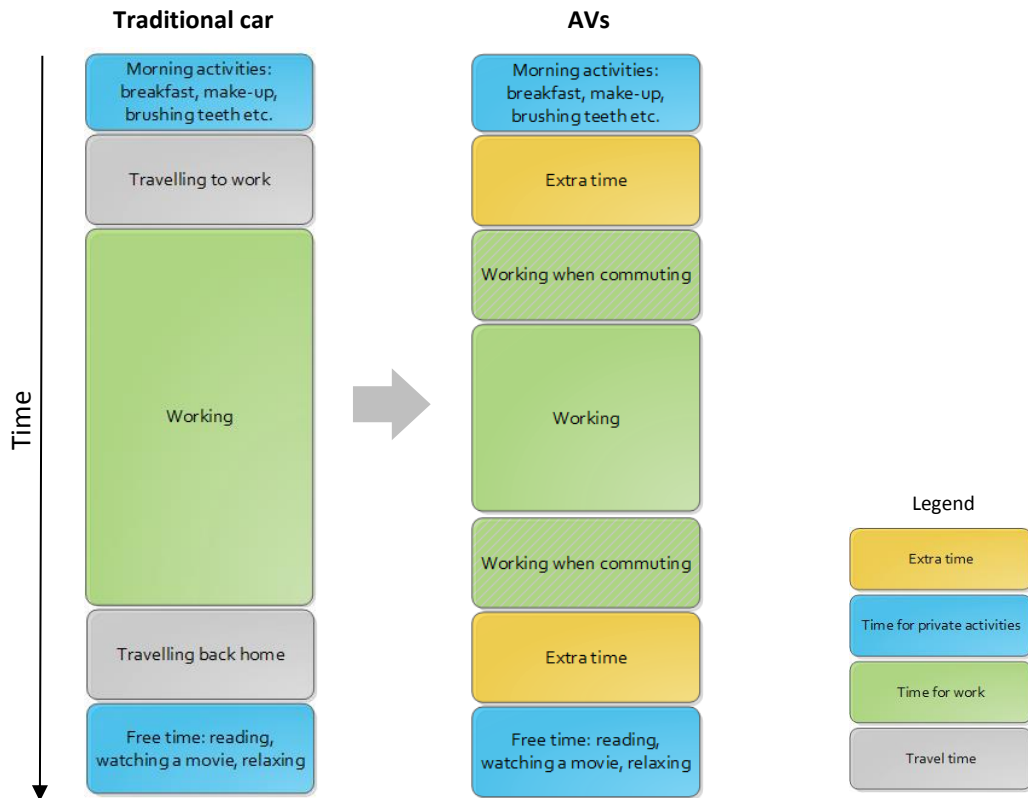


Figure 7. Example of a daily activity plan rearrangement (2)

Similarly as in previous example, certain amount of extra time becomes available during the day. The key question regarding this kind of rearrangements is how people will use this extra time. As already mentioned in case of the preceding diagram, it might simply serve as private time for spontaneous use and be utilised to improve life quality. However, it might also be utilised for extra travel.

It has to be noted that the above examples present commuting-based rearrangements. However, also more complex modifications of daily activity plans are possible. The situation presented in the picture below is an example of such case. The following diagram is an extension of the first one. In this case, the person has one more activity in the schedule for the day: picking up a friend from the airport in the late afternoon. With a conventional car, the daily plan could be to first go home after work, spend the afternoon on leisure, in the evening go to the airport and bring the friend back home. However, with the AV the day can be organised differently. The person can go to the airport straight after work and wait for the plane in the AV on a parking lot, while spending time productively

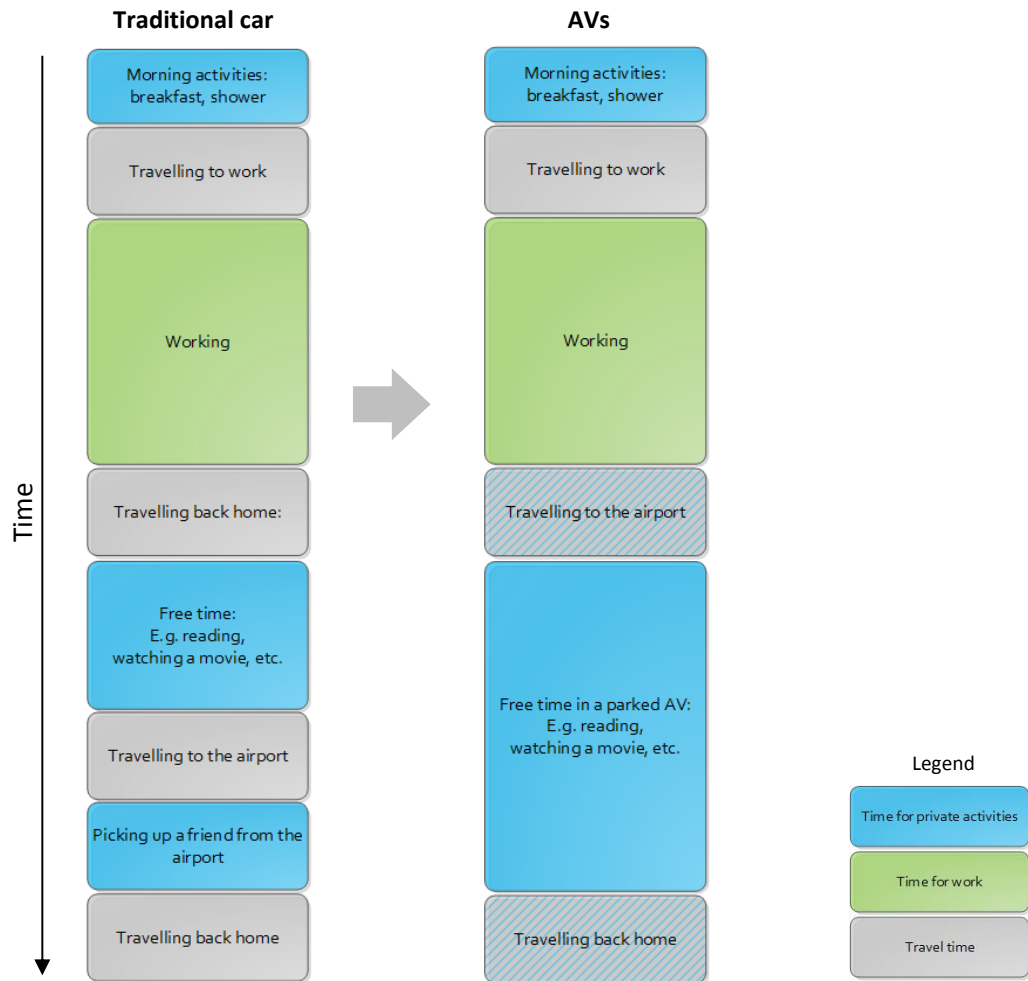


Figure 8. Example of a daily activity plan rearrangement (3)

inside the vehicle. The advantage of this scenario is maintaining continuity of the performed activities. With the conventional car, the time after work is split into small ‘chunks’ of time spent inside and outside of the car, which is not the case for the AV. Such continuity might be important for performing some activities, for example sleeping, working or watching a movie, all preferably not interrupted. It has to be highlighted that in the last example of daily activities rearrangement, the travel distance is in fact shorter than for a conventional car, leading to actual reduction of VMT on the aggregate level.

This fact, together with the previous examples clearly shows that the interrelation between activities in AVs, daily activity plans and travel and location choices needs to be closely examined in order to predict high-level impacts of AVs. In that way the introduction arrives at the research problem which is properly formalized further in the current chapter, after discussion of existing literature.

For the sake of clarity, knowing the nature of all the relations represented in Figure 4, it is now possible to explain the direction of the arrows. Contrary to what is presented, one might argue that the included relations are bidirectional: certain activities might be performed in AVs as a consequence of a particular daily activity plan, travel choices or residential location. Similarly, certain residential location might determine the activity plan. However, in the context of this study the freedom to perform activities in the AV is treated as a reason for potential changes in travel and location choices. It is therefore the source of this change. It is captured by Figure 4, thus the relation between activities in AVs and travel and location choices is presented as unidirectional (from the cause to the effect).

2.2.3. Travel time use in AVs – existing literature.

So far, very little attention has been devoted to the possible use of travel time in AVs. Yap et al. (2016) made an attempt to assess attractiveness of AVs compared to other modes, focusing on using the AV as egress mode for train trips in the Netherlands. Contrary to their initial predictions, the respondents assign on average more disutility to the time spent in AVs than in conventional cars. The possible reasons suggested by the authors are difficulty to imagine the AVs benefits, safety concerns and short distance of egress train trips: they do not allow to fully appreciate the possibility to perform activities in AVs. Similar conclusions were made by Cyganski et al. (2014), who examined perception of AVs by an online survey, with focus on in-vehicle time use. Only a minor share of respondents declared the possibility of working in AVs as an advantage. It was mostly the point of view of people who already work while commuting. Also other participants claimed to replicate their current behaviour, e.g. gazing, conversing or listening to music. The authors speculate about similar underlying reasons for these results as those suggested Yap et al. (2016). The fact that respondents tend to duplicate current travel behaviours for AVs rather than coming up with new, unique ideas was also indicated by König & Neumayr (2017). Kyriakidis et al. (2015) examined on-board activities with a large online survey, showing that respondents were willing to spend AV time actively (e.g. on reading, eating or using mobile phone) rather than doing nothing. However, the survey was designed to compare willingness of respondents to perform activities in AVs of various level of automation, which allows rather for comparison between different levels than deriving general conclusions on AVs activities, especially for FAVs.

2.2.4. Travel activities in other modes of transport

Since the existing body of knowledge on AVs activities is so scarce, it is informative to analyse available literature on perception and use of travel time in somewhat similar modes of transport (e.g. trains). It is expected to shed some initial light on possible travel time use in AVs.

Ohmori and Harata (2008) examined activities carried out by Tokyo train passengers during their daily commute. Based on observation and questionnaire, they found out that train environment, travel duration and type of working hours affected participation rate for different types of activities. When having a seat, people were performing activities requiring certain amount of personal space (e.g. reading, sleeping, using mobile phones) compared to when they had to stand (e.g. thinking, observing the scenery, doing nothing). In high-class trains with improved level of privacy more people were eating, drinking, and engaging in work-related activities. As for temporal characteristics, apart from travel duration, it was also found relevant whether the travel is seamless or requires an interchange. Some activities might be fragmented into smaller pieces over time and space, while others require no interruption (e.g. reading or sleeping). Furthermore, the more flexible working hours, the more passengers engage in work-related activities. Some of these conclusions might also be found in work of Gripsrud and Hjorthol (2012), who examined train activities of commuters and business travellers in Norway. For both groups, work is the most frequent travel activity. It was found that for working during travel not only work flexibility is relevant, but also whether the travel time is accounted as working time. Again, privacy was found to be an important factor: access to a 'silent' train compartment facilitates working. Also the facilities available during travel bear importance. Access to ICT (most importantly Internet) is usually a necessary prerequisite for work: it allows to turn almost any environment into a mobile office (confirmed by other studies, e.g. Tang et al., 2017). Gripsrud and Hjorthol (2012) also point at increasing fragmentation of activities due technological advancement. It is possible to conduct some of them at more spatially and temporally scattered locations, which found confirmation in multiple other studies (e.g. Ben-Elia et al., 2014; Lenz & Nobis, 2007). If no electronic

devices and sockets are available, people in trains seems to engage rather in non-work activities, like enjoying the view or listening to music (Yosritzal & Adji, 2017). The significance of ICT for travel activities has grown significantly over relatively short period time. Lyons et al. (2007) stated, that “the majority of rail passengers who are equipped with these two items that potentially create the mobile office do not use them”. However a follow-up study conducted almost a decade later showed “a fall of paper based technology” and considerable growth of ICT usage among rail passengers (Lyons et al., 2016).

A matter closely intertwined with onboard activities is travel time perception, namely the perceived role and value of travel time. Generally, performing activities tend to increase the perceived value of travel (Lyons et al., 2007; Ettema et al., 2012). Moreover, in contrary to the classic way of treating travel merely as a derived demand, a number of studies concludes that travel time might have positive value itself. Mokhtarian et al. (2001) identified three ways how positive utility might be derived from travel: “1. the activities conducted at the destination; 2. activities that can be conducted while travelling; 3. the activity of travelling itself”. It implies that travel decisions might be made to some extent for the sake of travelling, and limited activities when on the move might not bring disutility. Jain & Lyons (2008) propose the notion of “travel time as a gift”. They distinguish two types of travel time role: “transition time” (a need for experiencing distance and the opportunity for gearing up to the destination’s demands) and “time out” (escape from the obligations created through co-presence or fixed space that enable time for a ‘backstage’ time to be oneself or a specific activity (e.g. reading)). Several studies focused particularly on satisfaction with travel, finding that it depends not only on the in-vehicle activities but also on the purpose of the trip (Beirão & Sarsfield, 2007) and mode of transport (Lancée et al., 2017; Morris & Guerra, 2015).

2.3. Problem definition

In the present section the research problem is formalized in four steps. First, the problem statement is presented: it explains what is the problem and why it is relevant. Secondly, the exact knowledge gap within the identified problem is described. In the subsequent section the research motivation is addressed: it serves to introduce the purpose behind the study. Lastly, the research questions are presented and discussed.

2.3.1. Problem statement

Automated driving is developing rapidly: experts claim that introduction of FAVs on the market is going to happen around year 2030. Thanks to technological advancement, AVs are expected to bring significant improvement in overall safety, traffic flow, energy-use and access to mobility. Eliminating the burden of driving is also a crucial benefit of the technology.

However, a lot of uncertainty exists regarding long-term effects of AVs on a large scale. The aggregated impact on transport system, land-use, energy use and environment are mostly unknown and depend on human adaptation to the technology. The convenience of AVs and freedom to perform activities on-board might encourage people to travel more. Either by directly influencing travel and location choices, or by affecting them through changes in daily activity plans, AVs might increase the overall VMT, having impact on environment and the whole transport system on aggregate level.

In such way the problem statement emerges: AV technology is approaching quickly, thus predictions are needed about its high-level impact. However, it is impossible to make any accurate forecast without taking into consideration behavioral adaptation to the technology.

2.3.2. Knowledge gap

Behavioral adaptation to AVs is identified as the broad knowledge gap, which the present study aims to fill. Despite crucial importance of this topic, it has not yet been treated in scientific literature with sufficient attention. The way of utilizing the in-vehicle time and its impact on daily activities is identified by Milakis et al. (2017) as a “critical knowledge gap”.

Within this broad gap a number of smaller gaps exists, which are addressed by the current research. First of them is the question what kind of activities will be performed in AVs and under what circumstances. Part of this question is also the perceived role of AV travel time. Secondly, it is unclear how people’s daily activity plans will be affected by in-vehicle activities. Within this gap also further gaps can be distinguished: whether the activities will be transferred into the AV from outside the vehicle; whether there will be a rearrangement of activities within the day; and how people would be willing to use the “extra time” provided by AVs during the day. The impact of AVs on travel and location choices has also not been properly addressed so far: neither as a direct effect of AVs, nor as indirect effect caused by daily activity plans adaptation.

2.3.3. Research motivation

Conducting the present study is motivated by two purposes.

Firstly, the outcome will be used as an input for a stated choice experiment. The experiment will be a part of a research conducted by Baiba Pudāne, a TU Delft PhD student. Her research goal is to explore effects of automated driving on people’s medium- and long-term travel and location choices. The PhD thesis is a part of STAD research project (Spatial and Transport impacts of Automated Driving). The goal of the project is to explore the implications of autonomous driving technologies on accessibility, spatial development and mobility in the future. The present study is expected to give answers about what activities might be rearranged in what way and in which circumstances, which will serve as basis for the stated choice experiment questions. Eventually, the results of the experiment will be used as an input for a quantitative model allowing for utility calculation of activities inside/outside AVs.

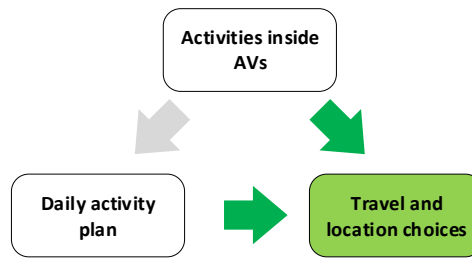
Secondly, the work is expected to help policymakers to make better informed policy decisions regarding AVs in the future. The outcome of the research is expected to bring knowledge about the potential problems regarding AVs. Some areas which will likely require regulation are: infrastructure development, land-use policies, regulations of car-sharing or use of empty AVs on public roads. However, it has to be noted that the present document does not aim at providing very specific policy recommendations, but rather at identifying potentially relevant issues regarding AVs.

2.3.4. Research questions

The main research question is designed to capture the ultimate, overarching goal of the study. It is therefore formulated as follows:

What is the expected impact of activities performed inside AVs on travel and residential location choices?

In the context of the earlier presented triangle representing the study focus it addresses the following elements:



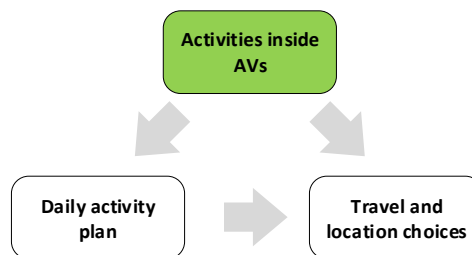
As explained already (and as it is apparent in the triangle), the impacts visualized above might be realized in either direct and indirect way. However, at the core of both these options are the activities inside the AV, being the very source of possible impacts on travel and location choices. For that reason this element of the triangle requires particular attention. Therefore, two separate sub-questions are devoted to this topic:

1. How will AV travel time be perceived by the AVs users compared to conventional modes of transport?

Answering the first sub-question is expected to bring information on the possible role of AV travel time. Considering various roles of travel time currently proposed by the literature, it is necessary to understand how the AV travel might be perceived. One of the considerations is whether it would indeed be seen as extra private time during the day (as speculated in the introduction), or rather still as regular travel time. The latter option rises more possibilities: would it serve as the aforementioned “transition time” or “time out”, or would it have yet some different role. Gaining insight into the AV travel time perception will serve as a basis for further exploration of possible AVs activities.

2. What activities are expected to be performed by AVs users on-board?

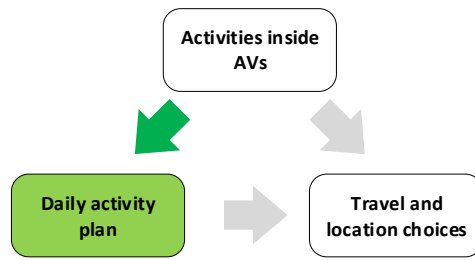
The second sub-question directly addresses one of the key research gaps, namely the kind of activities to be performed in AVs. In that way, the first two sub-questions cover the upper rectangle in the triangle:



Answering 1st and 2nd sub-question will provide the knowledge necessary to answer the main question regarding the direct impact of AVs activities on travel and location choices. However, in order to find the indirect impact it is necessary to first explore the impact of in-vehicle activities on daily activity plans. This element is covered by the 3rd sub-question.

3. What is the expected impact of activities inside AVs on daily activity plans?

The above question aims at exploring possible activity transfers, activity rearrangements throughout the day and use of “extra time” gained thanks to the AV. The 3rd sub-question covers the following part of the triangle:



In this way, by asking the main question supported by the sub-questions, the whole scope of the study is covered.

3. Methodology

To capture behavioural changes underlying second- and third- order effect of AVs, Milakis et al. (2017) propose to use a mix of qualitative (focus groups, in-depth interviews) and quantitative (stated choice experiments) methods. According to them, they serve well to examine the impact of AVs on aspects like travel comfort, value of time, travel and location choices, and utilization of time when on the move. Taking this into account, for the purpose of this study a qualitative approach was chosen, more precisely focus groups (hereinafter abbreviated as FGs) followed by content analysis. These two methods will be now addressed separately in more detail.

3.1. Focus groups

FGs are introduced below in four steps: first, a general description of the method is provided, followed by the rationale for using it for this particular study. This is followed by addressing the applications of FGs in AVs research up to now. In the next step, various properties of FGs are described in more detail, both from theoretical perspective and in the context of the present study. Lastly, the scenario which was presented to the FGs participants is addressed.

3.1.1. General introduction and rationale for application

Below, a basic introduction of FGs is provided, followed by justification of applying them for this particular study. These two elements are addressed in separate subsections.

3.1.1.1. Focus groups basics

FGs is a method of collecting qualitative data, based on group interviews. The difference lies mainly in the way the participants are involved in the discussion and the role of their interaction in data gathering. Although group interviews are often used for quick and easy way of data collection from several respondents simultaneously, FGs emphasize group interaction as the key element of the method (Kitzinger, 1995). The participants need to react on statements from the others and make connections to various concepts appearing throughout the FG. To facilitate the discussion and emergence of new ideas, the questions in a FG are usually more open-ended in comparison to surveys or classic interviews. FGs can also be used to observe non-verbal behavior of the participants, which can be a significant source of data in some cases (e.g. observing reactions of men and women when discussing gender equity) (Nagle & Williams, 2008).

The nature of FGs makes them a particularly suitable method for exploratory studies in new, unexplored areas. According to Freitas et al. (1998), FGs “are advisable for generating ideas for investigation or action in new fields; for generating hypotheses based on the perception of the participants; to evaluate different research situations or study populations; to develop drafts of interviews and questionnaires; to supply interpretations of the participants' results from initial studies; and for generating additional information for a study on a wide scale”. Thanks to their versatility, FGs were applied in the past in exploratory studies in many various areas: education, political science, public health, marketing and many kinds of sociological research.

FGs can be used both as a stand-alone method, as well as applied together with other methods, both qualitative and quantitative. Most frequently they are combined with either in-depth interviews, individual interviews or surveys (Morgan, 1996). According to Masadeh (2012), FGs are commonly used in some studies because of their ability to generate items for developing a questionnaire. In such cases often the primary goal of the FG is not to generalize, but to serve as an exploratory step in the research framework, aiming at providing input for the subsequent survey design process.

3.1.1.2. Rationale for applying focus groups to AVs research

The characteristics of FGs make them a suitable tool for exploring the topic of AVs. So far, scientific research about people's attitude towards AVs used methods like surveys or interviews (Becker & Axhausen, 2017). For exploring a technology which is still in its infancy such methods have significant downsides. Most importantly, as already mentioned, people seem to have difficulties with imagining how AVs would actually work and what impact they could have on their lives (Yap et al., 2016). That causes the respondents to duplicate current travelling behaviours in their answers rather than truly account the uniqueness of AVs and produce new ideas (König & Neumayr, 2017). FGs solve this problem by group interaction and proper moderation of the discussion. Participants can explore the topic of AVs deeper and from different perspectives by reacting to each other's ideas, and are supported by the moderator to understand the subject correctly.

Another disadvantage of surveys and interviews is that they are built on initial preconceptions and knowledge of the researcher. For example, questions asked in a survey are often based on existing knowledge and expectations of its creator, thus might be biased and not lead to any new insights. FGs allow to collect knowledge in a more inductive way, by confronting the participants with open-ended questions and letting them explore them in a rather unconstrained manner. This can often lead to emergence of new, previously unknown results.

Lastly, as already mentioned before, for this study the FGs will also be used as input for the subsequent stated choice experiment. The fact that FGs are a widely used method for gathering data for survey design is another argument for applying it in this case.

3.1.2. Existing applications of focus groups in AVs research

A number of examples of applying FGs to AVs research can be found in the existing literature. Level of importance and exploitation of the method differs per study, but in principle it was used in combination with other methods, like surveys, workshops or individual interviews.

Robertson et al. (2017) applied FGs along with an online survey to explore behavioural adaptation of Canadian car drivers to not fully-automated AVs. They conducted FGs consisting in total of 25 participants. The purpose of applying the method was in this case providing contextual information used for interpretation of the survey results, as well as exploring different perspectives on AVs. For that reason, the groups were distinctly segmented: two groups consisting of drivers, one of non-driving adults older than 65 years old and one group including people unable to drive due to physical inabilities. The authors claim to achieve representativeness of the groups in terms of age, gender, education and income. From the conclusions it is apparent that FGs were used as a supplement for the survey, since only very general findings were derived based on them. The results were mostly used to explain the reasons behind the answers given by the respondents in the survey. As a potential problem of FGs, Robertson et al. (2017) mention possible bias of the participants, who might educate themselves on the discussed matter prior to the discussion, if the topic is revealed to them beforehand.

FGs were also used to lesser extent by Daziano et al. (2017), who conducted two of them as an input for survey design leading to a discrete choice model. Their goal was to explore preferences and attitudes towards AVs among randomly selected potential car buyers. In this case, the researchers decided to invite a relatively high number of participants (12 and 15). Next to rather common statements about benefits and dangers of AVs, the safety of new technology appeared to be the most vital topic of the discussions, causing a lot of controversies and differences among the participants.

Silberg et al. (2013) used FGs to explore the willingness to use AVs, as a part of a large research project. For that purpose three two-hours long FGs were conducted, involving in total 32 participants. Although

the authors justify applying FGs by the qualitative, directional character of insight they provide, in contrary to Robertson et al. (2017) they also emphasize that the conclusions cannot be treated as representative for wide population. The goal was to examine opinions of people coming from various geographical and cultural background, therefore residential location was the factor used for segmentation and three diverse cities were chosen to conduct the discussions (Los Angeles, Chicago, Iselin). For the sake of consistency and comparison between the groups, characteristics like age, car ownership, education and income level were kept homogenous across the groups. Three main findings are brought up by Silberg et al. (2013): first, improvement of life quality is a strong incentive for the consumers for AVs adoption, secondly, the radical change of automotive technology might open opportunities for entering the market for new, high-tech companies and lastly, high possible impact of AVs on Mobility on Demand services. Regarding the respondents, the authors concluded that receptivity to self-driving is influenced by characteristics like age, gender, residential location, affinity to driving and kind of currently used car (premium or mass market).

3.1.3. Properties of focus groups

Various elements of FGs, which have to be taken into account when designing the study are addressed in this section. Each of these properties is discussed in a separate subsection: first from theoretical perspective, and then in the context of the present study.

3.1.3.1. Number of groups

Determining the number of FGs to conduct is related to the notion of saturation (Krueger & Casey, 2009). This term describes the point when new FGs do not bring any new data and the outcome starts to be repetitive. Ideally, FGs should be carried out until the point of saturation is reached, which usually happens after 4 to 6 groups. However, there are examples of studies involving as many as 52 groups (Morgan, 1996). In reality, the number of groups depends on the design of the study and available resources (time and money). The design determines how many different categories of participants will form the groups (e.g. for the purpose of comparison between different groups) and whether the questions will differ among the groups. For example, single-category design (involving only one category of participants for all groups) requires less FGs to achieve saturation than multiple-category or double-layer design, which aim at comparing design for different groups or asking various sets of questions (Krueger & Casey, 2009).

The present study can be treated as single-category design: the focus is on commuters, which is addressed more elaborately in the next section. Although different subcategories of participants are distinguished, the primary reason for that is not comparison of various groups, but rather generating richer data and facilitating discussion. Thus, according to the rule of thumb (4 to 6 groups) 5 groups were organized. This choice was also determined by limited budget for recruiting participants and time constraints.

3.1.3.2. Number of participants

Although the rule of thumb says the number of participants in a FG should be between 6 and 12 (Onwuegbuzie et al., 2009), examples of successful FGs as small as 3 and as large as 31 are known (Masadeh, 2012). In general, smaller groups are more appropriate for emotionally charged topics generating a lot of involvement, and larger groups work better with more neutral topic entailing less personal connection. However, the decision results in a trade-off between investigating more in-depth the opinions of single participants and getting more variety of viewpoints. Larger groups might also intimidate some people and create uncomfortable atmosphere for sharing personal thoughts. Depending on the topic, the size of the group also influences difficulty for the moderator (Morgan, 1996). Krueger and Casey (2009) define the optimal number of participants as 5 to 8, recommending

considering the following factors for determining the group size: the purpose of the study (understand an issue or behavior: fewer people, pilot-test an idea: more people), complexity of the topic (more complex: fewer people), participants' level of expertise (more expertise, fewer people), participants' level of passion about the topic (more passionate: fewer people) and number of questions (more questions: fewer people).

In the present study, it was decided to keep the groups relatively small. One reason is that the goal is to explore behavioral response to a very innovative technology. Secondly, high complexity of the topic favors rather small groups. Thirdly, finding participants both by an advertisement and a marketing company brings risk of self-selection of people either interested in the topic or inclined for group discussions. The fourth reason is relatively high number of questions and the planned duration of 1,5h per group. Lastly, budget constraints and relative inexperience of the moderator with FGs were also arguments for lower number of participants. Eventually, the first group consisted of 7 participants. It also served for testing the research setup for the subsequent groups. It was concluded that, due to complex nature of the topic, such number poses too great challenge for the moderator. Therefore, for the remaining groups the number of participants was reduced to 6.

3.1.3.3. Choice of participants

The choice of participants is driven by the study purpose. Most importantly, the researcher should decide what kind of people are able to bring significant insight about the topic of interest (Freitas et al., 1998). Another challenge is finding the right balance between homogeneity and heterogeneity of the participants. On one hand, to facilitate the discussion the group should be reasonably homogenous regarding background and socio-demographic characteristics. On the other hand, a too homogeneous group might bring less interesting or superficial result, because no different points of views will be confronted. The most common factors used to divide the groups are age, gender, ethnic group and social class (Freitas et al., 1998). Of course, this choice depends on the subject of the study. For example, age and gender might be relevant for discussing abortion, while they could have less impact in a discussion about e.g. acceptance of a new technology. Although too much heterogeneity within a group is not advised, it might be introduced across the groups deliberately, for the purpose of segmentation. Segmentation means consciously varying the composition of the groups. The most obvious kinds of segmentation capture something about the research topic itself, for example if gender differences are of interest, then the groups might be divided into male and female groups. Two main reasons for introducing segmentation is creating a comparative dimension to the analysis and facilitating the discussion by increasing homogeneity of the groups (Morgan, 1996).

In the present study, the purpose of the research was decisive for the participants choice. Focus of the study on daily activity plans is the reason why only regular commuters were considered: due to regular travel patterns they are particularly interesting in the context of daily activities rearrangement. Furthermore, commuters constitute a very large group in the general population, thus their individual decisions have a significant impact on aggregate level. Because AVs are not considered a controversial or personal topic, the sociodemographic characteristics were not included as a criterion and were random. Differences in educational level, career status or age were considered as potential obstacles for a smooth discussion. However, taking into account Dutch culture of speaking up and open discussion, these concerns were eventually rejected.

Eventually two factors were chosen to determine groups composition: transport mode and travel duration. The mode was diversified within every group to facilitate the discussion. Two modes were considered: private cars and PT. The users of the latter already have the opportunity to perform a quite broad range of activities when travelling, whereas car drivers are more limited in that respect. Thus, travel time perceptions of these two groups might be significantly different and confronting them is

expected to bring interesting insight. Users of active modes were excluded for the sake of sufficient homogeneity of the groups: short travel time and distance of active modes trips could make it difficult to see benefits of AVs and hinder thoughts exchange with other participants.

Travel duration served to bring variety between the groups: it was diversified between the groups, but not within them. According to literature, in-vehicle time is the major factor influencing the kind of performed activities (Ohmori & Harata, 2008). It was therefore expected that also activities in AVs might depend strongly on this factor. Thus, commuting time was used for segmentation of the groups: one group consisted of people with short commuting time (approx. 30 minutes), one people with long commuting time (approx. 1 hour) and two groups mixed both these kinds of participants together. The reasoning behind such choice was to examine ideas of both the groups separately, and also explore possible difference of viewpoints.

The criteria described above do not apply to the first FG, which consisted of TU Delft students. The purpose of it was not only to gather data, but also to test the setup for the remaining FGs. In that way any necessary adjustments could be made for the groups composed of people selected by the relevant criteria described above (transport mode and travel duration). Still, the group consisting of students was treated as a valuable source of data and was considered on equal terms with other groups during data analysis.

3.1.3.4. Questions

FGs questions must fulfil a number of basic requirements. They should be clear, short, open-ended, easy to say and one-dimensional (so that the meaning is not a subject for interpretation). Furthermore, also the course of questioning is important. Typically it includes a few categories of questions: opening questions (not related to the subject of discussion, used to make participants more comfortable), introductory question (used for introducing the actual topic), transition question (move the conversation towards the key questions), key questions (regarding main point of interest) and ending questions (bring closure to the discussion and allow for reflection). It is important to prepare a right number of questions for the planned FG duration - there should be sufficient time for answering each of them. When estimating required time it is necessary to consider complexity and category of questions, FG size, participants' expertise and the required depth of discussion for each question. Usually, the time spent on one question varies between 5 and 20 minutes (Krueger & Casey, 2009).

In general, questions should remain rather consistent throughout the FGs: it not only enables to compare answers across the groups, but also makes it easier to achieve saturation. If the questions are kept consistent, during the analysis themes and patterns emerge more clearly from the data. However, there are two cases when it is wise to change questions. First, when the question does not work: it creates confusion or does not lead to any useful answers. Second, when saturation for the particular question clearly occurred and the answers stopped bringing any new knowledge. In such case there is more to gain by changing the particular questions, building on knowledge from the previous groups (Krueger & Casey, 2009).

In the present study, the list of questions was based on the recommended course of questioning presented above. Considering the time required for various questions, the single group duration of 1,5h and the number of 6 participants per group, it was decided to ask 10 to 11 questions per group. Since the research goal was not to compare, but rather to explore, more flexibility in adjusting the questions was assumed. Adjustments were necessary especially after the first FG, to eliminate questions which were unclear or led to overlapping answers. To facilitate understanding of the questions by the participants, each of them was also presented on a screen during the discussion, accompanied by a graphical visualisation of the question meaning (if possible to visualize).

The list of questions for one of the groups (4th FG) is presented below. Although the questions were slightly changed throughout the process for the reasons mentioned above, the list can be seen as representative for the general line of questioning during all the FGs. Each of the questions is supported by a short comment explaining the purpose of including it in the list.

Question	Purpose
1. <i>Introduce yourself briefly</i>	The opening question, used as an ice-breaker.
2. <i>How do you travel normally?</i> - <i>Train/car/...?</i> - <i>How long does the trip take?</i> - <i>What do you do during the travel?</i>	An introductory question. Its purpose is to make people think about travel time, namely the way it is spent and whether it could be spent differently.
3. <i>Are you satisfied with how you use your travel time or would you like to use it differently?</i> <i>Travel time is for you:</i> - <i>Time to relax</i> - <i>Time to do something</i> - <i>Wasted time</i> - <i>Time to kill</i>	Same as question 2.
4. <i>Imagine that you travel with an AV. What are pros and cons in comparison to your normal way of travelling?</i>	A transition question: it shifts the discussion towards AVs. It is supposed to make people think about how AV travel would <i>feel</i> compared to their usual mode of transport, and consequently what would be possible to do inside.
5. <i>Imagine that you have an AV and can arrange the interior the way you want. What would you like to do when travelling and why?</i>	First of the key questions: aims at answering the 1 st and 2 nd research sub-question.
6. <i>Would you like to perform in the AV activities which you normally do in traditional environment like home or work? If so, do you think you can save time for other things which you would like (or have to) do?</i>	The second key question: aims at answering the 3 rd research question.
7. <i>Would you change anything in your daily routine if you had an AV?</i>	The third key question: aims at answering the 3 rd research question.
8. <i>Would you travel further or more frequently to perform activities if you had an AV?</i>	The fourth key question: aims at answering the main research question.
9. <i>Would an AV be a good alternative for trips which you usually do by a bike or PT?</i>	The question was added for this specific FG as an extra question, when saturation was detected in the results from previous group. It was supposed to possibly bring interesting insights regarding all the research question.
10. <i>Would you like to move if you had an AV?</i> - <i>If yes, where to?</i> - <i>If no, imagine you need to move (e.g. because of a job). Would an AV influence your decision?</i>	The fifth key question: aims at answering the main research question.
11. <i>Would an AV make your life better or worse?</i>	The ending question. It has a broader, more open character: aims at prompting the participants to reflection on what has been said.

Table 4. A representative list of FG questions (the list coming from the 4th FG)

3.1.3.5. Moderation

Another important aspect of FGs is the choice of moderator. The moderator is responsible for asking questions, facilitating the discussion, prompting people to speak, requesting too talkative participants to let others talk and encouraging all the group members to participate (Onwuegbuzie et al., 2009). The key aspect regarding moderation is the moderator's level of involvement. At one extreme it can be low and their role might be limited to basically asking the questions to the participants. On the other hand, it might be very significant, so that the dynamics and content of the discussion are under strict control. The choice of moderating style depends on the study purpose. If it has exploratory character or involves subsequent content analysis, less moderator's involvement is advised, whereas if the purpose is to compare results from various groups, more structure and consistency is required, thus more strict way of moderating (Freitas et al., 1998). Besides, the level of moderation also depends on number of questions and participants. The larger the group and the more questions, the higher and stricter moderator's involvement has to be (Morgan, 1996).

In the present study, determining the right level of moderation was a challenging task. On one hand, exploring an unknown area and generating new insights were considered the goal of the study, which is an argument for less moderator's involvement. On the other hand, the research is focused on activities inside AVs and their implications, therefore the FGs should be concentrated around this particular topic. It was therefore important to keep the participants focused on activities and not let them be confused by discussing aspects less significant in this context, e.g. safety, car sharing or technical characteristics. To some extent, diverging to these areas was already limited by the scope (the used scenario). However, letting people explore these areas collectively to some extent could also bring insights relevant for the main interest of the study. Therefore the participants were also allowed to diverge slightly from the main questions to other areas, however were reminded to return to the question if the digression was deemed as not leading to any valuable outcome.

3.1.3.6. Contribution of third parties

FGs required an experienced interviewer with good intuition. Furthermore, it had to be a Dutch native speaker to allow easy communication and free expression for the Dutch participants of the groups. Niek Mouter, an assistant professor at TU Delft, kindly volunteered to be the moderator, being a person fulfilling both these requirements. Because of relevance of the study for Baiba Pudāne, she was directly involved into technical aspects of FGs organisation, namely contacting the marketing company, catering, setting up the recording. Questions presented to the participants were also discussed with her prior to each FG. The transcripts were prepared and translated into English by a Dutch student assistant, Dion Munsters.

3.1.4. Scope of the used scenario.

Because the explored technology is basically not yet present in daily life, the FGs have a purely speculative character. Due to revolutionary character of AVs and high number of uncertainties, the participants could feel confused and get distracted by the aspects of AVs irrelevant for the present study. Therefore, the scope of the discussions had to be limited. It was achieved by properly adjusting the scenario presented to the FGs participants. It facilitated the discussions to revolve around the core topic (activities) and prevented diverging to topics irrelevant for the study (e.g. security or legislation). Below, various aspect of the applied scenario will be addressed in more detail.

The participants were presented with a long-term scenario, in which the penetration rate of AVs is equal to 100% and no traditional cars are available. Furthermore, lower levels of automation were excluded due to their negative influence on the range of possible in-vehicle activities: only FAVs were

considered. As a consequence, it was also assumed that all the necessary infrastructure exists and there are no unresolved legal issues around AVs. These two aspects were also left out in the FGs.

In reality a serious problem regarding AVs might be user’s acceptance, affected by the feeling of lack of control, as well as safety and security concerns. In the FGs scenario AVs were assumed to be 100% safe and the possibility of malfunctions or cyberattacks was excluded. Although the assumption of AVs being 100% safe is quite unrealistic, they are still expected to bring a major improvement in that respect. Since eventually they are expected to still be much safer than conventional cars, such assumption can be seen as justified.

Another assumption is that AVs are affordable for everyone and their operational costs are equal to traditional cars. In reality costs would likely have influence on the amount of travel, however the nature of the research is qualitative and focuses rather on non-monetary factors. This assumption can still be justified by the predictions existing in the literature. Although the fixed cost of AVs might be initially significantly higher than for conventional vehicles, the scale effects will cause a drop in price as the penetration rate increases. Fagnant and Kockelman (2015) claim that difference in price will go down to 3000\$ for 90% penetration rate. Also the operating costs are expected to be within range of 0.50\$/mile, which is comparable to the cost of operating traditional cars (Litman, 2017) .

Another confusing aspect could be car-sharing: it potentially reduces the flexibility that comes with AVs and makes the range of possible activities narrower. Still, an increase in car-sharing is one of the widely discussed possible impacts of AVs. For that reason it was not completely eliminated from the scenario, but was also not explicitly mentioned to the participants. In principle, some freedom to discuss this aspect was given, but if it did not lead to any relevant insights the participants were reminded by the moderator to return to the main topic of the discussion.

Similarly, availability of PT was not explicitly determined prior to the FGs. Similar as for car-sharing, the participants were also given some freedom to discuss it.

Lastly, it was inexplicitly assumed that society will not be different from today in terms of working or leisure habits. This assumption is justified by the expected implementation date of fully-automated AVs, which is within the next 30 years. Although it is still a relatively distant date, assuming no drastic changes in society in that time is fairly reasonable. Thus, the considered scenario assumes the world to look pretty much like today, except for the wide presence of AVs.

All the assumptions are presented together in the list below:

Aspect of the scenario	Assumption
AVs penetration rate	100%
Presence of conventional cars	No conventional cars
Level of automation	Only 5th (fully-automated AVs)
Infrastructure required by AVs	100% available
Legal issues regarding AVs	100% solved
Safety of AVs	100% safe
Security of AVs	100% secure
Price and operational costs of AVs	Equal to conventional cars
Car-sharing	Not explicitly mentioned to the participants, discussion allowed to a limited extent

Availability of PT	Not explicitly mentioned to the participants, discussion allowed to a limited extent
Condition of society	No different from today

Table 5. Assumptions in the scenario presented to the FGs participants.

3.2. Content analysis

Although there is abundant information available on how to conduct FGs, information on how to analyze them is rather scarce (Onwuegbuzie et al., 2009). Since FGs produce qualitative data, one of common techniques for qualitative analysis might be applied. For the purpose of the present study content analysis was used.

Content analysis is a method allowing for a systematic and objective description of phenomena in qualitative data. In the process of content analysis words are distilled into fewer content-related categories. The goal of the analysis is to achieve a condense and broad description of the phenomenon: the outcome consists of concepts or categories describing it. These concepts and categories are eventually used for building a model or a conceptual map, which are the final result of the analysis (Elo & Kyngas, 2008). The process of analysis consists of three main stages: preparation, organizing and reporting. Apart from that there are no systematic rules of analyzing the data.

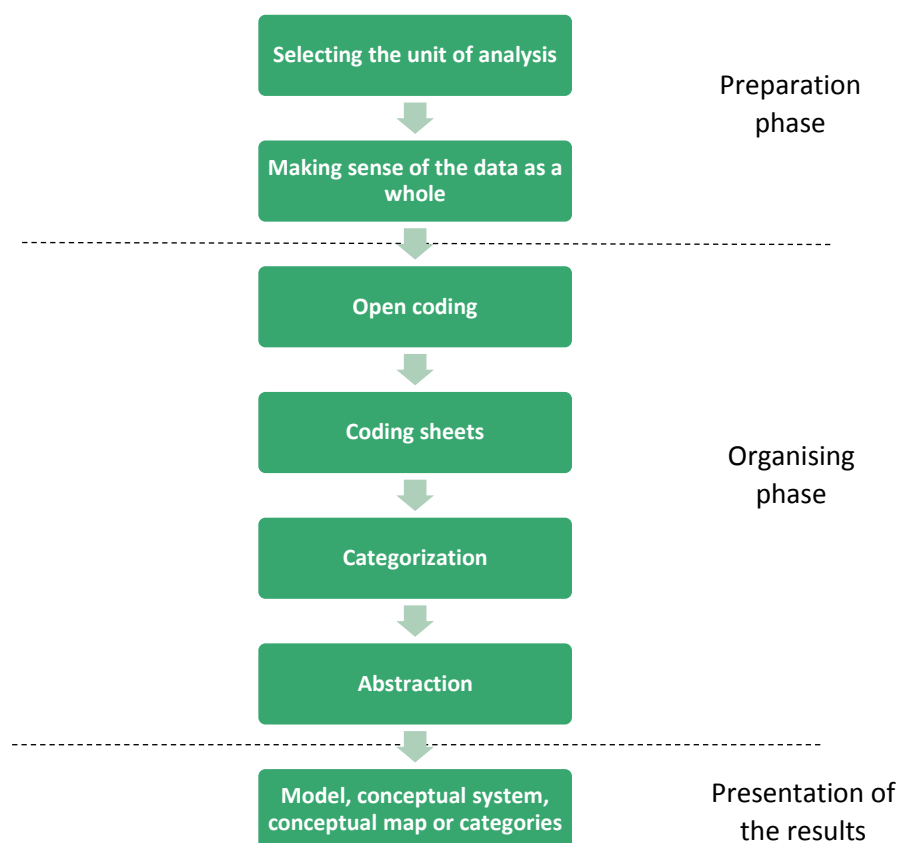


Figure 9. Inductive content analysis process (Elo & Kyngas, 2008)

During the **preparation phase** the unit of analysis is chosen. Depending on the level of detail of analysis it can be a word or a theme. The unit of analysis can consist of more than one sentence and contain multiple meanings. In such case the process of analysis might be difficult and challenging, but on the

other hand, analysis that is too narrow may result in fragmentation of results. At this stage the researcher also has to decide whether the latent content will be analyzed, namely taking into account silence, sighs, laughter, posture, etc. Last step of the preparation phase is an attempt to make sense of the data as a whole, which is done by reading transcripts several times. The goal is to become immersed in the data. The unit of analysis used for the purpose of the present study were usually single statements of the participants, consisting of one to few sentences. In some cases an exchange of few sentences between the participants was used: it allowed to capture the context in which particular statement was expressed. Latent content was not analyzed, because it was found not relevant for this particular study.

Next step in the process is **organising phase**. It includes open coding, categorizing and abstraction. During the open coding phase notes and headings (“codes”) are written in the text while reading it. This is repeated until all the relevant aspects of the data are captured. All the codes and corresponding fragments of text are then organized in coding sheets. The exact design of a coding sheet might differ, but the purpose is to gather all the codes with relevant quotations together in a systematic way, in order to facilitate the following process of categorization. A list containing all the codes with exemplary quotes can be found in **Appendix C**. During the categorization the codes are grouped into higher-level headings. This step includes reduction of the number of existing codes, by grouping them or merging them together into broader categories. The main goal is however not reducing the data, but classifying it as “belonging” to a particular group. This classification depends on the researcher’s interpretation and is a result of iterative process of comparison of data and categories. Finally, a general description of data is done through the process of abstraction. In this step subcategories with similar events or incidents are grouped together into categories, and those are grouped into main categories. The process of abstraction can continue as far and deep as it is reasonable and possible. An example of abstraction is shown below.

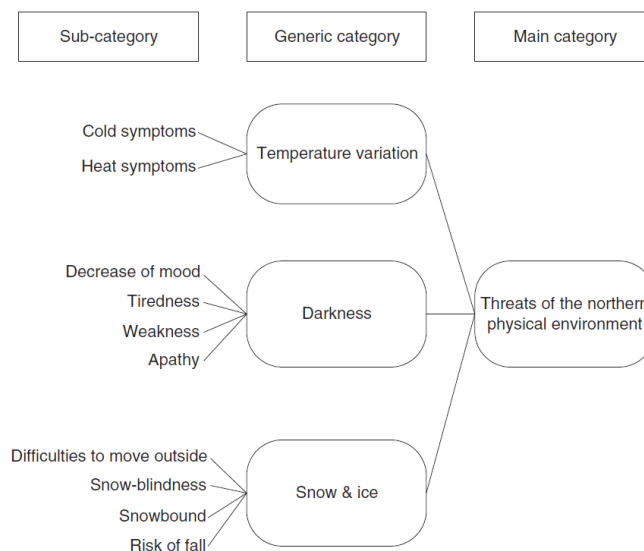


Figure 10. An example of the abstraction process (Elo & Kyngas, 2008)

To show how the above process was applied in the present study, an example of the consecutive analysis steps for a small part of the data is presented in **Appendix D**.

Presentation of the results is usually done in a form of a model or map of categories, showing the interrelations between them. The categories and interrelations are further provided with a written explanation of the conceptualization. The statements made in the presentation of the results are backed up by including relevant quotations.

The method might be used in two ways: inductive or deductive. The choice of approach is determined by the purpose of the study. In case there is not enough knowledge about the researched phenomenon, or the knowledge is fragmented, the inductive approach is recommended. In inductive content analysis the categories are derived from the data, without using any previous knowledge or preconceptions. It is therefore useful for building new theories or exploring unknown phenomena. Deductive approach is built on previous knowledge and can be used for e.g. theory testing. While the deductive approach moves from the general to the specific, inductive content analysis moves from the specific to the general, eventually combining the single observations and categories into a larger general statement.

For the analysis of the FG in this study in principle the inductive approach was used. The reason for that was scarcity of preexisting knowledge on the researched topic and explorative character of the study. The goal was to generate new insights and build knowledge, therefore it was necessary to choose an approach not based on any existing preconceptions. However, it has to be also noted that data analysis was driven by the attempt to answer the research questions. Thus, some initial directions were required and might be seen as preconceptions (e.g. focus on travel time activities, daily activity plans, etc.). Still, in principle data analysis was inductive and also data not falling directly into the most relevant areas was coded and used to derive final conclusions.

4. Results

The results section is structured in accordance with the diagram representing the core of the research. The three coloured elements in the figure below are addressed separately:

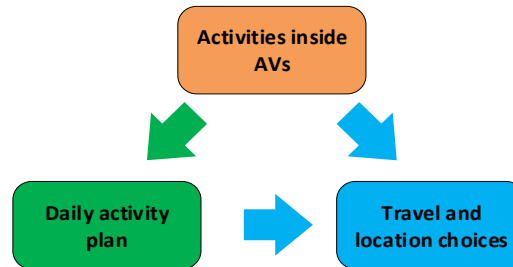


Figure 11. Structure of the results

The key element of the diagram are activities inside AVs: the other elements are seen as dependent on this central theme. Thus, it is elaborately addressed in the first place. Section 4.1 presents the identified mechanism determining perception and use of travel time, for both conventional modes and AVs. In that way the first two research sub-questions are addressed.

Secondly, the focus is zoomed out from merely discussing the AVs activities to addressing their actual impact on daily activity plans. Section 4.2 is dedicated to the impact of the former on the latter. In that way it covers the third research sub-question.

Eventually, the overarching interest of the study is addressed, namely the possible impact of AVs activities on travel and residential location choices. First, results regarding travel choices are presented in section 4.3. The location choices are discussed separately in chapter 4.4. The two sections use the knowledge from preceding chapters to address both direct and indirect effects of AV activities on travel and location choices. In that way, the both sections cover the main research question.

Important information for the reader

To justify the statements made throughout the results, they are supported by quotations coming from the participants. They are included all through the chapter in italics and are clearly distinguished. To keep the results concise, the number of quotes was limited in the main text of the document. In many cases multiple quotations supporting one particular statement or concept exist: those not included in the main text can be found in **Appendix A**. Whenever the extra quotes are available, it is indicated in the results by a reference **A.X**, where **X** indicates the location of the relevant quote in the mentioned appendix.

Furthermore, it is important to note that in the FGs the participants make two sorts of statements: either sharing general and abstract ideas, or making claims about their own life and behaviour. Although both of these are valuable and were included in the analysis, in some cases it is informative to look closer at a specific personal story and the associated context. In such case the quotes were placed in an additional orange box with a 👤 symbol. In case a general concept emerges from the discussion, it is presented separately in an orange box and marked by a 🧠 symbol.

The authors of the quotes are explicitly named. The original names were changed. When reading the results, it is possible to keep track of each individual participant. Sociodemographic data, as well as summary of their statements are available in a table in **Appendix B**.

4.1. Travel time use mechanism

Based on the findings coming from the FGs, travel time use was conceptualized as a variable dependent on three elements: internal characteristics of travel timespace, personal characteristics of the traveler and external incentives to perform activities. The picture below represents this way of looking at a travel situation.

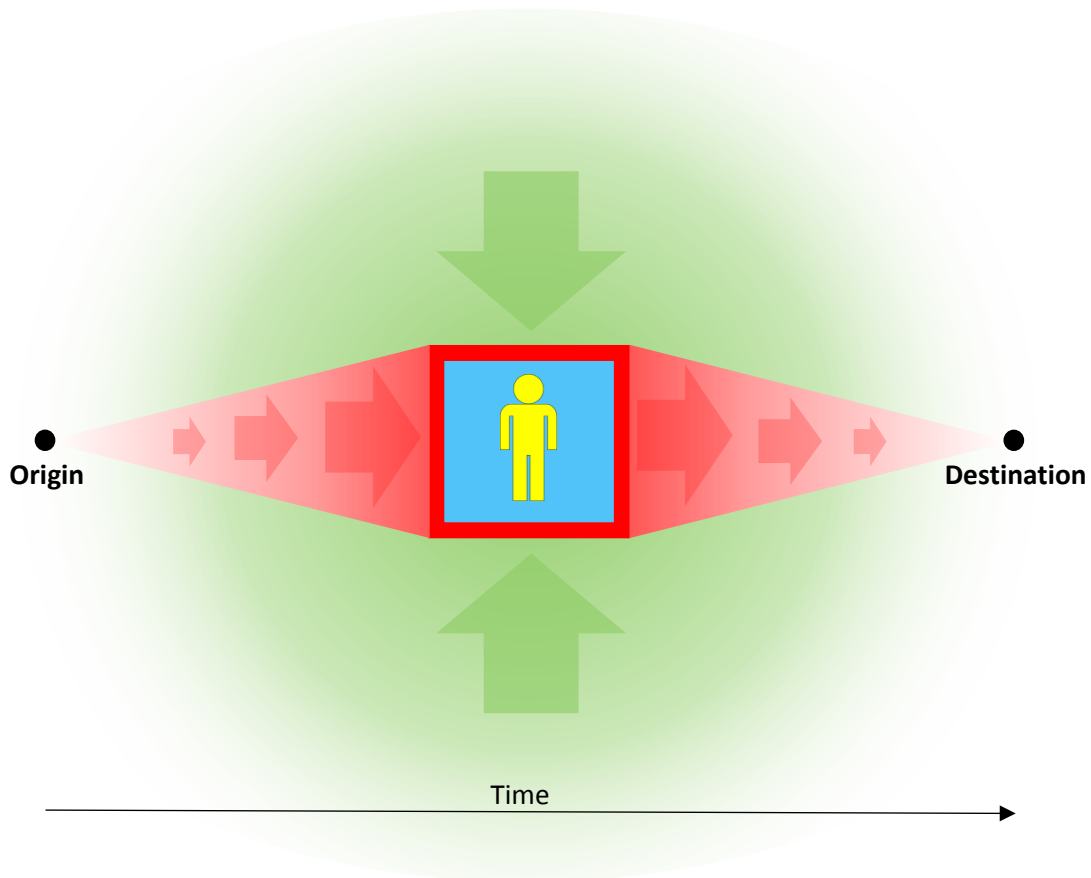


Figure 12. Conceptualisation of a travel situation

All the elements of the conceptualization are represented with separate colors. The **travel timespace** represents the characteristics of the travel environment available to the traveler for a certain time. The travel timespace contains the traveler possessing certain **personal characteristics**. The traveler has the possibility to perform activities within the travel timespace. However, what exactly is done during travel depends not only on the traveler and travel timespace but is also influenced by **external factors**: circumstances not related to personal characteristics of the traveler nor the travel timespace properties, but external to both of them. These three elements together have impact on the actual **perception and use of travel time**.

The above framework will be used throughout the results section to structure the discussion on travel time use. It has to be noted that a matter as intricate as travel time use is difficult to conceptualize unambiguously. One can easily argue that some elements which were assigned to one of the defined categories belong to a different category or create a category on its own. One of such concepts could be comfort of travel: is it an inherent property of travel timespace, or perhaps rather a relative impression, depending on individual personal perception? Or perhaps all the elements can be eventually seen only as a manifestation of characteristics of the particular person, and there are no “external” or “internal” elements?

Thus, the presented way of looking at travel time use needs to be seen as a subjective point of view of the researcher, serving as a starting point to structure the discussion, rather than a rigid conclusion about the nature of this phenomenon. Building on this concept, it is possible to look closer at travel time use. The figure below presents an expansion of the above travel conceptualization into travel time use mechanism:

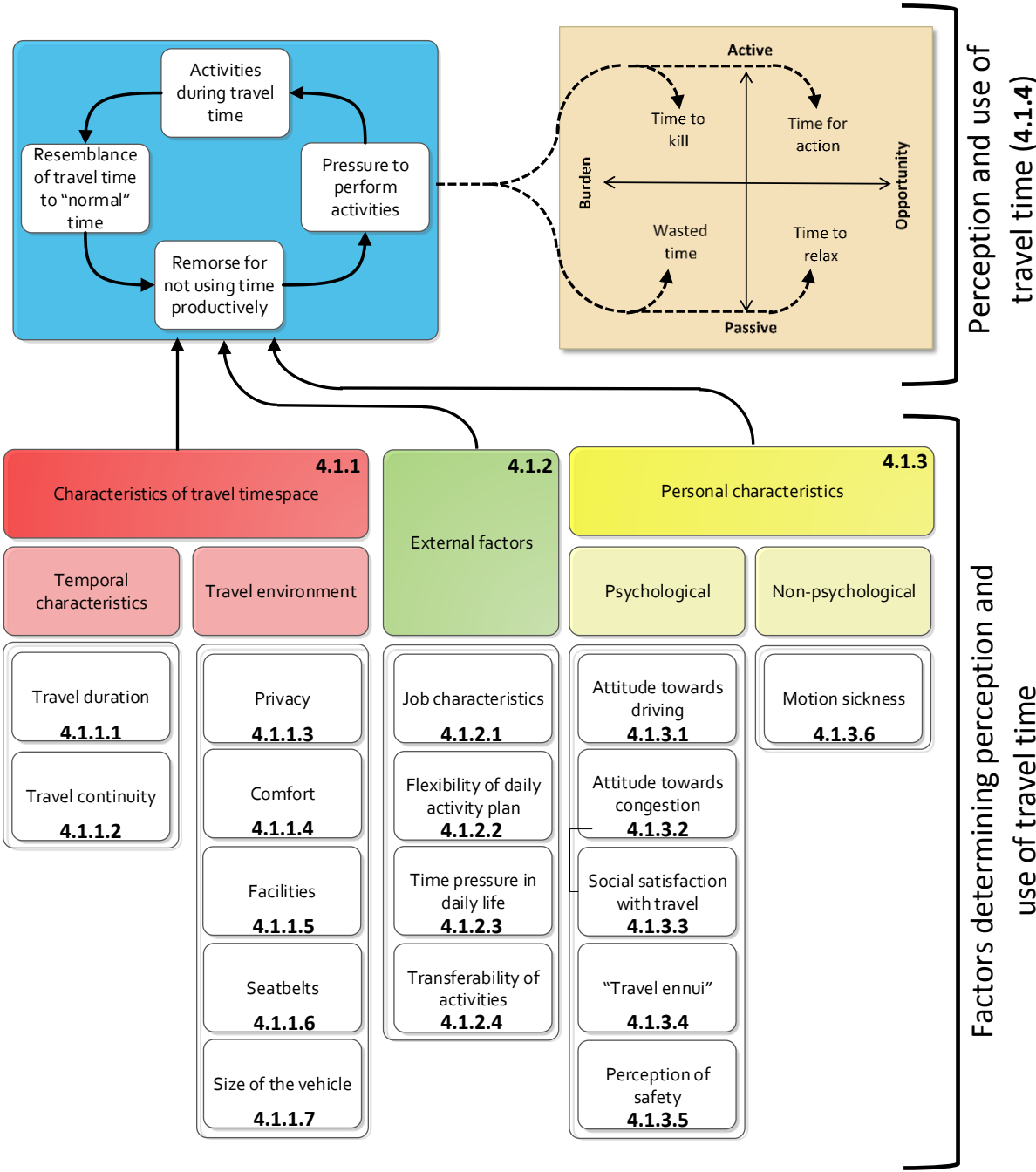


Figure 13. Travel time use mechanism

As it can be seen in the diagram, the travel time use mechanism consists of two tiers: the lower contains the factors influencing perception and use of travel time, and the upper explains how exactly these factors combined together result in perceiving and using travel time in certain way.

In the following sections, all the elements presented in the figure will be discussed in more detail. First, the lower tier will be addressed: all the three large groups of travel time determinants will be discussed separately. Secondly, the discussion will arrive at the upper part of the travel time use mechanism: perception and use of travel time. The numbers of chapters addressing each particular element can be found in the above diagram.

It is important to note that the discussion of current travel modes and AVs must be intertwined to a fairly large degree. The FG participants built their statements by combining current experience with imagination, due to lack of any actual experience with real AVs. Therefore, it is impossible to talk about AVs in complete separation from current travel time use. For that reason, the majority of discussed factors is addressed both in current and future (AV) context. The discussion diverges more clearly into these two areas when addressing the upper tier of the mechanism: travel time perception and use. This part is discussed separately for both current modes and for AVs.

4.1.1. Characteristics of travel timespace

First group of factors determining perception and use of travel time are the characteristics of a given travel timespace. They were categorized into two groups: temporal characteristics and travel environment. All the factors will be addressed now separately, order as indicated in Figure 13.

4.1.1.1. Travel duration

The amount of time people spend on travelling is one of the main factors determining their activities. However, it has to be stressed that it is a highly relative one. It is basically meaningless if considered only on its own - in complete separation from other factors. The impact of travel duration on perception and use of travel time is only relevant in context of intricate combination of all other circumstances. Keeping that in mind, in general it can be stated that in case of short travel duration there is a tendency to simply kill the time, but as it becomes longer there is a better opportunity to spend it in a purposeful way. (A.1)

CAROLINE: *“I think it (use of travel time) really depends on the travel time, how long I am in a train? Or in a car? Or bus? (...) Maybe it is because I don’t regularly travel and the travel time is not too long. I do not find it productive.”*

Taking this into account, **in case of short trips (e.g. daily commuting) the potential of carrying out activities inside AVs should not be overestimated.** (A.2) It has been recognized by the participants that having an AV might in fact not have much influence on daily routines of people with short daily travel times.

PAULIEN: *“I think if you drive very short distances, every day, then you do not change that much (with AV).”*

Short travel time also brings the risk that a particular task carried out in the AV will be **not finished when arriving at the destination**, and will have to be interrupted. Currently, some people feel anxious if the travel duration is different than expected (A.3). This uncertainty might discourage AV users from undertaking more engaging and time-consuming tasks (A.4). Actions requiring relatively long, uninterrupted travel time, (e.g. watching a movie, work tasks demanding steady, extended

concentration) might be performed in AVs less willingly, unless the traveler is able to continue the activity after reaching the destination.

LAURENS: *“Also that it (the AV) is linked to home... So that when I start watching a movie in the AV and I arrive at home, I do not think: how am I going to watch further? That it is connected to my home and that I can walk inside and I can watch further immediately.”*

Potential advantage of AVs lies in the possibility of **extending travel time** by the user in case of time shortage. The fact that sometimes the traveler might want to prolong the journey to finish an activity hints at the chance of performing activities in a parked AV. This concept is presented in the figure below.

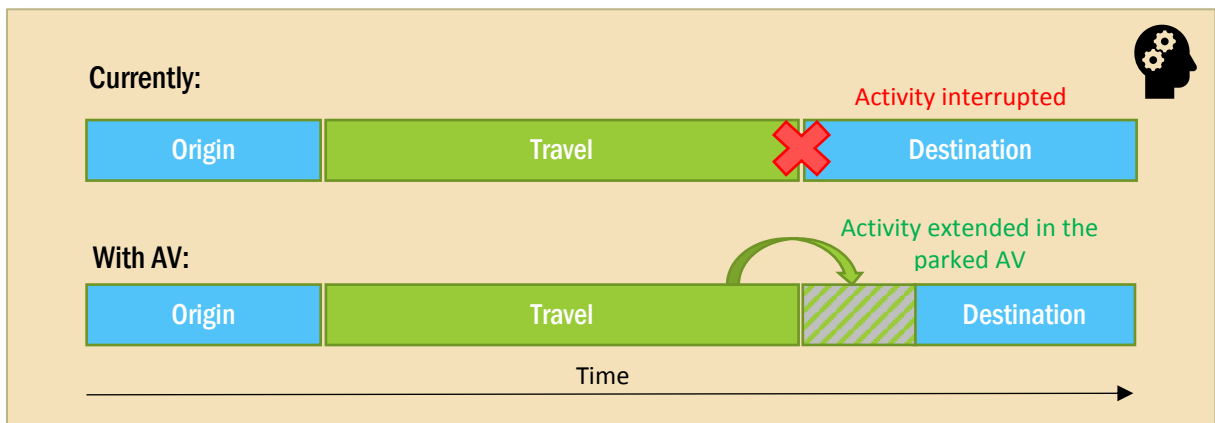


Figure 14. Possibility of extending activities in a parked AV

It has to be noted that the above idea is hypothesized: it was not expressed explicitly by any of the participants of the FGs.

4.1.1.2. Travel continuity

The notion of travel continuity captures whether travel time is smooth and uninterrupted, or fragmented (for example by transfer between modes). For some participants fragmentation of daily trips is a major obstacle to perform activities when travelling. Sometimes, even though the trip is relatively long, still the fragmentation makes any activities impossible (A.5).

CAROLINE : *“If I have a transfer on my way I don’t do anything because I am just waiting for changing the trains or changing the bus.”*

People seem to acknowledge the AVs benefit of **merging multiple short trips into one smooth journey**. They recognize the improved chance to perform activities during the travel.

NORBERT: *I could see that (the AV) as a big advantage, you do not have to wait, you do not have to switch, there are no people making phone calls.*

The idea can be conceptualized as follows:

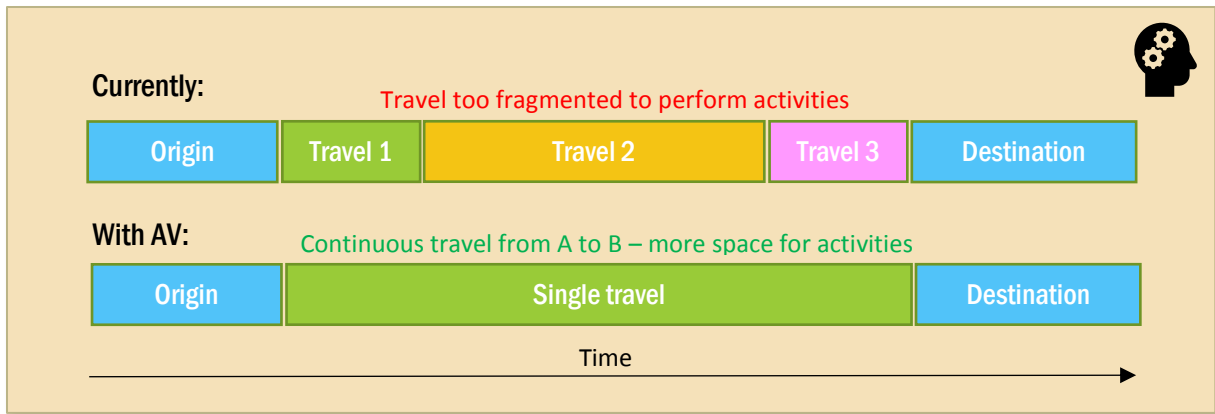


Figure 15. Benefit of AVs in terms of travel continuity

Such merging is especially advantageous for people using PT on daily basis, since those are most affected by travel discontinuity. Thus, it is possible that the advantage of continuous travel time will make current PT users more willing to use AVs instead (A.6).

PAULIEN: *“It (the AV) would be an alternative for me if I had to take the bike and change to the bus and the metro, 2 times or 3 times. That is not a direct connection. Then you are on the road for one hour instead of 20 minutes. Then I take the AV.”*

4.1.1.3. Privacy

Besides the temporal aspect, the travel timespace also captures characteristics of travel environment, namely properties of the space to which the traveller is exposed. One of them is privacy. It is relevant almost exclusively for PT users. It refers to **presence of other people** (unfamiliar to the traveler) in the travel environment. Low privacy limits the range of possible activities. In case of heavy overcrowding there is basically no much other choice than to kill the time.

ELISABETH: *“I would like to use my time in PT differently. But I often travel at peak hours, I don’t like to open my laptop, then you’re on your cellphone for a bit, just on the internet doing nothing. (...) I think it’s good at other times in PT, but it’s just not a good idea at peak hours.”*

The participants recognize the advantage of AVs over PT in that respect (A.7). The AV is perceived by the participants as a **confined, private space**. It allows to focus better and creates a good environment for work, for example with a laptop.

BART: *“I would say AV will be different from PT, because in PT I don’t put my laptop out. (...) I will take the AV as a mini office space, movable office space, and do office work that does not need any interaction with people. So it is different because it is confined environment where I can concentrate.”*

The privacy provided by the AV could also allow people to perform some **brand new activities**.

CAROLINE: *“I think in my AV I would do something for what I never have time. For example, maybe use the car as a karaoke salon. I will sing, but now I don’t have time to do that.”*

4.1.1.4. Comfort

The comfort factor is understood as the **physical sensation** of the traveler when being in the travel environment. In this sense it represents things like level of noise, temperature, how comfortable the seats are etc. It is also related to presence of other people – in case of overcrowding it might be necessary to **stand** in the vehicle, which reduces the comfort.

“LINDA: I am annoyed by my train journey, especially if it is busy and you have to stand, then you can’t even read a newspaper. (...)

Compared to conventional modes, AVs are expected to provide much higher level of comfort. Again, the advantage is especially prominent when comparing AVs to PT.

NORBERT: “(...) You have the comfort of your own room, no noise, no people who are calling, you do not have that.”

Of course the feeling of comfort is a highly subjective matter and one could argue that it should be seen rather as a personal characteristic than a property of travel environment. However, eventually it is always a function of the latter, thus it is still categorized as one of the travel timespace factors.

4.1.1.5. Facilities

Accessibility to facilities has important impact on the range of possible activities. Currently, the variety of facilities available to the traveller is rather limited. For car drivers it is mostly just a radio. For PT users an important facility is Internet which is sometimes available in the vehicle.

DANIEL: “Sometimes you get lucky when there is Internet inside the trains, then I read twitter.”

For AVs the significance of facilities is expected to be more crucial, due to more freedom one has to use them during travel. The participants came up with many **ideas of sophisticated facilities** they would like to have inside their vehicles if they could design them to their own taste (A.8).

“ELISABETH: A kind of work consultation. I mean your colleagues are also on their way home, you can just do it on the way.

JELMER: In your AV, skype.

GABRIELLE: Yes a good screen and a good sound system.

FELIX: Massage chair.

JOHANNA: Imagine a kitchen in it, you can prepare everything, you're home, eat everything, everything's done.”

As stated in the FGs, depending on the facilities the AV might resemble either **work space or home space**, (e.g. for relaxation) (A.9).

PIETER: “I think it has to do with how the design of the car will look like, it will become a relaxation room or it will become a working space.”

An interesting observation showing the high significance of AV facilities is the idea, that renting a suitably equipped vehicle might be in fact more appealing than having an own AV. Depending on the specific purpose of the person during a particular travel, an **AV with a suitable interior could be rented** (A.10).

ANDRÉ: *"I don't think people will have an AV with one interior. You just order a car and that you want to sleep, then a car with a bed comes in. Or I want a car with a desk or something. I don't think people would have their own car. You can just order a car. You know the blue bicycles in Delft. (...) That's how I see it. That will be fun. Or maybe one with friends, with a bar."*

The option seems to be appealing especially for specific, irregular travels, e.g. overnight trips to distant locations (a bed inside) or travelling with friends or relatives for leisure purposes (AV as an "entertainment room").

4.1.1.6. Size of the vehicle

Whereas the significance of vehicle size was not explicitly mentioned for current modes of transport, in case of AVs it was expressed on a few occasions. On one hand, size is an obvious limit to the facilities that can be fitted inside the vehicle.

"NORA: A relaxed chair or something.

NIEK: Well, it has to fit, I do not think it all fits."

On the other hand, the size also determines the way AV environment is perceived, having effect on the perceived range of suitable activities to be performed on-board.

"DANIEL: You can convert the AV to bar, and start drinking some alcohol.

BART: I don't feel like a car is a...maybe a big car, the size of a room can be a good place for a lunch with colleagues."

The above quote shows that the vehicle size will most probably have a psychological impact on the traveller. This matter is addressed more in detail later, when discussing perception and use of travel time for AVs.

4.1.1.7. Seatbelts

The last factor belonging to travel timespace refers to freedom of movement during travel. Currently, seatbelts reduce mobility of car users, however those are still limited anyway by other factors, e.g. necessity of steering the car. In case of AVs, the impact of seatbelts on the activities might be more prominent.

GABRIELLE: "I have another question: are there any belts in those cars? I ask myself that. I'm gonna do this, I'm gonna do that. But when you sit there, constricted..."

PAULIEN: "Yes, but also for the passengers, you are just playing a game inside the car and then the car suddenly brakes. How does that work?"

It also needs to be noted that seatbelts can be seen as an element of the Comfort factor. However, the current definition of Comfort does not explicitly cover **constriction of moves** when travelling, which is the main impact of seatbelts. Such constriction is expected to have a different significance for the range of activities than the elements composing the Comfort factor, thus seatbelts are treated as a separate factor.

4.1.2. External factors

Another group of factors in the travel time use mechanism are the external factors. Those are not connected in any way to the act of travel itself. They are also different from personal characteristics: while all personal characteristics (in the sense they are defined in the travel time use mechanism) represent different aspects of traveller's attitude to the act of travel, external factors capture those elements which are separate from it.

4.1.2.1. Job characteristics

First of these elements are characteristics of the performed job. One important distinction is whether the job is **stationary** or **non-stationary**. Stationary jobs require being daily in a single specific location at a specific time.

LAURA: *"Yes, I drive a lot in my car, I have to go to the office every day and if the travel time is shorter, that would be ideal."*

On the other hand, non-stationary jobs entail travelling to multiple locations.

"KOEN: *Yes, of course, I travel to work by car. One time it takes an hour the other time two and a half hours. It is a bit mixed during the week. (...)*

MODERATOR: *As a business consultant you obviously have to go to multiple destinations.*

KOEN: *Yes. Multiple locations."*

Consequently, stationary jobs are characterized by regular daily commuting, whereas for non-stationary jobs travels have irregular destinations and intensity. Another important job-related factor is whether **travel time is accounted as working time** by the employer. If not, some people do not see the benefit of working when travelling.

ANDRÉ: *"On the other hand, if I am going to work, why would I also work in the train?"*

This aspect is also relevant for working in the AV.

FELIX: *"If your employer also takes into account that your travel time is also your working time, then you can also stop earlier. Then you take that into the AV so you do not have a disadvantage at all from the travelling."*

4.1.2.2. Flexibility of daily activity plan

This factor represents how rigid a particular daily activity plan is, namely how much flexibility one has in changing the initial plans and shaping them dynamically as the day unfolds. Of course, people having stationary jobs have the most rigid plans. They can easily develop certain **travel time routines**. People with less stationary jobs have usually more freedom in redefining their schedules. Still, among the non-stationary jobs different levels of flexibility occur. For example, a participant working as a pedicure specialist has a predefined set of **locations which have to be visited throughout the day at specific times**:

"PAULIEN: *I work for myself as a pedicure specialist. (...) I travel back and forth with the car all day long.*

MODERATOR: *So not at a fixed location.*

PAULIEN: *No, at people's homes."*

The more random and entrepreneurial the job becomes the more flexibility one has in **shaping daily plans “on the go”**.

NICOLE: *“Well, I am satisfied (with my travel time) one day, then I get everything done. The other day I am not satisfied, because I do not have a permanent working place. I travel everywhere. For me, every day is different. Every day is a surprise. It depends on the time, one time you can do a lot, for example learning. But very often when my travel time is interrupted, you will not get into that flow. If you know that you have to go to work every day for 20 minutes or half an hour, then you have some time for yourself. But for me that is different every time. If I know that I have to be in the car for an hour, then I can also plan something, then I will do this and that. So that really changes. But I try to get done as much as I possibly can in the car.”*

This factor is especially significant for AVs – the more flexible the daily travel pattern the more room for various rearrangements. AVs might be found especially attractive by people with less rigid and predictable daily patterns. This fact is elaborated more when discussing the impact of AVs on daily activity plans.

4.1.2.3. Time pressure in daily life

Time pressure in daily life was found to be one of major determinants for travel time use. If a certain activity causes such pressure, it can either be performed during travel, or more time can be “made” for it by performing some other activities when on the move. Currently, the activities that are transferred are rather unsophisticated, due to all the limitations of current modes. The example below shows how time pressure causes transferring eating into the car.

PAULIEN: *“What I do on the way is often eating a sandwich, because otherwise I do not have time for it. Occasionally I stop and to do some grocery shopping. But only eating in the car.”*

In case of AVs the opportunity to transfer various activities into the vehicle will be much more broader, therefore time pressure is likely to have more impact on travel activities.

CAROLINE: *“I think in my AV I would do something for what I never have time. For example, maybe use the car as karaoke salon. I will sing, but now I don’t have to do that. So I don’t substitute that time, the working time. So I use it for something that I have never get time for.”*

4.1.2.4. Transferability of activities

Even if time pressure might be released by performing some of activities during travel, in order to do so the particular activity must be transferable into a vehicle. For example, since work is often a source of pressure, performing (some part of) it on the move could be beneficial. However, not all jobs are equally suitable to do when travelling and many of them are not even transferable at all (A.11) .

MAARTEN: *“The moment you have an AV, and you could work a lot in it, (...) it must be possible for your work. Because if you work at Hema (a Dutch store chain) then you can do nothing at home, maybe some administration, that might be possible. But I really do office work, so at the moment I could do that in the AV.”*

Of course, transferability is also relevant for non-professional activities. Certain activities require specific environment: it is impossible to swim or ski even in the largest possible and best equipped AV.

4.1.3. Personal characteristics

The last group of factors are personal characteristics of the traveller. It consists of individual features of the person, relevant for how travel time is perceived and used. They can be divided into two categories: psychological and non-psychological. Below, each factor is addressed in more detail.

4.1.3.1. Attitude towards driving

A lot of people find driving enjoyable. Some car users appreciate travelling by car and find it a **valuable time**, even though their activities during travel are highly limited.

CHRIS: *“Yeah, I like driving. Then I listen to music or radio or just do nothing, just take care of driving.”*

On the other hand, some people are unhappy with driving, because they need to constantly pay attention to the road (A.12).

MAARTEN: *“For me, travel time is really loss of my time. I think car driving is not really relaxed, especially when it is busy, then I notice that I do need a lot of focus to look at the road. (...) I would certainly spend my time more efficiently if that would be possible.”*

Whether driving a car is enjoyable or not depends not only on attitude to driving itself, but also on two other factors. One of them was already mentioned, namely **travel duration**. Usually people enjoy driving more if travel time is relatively short.

JOHANNA: *“Yes, I really like to drive the car, so I really like it as relaxation. Those 20-25 minutes to my job, (...) I always like it. (...) Only if I really have to drive big distances, for example to my parents, for 50 minutes, I think it's a bit boring.”*

The other factor is **congestion**, which is discussed more in detail separately, right after attitude towards driving.

LINDA: *“Yes, another disadvantage (of AVs): driving itself can also be quite nice, if you are not in a traffic jam. I also know people who, on Sundays, not the typical Sunday driver, but who just drive a bit on Sunday, just for fun.”*

The participants see the advantage of AVs in taking away the burden of steering the vehicle and paying constant attention (A.13).

PETRA: *“It (AV) is better, because now you do everything quickly, you can do it more relaxed by then. It is more free, you are comfortable, you do not have to pay attention to traffic. (...) The haste disappears.”*

However, the elimination of the act of driving might be seen as a disadvantage for people who are currently fond of it. This fact was recognized by the participants, who think that some people might **miss driving a regular car**.

MAARTEN: *“I think it only gets worse for people who really like driving a car, or find it exciting. I think that it can become worse for them, a kind of hobby that disappears.”*

ELISABETH: *“Just the driver role, I'm going to miss.”*

However, although the act of driving has currently positive influence on travel time perception for many drivers, it cannot be concluded that the absence of this act in case of AVs will bring any disutility.

4.1.3.2. Attitude towards congestion

Congestion is one of the factors negatively influencing pleasure from driving, even for people who normally find car driving relaxing. When being stuck in a traffic jam, very often travel time is immediately seen as lost time (A.14).

*“RENATE: At first I don't think that it (travel time) is lost time. But as soon as you stand still it is a lot more annoying. That gives a very different feeling.
PIETER: At the moment you are stuck then it will be lost time.
PAULIEN: Totally agree.”*

Due to this feeling, people in general seem to feel **pressure to perform activities** during congestion.

*“NORBERT: Yes, and quality of life. If you often get stuck in a traffic jam, I never have that myself, it seems to me, that you can get pretty grumpy about it.
NORA: A little depressed, but actually you just have to leave it behind you, otherwise you really get frustrated.
NORBERT: You cannot really do something.
NIEK: Yes you're stuck.
NORA: You have to pay attention, you have to concentrate. Yes, you cannot really do something. You also see people who are doing their make-up in the car.
NIEK: I even see people working.
NORA: That is bizarre.
PAULIEN: Usually everyone immediately gets on their mobile phone.”*

Again, this phenomenon and its significance is discussed more elaborately when addressing perception and use of travel time (4.1.4). AVs are expected to **remove the negative influence of congestion** on travel time perception. According to the statements of the participants, it would no longer be a reason to see travel time as wasted.

PIETER: “If you could spend your time in the car useful, at that moment, instead of watching the road, that would be fantastic. (...) It could be incredibly useful, because it is also the stress you experience, it is simply incredibly exhausting. Continuously have to pay attention, in case of congestion, during traffic jams. Cars can suddenly come from everywhere. You get all sorts of crazy situations when driving in a traffic jam.”

However, congestion could still bring disutility in case of strict time constraints (e.g. by causing risk of being late at the destination). Such problem was also explicitly recognized in the FGs:

LAURENS: “The example (from the FGs introduction movie) that the AV goes straight to the airport and you can take a nap there, I do not worry about that. But when it first goes home, and then he arrives in such a traffic jam, towards the airport, although it is automated, the person inside is still stressed because it has to be fast. Because he has to be at the airport on time. Then you are still tense in an AV.”

It has to be noted though, that the scenario used in the FGs assumed a flawlessly working transport system with smooth traffic flows. Therefore, although such problem was mentioned by the participants, it was excluded from the study scope.

4.1.3.3. Social satisfaction with travel

It was observed that people assign certain social value to the act of travel. It was not expected prior the FGs, but appeared repeatedly during the discussions. However, although the social element certainly plays a role in the act of travel, its exact nature remains unknown.

On one hand, travel time can be seen as quality time if it is spent with friends or family (A.15). This social dimension of travel is something that could be already expected. However, also **social interaction with random people** (strangers) seems to bring utility to the travel. Being around others, eye contact and casual interaction is seen as a valuable travel experience. It bears significance for both car and PT users (A.16).

BART: "Another disadvantage (of AVs) is that we may not go to the train stations anymore. So there is a bit of breaking some social aspects. I have good memories from train stations. There are people, we can go and have a coffee, buy a journal, and wait for the train. It is a pleasant time, when we can see people."

AVs might bring deterioration to this aspect of travel. Using such vehicle was compared to **travelling in a "bubble"**.

BART: "I am afraid that if we use AVs all the time we will find ourselves in bubbles. We go from point A to B in an isolated way. So there may be no be much room for interaction and unpredictable things. Like it may be too deterministic, less exciting."

This "property" of AVs not only reduces social interaction with other people, but also makes life more deterministic in general. It is captured by another factor – "travel ennui".

4.1.3.4. "Travel ennui"

Currently, the scenery during travel is constantly changing, making the travel experience more interesting and unpredictable. Moreover, it is possible to get lost or to spontaneously diverge from the planned route, e.g. to explore unknown areas. On contrary, AVs are characterized by an isolated, "A to B" manner of travel. They are expected to take away the element of **spontaneity** associated with the traditional way of traveling. The participants are afraid that travelling might become more boring and less bearable, compared to current modes (A.17).

"KOEN: I sometimes when I travel for my work, then I sometimes pick a village and then I walk through the center. But, now you enter the address and you go to where you have to go without stops."

MODERATOR: Unexpected things.

KATRIEN: Yes, they are not there anymore, I think."

Similarly to the social aspect of travel, the exact influence of "travel ennui" on travel time perception and use is difficult to determine. The possible impacts of these factors are discussed in more detail when addressing perception and use of travel time for AVs.

4.1.3.5. Perception of safety

For travel time use it is important how safe the traveler feels when performing particular activity on the move. This perception of safety is significant only for some modes, like car or cycling, whereas it has no influence in case of PT or train (they are very safe). Currently some activities in the car are perceived as too risky - people might resign to perform them for that reason.

KATRIEN: *“I think that there is a lot more possible, now people also do everything that is not allowed in the car. I see that continuously, I see people with open laptop when driving, on the 2nd and 3rd lane with 130/140, then I think: okay...”*

For the purpose of this study it was assumed that AVs are 100% safe, however in reality perceived safety could be a significant factor **limiting range of activities performed in AVs**.

LAURENS: *“My point remains, even if it is completely automated, I also think it is important that the person remains in control, at all times. Why? An automated system can have looked at all safety scenarios, but there is always a scenario that is not programmed.”*

Certain activities which fully take the attention of the traveller from the road, e.g. sleeping, might be performed in AVs less willingly. As the perceived safety increases, people might be willing to engage in more absorbing activities. This possible relation can be conceptualized as follows:

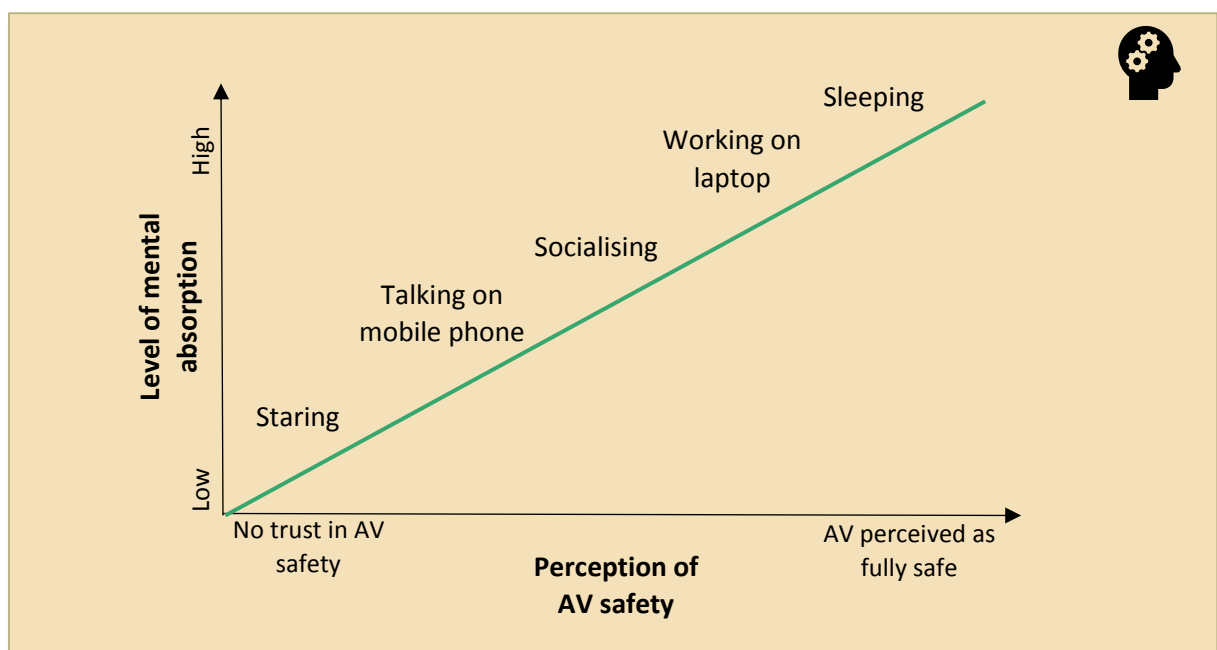


Figure 16. Hypothetical relation between perceived safety in AV and performed activities

The above relation is hypothetical: the activities presented in the figure do not come from the participants statements and were chosen subjectively. It is well possible that perception of AVs safety will increase in time, provided that their wide implementation will prove safety of the technology. Otherwise, the AVs users might stick to less absorbing activities on-board.

4.1.3.6. Motion sickness

Next to psychological characteristics, also non-psychological personal characteristics were identified. In the FGs only one such characteristic was mentioned: motion sickness. It was indicated only twice in the discussions, appearing in both current and future (AV) context.

CAROLINE: *“I used PT regularly and I used to have a presentation, so I could use that time for getting ready for the presentation. And it was very useful. Yeah... Despite of the fact that I feel dizzy when I do something when I am moving. But I could use that time just to get prepared for my presentation.”*

RENATE: *"I must say something about reading (...) So, I cannot actually read a book inside the car because I will get sick. Watching a movie is still possible, I would still do that. But, I hope that I will not suffer from it anymore. I never tried that behind the computer."*

Despite of little attention devoted to this topic in the FGs, its significance might be high. It is presumed that majority of participants was in fact not able to accurately imagine how performing discussed activities in an AV would *feel* like, thus so little discussion about motion sickness.

4.1.4. Perception and use of travel time

After addressing the factors determining travel time perception and use it is possible to arrive at the upper tier of Figure 13. The way travel time is perceived and used turned out to be remarkably different for both current modes and the AV. Therefore, these two will be further discussed separately.

4.1.4.1. Perception and use of travel time currently

Regarding the current situation, most importantly it has to be noted that travel time is clearly seen as a different kind of time than "normal" time outside the vehicle - its relative value is lower. This fact finds direct confirmation in some statements of the participants. An example is using the time for activities for which "normal" time is too valuable:

GABRIELLE: *"I'm using travel time to do something fun, for example, people I have not seen a long time, I can call them when I'm in the car (...) But then I don't think it is lost time. If I have to do that at home otherwise, then I find it lost time to call people."*

The reason for such treatment of travel time is a result of a psychological mechanism involving the factors addressed in the preceding section (see Figure 13). A more detailed version of the mechanism is presented in the figure below.

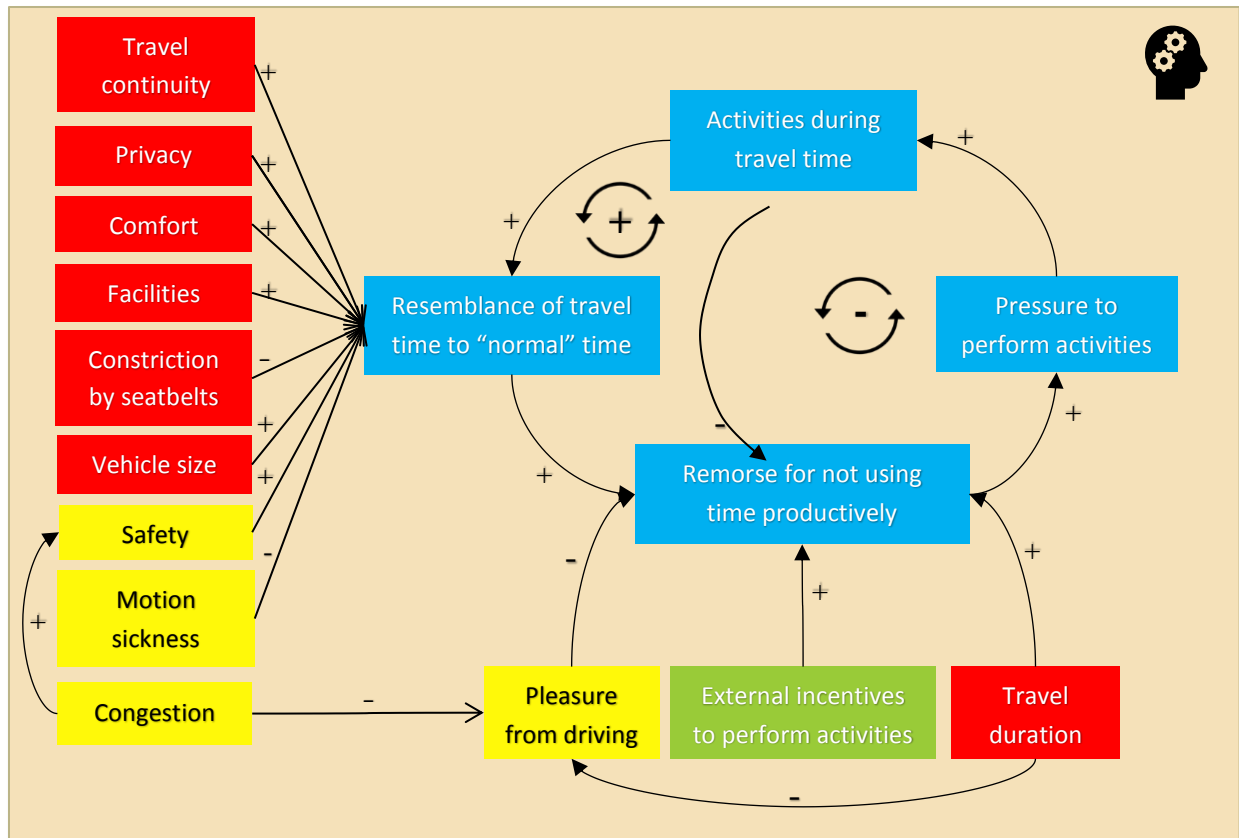


Figure 17. Interaction of various travel factors for current modes of transport.

The red, yellow and green rectangles are the earlier identified factors, and the blue rectangles represent the way they interact together determining travel time perception and use. The colours correspond to the Figure 13. For clarity, all the external factors are combined into a single green rectangle. Social satisfaction with travel and “travel ennui” are not included, because their possible role is too ambiguous and difficult to determine in context of the above diagram.

The factors on the left side of the figure determine how much the travel time resembles “normal” time. The more it does, the higher the “quality” of travel time, which increases the feeling of remorse if time is not used productively. Whereas most of the presented relations are self-explanatory, the positive impact of congestion on safety might seem confusing. It has to be clarified, that in context of the above figure “safety” refers to the perceived safety of performing activities on-board. Thus, although driving itself might not get safer as congestion intensifies, performing activities is seen as safer due to lower speed, or even being in standstill.

The remorse is not only affected by the resemblance of travel time to “normal” time, but also by the three factors at the bottom of the diagram. For car drivers, the attitude towards driving plays an important role: a person fond of driving feels less remorse than someone finding car steering burdensome. As explained earlier, attitude towards driving depends also on congestion and travel duration. Furthermore, the more external incentives to perform activities and the longer the travel, the higher the remorse.


As the remorse increases, pressure to perform activities also grows. In consequence, the time in the vehicle is spent in a more active way. Performing an activity both reduces the remorse, and works as a positive feedback for resemblance of travel time to “normal” time. The last of these relations captures the bidirectional nature of travel time perception and travel time use. For example, the fact

that a person is working during travel might be realised in two ways. On one hand, it might originate at the factors on the left side of the picture. Due to their certain combination travel time might resemble office time. Thus, the traveller might perceive travel time as office time, and work during the travel. On the other hand, the factors directly affecting remorse might be decisive. If external pressure to work is high enough, working during travel becomes a necessity. As a result, travel time is still perceived as office time, but the perception arises from external factors rather than properties of the travel timespace. It shows that the relation between perception and use of travel time is mutual: either people do something during travel, because they perceive travel time in a certain way, or the other way around.

The diagram is valid for both car and PT users. For **car drivers**, factors like travel continuity, privacy and comfort resemble conditions during “normal” time, thereby increasing the remorse. However, the driver is very limited regarding activities by steering the vehicle. For that reason, in case of car travel the key factor is pleasure from driving. In uncongested conditions driving is more enjoyable and it is less safe to spend time actively due to high speed. It serves as a psychological “excuse” to not feel the remorse. As a result, many people claim to enjoy driving, unless congestion happens.

CAROLINE: “Usually people like driving if there is no traffic jam”

When congestion appears, the feeling of safety increases – the car is basically in standstill and constant attention and steering is not required. Moreover, the pleasure from driving diminishes - the remorse resulting from high resemblance of travel time to “normal time” is no longer counterbalanced by the joy of driving. Consequently, remorse and pressure to perform activities increases, reinforcing the positive loop in Figure 17. Statements coming from the participants illustrate this mechanism:

<p>Travel time perception:</p> <p>RENATE: “Well at the moment I think it, I also drive at times that it is generally not busy, then I find it, if it does not take too long, I also find it kind of relaxing to drive. If it all just goes nice then I just think, good. Music on, my cappuccino. Then I do not think it's all that bad.”</p>	 <p>Congestion Tr. duration Pleasure fr. driv. Facilities (indirectly privacy, comfort)</p>
<p>Activities:</p> <p>RENATE: “And indeed if you end up in a traffic jam and you think: oh, I still have to send a WhatsApp, so then I do that. I know it is not allowed but it's useless time, especially when you are standing still.”</p>	<p>Congestion Ext. incentives Safety Remorse</p>

The above participant perceives travel time as time to relax, at least in uncongested conditions. However, when congestion appears, travel time is perceived rather as time for action (or time to kill). Quite opposite example comes from another participant, who used to be exposed to heavy congestion on a daily basis:

Travel time perception:

ARJUN: "I used to drive car in my country, in India. It is the second most populated country in the world as you know. I used to face **a lot of congestion**. (...) People keep on honking. I used to get suck up at traffic for **two hours**. (...) It's normal. To get stuck for two hours, yeah. (...) **I don't think it (travel time) is productive, it is totally unproductive**. So, even **if I could work on my laptop I would prefer to send some mails, which could be short tasks I can finish** when travelling."

Activities:

"MODERATOR: What do you do when you have these congested moments?"

ARJUN: **I get frustrated that's all.**"



Congestion

Tr. duration

Remorse

Ext. incentives

Remorse

In case of the above participant, exposure to heavy congestion for a long period of time caused strong remorse. At the same time, the range of possible activities is heavily constrained by the act of driving. The time is considered by the participant as wasted.

Figure 17 is relevant not only for car drivers, but after removing car-specific factors (attitude to driving and congestion) holds also for **PT users**. Their absence eliminates the negative, counterbalancing influence of pleasure from driving on the remorse. Thereby, in comparison to the car, the impact of factors in the left part of the diagram becomes more prominent. Some of them make travel environment more resembling "normal environment" than in case of a car: absence of seatbelts, vehicle size, safety and motion sickness. Some others have more negative influence on the resemblance, like travel continuity, privacy, comfort (the last two depend however also on specific PT circumstances). Compared to a car, on-board facilities gain importance: the traveller is less constricted and has more freedom to use them. Some of the factors are exemplified in the following example:

Travel time perception:

DANIEL: "I think for me it (travel time) is something between productive and unproductive. **I can't say it is totally unproductive, because if I have this time at home, I have wasted this time completely even worse than when being on a train**. It is not totally unproductive as well, because at least I can check the Internet. "

Activities:

DANIEL: "I often use the train. To commute through the Netherlands or to the airport. But inside the train I do approximately the same as when I am riding a bicycle. I listen to music or audiobook. Or just stare through the window. **Sometimes you get lucky when there is internet inside the trains, then I read twitter**.

MODERATOR: At some places, yeah

DANIEL: It is not always an option in all trains. On early mornings I can't do much, and then I just sleep. I try to sleep, it is not always...

MODERATOR: You start early?

DANIEL: Sometimes at 5

MODERATOR: Seriously? Why?

DANIEL: **Because I need to go to Eindhoven**. (1,5 hour journey)"




Remorse

Facilities

Tr. duration

The above participant treats travel time in the train as time to kill. He takes advantage of the facilities in the vehicle to use Internet on his phone during a relatively long journey. Still, he does not feel the remorse for not spending this time more productively. The reason is presumably the fact that train environment bears little resemblance to any “normal” environment, but also the early time of day. Another example below shows a PT user annoyed by the travel time, if it does not allow to perform some pending tasks. In this case, perception of travel time is on the verge of time to kill and wasted time.

Travel time perception:	
<p>LINDA: “I usually travel by train. I live in Rotterdam and I have to go to The Hague, then the car is not really an option. (...) I live on the eastern side of Rotterdam so I have to switch, so it's a short piece that I travel. It is an hour or so from door to door. I cycle a bit, then the train, then switch again, another train, then a tram. So a lot of fragmented trips.”</p>	<p>Tr. duration Tr. continuity</p>
<p>LINDA: I am annoyed by my train journey, especially if it is busy and you have to stand, than you cannot really read a newspaper. And the fact that I have to make switches leads to the fact that I cannot really do anything, prepare for work or whatever. It could be more optimal, that what I do, I adapt to the possibilities that I have at that moment.</p>	<p>Remorse Comfort; privacy Tr. continuity</p>
<p>MODERATOR: What would you like to do then?</p>	
<p>LINDA: Well, in some cases, really reading something, or having a telephone conversation, answering my mail is partly possible on my mobile phone. This is easier when you are sitting down compared to when you are standing. If the train is slightly smaller than planned, that is rather annoying.</p>	<p>Ext. incentives Comfort Vehicle size</p>
<p>MODERATOR: And of course you have small, short trips.</p>	
<p>LINDA: Yes, that makes it all even more annoying, you do not start reading something that you have to read for your ten-hour conversation, you do not just do that, that's a bit tricky.”</p>	<p>Remorse Ext. incentives</p>
<p>Activities:</p>	
<p>LINDA: “So what I mostly do when I travel, especially at night, watching Facebook, reading some news in the morning and staying up to date. Sometimes watching a movie or whatever.”</p>	

By applying similar analysis to all FG data, it was found that through interplay of various factors a traveler might belong to one of four different travel time perception categories. On one hand, mostly depending on travel timespace and personal characteristics, travel time can be seen as a burden or as an opportunity. On the other hand, it can be spent in either active or passive way. This is determined primarily by external factors. In that way, perception of travel time can be classified into following categories: time for action, time to relax, time to kill and time wasted. This categorization was proposed by Baiba Pudāne prior to the study. It is also applied in the analysis of the actual results, because it fits and explains properly different attitudes of the FGs participants. The four categories are presented below.

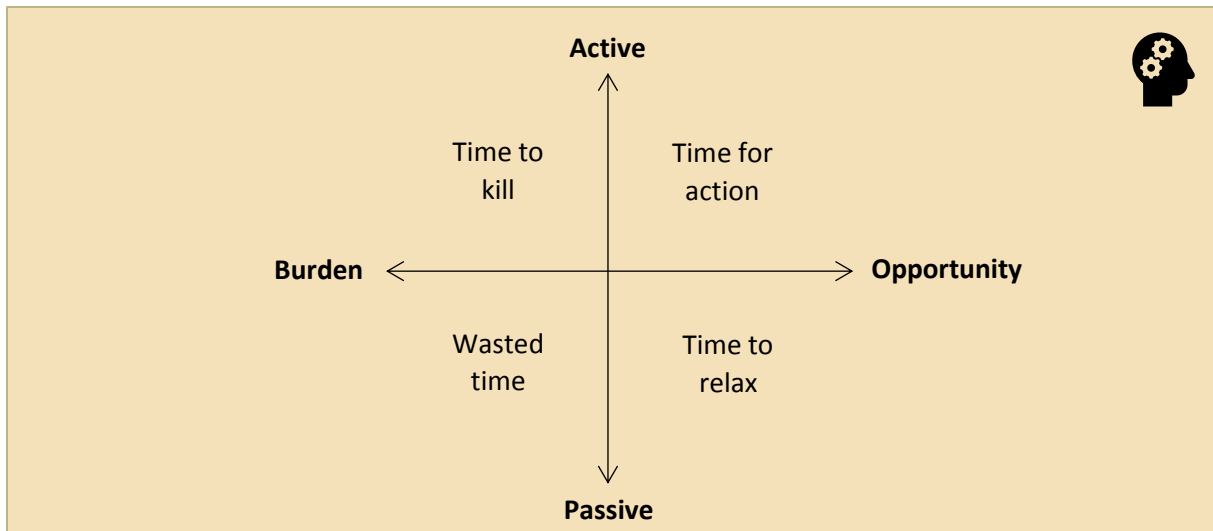


Figure 18. Categorization of current travel time perception

The four categories are shortly discussed below. It is important to note, that a particular traveler is not assigned to one of these categories once and for all. The assignment changes dynamically, depending on the dynamics of the factors. Consequently, a single traveler might even switch the category a couple of times during a single journey.

Time to kill

On one side of the horizontal axis are those who see travel time as a burden. Within the group, two categories can be distinguished. One of them includes those perceiving travel time as **necessary burden**. The travel has to be made anyway so at least the time can be made more pleasant by performing simple activities, e.g. listening to the radio.

Travel time perception:

NORA: *“For me, travel time is normal. It’s in my system. I do not see how I can change that, I have to go to work anyway. Whether there is a traffic jam or not, I have to go there anyway. I’m just going there and I’m not worried about it. (...) So I am just satisfied with my travel time, the distance is not that far.”*

Activities:

NORA: *“ Yes, then you get stuck (in case of congestion). Then you can do nothing but wait quietly. I never look at my mobile phone on the road. I do not do that. So I just focus on the road. So I’m not busy with other things when I am on my way, yes, paying attention and driving a car. (...) Music as well, 100% NL and then sing along.”*

In case of “killing” time, it can be concluded that the activities are dictated by travel time perception rather than the other way around. A very limited environment is available for certain time: possibilities are constrained, therefore the best one can do is to reduce the remorse by killing the time in a rather random manner. Moreover, this fact is rather accepted and not usually seen as something negative. People belonging to this group feel mostly **satisfied or neutral** about their travel time (A.18):

“MODERATOR: So André, if we go back to your book reading, playing with your phone (during travel time). Do you think it is productive? You can say yes and then you are finished. But if it is unproductive, can you also think of how you would utilize it otherwise?
 ANDRÉ: It is not really productive, I would say. I could use the time to prepare homework or studies. That would be a more productive way to spend it. (...)
 MODERATOR: (...) But you are happy with the way you spend your time during the trip? Don't want to really change it?
 ANDRÉ: No, I am quite happy with it.”

Wasted time

Another group perceiving travel time as a burden are those who see it simply as wasted time. Often they do not pursue any activities. However, even if they do, their **perception of travel time is clearly negative**: it is a source of stress and frustration. (A.19)

Travel time perception:

MAARTEN: “For me, travel time is really loss of my time. I think car driving is not really relaxed, especially when it is busy, then I notice that I do need a lot of focus to look at the road. The same holds for cycling, it is not like: I do it for relaxation. It is more that you have to do it to get to work. But to really say that I find it relaxing, or that I think I spent that time useful: no. I would certainly spend my time more efficiently if that would be possible.”



Activities:

MAARTEN: “I usually listen to the radio. Sometimes I also listen to a podcast. On the bike it is actually the same, also a podcast or audio book.”

In this case the impact of travel time use on travel time perception seems to be more prevalent than the opposite relation. Even though other factors also play an important role, it is mainly the inability to use travel time productively that makes this time “wasted”.

Time for action

People being on the opposite side of the horizontal axis see travel time as an opportunity. Those who choose to spend it actively perceive travel time as time for action. Within this group a few different types of travelers can be distinguished.

For some people, the fact that travel time has a lower value than “normal” time **makes it particularly suitable for certain activities**. Those activities, if performed in other circumstances, would be seen as a waste of time.

Travel time perception:



GABRIELLE: *"I'm using the (travel) time to do something fun, for example, people I have not seen in a long time, I can call when I am in the car. (...) But then I do not think it is lost time. If I have to do that at home otherwise, then I find lost time to call people."*

Activities:

GABRIELLE: *"If I drive my car, I use my phone but then with Bluetooth. I think that's easier, so I can talk a little longer and more relaxed with people. If I go by train then I do a lot of work on my phone."*

In a similar way, for some people the act of travel itself is a **stimulation to perform activities**. The mechanism resembles the one in the above example: travel time is a "special" kind of time, which makes it particularly suitable for certain activities.

Travel time perception:



BART: *"Yeah, (travel time is) quite productive, actually in PT I used to read quite a lot, more than when I am at home. So, when I travel, I used to, I don't know, maybe it's psychological, I used to read a lot. (...) Yeah, the aspect of moving and changing places make me willing to read. (...) We are changing places so we change environment and it gives the will, I think, to see differences, different experiences, traveling is an experience. Reading is an experience as well. It is a kind of travelling. (...) Yeah, it is quite stimulating."*

Activities:

BART: *"I used to take PT. So mainly I used to read. And sometimes just looking at the landscape. (...), looking around."*

What seems to be common for all the people perceiving travel time as time for action is that there is a certain **routine** which they follow when travelling. The actions are not spontaneous, but rather regular and planned. The time is not spent purposelessly and randomly, like in the case of people who see travel time as a burden.

Travel time perception:



NORBERT: *"I really like it (using travel time) this way. Especially in the morning. In the afternoon I'm usually fatigued, so I care less. But then I also like what I do, whatever I do. Often I do nothing, I'm tired too. No, I would not know how that could be more pleasant. I like it as it is at this moment."*

Activities:

NORBERT: *"In the morning I read the newspaper, nothing else actually. In the afternoon, every now and then the newspaper, usually my phone or I do nothing, listen to music. (...) It is (reading the newspaper) for my work, I must of course stay updated about news. But I also find it very relaxing. It is a very nice ritual, very relaxed."*

Another type of people seeing travel time as time for action are those who spend **a lot of time on travelling**. It is often related to the type of performed work: for some people travel time is in fact their working time. Generally speaking, people travelling a lot feel higher remorse for not using travel time productively, thus they spend it more actively.



Travel time perception:

JELMER: *“The rush you have, that can be quite stressful, quite a lot even, if you drive, two phones, one on the app and the other one on google, then you are sending a WhatsApp, next moment someone sends you a message. And then you're half in traffic jam. Then I get stressed pretty fast indeed. (...) If I'm stressed then everything goes wrong. Then I make mistakes.”*

Activities:

“JELMER: Yes, to my big shame, I have to admit that I send WhatsApp's behind the steering wheel, but it is not possible to do it different for me, it's for my work. On my way, I make calls, I try to put it on Bluetooth, with calls, I usually do. Often my boss sends me a WhatsApp to me, that's the only time I have contact with that man (...), someone has called in sick, I have to arrange a new guy. And I actually travel throughout the country. Amsterdam we have people, Tilburg and the Hague, we have people, so all the work projects have to be done, and on the way I'm just calling.

MODERATOR: *You are just working in the car?*

JELMER: *Yes*

MODERATOR: *And is there a moment of rest, or does it almost never occur?*

JELMER: *Almost never, I also eat on my way and then I'm at the Mac, then I'm with my computer.”*

The example above addresses working in the car, which is often stressful. In this sense travel time is a “burden”, but in the sense of “usefulness” of time, which is captured by the Figure 18, it is considered as opportunity (A.20).

Time to relax

The fourth, last category of travel time perception consists of people who see travel time as time to relax. Those are the ones perceiving travel as opportunity, and at the same time choosing to spend it passively. **Pleasure from driving** often determines belonging to this group (A.21).



Travel time perception:

CHRIS: *Yeah, I like driving. (...) I love to drive, and also I love to bike. Less PT. I don't like so much PT. So I prefer either bike or drive. (...) Yeah, of course when you are driving, you don't do anything you're just driving. I cannot do any work.*

MODERATOR: *But it makes you happy, you said so.*

CHRIS: *Yeah*

Activities:

CHRIS: *“Then (when driving) I listen during the driving to music or radio or just nothing, just take care of driving.”*

PT travelers perceiving travel time as time to relax, see the travel as a **resting moment**. It is a private moment during the day to calm down and rest. Some participants stressed the importance of having such moment in the daily routine (A.22).

Travel time perception:

CAROLINE: *“For me the work should be done in the office, the time during the PT or cycling is for myself. I just want to concentrate, be free, it is a kind of a rest.”*



Activities:

“CAROLINE: I prefer to do nothing.

MODERATOR: OK, and if you are doing nothing, what is doing nothing?

CAROLINE: Just check on my phone, or talking to, if I have a company. Talking or yeah.”

4.1.4.2. Perception and use of travel time for AVs

From the FGs it becomes clear, that for AVs travel time will be perceived differently than for current modes. This transition of perception is introduced below in two steps. First, the new (AV-specific) categorization of travel time perception is presented. Secondly, the reasons behind this change are addressed, namely the change of meaning and significance of the factors. Moreover, the transition of travel time perception entails two AV-specific phenomena, presumably having important significance for the actual AVs use: a feeling of being “trapped” in the vehicle and increased pressure to perform activities when travelling. These aspects will be addressed in the last part of this subchapter.

New (AV-specific) categorization of travel time perception

Currently, the way travel time is perceived highly depends on the mode of transport. In case of AVs the advantages of various modes are combined. It means both removing the existing disadvantages of a car (e.g. necessity of driving) and PT (e.g. limited privacy) and combining their benefits (e.g. flexibility of a car and freedom to perform activities in PT). A common way is then treating the **AV as a kind of ‘private PT’**. This point of view appeared frequently during the FGs (A.23).

LINDA: “Well, I really see it as a kind of individual PT, individual automated transport. The two conveniences of the current means of transport are combined, in PT you do not have the worry about the fact that you have to pay attention in traffic, you have the freedom of: I get into the car when it suits me and that car is ready for me at front of my door.”

In case of this “new mode”, different factors are decisive for travel time perception than for conventional modes. One of the most obvious is the interior. Depending on the internal design, the AV **can resemble either home or work environment**. This way of thinking was very common during the discussions.

ELISABETH: “Yes, it will be a kind of extension of your work or of your home.”

LAURENS: “Yes, it's just convenience, it's an extension of what you're doing.”

RENATE: “It will also be an extension of home, because at home you just do what you feel like doing. This will also be like that.”

LINDA: “If you switch mentally then you are somewhere else.”

GABRIELLE: “Yes, it's an extension of your office then, actually.”

If the vehicle is seen as extension of either home or work, travel time is perceived in terms of opportunity rather than a burden. Therefore, the horizontal axis in Figure 18 does no longer represent burden and opportunity, but only different dimensions of opportunity: on one hand opportunities of

work environment, on the other hand opportunities of home environment. Based on that, the categorization of travel time perception for AVs is proposed as follows:

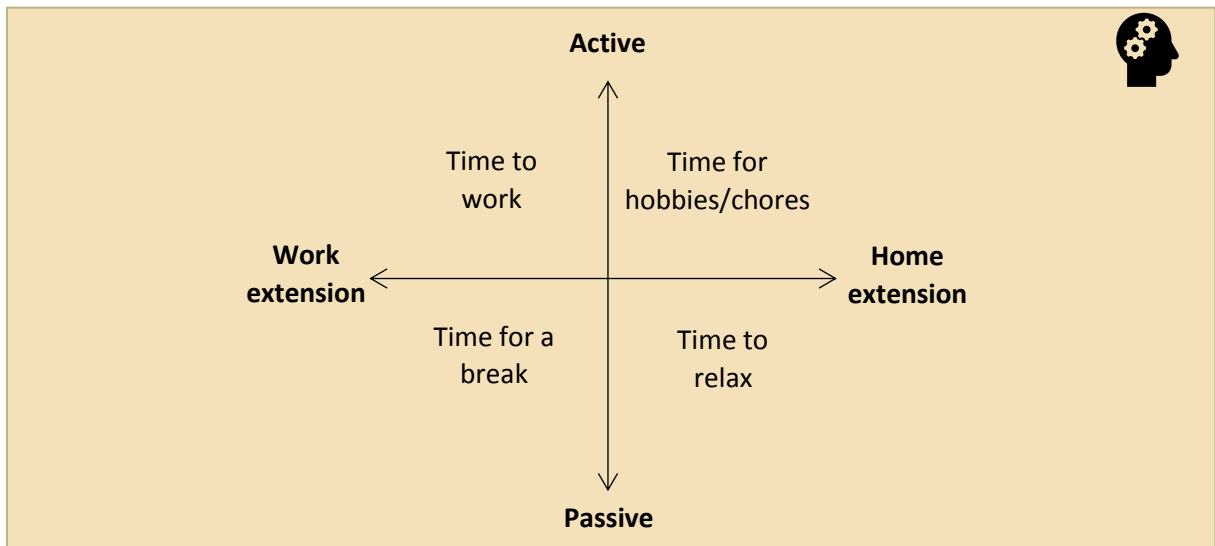



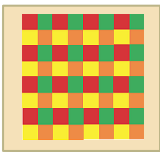
Figure 19. Categorization of attitudes towards travel time for AVs

It is important to note that terms “work” and “home” refer here rather to activities than places. Namely, when serving as a “home extension” the AV is not an extension of the house as such, but rather an **extension of private life**. Thus, also private activities not associated primarily with home are included in this category, e.g. exercising (associated rather with a gym).

Transition from the current to the future (AV-specific) travel time perception

Although the new categorization is justified by some explicit statements cited above, it requires more precise explanation. To justify why the “new” categorization is more suitable for AVs than the “old” one, it is necessary to address significance of each factor for both AVs and conventional modes.

In this section, the impact of every factor is visualised in the context of both “old” and “new” categorization. However, it is impossible to visualize the impact of all the factors. Therefore, different cases were distinguished and visualized in a different manner. Meaning of all the graphical elements is addressed in the table below.

Element	Meaning
	<p>1. Impact of the factor on falling into specific travel time perception category exists and can be conceptualized. This is the case for most of the factors.</p>
	<p>2. Impact of the factor on falling into specific travel time perception category exists but cannot be conceptualized. These are the factors which have impact but it cannot be determined in separation from other factors.</p> <p>An example is travel duration. If it is short, the travel can be seen either as Wasted time (not enough time for desired activities), Time to kill (because it is not long enough for desired activities it is killed), Time for action (short time can be perfect for e.g. checking mailbox) or Time to relax (short commute might be ideal e.g. for a quick relaxation). Similarly, in case of long travel time it can be either seen as Wasted time (e.g. if the travel time is very long but there are no facilities available</p>


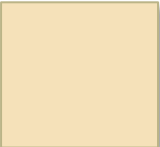

	for a desired activity), Time to kill (e.g. long travel by bus – comfort and privacy might not allow for the desired activities), Time for action (e.g. long travel in a train might be a perfect opportunity to use laptop and catch up with work) or Time to relax (the same train travel can be used for a long sleep).
	3. Impact of the factor on falling into specific travel time perception category cannot be claimed to exist with any certainty. An example can be social value of travel. Based on the statements of participants it clearly has some importance in the act of travel. However, it is impossible to say if it has any impact on travel time perception in the context of the presented categorizations.
	4. If a factor has no impact on travel time perception (or a certain category of it) no colour is used in the diagram – such fragment is left blank. This element is only applied to AVs – for them some factors lose their relevance. It has to be stressed that “losing relevance” in this context means, that the particular factor is no longer relevant for whether travel time perception for AVs falls into one perception category or another. For example, comfort is still relevant as such, but it is assumed to be on such high level, that it creates equally suitable environment for all the travel time perception categories.
	An arrow is used to explain the transition of travel time perception , in case the “old categorization” is applied to AVs. It represents the “movement” of the traveller from a certain category to another, when using an AV instead of conventional modes.

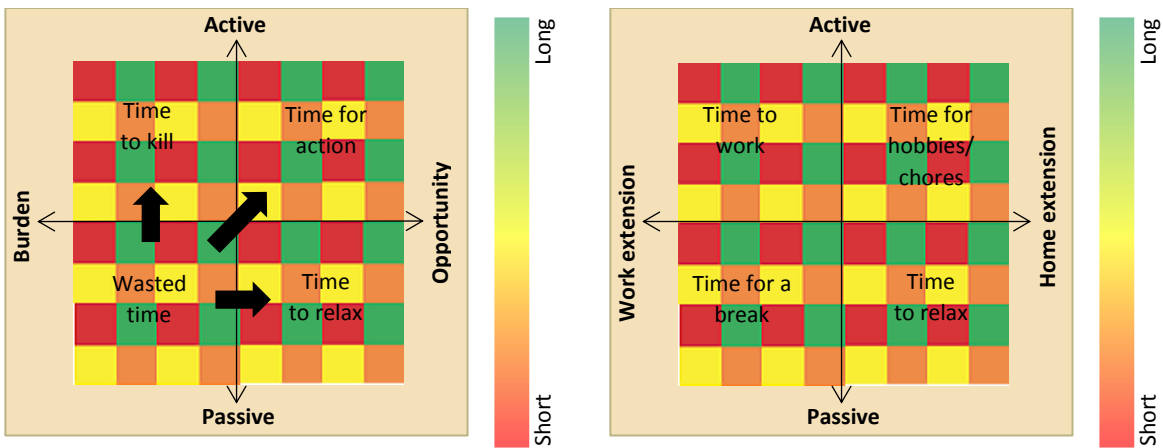
Table 6. Graphical elements used in the travel time perception diagrams

It is important to remember that ultimately travel time perception is a result of an intricate interplay of all the factors (see Figure 17). Moreover, also factors not identified during the FGs or simply random (e.g. personal character) play a role. It is impossible to say exactly how different combinations of all the factors lead to perceiving travel time in one way or another. Thus, it has to be stressed that the impact of each factor is addressed in complete **isolation from all the other factors**. For example, if travel is uncomfortable, it does not mean immediately that travel time is perceived as wasted. However, ignoring the impact of all the other factors, one could conceptualize the impact of comfort this way. Keeping this assumption in mind is crucial to avoid confusion.

Moreover, the applied graphical method does not allow to fully capture the complexity of some impacts: certain simplifications are required. The distinctions active-passive and burden-opportunity were considered **in a discrete way**: the intention of the diagrams is not to go as deep as various “levels” of these distinctions, e.g. influence of a factor on using time in less/medium/more active way, or perceiving time as a light/medium/heavy burden. Impacts on that level are not included in the graphs. Instead, the scope of the diagrams is on the level of the travel time perception categories: they show the impact of each factor on belonging to one category or the other.

Below, the diagrams for every factor are presented, addressing their meaning both in case of “**old**” (**left**) categorization and the “**new**” (**right**), AV-specific one.

Travel duration

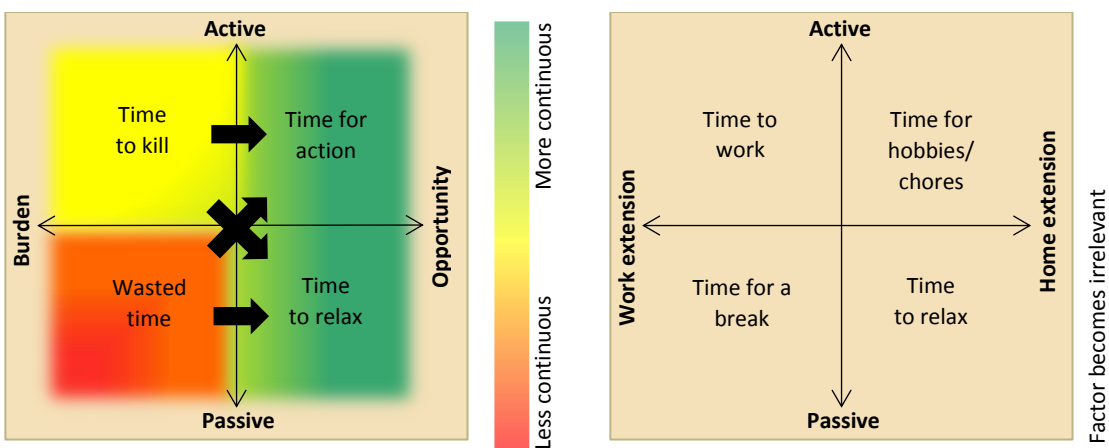


Travel duration plays important role for both conventional modes and the AV. However, it is quite meaningless on its own: its impact cannot be determined in separation from other factors. Because the burdensome influence of multiple other factors diminishes or disappears in case of AVs, the context to which travel duration is *applied* makes it unjustified to treat time as wasted.

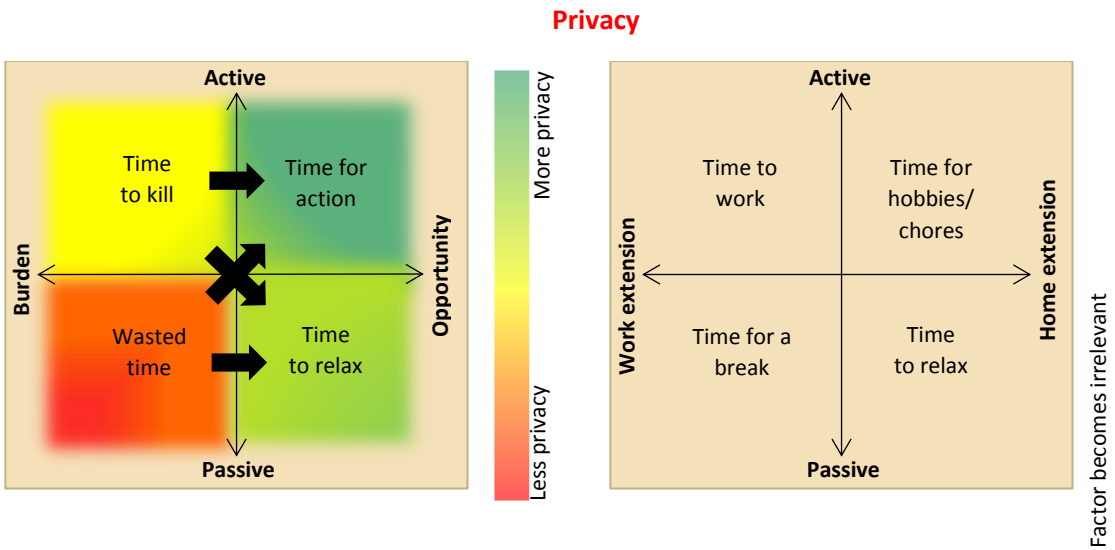
It could still be argued that very short or very long travel duration could result in seeing time as wasted. However, it is assumed that it can happen only up from a certain minimum travel duration – very short trips do not bring enough disutility. On the other hand, for very long travels it is possible that after long enough time the AV user will either lose mental capacity for the task performed on-board or get tired with the confined space of the vehicle. Although this inconvenience was recognized by the participants, it seems to not be strong enough to treat the time as wasted. Thus, for AVs an “outflow” of people perceiving travel time as wasted to other categories is visualised.

For the diagram on the right the impact is quite straightforward: different travel durations are appropriate for different activities in different circumstances

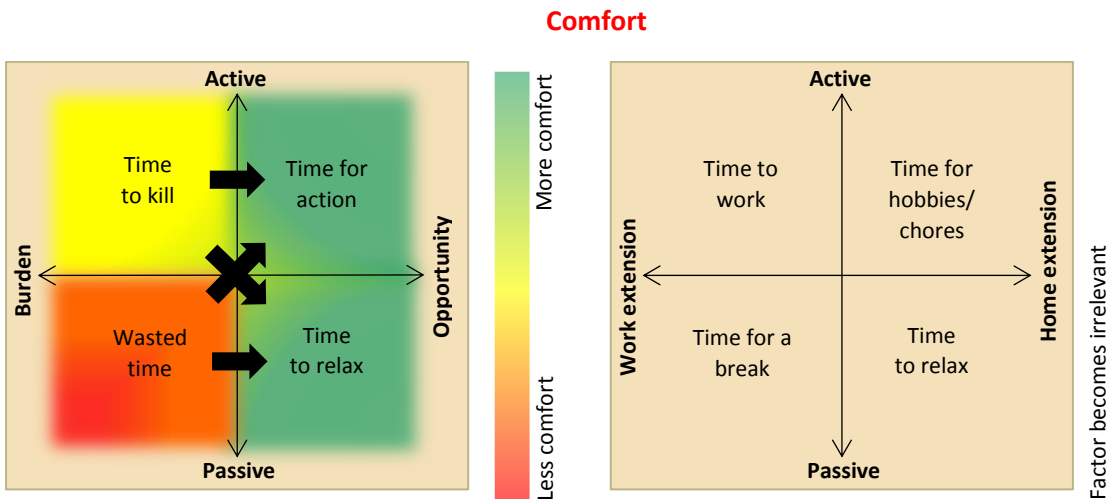
Travel continuity



Travel continuity loses its significance for AVs. It can no longer be a reason why the travel is a burden, which is visualised in the diagram on the left. The factor is no longer relevant for AVs.

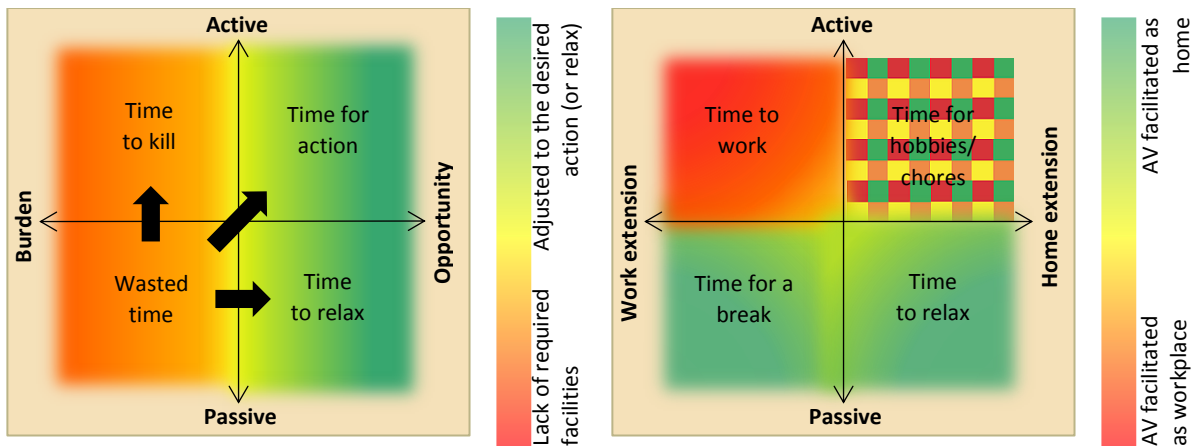


Similarly, also **privacy** becomes irrelevant for AVs – they provide full privacy (at least if they serve as private vehicles, like in the FGs scenario)



Also **comfort** loses its relevance. Comfort is expected to be remarkably higher for AVs than for conventional modes (comfortable seats, no noise, no need to stand, self-designed interior etc.). In the sense this factor is defined it is seen as irrelevant for AVs.

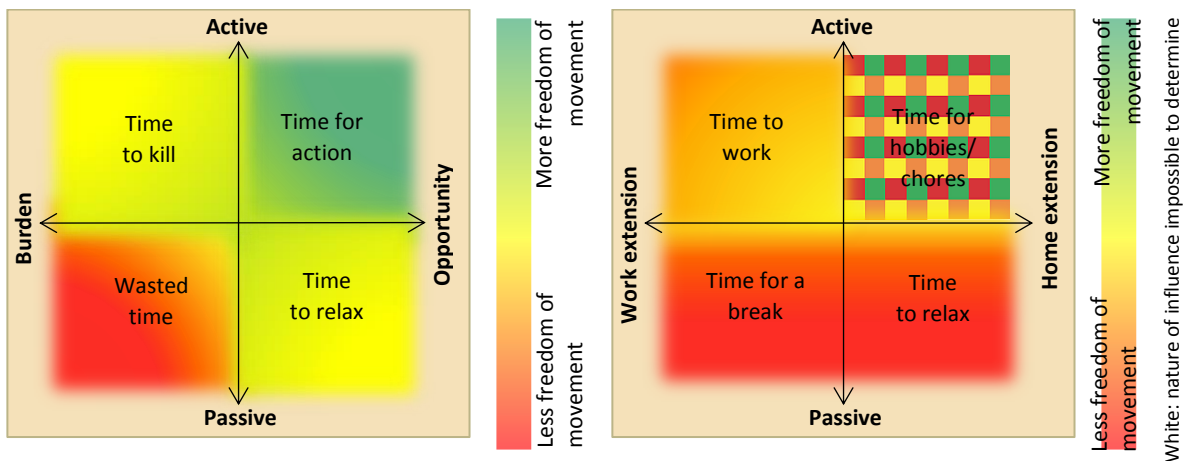
Facilities



Facilities still maintain an important role for AVs. If they do not allow for performing the desired activity, it is undesirable from the point of traveller. However, in AVs still a broad variety of actions is possible. It is always possible to perform a range of alternative activities, still likely to bring positive utility. Therefore, the worst considered case is that AV time would be treated as time to kill.

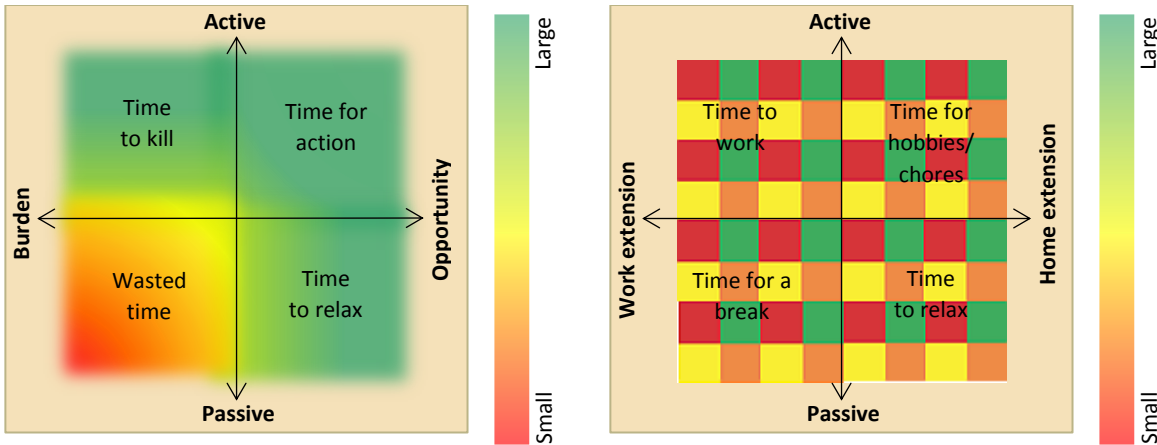
In case of the AV-specific categorization on the right, facilities on-board are decisive for whether AV is more suitable for work or for home activities. Whereas working usually requires no more than a desk and comfortable seat, for non-work activities the range of required facilities might be much broader: it might range from a gym set to a large TV screen. Thus, impact on this category cannot be conceptualized in this diagram. For more passive ways of spending travel time the interior must be facilitated in a manner resembling home: e.g. with a bed.

Seatbelts



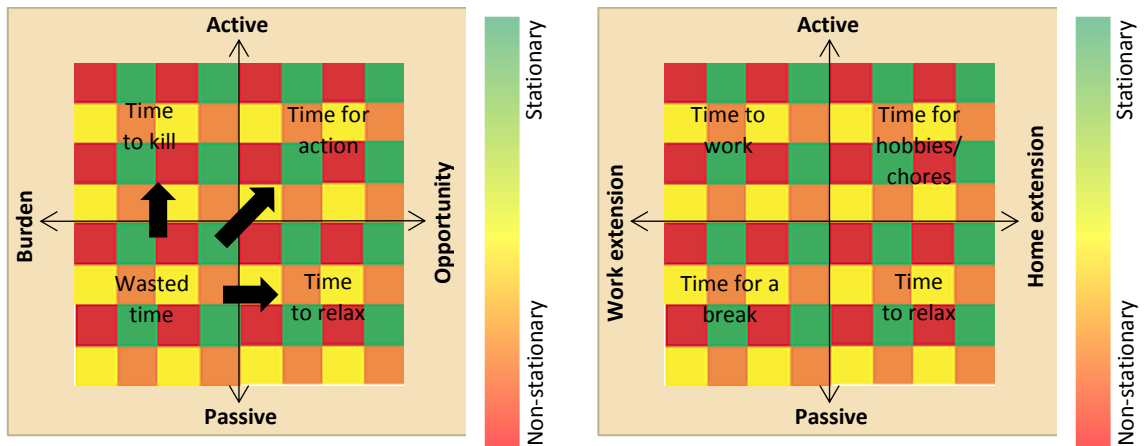
Seatbelts are still likely to have significant influence on time perception for AVs. For that reason there are no arrows in the left diagram – it is assumed to hold also for AVs. For the diagram on the right, it is assumed that whereas working (e.g. on a laptop) does not require that much freedom of movement, some private activities might do (e.g. physical exercise). Thus, the impact is more ambiguous. More passive activities require little freedom of movement.

Size of the vehicle



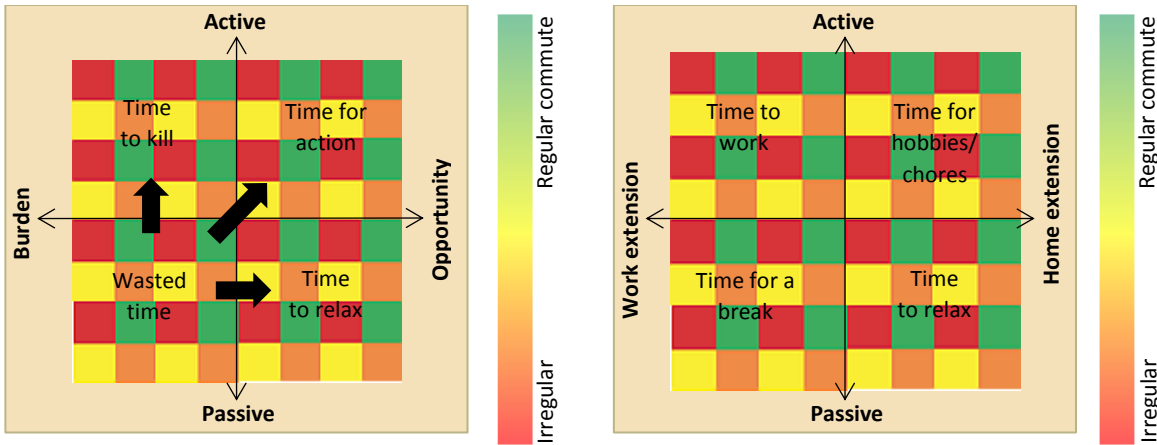
Size of the vehicle is expected to still have impact for AV, therefore no arrows are added on the left. The exact impact is however difficult to assess, which is captured in the right diagram. From the statements of the participants it is clear, that the size of the AV has its psychological impact. However, it cannot be addressed in this graph - it is elaborated more when discussing the feeling on being “trapped” in the AV.

Job characteristics



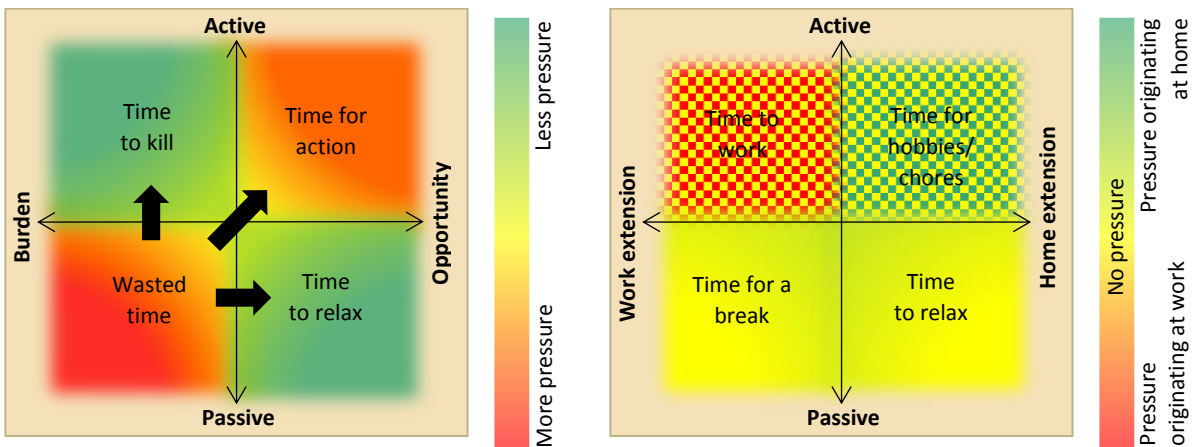
Job characteristics address whether the job is stationary or non-stationary. Although the impact of this factor cannot be shown exactly in the diagrams above, again the context to which it is applied makes it unjustified to treat time as wasted (similar as travel duration). The impact of this factor becomes more prominent in the section 4.2 – “Activities in AVs and daily activity plans” – it gains meaning with this specific background.

Flexibility of daily activity plan



Type of daily travel pattern describes whether daily trips have form of simple commuting or are more intense and irregular. The above description for job characteristics also applies to this factor.

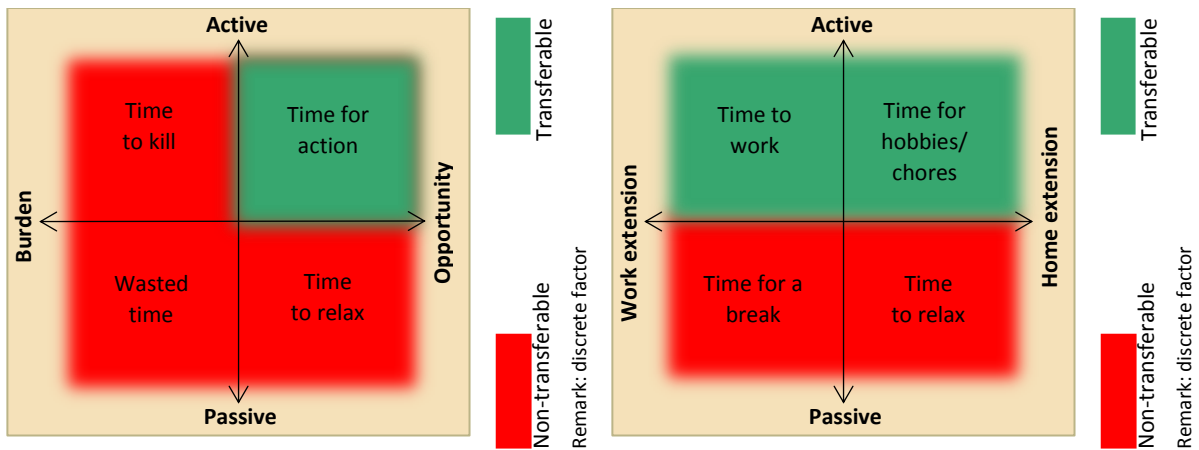
Time pressure in daily life



Time pressure in daily life is significant for both conventional modes and AVs. For the former, in case of no pressure travel time can be either killed or used for relaxation. In case pressure appears, if it can be released during travel, travel time becomes time for action. It can be done either by performing the very activity causing pressure or by performing some other activity (and saving time). If time pressure cannot be eliminated in any of these ways, the time is categorized as wasted. For AVs, the range of possible activities is so broad, that the arrows represent the “outflow” from the category Time wasted to other categories.

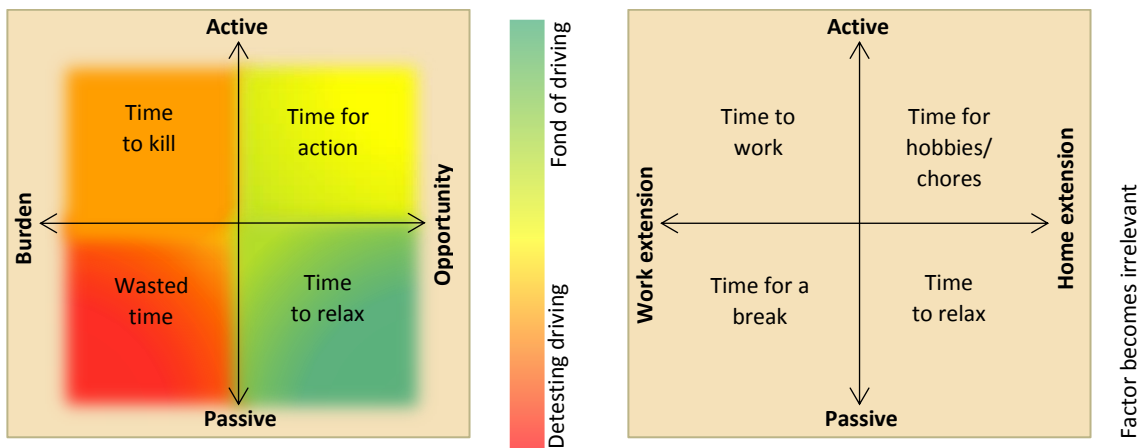
The broad possibilities are represented in the diagram on the right. The origin of time pressure is decisive for whether travel time is treated as time for work or private chores. In case of no pressure it is assumed that travel perception might belong to each category with equal probability.

Transferability of activities



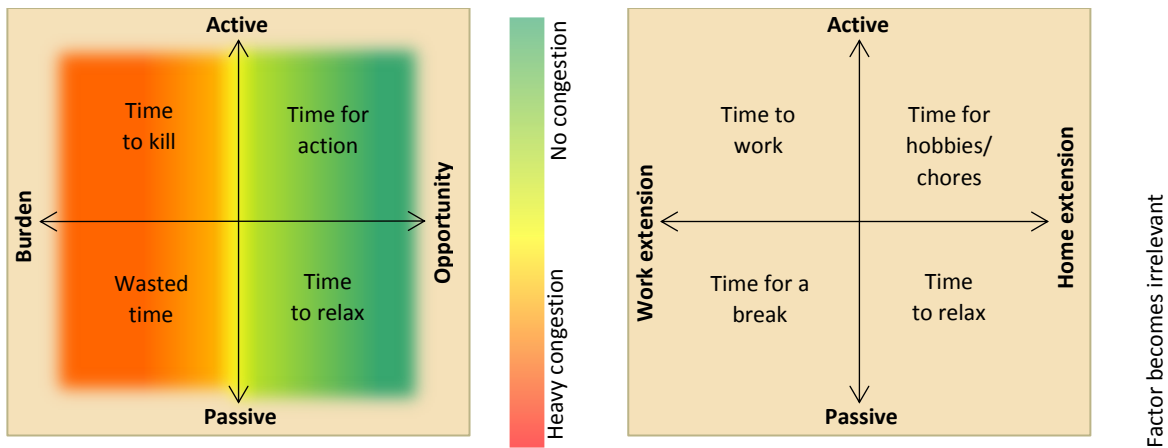
Transferability of activities is treated as a discrete value – the desired activity can either be transferred to the vehicle or not. Some actions require being at certain locations and cannot be transferred by any means (e.g. playing football or working as a shop assistant). The significance of this factor for both diagrams is fairly straightforward: if the given activity can be transferred, travel time is perceived as time for action. Otherwise, it belongs to one of three other categories with equal probability. This distinction still holds for AVs, thus there are no arrows on the left. In case of AV “action” is further broken down into “work actions” and “home actions”.

Attitude towards driving



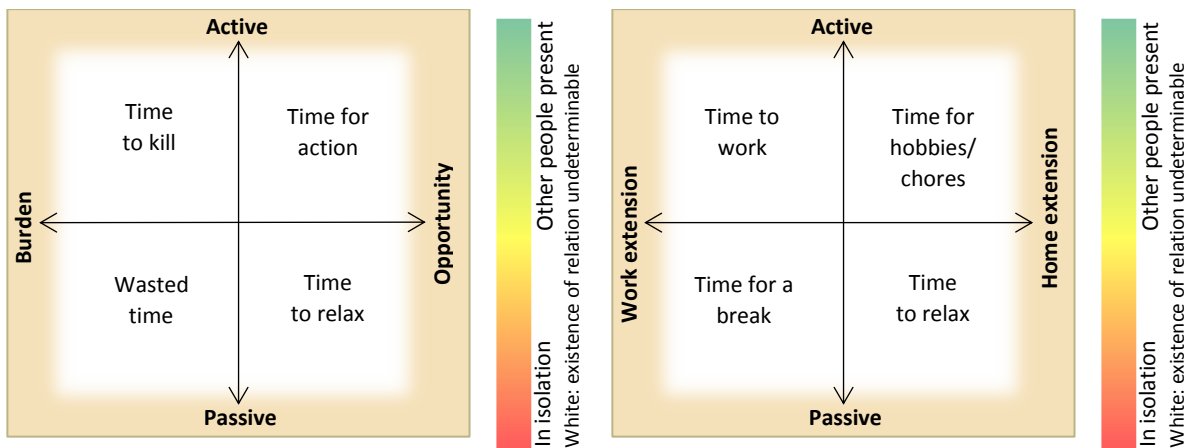
Attitude towards driving is only relevant for current modes, specifically for car drivers. For AVs the factor is considered as irrelevant, therefore no arrows are present and the right diagram is empty.

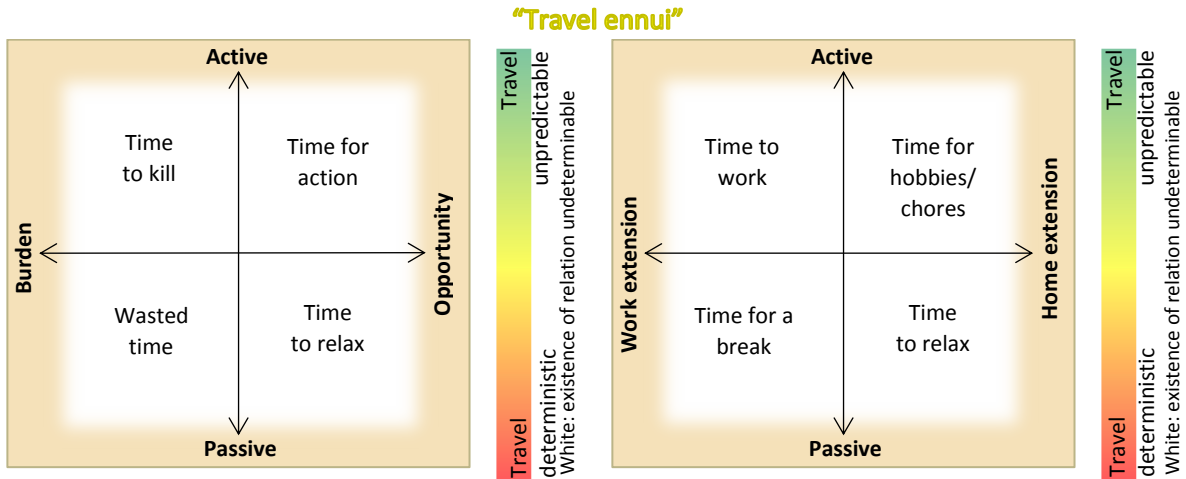
Attitude towards congestion



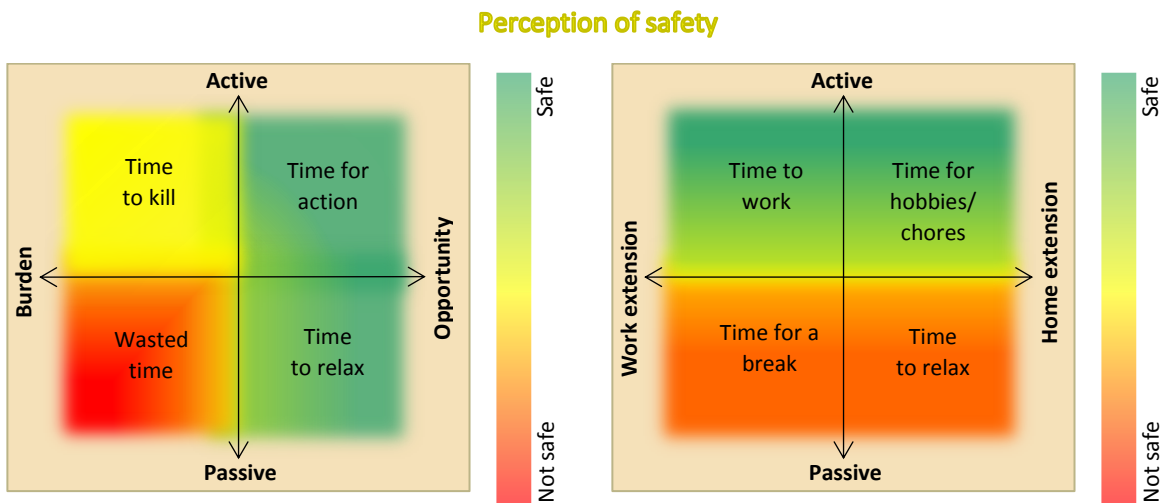
Similarly, **attitude towards congestion** is deemed irrelevant for AVs. Whereas currently it creates pressure to perform activities and gives a feeling of wasted time, for AVs it is not expected to have any impact. It would most probably be still relevant if congestion would lead to negative time effects, e.g. being late for an appointment. This is however out of the research scenario – it was assumed that the whole technology works flawlessly, including traffic flows.

Social satisfaction with travel



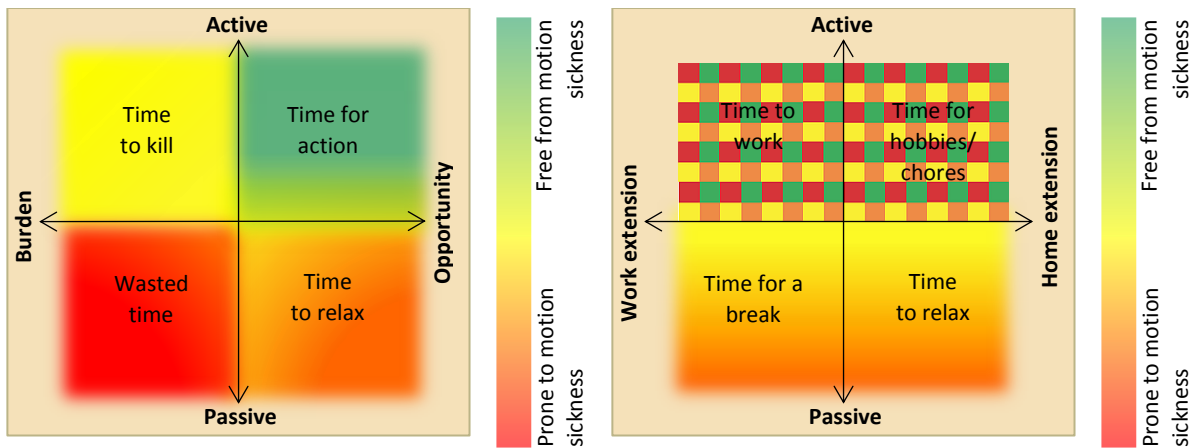


Social aspect of travel and **"travel ennui"** are both factors which certainly play their role in the act of travel. However, due to ambiguity of these factors it is impossible to say anything about their actual impact in the context of the above diagrams. Their possible significance is addressed more elaborately later in the current section, as a part of "trapped in the AV" phenomenon.



Perception of safety is seen as a factor relevant for both categorizations. However, it has to be once more highlighted that in the FGs scenario AVs were assumed to be 100% safe. Therefore, this aspect was ignored by the participants. However in real life, which the diagrams aim to capture, safety would still be important. The less safe the AV is perceived, the more passive travel time use is assumed (with the exception of sleeping).

Motion sickness



Motion sickness is a significant factor, however it was practically neglected in the FGs. The more prone the person is to motion sickness, the more the travel becomes a burden and activities become more passive. This fact is represented in both diagrams. Moreover, different severity of motion sickness for various activities is taken into account in the diagram on the right. This distinction was made because, in comparison to conventional modes, AVs provide a much broader range of possible activities.

From the above diagrams it becomes apparent that multiple factors change their significance for AVs, shifting travel time perception more in the direction of opportunity rather than a burden (which is represented by the arrows). Combining this shift with the impact of external factors leads to perceiving the AV as an extension of either work or home.

Moreover, a number of factors becomes irrelevant for AVs travel time perception. Furthermore, significance of some factors was difficult or impossible for the participants to express. Some of them are too intangible, e.g. social aspect of travel. Although it was recognised as a significant element of travelling, its exact value remains unknown:

NORBERT: “(...) Currently, you walk around a bit on the platform, or see who is in the subway, in the train, you watch what people look like, you hear how people talk (...). (In PT) something strange happens and someone makes a joke about it, that's a funny moment right? And all those kind of moments you will miss. I don't think people like to meet each other when traveling by PT, but it is becoming more individualistic (with AV). What the essential value of it is, I am not sure.”

Some other factors were impossible to imagine accurately (e.g. importance of seatbelts) or were simply neglected by the scenario of the FGs itself (e.g. safety). Therefore it is important to keep in mind that, **in the FGs context, the participants built their statements on AVs use based on a limited number of factors**. Although the mentioned factors appeared during the discussions, it was either incidental or raised as a general remark. Their impact on the overall discussion on the activities, activity plans and travel decisions was very limited. To illustrate the factors which played major role in the discussions, both the irrelevant factors and those likely underestimated are highlighted below in the diagram of travel time use mechanism.

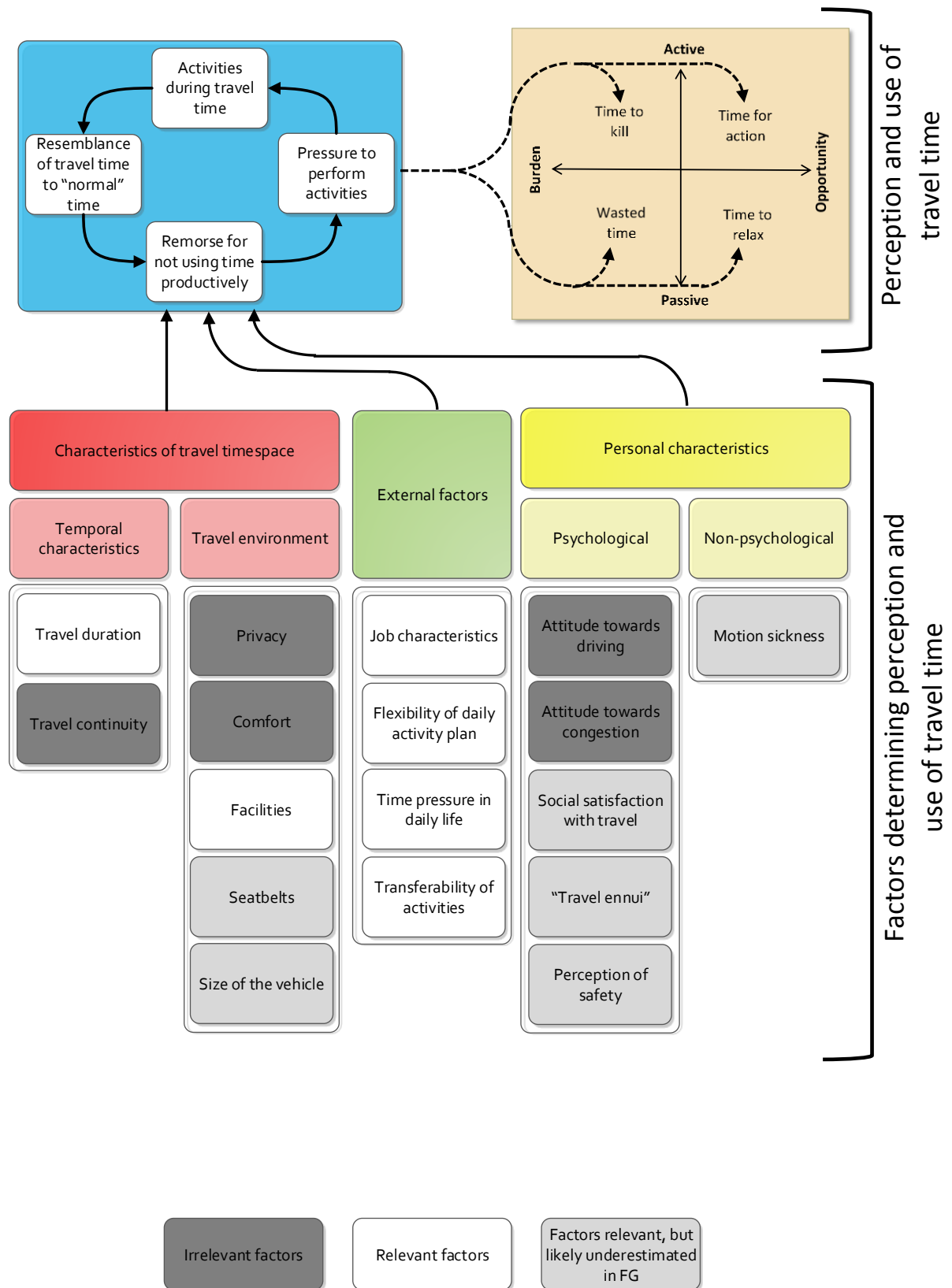


Figure 20. Travel time use mechanism for AVs

After leaving out the highlighted factors, travel time use is determined predominantly by external factors and the AV interior. A specific role is played by travel duration – it allows the timespace to materialize as either home or work extension, depending on external factors and facilities. **However, it has to be noted that although such dichotomous way of looking at AV time reflects the way the participants were mostly thinking in the FGs context, it might not fully hold in reality.** The fact that some burdensome factors become irrelevant and others are difficult to grasp makes it impossible to imagine how travelling in the AV would actually *feel*. Although these factors were largely neglected when talking about activities in AVs and travel and location decisions, their possible impact can be expressed by two AV-specific phenomena: increased pressure to perform activities and a feeling of being “trapped” in the vehicle. These two concepts will be now addressed in more detail.

“Trapped” in the AV

Presumably due to a combination of psychological factors and limitations of AV interior, people still assign certain disutility to the time spent in such vehicle. The AV interior is still a confined, isolated space, which might cause a sort of claustrophobic feeling.

ELISABETH: “Because you're just locked up. I mean you can do a lot, you can have a lot of contact, but of course not really. Of course you can shop on the web or cut your stuff. You're just locked up in a small physical space.”

Similar statements appeared frequently in the FGs (A.24). In the diagram below, the factors which seem to be relevant for this feeling are presented. All these factors can be deemed as underestimated in the FGs discussions. “Travel ennui” is represented by “Intensity of unexpected external stimuli” (to show the direction of influence), other elements are self-explanatory.

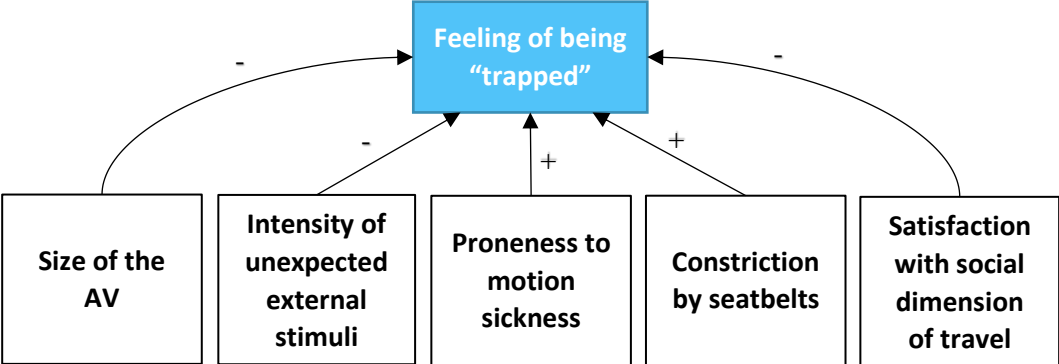


Figure 21. Factors influencing the feeling of “being trapped” in the AV

It can be further hypothesized that the feeling of being “trapped” is not only dependent on the five above factors, but is also a function of travel duration and frequency. Whereas the factors in the figure directly cause the “trapped” feeling, it cannot be stated that more frequent or longer travelling itself makes one feel more “trapped”. These are rather secondary factors, which together provide a context in which the above mechanism might be more or less intense and burdensome. This relation is shown in the diagram below (travel frequency and duration combined constitute “travel intensity”):

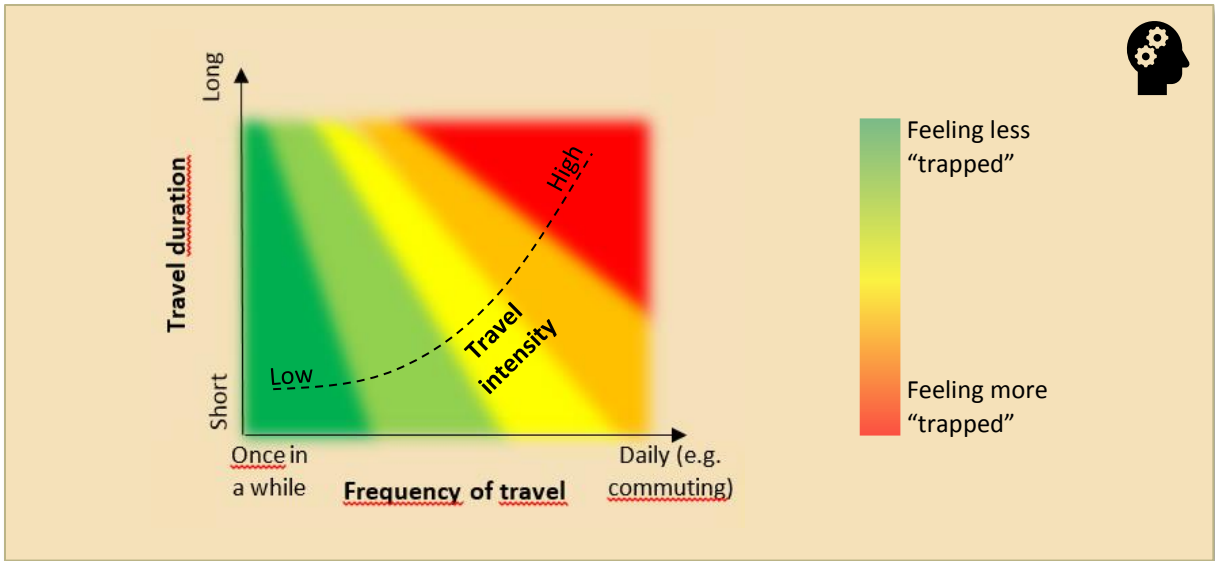


Figure 22. Travel intensity and the feeling of “being trapped”

The above relation is hypothesized based on statements from the FGs, particularly those regarding “Travel ennui” and Social satisfaction with travel. Although they do not point it out directly, they hint at significance of these factors especially in case of daily travelling. Thus, it is presumed that AVs might be a better alternative for less regular, special travels rather than daily commuting. In fact, in case of such travels being isolated might be seen as a benefit, while it likely becomes more burdensome on a regular basis, e.g. in case of commuting.

The phenomenon of being “trapped” shows that in reality travel time perception for AVs might not always vary between categories “home extension” and “work extension”. Presumably, the higher is the burden of being “trapped”, the less accurate is treating travel time as any of these extensions. Thus, although such dichotomous categorization reflects people’s way of thinking in the FGs, in reality this “discrete” distinction is unlikely to hold at all times. The longer and more frequent the travel, the more it could resemble a burdensome “trap”, as in the figure below.

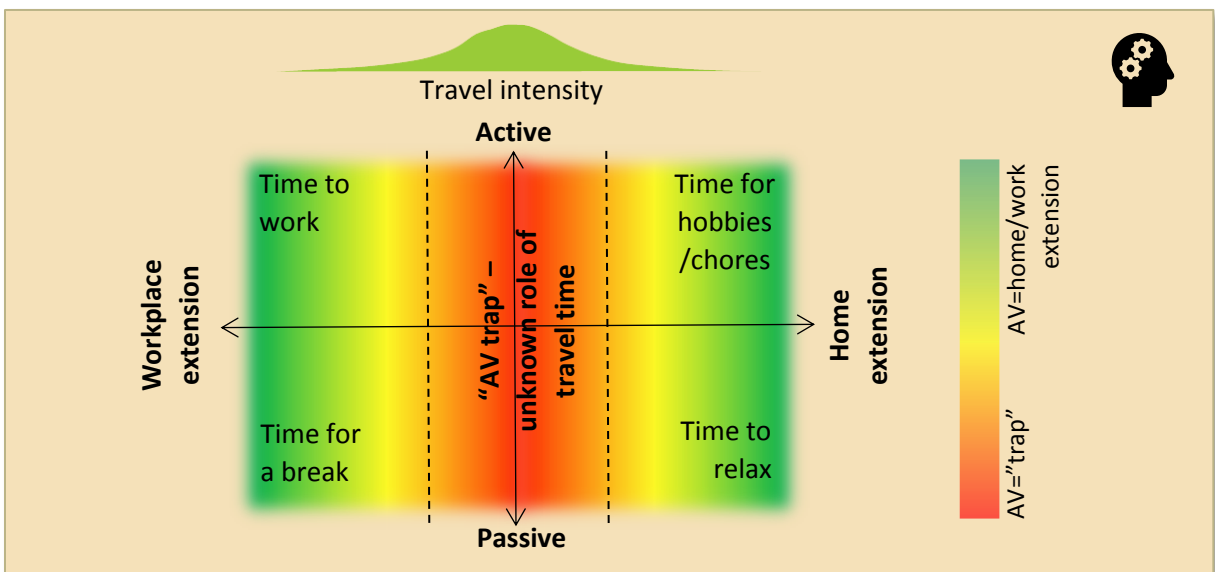


Figure 23. Hypothetical impact of “being trapped” feeling on travel time perception for AVs

Increased pressure to perform activities

Another AV-specific phenomenon is the possibility of increased pressure to spend travel time actively. Similarly to the feeling of “being trapped”, it is related to the factors underestimated during the FGs, but also to those which lose their relevance for AVs. The figure below is a new, AV-specific version of Figure 17. Factors deemed irrelevant were removed, and the underestimated factors were coloured grey.

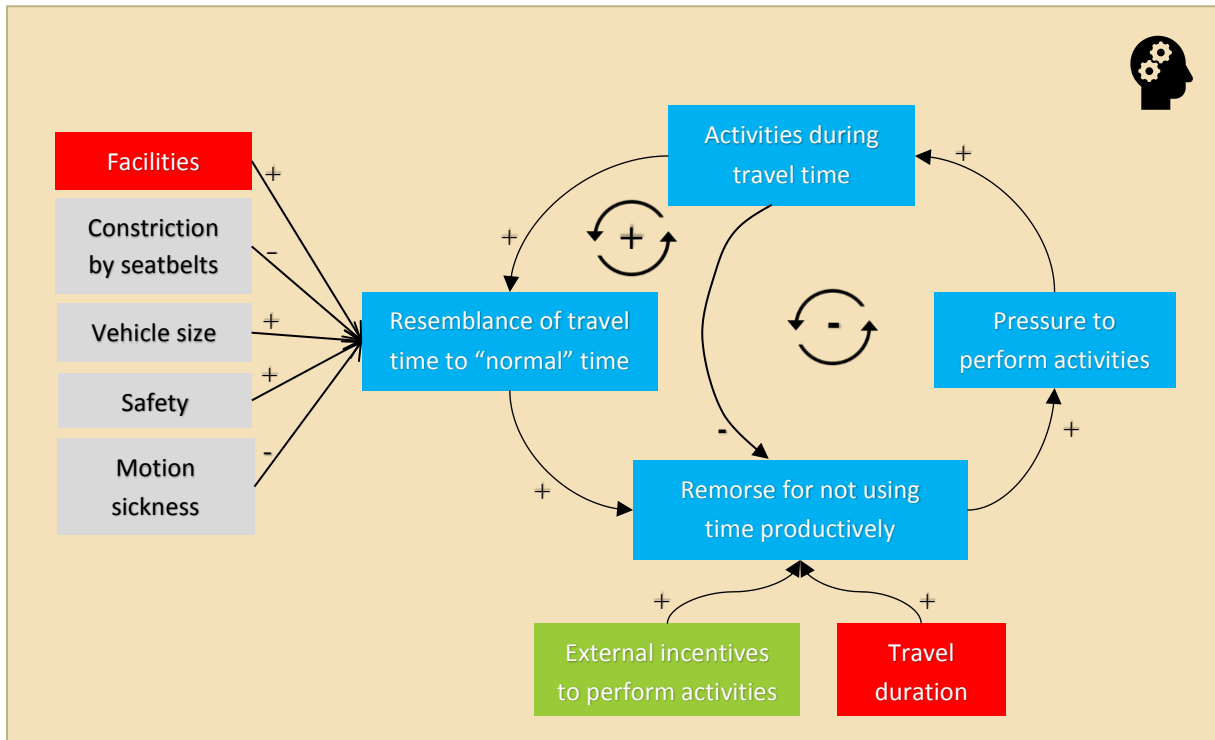


Figure 24 Increased pressure to perform activities for AVs.

As it can be seen, pleasure from driving no longer counterbalances the remorse. Multiple factors reducing resemblance to “normal” time lose their significance: they either become irrelevant or are underestimated. As a result, the impact reducing the remorse and pressure to perform activities weakens. Moreover, as travel duration increases and external incentives intensify, more and more pressure appears and reinforces the loops. Similar kind of pressure mechanism was earlier addressed for car drivers in case of congestion. The participants recognized it also as a potential threat of AVs:

ERIC: *“The expectation pattern is present, you cannot choose anymore. You may want to spend some quality time with your partner in that car if it drives on its own. You can just say there's nothing to check, data and that kind of things. What you just said, I also understand that, email, if the content of the email is not positive, you are really busy in your head with that email. Definitely, if you're behind the wheel, if you drive an electrical car, of course, you're supposed to do it anyway. You almost have to...”*

It was pointed out, that even though some of the participants expressed the willingness to use AVs for relaxation (as a home extension), in fact the travel time might be used for work anyway (A.25).

“PETRA: *That's what I am wondering about, because I also think people will work more because of this. So people can use that time to relax or to work even more.*

PIETER: Yes, that is correct. You will work for more hours. Not only the hours in your car but also the hours after or before you work at home or at the company. Yes, then you will work more.

PETRA: You can plan it differently or more useful, I understand that, but I think it's a pitfall for people to misuse that time. Then I think that you only get overworked."

Pressure to work might be also increased by external incentives, coming from the employer. An expectation might arise that the employee will also work during travel. The work pressure might be also driven by the employees themselves. If some will start to spend the AV time on working, others will have to follow in order to "keep up", thus reinforcing the "AV rat race".

"RENATE: And if you like to work, you put a desk in it.

MODERATOR: It is interesting, what do you think of Petra's comment, that it might also be a pitfall.

PIETER: Yes, that chance is quite big, because the hours you're in the car, that's working hours. (...) Of course, your employer may also expect that you work inside the car. You have an AV, so you can work in the car for 3 hours."

Due to the mechanism of increased activity pressure it is possible, that instead of improving the quality of life AVs could eventually lead to its deterioration.

"MODERATOR: Yes, that is also interesting, I personally find that interesting. How this will look like. What working days will look like. And for you, will life become better or worse with AV?

RENATE: Yes, better, if we don't misuse it."

4.2. Activities in AVs and daily activity plans

After addressing the general mechanism of travel time use, it is possible to focus on travel activities in a broader context, namely on their interrelation with daily activity plans. Whereas the preceding discussion concerned also travel time use for conventional modes, the remaining part of the document concentrates only on activities in AVs.

As already noted (see Figure 20), in case of AVs three main factors play a role in determining travel time use and perception – AV interior, travel duration and external factors. Taking this into account, the identified roles of AV travel time in the context of daily activity plans are presented in the figure below. The diagram is structured with respect to external factors: time pressure in daily life and job characteristics. Travel duration is inexplicitly expressed by job characteristics. The interior characteristics are captured by showing as which of the two (work or home) extensions the AV serves in each case.

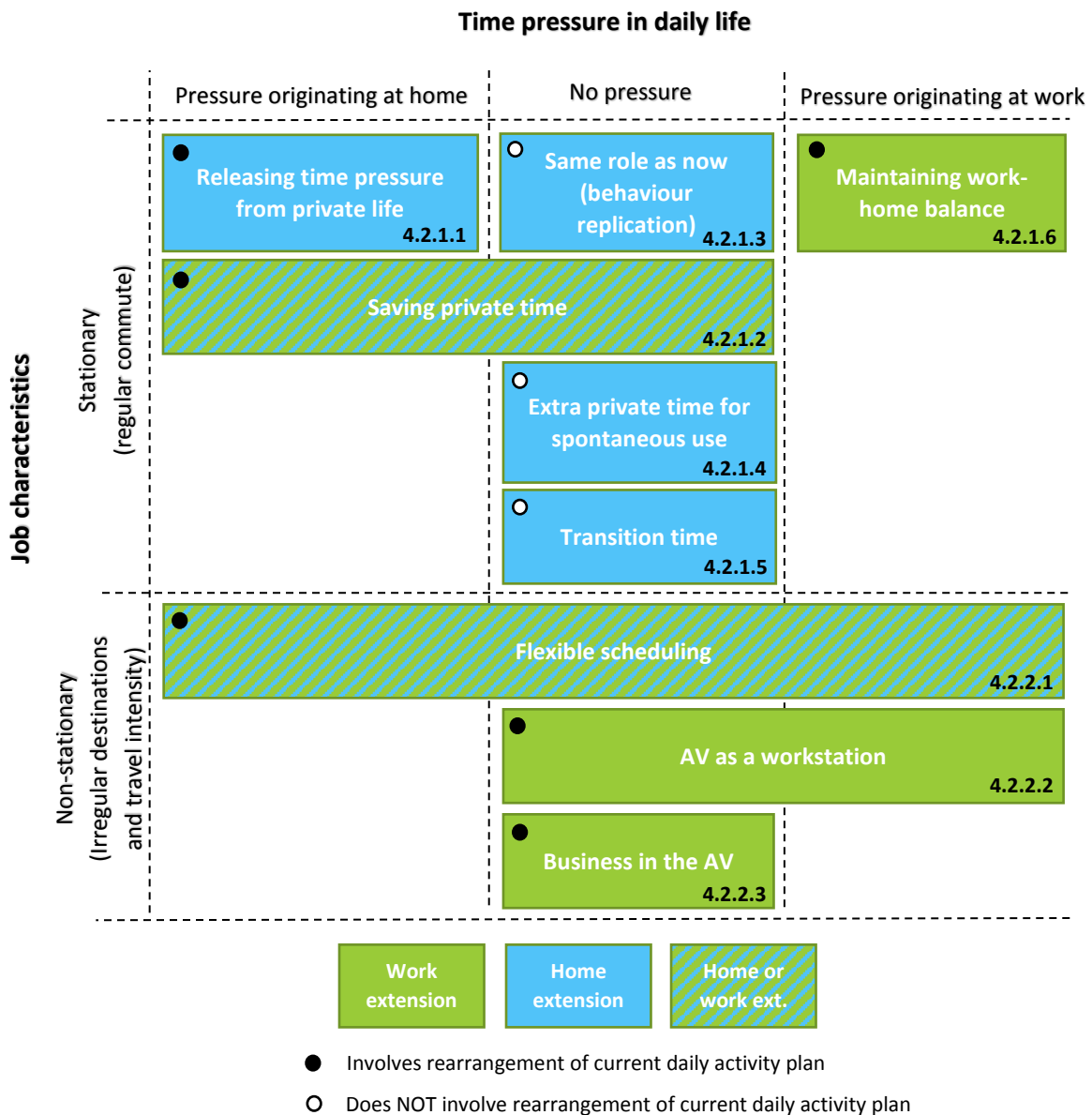


Figure 25. Identified roles of AV travel time in the context of daily activity plans.

In the following section, each of the categories shown in the above figure will be addressed separately. To structure the results, first behavioural adaptations for regular commuters (stationary job) will be addressed, followed by possible adjustments for people with irregular daily travel patterns (non-stationary jobs). Moreover, it was also found, that some participants exhibit scepticism about the actual impact of AVs on daily plans. This is shortly addressed in the subsection 4.2.3.

4.2.1. People with regular commute

For regular commuters six types of behavioural adaptation were identified, depending on whether time pressure exists in daily life and where it originates: it can be created either at work or at home (in private time). Below, various adaptations of daily activity plans are addressed, first for pressure originating at home, through cases when no pressure exist in daily life and arriving at the case when pressure originates at work.

4.2.1.1. Releasing time pressure from private life

Time pressure is generated in private life if there are too many non-work related activities and not enough private time. In that case travel time in AVs can be used to release it. Due to insufficient time, some of **daily chores are performed under time pressure**. To make daily life less hectic it is possible to transfer them into the AV.

RENATE: “For example, if I talk about traveling with children, I would really like to practice with my daughter while traveling. Speech therapy. Then we have had that while traveling. Because now it is always such a hassle. Food must be prepared, go in bath, then this, then that. That would be a big deal for me. Yes, if I can do that in there, yes.”

A frequent problem is lack of time for **morning activities**, which are done in a hurry or not done at all. Currently, some people do not eat breakfast at home or do their make-up in the car due to lack of time in the morning. AVs will allow for transferring such activities into the vehicle. (A.26)

NIK: “If you do not have time in the morning to have breakfast, you can do it on the road. Easy in the car.”

A variation of this behavioural adaptation is transferring the morning routine to the AV in order to **extend sleep duration in the morning**. (A.27)

“ARJUN: I’ll get five more minutes of sleep in the morning. At home, so I can sleep for 5, 10 more minutes. And I can get ready in my AV.

MODERATOR: So the AV saves you time.

ARJUN: Yeah.”

This idea can be conceptualized as follows:

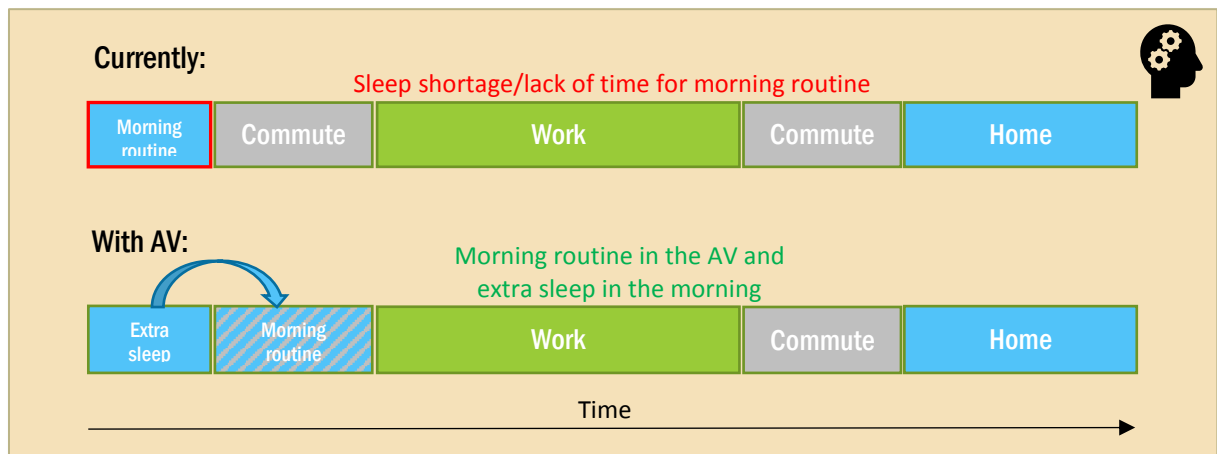


Figure 26. Morning routine transfer

Another kind of home-generated time pressure arises due to **postponing time-flexible duties** in time. Whereas for some duties certain fixed time of day is assigned (e.g. morning toilet), some duties can be (and often are) postponed in time. The time to carry out such activities is often difficult to find, and constant putting them off eventually creates time pressure. Example of such activities can be paying bills, paperwork, etc.

"FELIX: Then I get another one. My administration that I've been wanting to do for weeks, stacks of posts that need to be cleaned up. That's all possible (in the AV).

MODERATOR: Some things that need to be done.

ELISABETH: Yes, I think that I would do that too, the administration which is already stupid, if you do it on the way, you have already done it when you are on the way."

Time pressure in daily life does not only concern chores - also **leisure activities** might be negatively affected by it. On one hand, leisure time can be spoiled by pressure caused by other activities, e.g. the necessity to go to sleep at a certain time. Transferring leisure to AVs might release this pressure and bring more enjoyment to fun activities.

FELIX: "At the end of the day watching quickly an episode (of TV series), which results in staying up until midnight (...). So I can just do that in the AV. Then I think you're spending more time on leisure activities, I feel so busy that I have to watch my series in a rush. So now it's not really relaxing if I'm watching an episode at home. So I would indeed do that in the AV."

The extreme situation is when time pressure in private life is so high that it causes **lack of time for leisure activities**. In such case, AVs could "liberate" extra time that might be used for that purpose.

CAROLINE: "I think in my AV I would do something for what I never have time. For example, maybe use the car as karaoke salon. I will sing, but now I don't have to do that. So I don't substitute that time, the working time. So I use it for something that I have never get time for."

4.2.1.2. Saving private time

In case no time pressure appears in daily life, AV travel time can be used in various ways. One of them is taking the advantage of the AV to save private time. This type of behavioural adaptation bears some resemblance to the preceding one, but it does not contain a clear time pressure element. Certain activities are performed during travel to gain extra private time – not to release explicitly existing time pressure. However, it is possible to argue that if one decides to save private time anyway, it is still an indication of private time shortage. Thus, this role of travel time is stretched in the diagram over two time pressure categories: no time pressure and pressure generated at home. The obtained extra private time might be used for other activities, but it is not clear for what exactly.

ERIC: "Because you save time, that is why you have time, so if you step out of the car, you now have more time to do other things that you might not do at the moment."

Saving time might be realised in various ways. One idea is performing **inevitable daily chores** during travel time. An example is cooking, which occupies part of daily private time for people who dine at home. By transferring (part of) the cooking into the AV, this private time can be saved and used e.g. for leisure.

"MODERATOR: Yes, you can cook and you do not have to cook at home anymore.

JOHANNA: Or cut indeed.

MODERATOR: Yes, indeed, cut."

MAARTEN: "Peel the potatoes."

PIETER: *How about preparing food in the car (...). Then you arrive and then the food is ready.*

The idea can be conceptualised as follows (yellow represents chores):

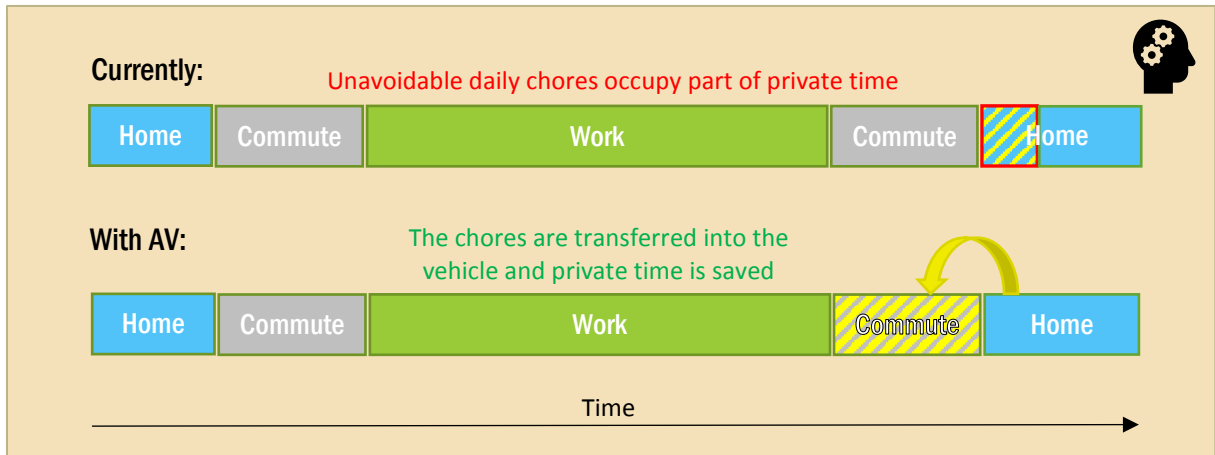


Figure 27. Transferring daily chores to the AV to save private time.

A variation of this concept is doing the regular workout in the AV instead of in a gym. The idea of using the vehicle as a mobile gym appeared a couple of times during the FGs.

“KOEN: *Yes exactly. That would be nice, if you can work out right when you leave from your work.*

LAURA: *Then you do not have to go to the gym anymore, that's possible in the car.*

KOEN: *And then you can go home right away.”*

Next to the possibility of transferring activities originating on private side of life, there is also the opportunity of saving private time by **transferring work to the AV**. Using commuting time to work would reduce the time that has to be spent in the office and save time for private activities. (A.28)

KOEN: *“Start working earlier. Then I am more at home. Then I have already spent two hours on work. Then I have more time left for myself in the evening. Then you could eat with friends. More often to the gym. More often to the cinema. Those kind of things. So you adjust things for your social life. But for work, yes, you can work in the AV.”*

Theoretically, in such way the daily amount of private time could be extended by the duration of total current commuting time. This concept can be visualized as follows:

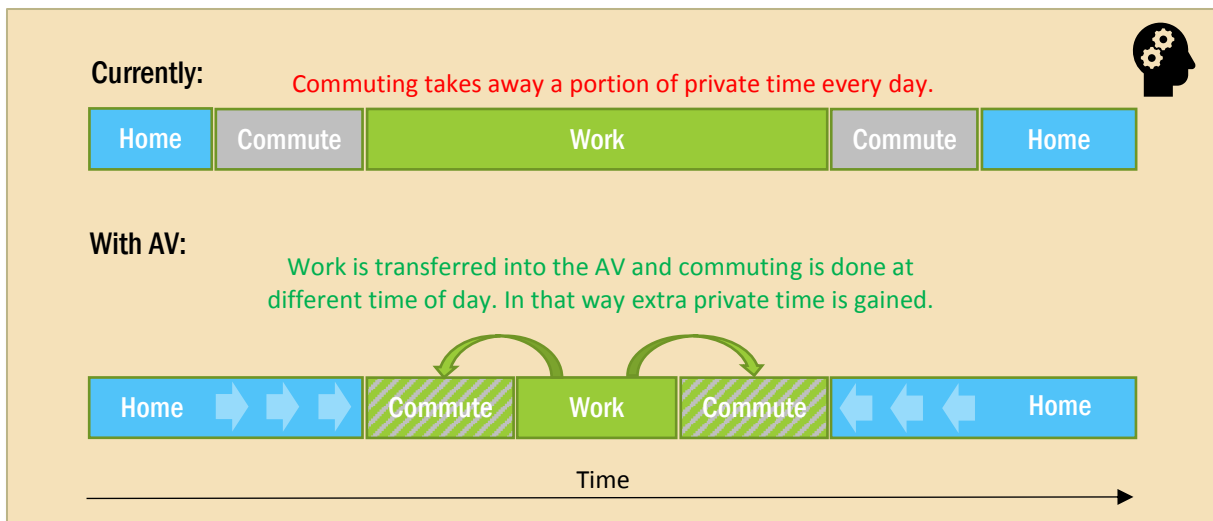


Figure 28. Saving extra private time by working during commute.

Saving time in this way might lead to further rearrangements of activities in private time:

GABRIELLE: “Yes, if I’m home earlier, say 20-30 minutes, then I’m at the gym earlier. That’s another bonus.”

Of course using AV travel time in this way depends on whether travel time is accounted as working time by the employer or not. If not, people are not willing to use the AV for work in case there is no explicit time pressure originating at work. Another necessary prerequisite is transferability of work: not all jobs are equally suitable to perform in a vehicle.

4.2.1.3. Same role as now (behaviour replication)

Another type of behavioural adaptation in case of no time pressure in daily life is simply replicating current travel behaviour. On one hand the willingness to do so is typical for people who are **satisfied with current travel time use** and daily activity plans. Furthermore, if a **well-established travel routine** exists, the chances are higher that the person will be willing to replicate the behaviour (A.29).

Current travel behaviour:

NORBERT: “My journey lasts from door to door, forty-five minutes to an hour. In the morning I read the newspaper, nothing else actually. In the afternoon, every now and then the newspaper, usually my phone or I do nothing, listen to music. Yes that is it.”

Current satisfaction with travel time:

NORBERT: “Yes, it is for my work, I must of course stay updated about news. But I also find it very relaxing. It is a very nice ritual, very relaxed. (...) I really like it this way”

Behaviour in AV:

NORBERT: “No, I do not think I would change anything. Ideally, you could do everything, in such a car. Brushing your teeth, putting on your lenses, everything. For me personally, the difference would not be that big. I do not have to concentrate at all in the morning. I’m just going to sit down. How I would spend my time would not be very different.”

On the other hand, an important reason for behaviour replication can be **difficulty to imagine** any possible activity rearrangements. The idea of travelling in an AV is so abstract that some participants cannot get a clear idea about the potential use of time in the vehicle (A.30).

Current travel behaviour:

LAURA: *"I vary between car and train. By train I travel back and forth to Rotterdam within half an hour. Ideal. I spend an hour when traveling by the car. You're just an hour on the road, you're in a traffic jam. It is completely jammed in Rotterdam. I just listen to my radio. When I am on the train, I am very relaxed. I do not prepare work in the train, I do not need that for my job. I call my sister."*



Difficulty to imagine:

LAURA: *"I do not sit in a car very often. (...) I do not think that I can save a lot of time in the AV. I drive to my father in Utrecht for an hour, then I do not know what to do. Yes, look outside. (...) Yes, I find it very difficult, what am I going to do in such a car?"*

Behaviour in AV:

LAURA: *"If I can sit in it, I just sit and look outside and I think, enjoy nature."*

Another possible reason might be also **lack of external incentives** to change anything in daily activity plans, e.g. lack of time pressure, or having a job which is not transferable. In such case, replication of current behaviour might also be one of the possible responses.

4.2.1.4. Extra private time for spontaneous use

Some of the participants claim that they would treat AV time as extra private time. It would not be used to transfer or rearrange any of daily activities, but would rather serve as an extension of private time, for random use. Again, this behavioural adaptation is characteristic for people with less busy lifestyles, who do not seem to encounter pressure in daily lives. It has to be noted that great majority of people falling into this category can be assigned to "time to kill" category of current travel time perception. Some of them still perceive AV time in the same way:

NORA: *"I would look at my tablet or cell phone or something. Yes then I'm going to watch a movie on my tablet. Then I would indeed.. yes, then I use YouTube. Well, I don't know, or watch a TV program."*

Others however say explicitly that they would use this **time to relax or leisure**. (A.31)

JOHANNA: *Yes, it always takes (travelling) a lot of time, so it's time to kill.*

ERIC: *You do not kill time, you just have to enjoy. The freedom itself is nice, when I get in, I'm just going to do nothing or I'm going to eat or have a conversation, maybe even in the AV."*

Some people state that their choice of activities in the AV would be **spontaneous and dependent on their current mood** (A.32). Depending on the mood, the time can be spent in either active or passive way.

LAURENS: *"I would like to have multiple choices. Suppose I have a stressed day, then I want a massage chair and just my favourite music in the background. But indeed, another day I still have energy left, and then I want to exercise. (...)"*

That has to do with my mood, when I have a dip about my work, then the last thing I am waiting for is a customer who calls me and asks me something. But if I'm in a good mood, I want to have something to watch, listen to, or whatever. (When having bad mood), then I would just want something that relaxes me, while I'm just on my way to work."

This type of daily activity plan adaptation can be conceptualised as follows:

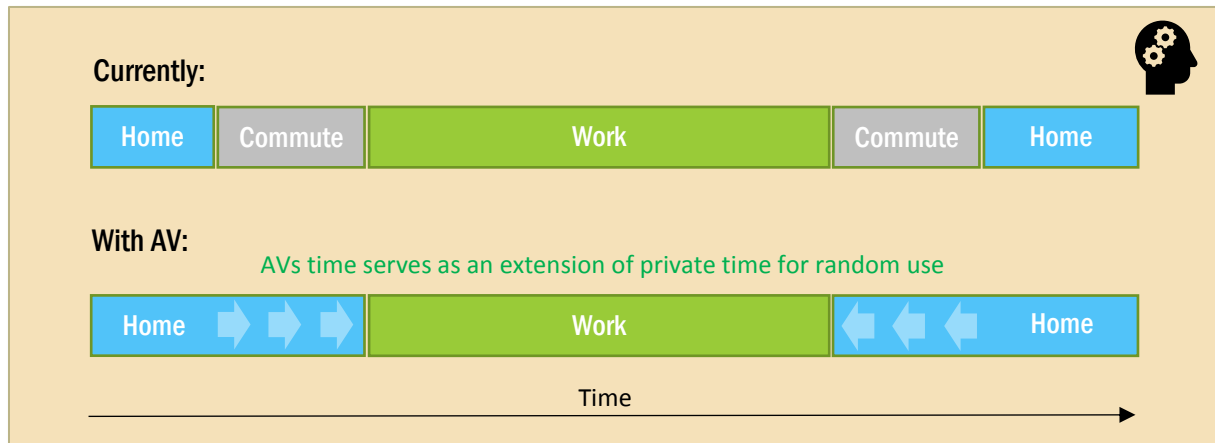


Figure 29. Extra private time for spontaneous use

The distinctive characteristic of this category of behavioural adaptation is that AV travel time is always perceived in terms of home extension, and serves exclusively for leisure. Thus, it is simply extra free private time during the day.

4.2.1.5. Transition time

Another idea in case of no time pressure in daily life is using commuting time in the AV as transition time between home and work. This way of using travel time appeared also in reference to the current use of travel time.

CHRIS: "It (the activities during travel) depends on when and how long. For example if you travel by PT, it depends when. If it is in the morning, and for instance for 20 minutes, it's good time because usually when I start working or turn on the electronic devices, first I read the news, check my email, so if it is in the morning for 20 minutes it is good."

Statements of some of the participants hint at similar use of travel time in case of AVs.

RENATE: "I would work inside the AV, on my way to work, so preparatory work."

LINDA: "For me, it would be more efficient use of time, your working time starts as soon as you get out of the door. On the other hand, your free time starts again when you step out of the door at work, or that last bit of work time you can do it on your way home. So that ultimately gives you more free time so you can be more relaxed in it."

BART: "I think I would check the news in the car. And do things I can do on my own, for work like - checking emails."

This concept can be visualised as follows:

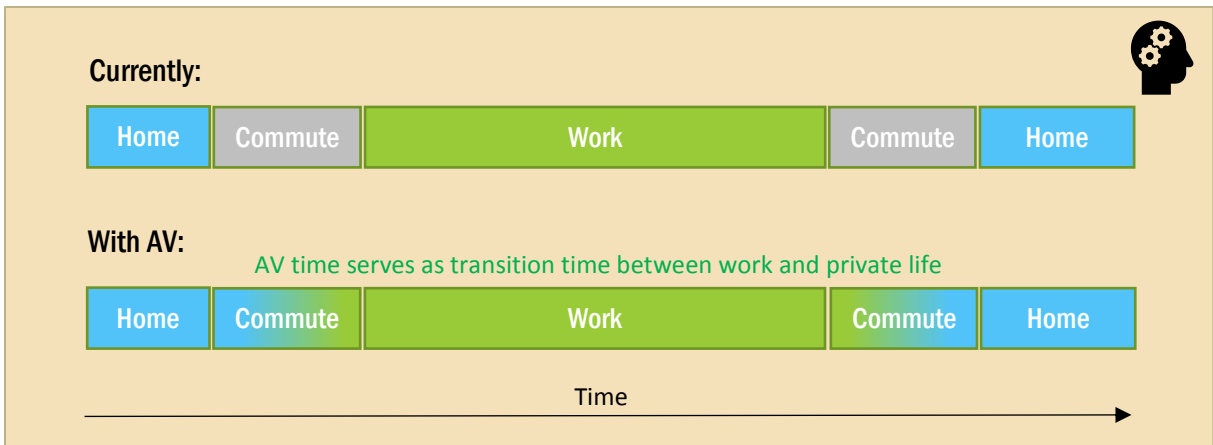


Figure 30. Using commuting time in AV as transition time between home and work.

4.2.1.6. Maintaining work-home balance

In case if time pressure appears in daily life due to work, a common response is to use AV travel time in order to release it and maintain work/home balance. Those who belong to this category would like to have a clear separation between professional and private life. In case of excessive work, this balance can be disrupted. In order to finish job tasks it might be necessary to take them home. The participants see the opportunity to **finish the work in the AV (A.33)**.

JELMER: *It also works the other way around, if you want to go home, at 6 o'clock 7 o'clock, and I have such a pile of work, I can do it in a rush, or I can take it too.*

ELISABETH: *You can just take it in your car.*

JELMER: *By the time I'm at home, everything is done properly."*

As claimed by some participants, the advantage of this activity transfer is to feel **"really at home when being home"** – the conflict arising between working and private time is eliminated (A.34).

JELMER: *"Yes if that is possible, I don't have to take my laptop home. Then my wife is also a lot happier. Sure. (...) Yes, I really think that's an advantage, but you are really at home when you are at home."*

The concept of using AV travel time to maintain work/life balance can be illustrated as follows:

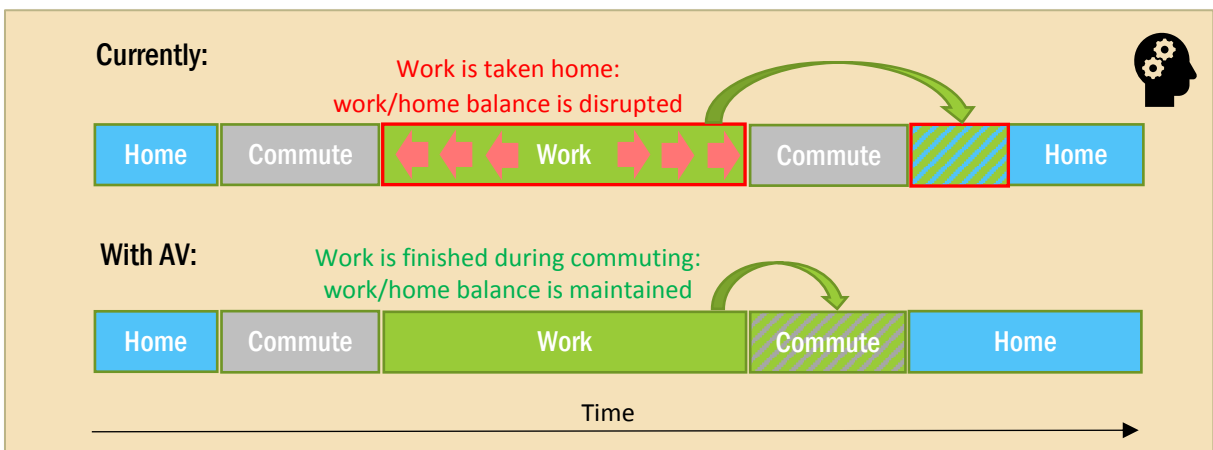


Figure 31. Using the AV to maintain work/life balance

Of course, to use the time this way it is again required that the professional tasks are in fact transferable and suitable to perform during travel time.

4.2.2. People with irregular destinations and travel intensity

Another broad category of people who need to be distinguished in the context of daily activity plans are those whose daily plans are not defined by a simple commuting routine, but rather by irregular travel patterns in terms of both destinations and intensity. The people belonging to this category are those holding more flexible, non-stationary jobs. Within this category, three different types of behavioural adaptations were identified.

4.2.2.1. Flexible scheduling

In general, the participants noted that AVs might be especially beneficial for busy people with hectic lives and dynamic agendas, spending a lot of time on travelling to various destinations. (A.35)

LAURENS: "I think it can be very interesting for business people, to be able to make conference call or appointment, to have a video conference. Or answer an email as Koen said. But they can also see their agenda, what their day looks like, whether they have to reschedule an appointment."

For this kind of people the flexibility provided by AVs might be particularly advantageous. In case when every day is different and **the plans might change dynamically**, the AV provides the freedom to shape daily schedules on the move.

JELMER: "You are working efficiently regarding your time schedule, you keep your own anatomy in traffic, so you can just change your calendar on the spot"

It seems to be an especially beneficial option for entrepreneurs and people living independent lifestyles, who decide fully on their own how each of their days will look like. An example from the FGs is presented below:

**Occupation:**

NICOLE: *“I am a freelancer, I actually work with women. We enrich the lives of women. It is about image coaching and skin care advice.”*

Current travel routine:

NICOLE: *“From January on I am going to expand my business, so because of my own activities I am more on the road than at home. And I have a son who plays soccer. We live in <removed> but he plays soccer in <removed>. So a lot on the road, also in weekends. I think I am only at home for eating and sleeping. (...) I do not have a permanent working place. I travel everywhere, for me, every day is different. Every day is a surprise.”*

Current travel activities:

NICOLE: *“If it is shorter, I call hands free and listen to music. If it is a longer trip, like next Friday I have to go to Helmond, then I do self-study. Then I switch between my music and study (...) for my work, for that it is about image coaching and some motivational things, about storytelling and how to present yourself.*

NICOLE: *“For me that is different every time. If I know that I have to be in the car for an hour, then I can also plan something, then I will do this and that. So that really changes. But I try to get done as much as I possibly can in the car.”*

AV use:

NICOLE: *“If it was an AV, I would do everything differently. More efficient working.(...) Now I am limited, would I go there or would I go there? Now I can shift the appointments, then I try to merge them with another appointment.”*

Flexible scheduling allows for dynamically adjusting the plans and optimising the daily plan on the move. In that way also possible time pressure could be more easily reduced from daily life. It can be noted that this particular person already strives to spend the time in the vehicle as productively as possible. This fact was already acknowledged before, when discussing the influence of travel duration on the remorse for not using productively. In general, people with longer travel times seem to see higher benefit from AVs – presumably due to their current travel experience.

4.2.2.2. AV as a workstation

Among non-stationary jobs are also those which do not have entrepreneurial character. The flexibility of rearranging and shaping the daily plan on the move is limited, yet still intense travel between various destinations is required. Travel time often means then simply working time. A significant share of professional duties is done on the move: phone calls, planning, simple bookkeeping etc. The hastiness of such profession often forces people to also spend their breaks in the vehicle, e.g. to eat in the car. Overall, this kind of work might often become a source of heavy stress. AVs would be especially beneficial for people with this kind of work – the vehicle would become their office and serve as a mobile workstation.

**Current travel routine:**

JELMER: *“And I actually travel throughout the country. Amsterdam we have people, Tilburg and The Hague, we have people, so all the work projects have to be done, and on the way I just make phone calls.”*

Current travel activities:

“JELMER: On my way, I make calls, I try to put it on Bluetooth, with calls, I usually do. Often my boss sends me a WhatsApp to me, that's the only time I have contact with that man. For the rest, someone called in sick, I have to arrange a new guy.

MODERATOR: *You are just working in the car?*

JELMER: *Yes*

MODERATOR: *And is there a moment of rest, or does it almost never occur?*

JELMER: *Almost never, I also eat on my way and then I'm at the Mac, then I'm with my computer.”*

AV use:

“JELMER: Yeah, automated car, I'm in for it. (...)Then the car would be my office in fact.

MODERATOR: *Yes, what it actually is already.*

JELMER: *Yes, that's actually it.”*

AV benefits:

JELMER: *“The most immediate effect if I would have such an AV tomorrow would be, less stressed because the work pressure is less. Or actually I can do much more. (...) Well, I could use my time very efficiently in such a car.”*

4.2.2.3. Business in the AV

One of the ideas from the FGs is moving the complete business into the AV. In case of jobs involving appointments with multiple clients throughout the day, the AV might be used to make a prescheduled tour among the clients. The interior could be adjusted to the specific requirements of the particular business. The time spent on moving between the clients could be used by the business owner to prepare for the next appointment. Not only jobs which currently entail similar tours might be moved to the AV, it is also possible that some jobs currently stationary might become non-stationary. One example could be medical professions: doctor, dentist, or veterinarian. In fact, numerous professions which require visiting a certain place by multiple clients could be “reverted” - it would be the “place” “visiting” the clients instead.

**Occupation:**

PAULIEN: *"I work for myself as a pedicure specialist."*

Current travel routine:

PAULIEN: *"I travel back and forth with the car all day long."*

MODERATOR: *"So not at a fixed location."*

PAULIEN: *"No, at people's homes."*

PAULIEN: *"I travel by car every day, my journey takes, depending on where my customers are, that can be in the region or elsewhere. (...) Half an hour to an hour and I have 5 customers on a day."*

Current travel activities:

PAULIEN: *"What I do on the way is often eating a sandwich, because otherwise I do not have time for it. Occasionally I stop and to do some grocery shopping. But only eating in the car."*

AV use:

PAULIEN: *"In my case, I no longer have to drive constantly from one side to the other. That would also save me a lot of energy. I always have to go to the customer with my suitcase, that is quite a heavy thing, that would save me a lot of time. Even energy."*

PETRA: *"You can make a studio in your car."*

PAULIEN: *"Yes, just a collapsible treatment chair. (...) Yes, and you have everything with you. That would be very ideal."*

PIETER: *"Yes, the car gets a completely different function. (...) You get all kinds of extra possibilities with such AV. Just pedicure in the car. You do not go to the people anymore but the people get into your car and in about half an hour or an hour you have made a roundtrip."*

PAULIEN: *"I do not have to do anything, I do not even have to drive to the next one. (...) Meanwhile, I can clean up my things for the next one. I must continue to do that myself. (...) No, that's a good invention, yes."*

4.2.3. Daily use of AVs: expectations vs. reality?

Although the adaptations of daily activity plans discussed above show a broad range of ideas, some participants also expressed their doubts about their occurrence in reality. They are of opinion that the extra time will not be used in any productive or meaningful way, because **people will quickly go back to their usual habits (A.36)**.

DANIEL: *"I think I would use this saved time for something useful like learning some new stuff, to code a bit more or some more words in Dutch. Or doing something healthier. But after some time I'll find some easier ways of gratification of myself like watching some more YouTube or more television more entertainment. Then the time will be wasted anyway."*

Another observation is that AVs will in fact create a sort of **illusion of extra time**.

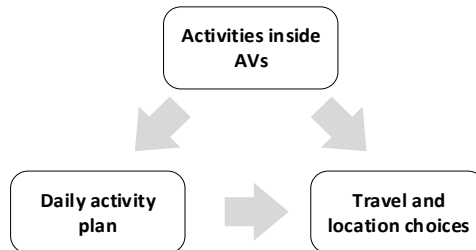
RENATE: “Yes, I also wonder if you are going to have time left. If you are going to organize things differently, you will never have time left. You are going to rearrange it anyway.”

ELISABETH: “Nice to be home and doing nothing. This time is of course very short, so to say, I fill it in, but you get used to it very fast, so you do not even appreciate having that extra time.”

The above statements hint at the fact, that people aim at optimizing their daily plans using the available resources. If an AV becomes available, after initial gain of extra time the daily pattern will be adapted accordingly. Thus, eventually the time benefit might not be so apparent anymore.

4.3. Activities in AVs and travel choices

As already stated, the impact of AV activities on travel choices might be twofold. On one hand, travel choices might change due to adjustments of daily activity schedules. However, also a more direct impact is possible. The fact that travel time can be spent in a certain way might encourage people to make more irregular (non-daily) trips to some destinations. Once more, the diagram showing these two ways can be seen below:



In this chapter, first the indirect impact will be addressed (Daily travel choices), followed by a discussion of the direct impact (Irregular travel choices)

4.3.1. Daily travel choices

As discussed in the preceding chapter, most changes regarding daily activity plans concerned different adjustments of commuting time. Whereas it might impact time of day choice (e.g. by switching commuting to earlier or later time and working in the vehicle), such adaptations have no influence on travel choices manifested eventually as VMT. The participants were not able to come up with concrete examples of adjustments leading to increased or reduced overall travel distance. Most probably, due to high intricacy of daily plans it is difficult to imagine possible changes. The plans are **already optimised** regarding available resources. If a new resource becomes available – an AV, the plans are likely to change, but the exact reorganisation of the daily plan is difficult to predict beforehand. Therefore, in the FGs only very **general statements** were made.

MODERATOR: *Perhaps, we have also talked about for a bit. Would you travel more often or further to carry out your activities?*

RENATE: *Yes.*

PAULIEN: *I would also travel more often.*

CHRIS: *Then yeah one of my hobbies would be changed to travel more.*

Also people with less stationary jobs, who do not have a regular commuting pattern, could not come with any really concrete examples. Although some statements show clearly that travel choices might be affected, it is impossible to say with any certainty if the change would lead to less or more travel.

NICOLE: *“If it was an AV, I would do everything differently. More efficient working.(...) Now I am limited, would I go there or would I go there? Now (with AV) I can shift the appointments, then I try to merge them with another appointment.”*

LINDA: *“My routine, how it will look like, I do not know, but my pattern will really change. How I would use my travel time is going to change, that can be organized more efficient. I do not think I would travel a lot of extra kilometers or travel more.”*

However, several themes were discovered during the discussions, which seem to have impact on daily travel choices. Namely, independent use of AVs by children, travelling to locations with parking problems and using AVs as couriers. These aspects will be now addressed in more detail.

4.3.1.1. Use of AVs by children

One of the expected benefits of AVs is that they will increase mobility of the members of society who currently are not allowed (or not able) to travel by car. Among them children, who could potentially travel by AVs on their own. In that case, children’s commute (to school) could be done separately from their parents commute (to work), whereas now it is often done together in one tour. Consequently, it could have impact on daily VMT. Some of the participants indeed recognize such use of AVs as advantage and declare they would allow children to travel in an AV on their own (A.37).

JELMER: *“Great advantage is that you do not have to bring your children anywhere. They do not need a driver's license, just get in the car.”*

However, people also clearly see disadvantages of such AV use. On one hand, it might take away an important opportunity to spend **quality time** together with their children (A.38).

CHRIS: *“I can remember when I was a child, sometimes my father came to my school, and he picked me up and during the ride he asked me, hey Chris what did you do? What was fun in school, or you had some discussion in between. Now sometimes you cannot find the time because your father is more busy most of the time. So this (AVs) will take that opportunity for the families”*

On the other hand, also the problem of AVs security was raised. It was claimed multiple times that parents would still prefer to travel together with their children due to **lack of trust** and anxiety about child’s safety (A.39).

KATRIEN: *“Well, my children are already much older, already grown up now, such a young child who is 8 or 10 years old, I would not just put it in the AV and say: you have to go there, the door opens and get inside yourself. I would also like to know if he actually arrives there.”*

Taking this into account, the possibility of using AVs by children on their own should not be overestimated, especially in case of those very young.

4.3.1.2. Locations with parking problems

Another aspect related to daily travel choices is the problem of parking. Currently, it is claimed to be one of the factors influencing travel choices. On one hand, it might be burdensome to find a parking place when travelling by car. For that reason people tend to choose other modes of transport.

PETRA: *“And parking, if you have to be in Rotterdam, PT is easier.”*

Another reason for that are high parking fees (A.40).

NORA: *“I think if you go to Maastricht with a car, you also have to pay for your parking ticket. Then I would go with that cheap train ticket.”*

In case of AVs parking seems to no longer be a problem. The traveler will step out of the vehicle and it will simply drive away and park itself.

CHRIS: *“If I have AV, then for the places that I have to park my car I don’t need a carpark, just maybe can automatically find a car park and I go shopping.”*

MODERATOR: *“You go to the centre of Amsterdam.”*

CHRIS: *“Yeah, exactly.”*

Regarding daily travel choices, it has to be therefore expected that with AVs people might travel more willingly to locations with limited parking capacity or high parking fees.

4.3.1.3. AV as a courier

Although an empty AV could be used as a courier also for irregular travels, it was mentioned during the FGs rather in daily context, therefore it is addressed in the present section. Some of the participants declare they would like to take advantage of this option to **travel less themselves and save time** for other activities. Still, the total amount of actual VMT would not decrease, and could even increase if people indeed would feel prompted to use AVs as couriers more regularly.

DANIEL: *“I think I would travel less (when having AV), I will send the AV without me to pick up children, if I would have them, or friends from airports. Or help somebody to deliver something. Usually you ask the person who has a car: please help me to move stuff in the weekend. I prefer to do something more useful.”*

It is difficult to predict in what exact circumstances people would be more prone to use AVs this way. For example, two participants declared the willingness to send AV for shopping, e.g. to pick up groceries (A.41). It seems that using the AV as a courier might be more prevalent for people who also currently seek ways to maximize their convenience by using car – even to an excessive degree.

Current behaviour:

PIETER: *“Sometimes I'm so lazy, that I do not even walk two streets to the supermarket, then I go by car.”*



Behaviour when having an AV:

PIETER: *“You can also let your car do some shopping for you. Everything is placed in your car and after that it drives back to your house. (...) I think I'll leave more to my AV. Grocery shopping, picking up or dropping someone. Mainly these thing.”*

Using the AV as a courier might also be particularly attractive for those living in **remote or sparsely inhabited areas** with poor PT accessibility. Such people currently often need to drive a car to pick up persons or items.

KOEN: *“I think that the AV itself would drive more often, but not me. (...) I think I would drive less myself. I live in Rotterdam but I live quite in the middle of nowhere. There is no PT, I always have to pick up people in that neighbourhood. Then I would send that car, so that would mean less driving.”*

Using the AV as a courier also seems to be particularly advantageous when a number of **people or items must be collected at various locations**. Instead of making such tour in person, it is possible to send an empty AV and save this time for doing something else.

PAULIEN: *“Those leisure trips, that is always very early somewhere to collect all the people, that is not needed anymore. Because if you arrive somewhere at 9 o'clock you have to collect all the people at 6 o'clock.”*

The example can be conceptualised as follows:

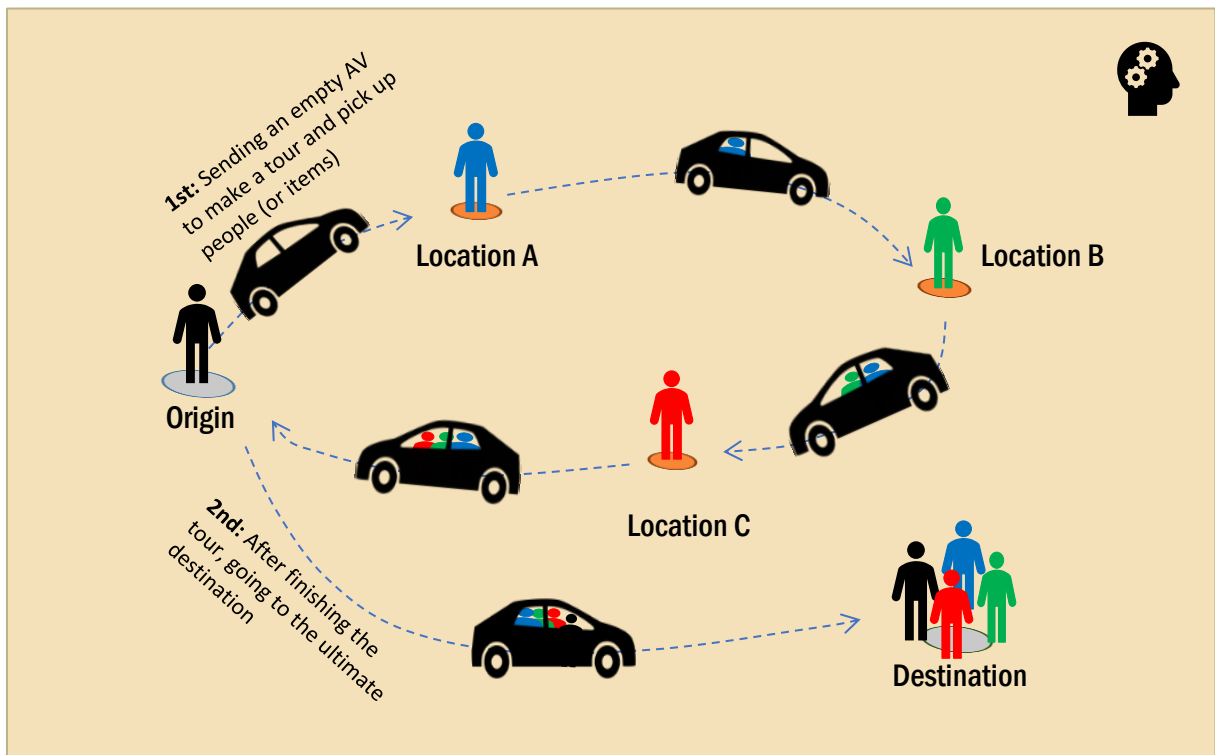


Figure 32. Advantage of using an empty AV in case of tour trips.

4.3.2. Irregular travel choices

The other type of impact on travel choices is direct – it does not manifest through changes in daily activity schedules. In case of irregular travels the participants had a far clearer idea about AVs application. Presumably due to the fact that a single trip made for one particular purpose is easier to imagine that rearrangements in a complex, already optimized daily activity plan. In context of irregular travels, the participants believe that the **AV is especially attractive for long trips**.

NORBERT: “Yes, especially for medium-long distances, it could be a very pleasant alternative.”

PIETER: “Yes, just long distances are ideal. I think that certain things will look different, work and private.”

In the remaining part of the current section, first the identified advantages of AVs for long travels are discussed. Secondly, different types of long-distance trips addressed during the FGs are described in more detail.

4.3.2.1. Advantages of AVs for long trips

Most of the advantages of AVs in context of long travels are a result of taking off the traveller the burden of steering the car. Moreover, AVs also have some specific benefits over PT.

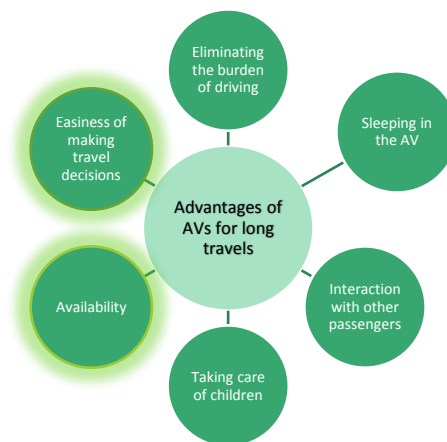


Figure 33. Advantages of AVs for long travels

All the above aspects will be now elaborated. It has to be noted, that the two distinguished elements represent advantages not related to the in-vehicle activities. Thus, they are not a manifestation of the link connecting activities in AVs with travel and location choices, but are rather an inherent property of the “Travel and location choices” element (in the triangle visualising the research scope). These advantages will be discussed last, after addressing all the other, activity-based advantages.

Eliminating the burden of driving

As already stated, long car travels are often seen as a burden, especially in case of heavy traffic. Driving becomes exhausting and problems with concentration might appear. Thus, the frequency of making faraway car trips is limited for some people. The AV eliminates this burden and allows to spend travel productively and comfortably. It might encourage AVs users to make long trips more often (A.42).

“RENATE: *The family of my partner lives in South Limburg, coincidentally I was there again last weekend, that is really... We were 3 hours on the road because we got a traffic jam, on the way back also more than 2 hours. This also raises a threshold of how often you travel to the South. I think we would travel to the South more often if you could spend the time in the car differently. (...) And that it is also less tiring.*

MODERATOR: *That you arrive completely rested.*

RENATE: *Yes, actually! It is simply tiring, traveling. Everyone is just stuck, stuck on your chair. Also as a co-driver you're just sitting there.”*

Sleeping in the AV

Another benefit is the possibility of sleeping in the AV. One could use this advantage at any time but, most importantly, it opens far broader opportunities for travelling at night. Furthermore, one could also sleep in the vehicle when it is parked, instead of a hotel. (A.43)

RENATE: *“You may also travel more during the night. If you can really organize your rhythm in such a way that you can actually sleep inside the AV.”*

PIETER: *“Now, you use the night to sleep at home but that is also possible inside the AV.”*

In comparison to other modes allowing for sleeping (e.g. coaches), AVs seem to be a more attractive alternative for long overnight trips, thanks to the comfort and facilities it provides.

BART: *“Maybe the same thing for night travels. For travelling in Europe. There are night buses. So if I know that I am able to sleep in the AV I would do the travel at night. So, arrive at the destination and maybe be able to shave and brush my teeth. It is a big help. I would arrive at my destination in a much better shape than when I have to sleep on a chair in a bus.”*

The convenience of AV sleep might have impact on travel choices – night traffic is likely to increase.

“PIETER: *You're going to travel more at night, you said?*

RENATE: *Yes. It has to fit with what you are going to do of course, but why not?”*

However, it needs to be again noted that the FGs participants considered a very **idealistic scenario**. In reality some people might find sleeping in the vehicle problematic, which was also pointed out at certain point:

“CHRIS: *Some people cannot sleep in the car.*

CAROLINE: *Why?*

CHRIS: *Some people are not comfortable to sleep in the car.”*

Interaction with other passengers

Currently, the person steering a car is limited in terms of interaction with other passengers. Spending travel time in a more social way is yet another argument for AVs suitability for long travels.

PAULIEN: *“On the way, it is currently spending less time with each other. Then (with AV) you will have more time for each other. If you are on the road for a long time, normally it is only about driving, and the rest, you do not know what is happening next to you.”*

Taking care of children

The interaction with other passengers is especially important in case of children. They often require a lot of attention from the adult during the trip. If the only adult in the vehicle is the car driver, the journey might not only become tiring, but also dangerous.

“NIEK: *It's about convenience. Now, someone is driving a car, a mother or a father, you often look backwards at your child who wants something. These are dangerous situations.*

MODERATOR: *Then (with AV) you can go to an amusement park much more relaxed, because you do not have to scream back and forth at your children.*

NIEK: *You can then just play games.”*

The advantage is especially important for **very young children**. Making long travels with a baby is particularly burdensome – it requires basically constant attention.

NIEK: *“You can just talk to everyone when you go out with your children. You can feed a baby, you don’t have to stop along the highway at a gas station any more. You can just do everything.”*

Availability

Regarding long travels, AVs have also a specific advantage over PT – they are available at any time of day.

“MODERATOR: *For what kind of travel is such an automatic vehicle especially better than other vehicles?*

PAULIEN: *Well, for PT that only drives until 1 o’clock.*

MODERATOR: *Yes, so especially night trips.*

PAULIEN: *It would be ideal for that.”*

Increased availability is also another AVs convenience which might encourage people to more overnight travels.

Easiness of making travel decisions

An especially striking feature of AVs in case of long travels is that they seem to require **little to no planning** compared to now. The AV gives seems to give a lot of freedom in making travel decisions: it is always waiting at the door and the only effort that has to be done is to get in and program it to go from point A to B.

LINDA: *“You have the freedom of: I get into the AV when it suits me and that AV is ready for me at front of my door.”*

The benefit is even more apparent if compared with the current situation, e.g. with PT:

ANDRÉ: *“My parents live in Brabant which is quite far. I could go there more often. Now it is doable in PT but you have to cycle to the station, to the train.”*

Currently, a plane trip to a distant city requires booking tickets in advance, getting to the airport, going through check-in, possibly customs, waiting for the plane, etc. In comparison to that, the flexibility and easiness of AV is remarkable. Furthermore, the travel time might be used for preparing other details of the trip – e.g. booking a hotel or finding more information about the chosen destination. (A.44)

NORBERT: *“I can imagine that it is easier to go to Paris or to Berlin, because you do not have to wait at an airport. You get in at your front door, sit down, you have movies you want to see with you, books you want to read, then you just go there. That, you do not have that you're on the plane, I can imagine that that can be extraordinarily pleasant. That also makes it more accessible to go somewhere. Yes, but of course it takes longer, right?”*

This easiness of making travel decision seems to have a psychological impact on people’s travel decisions. On one hand, people declare to make **more spontaneous decisions** about faraway trips when having an AV.

PAULIEN: “I never actually plan anything in advance, it is just spontaneous. When you go away for a weekend, I don’t know, you just take the AV, we go away for a weekend. Then I really go to Limburg or something, or Belgium or Germany. Just take all kinds of things along the way. And bring things along the way, so you can do useful things. You can spend time on it but it is not planned.”

PETRA: “You can often say now: I am going away for a weekend, to get some rest.”

Moreover, the easiness might create certain **psychological encouragement to travel** for people who usually spend their free time at home. Some participants state they might feel triggered to get into the AV and go somewhere, just because travelling to far away destinations becomes so strikingly easy.

NORBERT: “On Sundays, I usually don’t do anything, then I don’t even get out of my house, in that time frame from 12.00 to 20.00 in which you watch movies, watch football, you just do nothing. In that time frame you are in fact somewhere else, to look at something. So what I want to say: if you are comfortable, so not with 2 hours of waiting, checking-in and everything, I would be more triggered to go further away. I would do that.”

It is likely, that the easiness of travel associated with AVs might result in a significant increase in travel in reality.

4.3.2.2. Specific use of AVs for long trips

After addressing the identified advantages of AVs for long trips, it is now possible to look closer at specific types of long trips which people are willing to make. According to the participants, the above benefits make AVs especially attractive for **leisure purposes**. Within this category, three different applications can be distinguished: single-day trips, weekend trips and tourism (e.g. holidays). The reason for this distinction is difference in travel distance and the travel “mechanism” – it is addressed in detail for each case. Of course, professional life might require irregular (special) trips, too. Such examples also appeared during the FGs, but mostly leisure trips were discussed in the context of long trips.

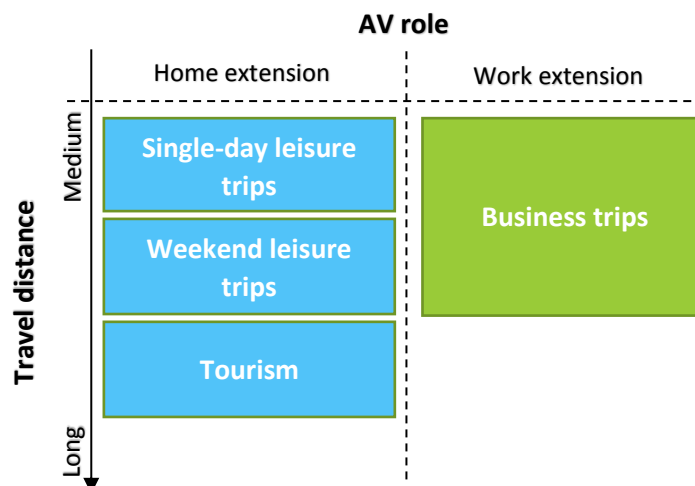


Figure 34. Application of AVs to long trips

The above types of long trips are addressed below in more detail.

Single-day leisure trips

This kind of trips concern destinations in medium range, accessible within few hours. In addition to already mentioned general AV benefits for long trips, it is also possible to organize the day in such a way, that there is **more time available for the actual activity** at the destination (A.45). Also the energy for the activity is better preserved, due to lack of driving burden and high comfort of the AV.

RENATE: "You can do that (sleep) inside the AV, even if you are less on the road than the whole night, I can imagine going to Disneyland for a day. Then we get in in the evening, inside the car, then we can all sleep and then you arrive in the morning at 5 o'clock, you just set the settings like this, then it parks itself in the parking lot. Then you just wait until you are awake and then you are already there."

On the other hand, also interaction among the passengers can make the **travel time also a part of the quality time**. Again, this advantage is especially important for travelling with children (A.46).

RENATE: "If I went for a day out with my family to a theme park far away, I would spend time with my family during the trip. Do something together, like a game."

These two ideas can be conceptualized as follows:

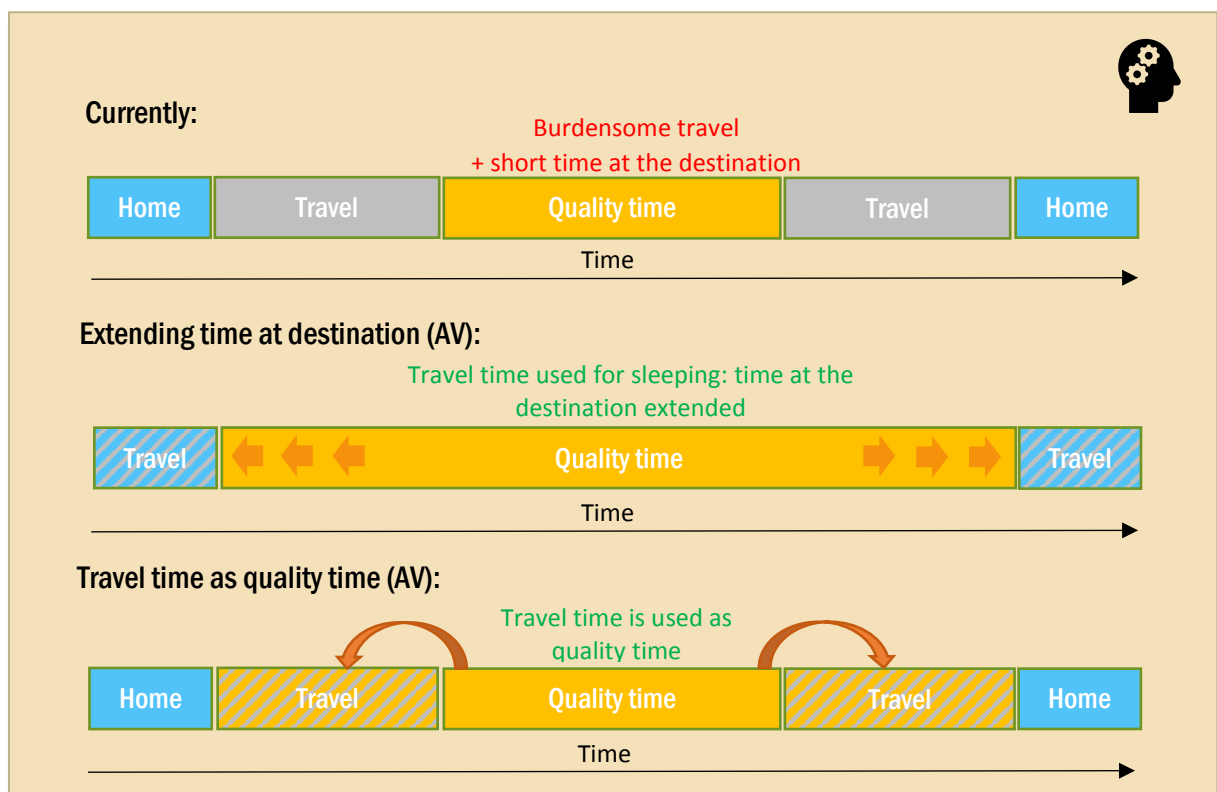


Figure 35. An example of a single-day leisure trip

Of course, the two above ways of using travel time with AV can also be combined during a single journey.

Weekend leisure trips

Another type of long leisure trips are weekend trips. In comparison to single-day leisure trips, the difference lies in further location of the destination. An example could be a visit to a capital of a

neighbour country. The attractiveness of such places, as well as much longer travel distance, are associated with longer preferred staying time at the destination. One of the obvious advantages of AVs is again eliminating the burden of long driving:

PAULIEN: *“For a weekend away you would easily take the AV. Normally you have to drive a whole day for a weekend away.”*

AVs would make such destinations more accessible, and at the same time would allow to smartly include them in weekend plans. (A.47)

ELISABETH: *“Just a weekend winter sport, I used to do that often. Then you think it's only a 10 hour drive. You will just do that. Then you leave at 12 in the afternoon with your AV. (...) The next day you have to work again and then it's nice if you're just...”*

This concept can be visualised in the following way:

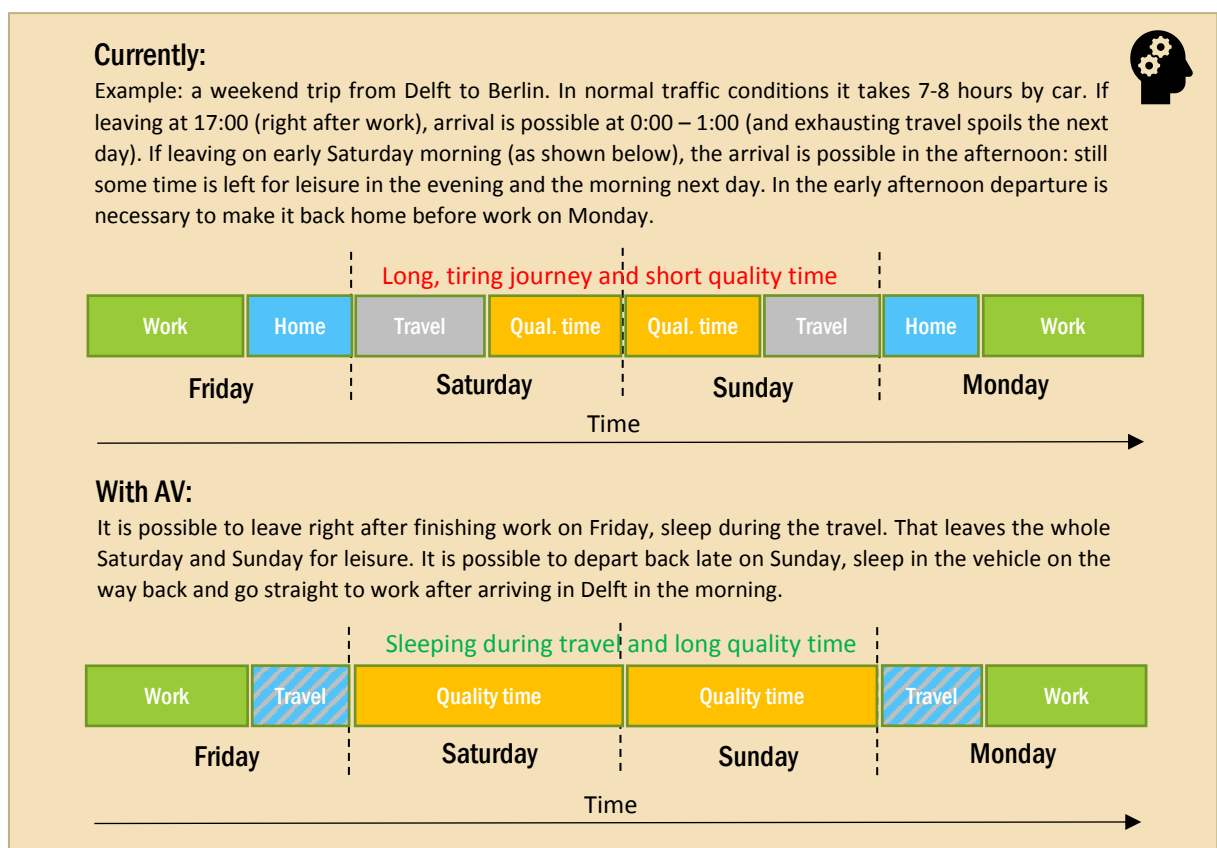


Figure 36. An example of a weekend trip

Because of the mentioned advantages of the AV for single-day and weekend leisure trips, some of the participants explicitly expressed their willingness to travel more often and further for such purposes.

JOHANNA: *“I think I would travel a lot, I think that would be a big difference. Going out in the weekends. Going abroad. Or to a city where I earn more, than I would definitely do that. That's what I think are the two big things for me. So travel and work.”*

However, no full agreement was reached regarding this willingness among the participants. Although AVs might improve accessibility of distant locations for leisure trips, again the **increase in range seems limited**.

“RENATE: It is definitely a time gain in many cases... Not always because, I'm thinking, I always go on holiday to Croatia but it is also a long drive. If I don't have to steer and just can sit in my car, it would be more comfortable because you can do what you want. But in the end you are still sitting for a day and a half in the car.

PIETER: It is a long time in the car. But, if you have all kinds of relaxation possibilities in the car then it may not matter at all if you have to sit in the car for 12 or 8 hours.”

Once more the feeling of “being trapped” in the AV is manifested by the above statement.

Tourism

The last type of long leisure travels is using the AV for touristic purposes. This category includes travelling very long distances and staying at the destination for a longer period of time than a day or few days. In case of such travels, some people see car driving as a factor limiting the range of their holiday destination. AV is seen as an good alternative in such situations.

LAURA: “If I go on holiday now, I prefer to go within one and a half hour, two hours, that is the limit for me. So in this case I would say: I sit down and drive to France for a few days.”

In case of very long trips, travelling by car becomes so inconvenient and brings such a high cost, that travelling by **plane is the preferred mode**.

NORA: “We have been to Slovenia by car. That was hell, I'll never do that again. Both of us have been driving, but it's really far away. At a certain moment your eyes really close, this is really dangerous. In Germany there are trucks everywhere on the side of the road, so you cannot park alongside with your car, because you cannot go there. You are obliged to continue driving, so you cannot get off the road in Germany. So, if you want to go far away on vacation, then an AV is a great solution. I would never choose to go that far by a car. Then I'll take the plane.”

According to the participants, AVs might influence the way of travelling to such faraway destinations. People seem to treat the **AV as a camper van** in such cases. Similarly to a car, the AV allows for flexibility shaping of the route, and combines it with the freedom of performing activities resembling PT. Thus, to some people the AV appears to be a perfect vehicle for tourism, particularly for a sort of a holiday tour: traveling from one destination to another over a long period of time.

LAURENS: “If it is implemented throughout Europe, you can even use it for your holidays. Then imagine your whole holiday, in terms of route, camping, hotel, or whatever, so you can also travel through Europe without getting fatigue.”

In that way it is possible to **visit multiple locations on the way**, which is attractive for people fond of sightseeing and visiting new places. Some participants state that they would prefer traveling by AV in this way rather than travelling by plane (**A.48**).

CAROLINE: “But for example I would go with my AV, because I am not concerned about being tired or sleepy. So maybe I travel to Iran, my country. It’s ok, I am comfortable. I can see all of the cities on the way. (...) I can see lots of cities on my way.”

This concept can be visualized as follows:

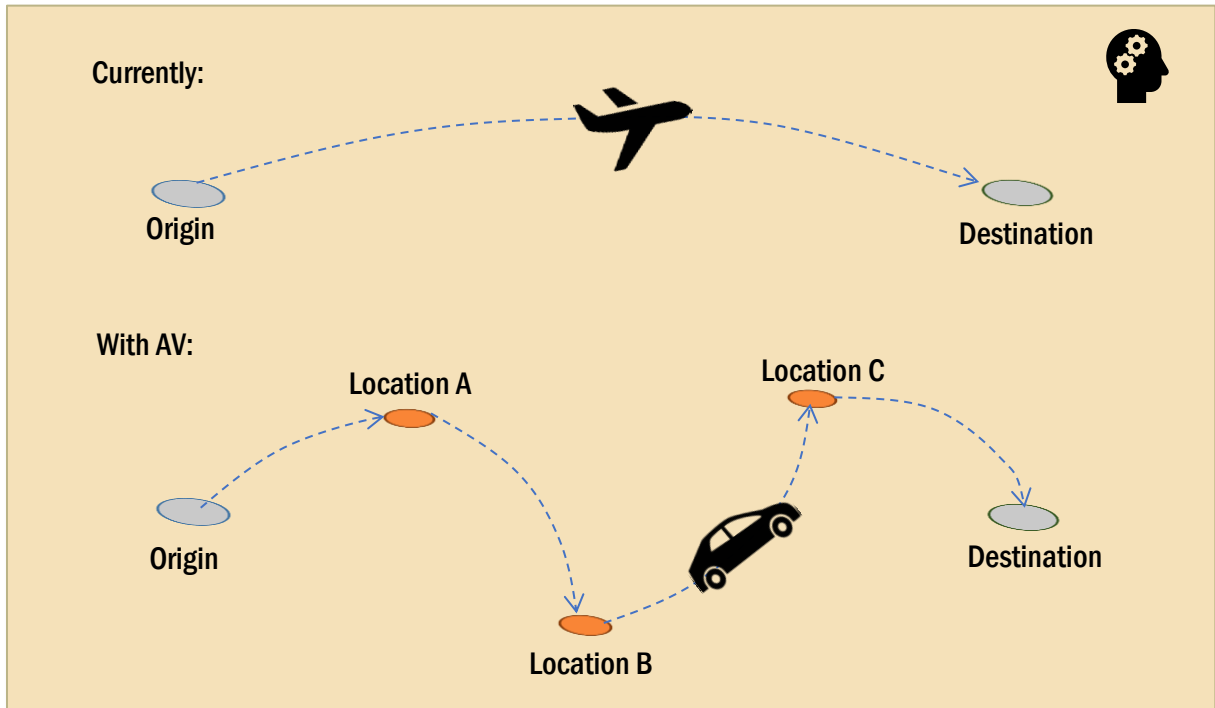


Figure 37. Possible use of AVs instead of planes for long tourist trips.

However, again there is no full agreement among the participants. For some, still plane is a better option.

LINDA: “I would not necessarily go more often, perhaps further, but not more often. I would still like to catch a plane for long travels. I just want to be there as soon as possible. I mean sitting in a car for a day is not fun, no matter how many movies you see.”

Again, the feeling of “being trapped” in case of long travel is manifested in the above statement.

Business trips

Apart from leisure trips, also the possibility of using AVs for long business trips was raised. Still, some of the already mentioned advantages would play a decisive role (e.g. sleeping, no burden of driving), as well as the possibility of using the AV as a work extension (and working in the vehicle).

MAARTEN: “A good example from my work as well: we have an office in Germany, I want to go there for one week. But I don’t see myself doing that because of the distance, with PT you’re on the road for 12 hours. That kind of things, if you have to do a business trip, I get in at 3 o’clock, I’ll sleep a bit in the AV.”

However, using the AV in this way was not elaborately discussed during the FGs.

4.4. Activities in AVs and location choices

The impact of AVs on residential location choices can be seen from two perspectives: On one hand the fact of having an AV might trigger a decision to change residential location. On the other hand, it might not be a reason to change location, but rather be a factor influencing relocation decision, when such necessity arises due to other reasons (e.g. changing a job). These two cases will be now discussed separately.

Significance of AVs in case of necessary relocation

On one hand, there was a broad agreement about the hypothetical influence of AVs on relocation decision caused by other reasons than the vehicle itself. In such situation the AV gives more freedom and would make the decision easier. (A.49)

PIETER: *“Yes, such AV makes it a little easier, that you do not have to live very close to that place or in that place itself. The AV makes it easier to move, to live further away.”*

Still, there are limits to the AV influence on location decision. Some participants are of opinion, that in case of slight increase of commuting time AV would not play any role and they would simply stick to their current transport modes. (A.50)

PAULIEN: *“No, it wouldn’t play a role in decision where I live. The Netherlands is not that big, I just assume that, when you have a car, you have to go 10 km further, so that does not matter that much.”*

Furthermore, even though an AV makes the relocation decision easier, there still seem to be an upper **limit of commuting distance**. Some participants claim that an AV would influence their decision, but only to a certain extent. (A.51)

ELISABETH: *“Yes, I might move, but not far beyond [gap] having a trip. Because you’re just locked up. I mean you can do a lot, you can have a lot of contact, but of course not really. Of course you can shop on the web or cut your stuff. You’re just locked up in a small physical space. It’s nice if it’s more efficient, but I would not want to live much further from my work. Maybe a little further. But I don’t feel like traveling 2 hours for work. Or: nice an assignment in Paris, we will do.”*

Again the problem of being “trapped” appears in the above statement. Overall, it seems that there is some range of commuting distance, within which AV would have influence on the decision. If the distance is too short, the benefits are not yet that “beneficial”, whether if the distance is too far, they are not able to counterbalance the costs.

AVs as a reason to relocate

Whereas people think that AV would influence their relocation decision if it was necessary, there is also a broad agreement on the fact that the AV itself would not be a reason to move somewhere else. Most of the people are **not willing to move “for a car”** (A.52).

“MAARTEN: *It would not really be a reason to move, but if I were already considering moving, this would make it easier.*

MODERATOR: *But if you are going to move, would this affect your location choice?*

MAARTEN: *Yes, I think so. I do not like travel time, but at the moment when you can organize travel time in a better way, that benefit would be taken into account, but not the other way around: I can now organize my travel time more useful, so I'm moving."*

In choosing residential location other factors seem far more important to people than the benefits of an AV. People stress the value of their own social life and neighbourhood. (A.53)

NORA: *"No, I'm not going to move. (...) Good neighbours, no, I'm not going to move. Certainly not for such a car, no."*

Although most of the participants would not like to move *because* of the AV, some people might feel triggered to relocate because of financial reasons, in case their current location is too expensive. If such problem appears and the other factors influencing relocation decision play lesser role, AV might convince people to move to cheaper areas further away from their workplace (A.54).

FELIX: *"I think I might move, I live in the center, which is quite expensive, for the same money, I can have a much bigger house at another location."*

5. Conclusions

The overarching goal of the research was to bring knowledge on the possible impact of in-vehicle activities of future AVs users on travel and location choices. Thus, the main research question was formulated as follows.

What is the expected impact of activities performed inside AVs on travel and residential location choices?

Since the mentioned impact might be realised in either direct or indirect way, to cover the entire range of the main research question it was supported by three sub-questions. In the current section, first each of the sub-questions will be answered separately, leading ultimately to the answer to the main question. The first sub-question focused on the perceived role of AV travel time in comparison to current modes of transport.

1. How will AV travel time be perceived by the AVs users compared to conventional modes of transport?

It was found that currently travel time is treated in terms of burden or opportunity, and in both cases can be spent in either passive or active way. Based on this distinction, travel time perception can belong to four categories: time to kill, time wasted, time for action and time to relax. The category, to which the traveller belongs at a particular point of time depends on characteristics of travel timespace (temporal properties and travel environment), personal characteristics relevant for travel and external factors: aspects considered as separate from the act of travel. Perception and use of travel time depends on an intricate combination of these factors (and other factors not revealed by the study). They serve as an input for a psychological mechanism, determining how much resemblance travel time bears to “normal” time and how much remorse one feels to not spend the time productively. The resulting pressure to perform activities (or lack of it) has impact on the actual use of time. Consequently, travel time perception belongs to one of the four aforementioned categories.

It was found, that the current categorization of travel time perception does not capture accurately the way travel time is perceived for AVs. This transition of perception is caused by changed significance of various identified factors in case of AVs. Some factors are expected to lose their relevance (e.g. level of privacy, some others will most likely be improved (e.g. available facilities). Due to these changes it is less possible to perceive travel in terms of burden, but rather in terms of opportunity. It leads to a new way of perceiving AV travel time, which was prevalent in the FGs: seeing the AV as either work or home extension (home in sense of private life rather than a place). Still, travel time might be spent in either active or passive way, which leads to a new, AV-specific categorization of travel time: time to work, time for a break (AV as a work extension), time for hobbies/chores, time to relax (AV as a home extension).

However, although the dichotomous distinction of AV travel time perception into work and home extensions describes well the general way of thinking about AVs activities in the FGs, such discrete categorization might not hold so clearly in reality. Two AV-specific phenomena unexpected prior to the study were discovered, most likely having influence on travel time perception. First of them is increased pressure to perform activities, which might make people in fact less able to spend time in AVs passively. Due to higher resemblance of travel time to “normal” time AV users might feel more remorse in case of not spending the in-vehicle time productively. The second phenomenon is related to the factors mentioned in the discussions in a general context, but largely neglected when discussing

the impact of AVs on daily activity plans and travel choices. Namely, deterministic manner of travel, lack of social interaction, limited size of the vehicle, constriction by seatbelts and motion sickness were found to be factors likely causing a feeling of being “trapped in the AV”. It is a phenomenon bringing an element of burden to AV travel, thus most probably negatively influencing travel time perception. Its impact on AVs activities cannot be determined, but it is hypothesized that it might negatively affect the willingness to make frequent, long travels with AVs.

The question of the actual use of travel time was addressed by the second research sub-question:

2. *What activities are expected to be performed by AVs users on-board?*

As it could be expected, it was found that AV activities are strongly context-dependent. Since multiple factors currently limiting in-vehicle activities will be improved or become irrelevant for AVs, the travel activities are expected to be driven prevalently by external incentives, on-board facilities and travel duration. In general, expected AV activities follow the presented work-home extension scheme. Whereas the activities in case of using the AV as a work extension are rather straightforward to imagine (e.g. working on laptop, sending emails, paperwork), in case of home extension also activities not associated predominantly with home environment might be performed (e.g. working out – usually done rather at the gym). The circumstances in which a particular activity will be performed in the vehicle in case of daily AV use is discussed more elaborately when addressing the third research subquestion.

In case of irregular (not daily) travels, the AV brings significant benefits regarding on-board activities. Most importantly, it eliminates the burden of long-lasting driving. It allows to use the travel time to sleep, which is seen as particularly attractive for long trips. Moreover, the AV provides better opportunity to interact with other passengers, which is especially appreciated in case of leisure trips (e.g. with friends) or travelling with children – in particular with very small ones who require almost constant care and attention.

In the context of on-board activities, it must be stressed that the FGs scenario assumed the vehicles to be 100% safe. Therefore, this aspect was left out from the discussions. Still, some statements of the participants clearly show that it will likely be a factor limiting the range of possible actions. It is hypothesized that as the perceived safety increases, the AVs users will be more willing to engage in more mentally absorbing activities.

To address the indirect type of impact included in the main research question it was necessary to look at the potential impact of activities in the AV on daily activity plans, which is covered by the 3rd sub-question.

3. *What is the expected impact of activities inside AVs on daily activity plans?*

Firstly, it was found that the impact on daily activity plans is going to be significantly different for regular commuters and for people with non-stationary jobs. Secondly, time pressure in daily life was concluded to be a major determinant of in-vehicle activities.

Some of the regular commuters exhibit willingness to use the commuting time for removing time pressure. If the pressure originates on private side of life, travel time could be used to perform the pressure-generating activities in the AV. Similarly, when pressure is generated by work, commuting time might be used to finish the remaining tasks on the move. Although such use of travel time implies rearrangement of daily activities, they can also occur in a situation of no time pressure. In case the pressure is not so apparent and explicit, some participants still expressed the willingness to work or

perform private activities in the vehicle, and “make” more private time by doing so. For example, it might be realised by working while commuting if travel time is accounted as working time. Such case is different than the previous one: AV time is used for a regular time-saving rearrangement of activities, and not as a time for optional work in case work pressure appears and might disrupt home-work balance. Moreover, people not experiencing any time pressure expressed the willingness to either replicate their current commuting activities, use AV time as extra private time or to treat it as a transition time between home and work.

People with non-stationary job acknowledge great advantage of AVs regarding their daily activities. For people travelling particularly intensely for their work, the time spent in the vehicle is currently often burdensome and stressful. The AV could serve as a mobile office, allowing for more freedom in performing work-related activities, but also for breaks, e.g. for meals. Moreover, the more entrepreneurial the non-stationary job is, the more important is the advantage of flexible scheduling, facilitated by the AV. If the daily schedule can be shaped depending on the circumstances of the unfolding day, the AV brings a lot of freedom to do so due to the possibility of spending the travel time productively. It allows for easier and smoother shifts of various tasks and appointments at multiple destinations, providing an important benefit for people with rather unstructured and unrepeatable daily activity plans. Lastly, AVs might be used for non-stationary jobs which require performing a pre-defined tour among various clients. The travel time might be then used for preparation to the next meeting. This aspect was found to be especially advantageous for specific types of jobs, e.g. doctor, hairdresser, etc.

In this way all the sub-questions have been answered, which brings the conclusions back to the main question:

What is the expected impact of activities performed inside AVs on travel and residential location choices?

The impact addressed in the main question might be realized in two ways, either direct (as a direct influence of activities on travel and location choices) or indirect (through changes in daily activity plans).

Regarding the indirect impact on travel choices, no strong conclusions can be made based on the study. Although the participants clearly exhibit the willingness to rearrange some of daily activities (which hints at possible changes in travel patterns), no structured evidence was found to claim it would manifest in change of total VMT. In case of regular commuters, the rearrangements concern commuting time, which is neutral for travel decisions (with exception of time of day choice). On the other hand, people with irregular travel patterns claim to organize “everything differently” with AVs, which however also does not allow to derive conclusions about the exact impact on travel choices. Very general, single sentence statements about predicted increase (or decrease) in total travel distance were concluded not eligible for making any valid conclusions.

However, some other aspects relevant for daily travel choices were found, not directly related to on-board activities. Firstly, the advertised benefit of increasing mobility of children might be exploited in reality only to a limited extent. Parents are not willing to allow their children travel alone in the AV due to safety and security concerns. Secondly, an increase in travel to destinations with parking problems might occur. Thirdly, using an empty AV as a courier is deemed by some participants as an attractive alternative, especially for remote and sparsely inhabited areas and for tour trips with the goal of picking up people or items at multiple locations.

Much more clear picture can be drawn in case of direct impact of AV activities on travel choices. AVs are expected to bring multiple benefits for long travels. As already addressed by the second sub-question, the technology will remove the burden of driving, allow for using long travel time for sleep, interaction with other passengers or taking care of a child. Such benefits were found particularly advantageous for single-day and weekend leisure trips, which frequency and distance might increase significantly. Furthermore, the amount of overnight trips might considerably increase due to the possibility of sleeping in the vehicle. Next to relatively short leisure trips, it is also possible to use the AV as a sort of a camper van, which is especially attractive for very long holiday trips. Some participants expressed willingness to use an AV instead of a plane, and visit multiple attractive locations on their way to the final holiday destinations. Such trend could lead to further increase of VMT and modal shift. Moreover, also the advantage of AVs for irregular, long business travels was mentioned, nevertheless it was not elaborately discussed in the FGs.

Next to the AV benefits related to the in-vehicle activities, also two other advantages for irregular and long travels were found. An advantage of AVs over PT is their availability, particularly for overnight trips. However, perhaps one of the most striking and relevant aspects for travel choices is the second advantage: The easiness of making a travel decision. Whereas currently long travels often require prior planning and preparations, and usually entail the burden of access/egress trip, check-in, customs and security control, in case of the AV the trip decision is as easy as getting inside the vehicle and programming it for the desired destination. It was claimed in the FGs that the AVs users might feel more triggered to make long, irregular leisure trips, which might bring significant increase in this kind of travels overall.

Regarding the impact of AVs activities on residential location decisions, its nature might be twofold. On one hand, the AV might serve as a reason triggering the relocation. In this case there was a broad agreement among the participants, claiming that they would not be willing to move “for a car”. People value their own neighbourhood and social circles too much to be convinced by the AV to relocate. On the other hand, the AV might play a role in residential location choice in case the relocation is unavoidable and caused by other reasons (e.g. starting a new job in another city). In this case also a broad consensus was reached: the AV would bring more flexibility and make the decision to live further away from the workplace easier. However, still the existence of upper commuting limit for the AV was identified. In this way, the feeling of being “trapped in the AV”, addressed when answering the 1st sub-question, is once more manifested. Overall, it has to be concluded that AVs have the potential to increase urban sprawl and consequently total VMT. However, since people are not willing to “move for a car” the process of this location shift in time will most probably not be too dynamic, at least in the initial stage of AVs introduction to the market.

6. Possible policy implications

As stated when discussing the motivation for the research, it is also meant to shed some initial light on potential policy challenges stemming from behavioural adaptation of the future AVs users. However, due to insufficient (and lack of quantitative) data, the goal is not to provide detailed policy recommendations, but rather to bring a more general indication of possible problems.

Most importantly, it needs to be acknowledged that AVs bring potential risk of increase in VMT and a modal shift of public transport. Whereas increase of travel was explicitly expressed in case of long, irregular travels, the results also hint at the possibility of an increase on a daily basis. The FGs participants acknowledged the convenience of the AV and claimed its advantage over PT, which can be basis for such prediction. To mitigate this negative effect, PT could be promoted and made more competitive with AVs, either by making it more attractive financially or by improving service quality.

Another category of potential problems concern the possibility of working in the AV. On one hand, the AV gives room for potential exploitation of employees. By creating pressure (possibly also inexplicit) to work during commute, employers might turn the in-vehicle time into extra, unpaid working time. This risk might require new measures regarding worker's right, specifically regarding acknowledging travel time as working hours. Moreover, AVs provide a broad opportunity for many traditionally stationary professions to be transferred completely into the vehicle. Some of them would surely require additional regulation regarding the AV interior, e.g. for providing appropriate sanitary conditions for medical professions. Another work-related problem is disappearance of professions requiring a human driver, which needs to find its place in the long-term agenda of labour market policy.

The matter of working in the AV is also intertwined with another potential problem, namely possible increase of commuting distance leading to urban sprawl. Although the spatial shift to more remote areas is not expected to be dynamic in the initial phase of AVs implementation, it might gain momentum over time, as the general population will keep getting other, non-AV related incentives to change their residential locations. To mitigate the negative effects of such spatial spread appropriate policy measures might be required, for instance subsidizing car-sharing for commuting purposes, or extra taxation of AV commuters above certain acceptable commuting distance. Another possibility is introducing an upper limit on daily time in the AV accounted as working time.

AVs might also bring new challenges for large cities, especially regarding city centers. Due to the possible increase of trips to locations with parking problems, as well as growth of AV-induced tourism, it might be advisable to restrict the access of AVs to the most central and busy areas of cities, or increase parking fees for such vehicles. It might also be a reason to introduce more, AV-dedicated parking infrastructure and further incentivize car-sharing, to avoid empty vehicles cruising purposelessly. The problem of overusing the empty vehicles might also be reinforced by using AVs as couriers. Although the magnitude of this particular kind of use cannot be predicted from the study, it is possible that such utilization of AVs will have to be restricted or even forbidden.

Due to the advantages of AVs in terms of long travels, a growth in weekend leisure trips, as well as overnight travels might be expected. Induced traffic might be expected on weekends and holidays, creating an effect similar to the French "Black Saturday" – day of the year when the traffic is most dense due to mass departures for holidays. AVs could cause a similar effect, but on a more frequent basis. Mitigating such harmful traffic growth could be realized by further promotion of PT, or maybe even introducing some restrictions regarding the use of AVs for leisure purposes.

7. Discussion

In this section limitations of the study are addressed, the results are compared with the existing literature, and suggestions for the further research are proposed. Lastly, a more personal reflection on the research process is presented.

7.1. Limitations

It needs to be stressed that a number of limitations exist regarding the present study. The limitations might be assigned to three different categories: limitations of the applied methods, limitations caused by the speculative character of the study, and limitations related to the scenario presented to the FGs participants.

Regarding the first of these three categories, both FGs and content analysis bear their own methodological shortcomings. FGs participants constitute a small and unrepresentative sample of the whole population. Thus, the results should be seen as an exploratory, general indication of possible behavioural adaptations rather than conclusions representative for the general population of future AVs users. Moreover, the results might be biased by possible self-selection of the participants, who knew the topic of the discussions beforehand and could educate themselves on AVs priorly. Another limitation of FGs, which is also one of the major advantages, is that the participants build their own opinions on the statements of the other participants throughout the discussion. Although it brings an exploratory, brainstorm character to FGs, it might also cause biasing each other's statements. Moreover, it is possible that the participants felt uncomfortable to share some of their opinions in front of other people. Although the topic of the discussions was not controversial, such possibility cannot be fully excluded. Lastly, a tendency of some of the FG participants to dominate the discussion and divert from the topic might lead to obtaining irrelevant results. Although in case of the present study such situation was not very apparent thanks to skillful moderation, still in the first focus groups this problem could be observed at some moments.

Limitations of content analysis are somewhat intertwined with those of FGs: the conclusions are ultimately built based on a very limited amount of data, which brings into question their actual validity. However, the main reason limiting the validity for content analysis is the purely subjective nature of analysis. It cannot be guaranteed with certainty, that given the same dataset another researcher would come to the exact same set of conclusions.

Second category of limitations regards the speculative character of the study. Since none of the participants had ever any prior experience with AVs, it was virtually impossible for them to imagine how the actual travel experience would *feel*. For that reason, it seems that many aspects relevant in real life were largely underestimated during the discussions. For example, the feeling of being "trapped in the AV" was almost exclusively brought up as a general reflection, but was basically neglected when discussing AVs in the context of daily activity plans and travel and location decisions. It brings a major doubt about credibility of those results, for which the mentioned feeling could play a significant role. For example, it raises the question whether people would be indeed willing to travel with AVs on a regular daily basis, or perhaps the burden of deterministic, isolated travel would be too heavy. Moreover, lack of experience with AVs and imaginary character of the discussions could cause replication of current travel behavior in the statements of the participants (see König & Neumayr, 2017). Such replication was identified as one of the possible ways of using travel time inside the AV, but due to this limitation it is not certain if it can be a valid conclusion regarding AVs users' behavioural adaptation. Furthermore, the speculative character of the study led to many very general statements

from the participants, which validity cannot be assessed in any way. One of such examples is the following quote:

“CHRIS: Then yeah, one of my hobbies would be changed to travel more.”

The above statement does not sound too strong, and without any actual context cannot lead to a credible conclusion that indeed an AV would cause more travel. A similar example could be using an empty AV as a courier. Whereas it is easy to “send” such vehicle to a grocery shop in a FG, this decision might not be so obvious when dealing with an actual, privately own vehicle in real life, which most likely cost a considerable amount of money.

The third, last category of limitations is related to the scenario presented to the FGs participants. To make the discussion actually possible and avoid confusion and diverting from the main point, major simplifications were assumed (see 3.1.4). Although the scenario facilitated carrying out the FGs, it is rather unlikely to happen in real life. Aspects like safety, reliability or automation level of AVs will certainly have a crucial impact on the actual activities in the vehicle. It must be noted that the scenario used in the study is improbable to happen in the exact same form in reality. This fact can be seen as perhaps the major limitation of the study.

7.2. Comparison to the existing literature

To bring depth to the findings and show their significance in the context of existing body of knowledge, the results were compared with existing literature.

With regard to the findings on travel time use and perception, the impact of multiple elements also identified by the present study was already stated by scientific papers. Factors like travel duration (e.g. Gamberini et al., 2012), travel continuity (Hine & Scott, 2000), privacy (Tirachini et al., 2013), comfort (Ohmori & Harata, 2008), facilities (Gripsrud & Hjorthol, 2012) already were acknowledged to be significant for travel time use.

Findings not expected prior to the study, e.g. importance of casual social interaction for travel time perception were also mentioned by a few papers. However, the existing literature on this topic (e.g. Ettema et al., 2012; Morris & Guerra, 2015) refers explicitly to a direct interaction, and does not take into account just “being among others” – the aspect found relevant in the current study. The influence of isolated manner of travel specific for AVs was not yet properly addressed in the scientific literature.

The question of motion sickness for AVs has also already found some interest. Diels & Bos (2015) state that motion sickness might prevent the users from engaging in non-driving tasks, which might be an obstacle in capitalizing the benefits of the technology. They state that “self-driving cars cannot be thought of as living rooms, offices, or entertainment venues on wheels and require careful consideration of the impact of a moving environment.” Sivak & Schoettle (2015) also acknowledged motion sickness as a serious problem for AVs and came up with some basic ways of alleviating it. More advanced technical solutions AVs were also proposed. Ekchian et al. (2016) came up with an idea of high bandwidth active suspension system, and Yusof & Karjanto (2017) developed a haptic feedback device to increase situation awareness and mitigate motion sickness.

Regarding interior design of AVs, Jorlöv et al. (2017) conducted a qualitative study on seating positions in AVs and their impact on in-vehicle activities. Many of the findings resonate with the current study, e.g. envisioning the AV by the respondents as “more than just a mean of transport”. The authors based on their results also speculate about the convenience of an “AV for rent”, suitable for specific occasions. The participants also showed little resistance towards hypothetical movement restraints

(e.g. seatbelts), but the exact impact of such restraints on travel time perception and use remains unknown.

Particular attractiveness of AVs for long leisure trips also resonates with the concept of travel time ratio, which claims the existence of a unique trade-off relationship between activity duration and travel time (Susilo & Dijst, 2009; Susilo & Dijst, 2010). It suggests that AVs might indeed make irregular leisure trips more common by extending the time spent at the actual location. The idea of travel time ratio can also be applied to commuting, which resonates with the observed limit of commuting time for AVs (Schwanen & Dijst, 2002). Enthusiasm of the respondents for using the AV for long travel also finds confirmation in the work of LaMondia et al., (2015). Moreover, the particular advantage of AVs for long travel with children is indicated by study of Price & Matthews (2013) who conclude that travel time might be used by parents and their children as quality time, which is also one of the findings on the current study. Taking into account the entire variety of factors relevant for mode choice in case of travelling with children, e.g. the ability to attend to child when travelling (McCarthy et al., 2017), confirms the advantage of AVs over other modes in that respect.

7.3. Suggestions for further research

Reflecting on the results of the present research, I believe that although it brings a number of interesting insights regarding behavioral adaptation to AVs, the actual credibility of the results is extremely difficult to assess. Speculative character of the study implies that the respondents manage hypothetical resources (their own time) by means of a vehicle they do not possess nor can conceive the actual *feeling* of being inside it. I believe that until real AVs are available for wide-scale tests on public roads, every attempt of examining public opinion on the technology either by qualitative or quantitative methods will bring an unavoidable bias for the mentioned reasons.

Therefore, I am of opinion that further research on human adaptation to AVs requires a major methodological shift, namely it should follow a path trying to emulate an actual AV as far as possible. I believe that capturing the actual significance of factors like social isolation, deterministic character of travelling, motion sickness or movement constriction on the activities inside the vehicle is only possible in an experimental setting.

A possible idea would be providing the examined person with a car equipped with a chauffeur for a certain period of time (e.g. a month). Assuming complete isolation of the respondent from the chauffeur (by using tinted windows and a wall inside the vehicle) and availability of the vehicle at all times, a reasonably close approximation of an actual AV could be achieved. Although this kind of research is likely to bring major financial cost, I believe it is far more reliable way of examining future behavioral response than purely speculative methods.

With help of such new methodological approach, a number of findings from the present study can be validated and extended. Most importantly, the potential psychological effects can be examined more closely. Among them, the possibly increased pressure to perform activities inside the vehicle, the feeling of “being trapped” and the impact of easiness of making travel decisions need to be researched further. These aspects might bear key significance for the actual willingness to use the technology. Moreover, assuming longer duration of the experiment, the proposed method might also bring more credible knowledge on in-vehicle activities, as well as rearrangement of daily activity plans.

7.4. Reflection on the process

Since the present study was my first encounter with qualitative study on any larger scale, I did not have a clear idea about what to expect. Now, richer with all the experience gained throughout the research,

it is possible for me to reflect on the entire process, which I hope can be also useful for students pursuing focus groups (or other qualitative methods) in the future.

Before conducting the first focus group, I was concerned that the discussions might not bring enough data, or that people would not say anything interesting. As it turned out, the outcome was exactly the opposite: a vast amount of data came out, and people said many interesting things, which was a major reason of many struggles which appeared during data analysis.

First of all, I have learned that analyzing qualitative data is an extremely iterative process. After I finished the analysis of all the data, I thought I arrived at a strong and rigid skeleton of what would be the final results in my thesis. However, as one starts to write the results down and gets more and more immersed in the data, the new doubts and ideas for improvements constantly keep appearing in one's head. At some point, as I was reading the transcripts for another time in a row, I decided to highlight the parts that I find irrelevant and I will surely not use. To my surprise, reading the transcripts once more at the very end, among these fragments I still found statements which were eventually included in the final document. Thus, my most important advice for qualitative researchers is to be humble about one's results, namely having an open, critical mind at any point of the process.

A matter closely intertwined with the above is staying immersed in the data. I experienced myself the negative impact of losing the overarching "grip" on the data as a whole. At one point I got very irritated with the data analysis, so I had a break of about one week, during which I did not touch anything related to the thesis. One could expect it would refresh the mind and bring useful distance, however I strongly discourage anyone from doing so. Going back from such a break makes one irritated even more, due to losing connection with the data and what has been done so far. It is therefore crucial to be as immersed in the data as possible. If this is the case, it is often possible that new concepts and connections of various data bits pop up in one's head involuntarily - in a supermarket or when cycling. From my own experience, I must say that at some point the FGs participants felt to me like people I have known for ages – even though in reality I knew almost nothing about any of them. But when I thought of a particular participant, I immediately had the whole story of this person in my head, which is extremely helpful when analyzing qualitative data.

At this moment it is also important to stress that it is quite sure that during the process the mental state is likely to vary a lot. My initial enthusiasm turned into anxiety, as I was first confronted with the immense amount of data to analyze. As the analysis continued, moments of true interest and even enjoyment appeared, as well as moments of puzzlement of pure burden and exhaustion. Now I realize that this is a quite common state of affairs when writing a thesis, but what I would like to stress is the importance to keep on going despite the circumstances. It can be even a little bit of work on one of the worse days but again, not losing the grip on the data as a whole and on what has been done so far is a key element.

One aspect to which I already referred is the problem of subjectivity of a qualitative study, especially such speculative one. It often happened, that a statement that I interpreted in a certain way on one day, the next day seemed to mean something different. Moreover, because all the statements on the AVs are based on imagination, one can often wonder: do the people indeed mean what they say? What can be concluded based on that? Is this conclusion still justified or am I making it up? After experiencing such issues, I feel entitled to say that no one has the ultimate answer to these questions, including me. I find it unjustified to say that every other researcher would arrive at exactly the same conclusions based on the same dataset. What is however important to keep in mind is the risk of excessive perfectionism. If subjectivity is such a vital element of analysis, one might easily fall into vicious circle of constant reanalyzing and rewriting. As mentioned, the iterative element is crucial for deep analysis,

but it is important to set the border, behind which the new iterations do not bring added value to the results.

As a final point, I have to admit that at some moment I also fell victim to perfectionism, and there are still things in the thesis I am not fully satisfied with. For example, I feel that the proposed travel time use mechanism could more accurately explain treating the time as time to relax. Even though I know what elements could enrich it, I believe they were not expressed explicit enough in the FGs to be included as part of the results, namely purpose of the travel, time of day, or simply mood, which is a very random factor. Thus, I made a decision to not adjust the data to fit my wishes and preconceptions, but rather to use it in as inductive manner as possible. Still, the above factors are acknowledged by the literature as significant for travel time use. Moreover, I also recognize the trouble with using notions like “productivity” when talking about travel time use. Even though it leaves a lot of room for discussion about what is *productive*, eventually I decided to use this term, being unable to find a more suitable expression. I also spent a lot of time trying to make the results more concise and easier to read. However again, making the trade-off between detailed explanation and compactness was a very challenging task, especially for such speculative research. I must admit that all such unresolved issues still leave the lingering feeling of unfulfillment.

However, I also admit that writing these final words I feel relief at the thought of submitting the final document and ultimately letting go of the uneasy thoughts on making certain things differently. Throughout the whole thesis process, I started to pay more attention to people talking about their travel experiences, and the use of travel time. To my satisfaction, I noticed certain patterns which are confirmation of many of my findings. It makes me hope that my research contributed in some little way to the exploration of the very complex phenomenon of travel time use, and perhaps might serve researchers in the future.

For everyone wishing to delve into qualitative research, in particular FGs, I wish best luck. Despite of the above difficulties and obstacles on the way I really encourage for it, since above all I believe that FGs are in fact a fun and interesting thing to do.

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Appendices

Appendix A: Relevant quotes

A.1

PAULIEN: “If (the travel) is shorter, I call hands free and listen to music. If it is a longer trip, like next Friday I have to go to Helmond, then I do self-study. Then I switch between my music and study.”

A.2

FELIX: We are talking about a travel time of 20, 40 minutes. It is not that you can do miracles in such a time. Half an hour longer in the car and then all your work is complete.

JELMER: No but I'm almost all day in the car.

FELIX: Yes for you, but for the rest.

MODERATOR: For him, a lot more productive.

FELIX: Yes, yes. But for me that's 20 minutes in the car, that work, how much work is that?"

CAROLINE: "Some people might leave their office earlier to do the rest in the car. But if the travel time is at least one hour. They may leave earlier to reach home earlier."

A.3

ERIC: "I'm happy when I look at the travel planner and I see that the trip takes an hour and twenty minutes and it indeed takes also an hour and twenty minutes. Then I get satisfied, then I have slept or whatever I have done. But if it takes longer then I'm annoyed. It has to do with the time that I used during the train journey. If the time indicated for it, is taken, then I'm going leaving the train much more relaxed."

A.4

LAURENS: "Also for work, (...) If you have 2 hours then it really matters. (...) But, within a short time there is nothing to do. The risk when you are busy in the AV and you arrive at your destination when you are not done yet. That might be a negative thing, at least for me. I'm worried about that."

"DENNIS: But if I am in a bus I think sometimes I feel like I want to extend the trip so I can finish this particular podcast. So sometimes the length of the audio varies, sometimes it is very short and sometimes it is more than 20 minutes. I consider it as nice entertainment and I don't want to stop.

MODERATOR: So sometimes the bus is delayed and all the people are 'grrr' and you are 'yes!'

DENNIS: Yes! Delayed!"

A.5

LINDA: "I live on the eastern side of Rotterdam so I have to switch, so it's short pieces that I travel. It is an hour or so from door to door. I cycle a bit, then the train, then switch again, another train, then a tram. So a lot of fragmented trips. (...) And the fact that I have to makes switches leads to the fact that I cannot really do anything, prepare for work or whatever. It could be more optimal, I adapt to the possibilities that I have at that moment."

ELISABETH: "I think it also depends on the connection you have, so if you have a long intercity trip then you open your laptop, then that's different from Delft to Rotterdam. Then you have to switch to the subway, then you have short trips and you just don't."

A.6

DENNIS: "Because I am in a bus I don't want to travel further for shopping activities on the way back from work or something. I don't want a trip chain. But I could if I had an AV. Because it comes together. I like my entertainment as well as doing shopping, with PT is too much of a hassle."

ANDRÉ: "My parents live in Brabant which is quite far. I could go there more often. Now it is doable in PT but you have to cycle to the station, to the train."

NORBERT: "What would be nice: now, I often have to wait because I have to transfer, that would be gone. Certainly in winter, it is also not very annoying, but that might be an advantage."

A.7

PAULIEN: *"The rush hour also. The subways are completely full, you can avoid that, when you travel with the AV."*

"ELISABETH: *I wonder if we need to assume that there is still PT (in the future) So when do you choose to go in your own customized AV and when do you just take a busy NS train?*

JELMER: *I think that they will go bankrupt, to be very honest.*

FELIX: *I do not see the value of PT anymore in the future."*

A.8

PIETER: *"Is it true that the chairs in an AV are design in a way such that you are facing each other? The basic situation is of course that we are sitting behind each other. Maybe they have swivel chairs."*

LAURENS: *"This ensures that you save time eventually. Then I would just like to have a luxury car, just a good bed. I rest my case."*

BART: *"Yeah, maybe thinking about resting like 'relaxation car' where I can lay down maybe with music and maybe perfumes."*

PETRA: *"I was just visualizing that you have some sort of room or you can go to bed or you can sit at your desk, that you indeed have these interiors."*

NORA: *"Then you build a coffee machine in your car, then you can just make coffee."*

A.9

"LAURENS: *It seems very strange to me, (outside) design does not matter anymore, yes functionality. Pub inside it.*

GABRIELLE: *Yes*

ELISABETH: *I think design matters.*

JELMER: *I think it's especially for the inside. One directs him as an office, the other like a pub, I think that's where the focus will be."*

A.10

BART: *"Maybe AVs that are available for rent. A collection of AVs with different functions. They may be available for rent. (...) You rent the car when you need it, when you go away for the weekend, they tell you the position of the car in the city."*

LINDA: *"You will get a kind of lease construction, you get a subscription on three types of AVs, sports AV, the chill AV and the business AV. In the morning I will book the business AV, in the afternoon I will take the chill AV, and it is there when you need it."*

ARJUN: *"(In the AV) you can play chess, you can play darts, cards. Books reading. I mean you can have a small shelves of books. Even you can have like a whole menu like in restaurants: which kind of car you want."*

A.11

NORA: *"I have no work that I can do within my car. So from my job perspective, my work is really my job, so I do not have do that in my car. So I would go and watch a movie."*

A.12

ARJUN: *"I don't think it (traveling by car) is productive, it is totally unproductive. So, even if I could work on my laptop I would prefer to send some mails, which could be short tasks, that I could finish when travelling."*

CHRIS: *"Yeah, of course when you are driving, you don't do anything, you're just driving. I cannot do any work."*

A.13

MAARTEN: *"Yes, imagine sitting in the AV, you don't have to pay attention to the traffic all the time and look if you have to intervene. The moment a car drives itself and you no longer need to focus on the road, it will ensure that you can relax a bit more."*

NIEK: *"In my case, if I would use an AV, I would see it more as a moment of relaxation. (...) You do not have to pay attention to the road by yourself. It is not that I am going to do all sorts of stuff in the AV, brushing teeth, working, mailing or something."*

CHRIS: *"It is interesting to sit in a car that moves automatically, you have no stress. (...) You are relaxed, sitting in a car, smooth, automatically. It is good. If it is your personal AV you can check email, read the news, easily talk with phone, send message."*

MAARTEN: *"I just noticed that in a car, you are always very limited in the things you can do. So the moment you have your hands free (in AV), and you do not have to concentrate, then you are a lot more free."*

PIETER: *"Yes, if you can fully rely on the equipment of the car, in terms of safety, then you are very relaxed in the car. Then you can do a lot of other things."*

A.14

ELISABETH: *"I'm really annoyed when I'm on the highway, stuck behind a slow car for a long time and it just does not go smoothly."*

A.15

DENNIS: *"So when I cycle with my wife (...) it's meaningful. You're just talking and spending time together. But if I was alone, probably I want to reach my destination as fast as possible, because I don't think it is really productive if I was cycling alone."*

A.16

KATRIEN: *"There is always the fact that you are in a traffic jam with several people and not alone. And you can look around you at what the rest is doing."*

GABRIELLE: *"No one seems to look at you anymore. You all have your own world in that car. So nobody is looking at each other anymore. Once you get in, you're doing something. (...) It will be a completely different dimension."*

A.17

NORBERT: *"If you have to travel by PT, like me, sometimes you encounter unexpected moment right? How should I say this, if you have the same trip every day in that AV, then every day is the same. What you see, whether it rains, if the sun shines, or you see how people walk, what people say, what people look like, all those things. It becomes monotonous. Then you are no longer surprised either in a positive or in a negative sense."*

LAURENS: *"A few weeks ago I drove with my girlfriend, at a certain moment I followed the signs to Nijmegen. That was not the road we drove before. Then we passed a part of the Netherlands where you had houses in hills and we really thought like: damn that's fun!"*

ELISABETH: *I think you can no longer really decide on what your route looks like at this time and how you feel at that moment. You're just handed over to the device you're in. While I normally thought, here you can really tear up. Or stop at that petrol pump.*

FELIX: *That is still possible, I think?*

ELISABETH: *Yes, you can, but you have to re-enter and schedule it. That vehicle will not pass other cars at the moment you're in a hurry.*

GABRIELLE: *Yes, the control factor of course. That's gone. Completely gone. You are only in control when programming. What kind of stop you're going to make, but that's it. Then no more. I think you're mentally a little less good. Now, of course, you must react alertly and respond ad hoc if something happens and so on. I think that little bit in your brain just dies.*

A.18

Travel time perception:

LAURENS: *"I am more or less happy with it (travel time) You are used to it and it is until here and not further, in the sense of: if I want to relax then I put on my music and then I am not available (...). I understand Koen's frustration with traffic. I also worked in Amsterdam for 6 months, so I know exactly what it is about. But at the same time I think: I cannot get through it, I cannot go over it, not under it, so just try to stay calm, it is just a mindset."*

Activities:

LAURENS: *"Listening to music, smoking a cigarette, putting the day planning in my head."*



A.19

Travel time perception:

KOEN: *"I am not happy at all with the travel time that I have. (...) So, if I have to be somewhere at 8 o'clock, and it's a two hour drive, I have to leave at 6 o'clock. Then I think, in that time I could easily answer my e-mail, make phone calls, things like that. (...) At the end of a working day it would be nice if you could relax, instead of being annoyed and still have to go all the way home."*

Activities:

KOEN: *"I travel to work by car. One time it takes an hour, the other time two and a half. It is a bit mixed during the week. What do I do when I am on the road? Watching traffic. And I do listen to the radio or Spotify in the car. So pay attention and listen to music and being irritated."*



A.20

Travel time perception:

PIETER: *"I sell plastic window frames, dormer windows, sliding doors. I am very much on the road, they sometimes send me to Vlissingen. It may also be the case that I have to go to Almere or Den Helder. I also notice that it is getting busier. Compared to a year and a half ago, extremely busy. (...) The stress you experience, it is simply incredibly exhausting. Continuously have to pay attention, in case of congestion, during traffic jams. Cars can suddenly come from everywhere. You get all sorts of crazy situations when driving in a traffic jam."*

Activities:

PIETER: *"On the way, I eat in the car, I call, I mail, I send WhatsApps (...), sometimes also a bit of administration, keep track of things in terms of financial numbers, (...) just in a notebook."*



A.21

Travel time perception:

JOHANNA: *"I really like to drive the car, so I really see it as relaxation. I'm also driving too fast, I like it. Those 20, 25 minutes to my job, I always like it. But, I have to say, I'm annoyed by people who are driving too slow, so that's not nice."*

Activities:

JOHANNA: *"What do I do in the car? Listen to music, singing, sometimes make my makeup when I'm in front of a traffic light, if I forgot that. The mobile I try to conceal as much as possible. Sometimes it happens that I look at it, send a little message, but not often. Almost never actually."*



Travel time perception:

LAURA: *"When I am on the train, I am very relaxed. (...) When I go by car, I'm going to do something nice. So then I am especially happy. (...) At that moment, for example, I go for dinner to my mother. That's why I pick the car. I do not feel like my time is lost in the car."*

MODERATOR: *You see it mainly as time to relax?*

LAURA: *Yes."*

Activities:

LAURA: *"(In the car) I just listen to my radio. (...) I do not prepare work in the train, I do not need that for my job. I call my sister."*



A.22

NORBERT: *"Doing nothing may also be good for your mind and body. (...) So I am thinking, just like doing nothing, like listening to radio, listening to music in the car, I think that is important, just relaxed, that you do not have a feeling of being rushed all the time, like: I still have to do this, I still have to do that, I'm not going to make it. The time that I have, that you just don't need to do anything, walk quietly to the station, the time that you listen to music, the time you're not busy. That may also be good."*

A.23

JELMER: *"Yes, if you have such an automatic car and you drive it, the highway becomes a kind of express train."*

ELISABETH: *"The question is whether there is still PT and private transport, or the AV in an ideal world is PT. (...) Actually a kind of taxi."*

NIEK: *"Well I would, just like when you get on a bus, just relax, just sit down and relax. (...) Normally you are constantly paying attention to the road. You must now imagine that you are going to travel by bus. (...) So, a driver who drives the bus, but you do not have to do anything. You can just sit very relaxed."*

A.24

LINDA: *"I would still like to catch a plane for a long travels. I just want to be there as soon as possible. I mean sitting in a car for a day is not fun, no matter how many movies you see."*

RENATE: *"If I do not have to steer and just can sit in my car, it would be more comfortable because you can do what you want, but in the end you are still sitting for a day and a half in the car. Pieter: It is a long time in the car."*

LINDA: *"However, I still think I will get bored at a certain moment, you are still locked up. You get some more degrees of freedom, but you're still trapped."*

CAROLINE: *"We shouldn't spend more time in the AV because it is comfortable. My home is also comfortable so why not spend time there? (...) So, I just forget about the house, and I can live in my AV? Because of being comfortable I should not spend more time in the car. It does not make sense for me."*

A.25

LAURENS: *"Yes, if you now enter the car, you get in, then you have no sense of freedom. You can decide what's going to happen, music, no music, it also works a bit therapeutically so to say. Having thoughts about whatever. Later on you will think, drive across the country, I have a 2 hour drive, this means that there is a workload because you have a 2 hour drive. You assume it's all going to happen. It just becomes working time."*

PAULIEN: *"But when it comes to work in the AV or whatever, you have to know your own limits. Then I think the car makes it better. I mean regarding to your work, that you do not just keep going because you have more time, then you go on and on, with everything. For relaxation, the car makes it better. But if you are going to work, work, work and when you have free time you also work, you also take your phone in your bed, then you have no limits anymore. Then you cannot relax. You think you have more time to relax, but it is not. If you have everything in balance, then it is just better."*

A.26

ARJUN: *I can read news in my AV and have breakfast.*

MODERATOR: *Breakfast, ok. Normally you have your breakfast at home but now you change your breakfast to...*

ARJUN: *Normally I don't have breakfast because I don't have time in the morning."*

MAARTEN: *"Yes, also what Norbert says, you can shift your program a bit more. Breakfast, brushing teeth that kind of things you do at home before you leave. (...) I am not someone who is looking forward to a very long travel time, even though you can set up your car as a kind of living room. But still, this would be something that I think is really nice. To move your morning program to your trip."*

A.27

CHRIS: *"If I used the AV in the morning so I can sleep more and have breakfast in the AV."*

KOEN: *"Well I can sleep longer. Imagine that you can do your make-up in the AV, wash yourself or name it, you can sleep longer, you can change clothes when you go to work in the AV, do your hair, you name it. I really see time saving."*

A.28

NORBERT: *"You have a contract that you have to work 8 hours a day, those hours you normally work, not more. But if you have two hours of travel time in which you cannot do anything, then you have lost those two hours. But if you can already use these two hours, then you really do have time left. I can imagine that it could be a very big advantage."*

CAROLINE: *"Some people might leave their office earlier to do the rest in the car. But if the travel time is at least one hour. They may leave earlier to reach home earlier."*

A.29

Current travel behaviour:

DENNIS: *"So when I am cycling I don't do anything. I usually cycle with my wife so I have to talk to her. Or look at the landscape or try to be faster, asking her come faster. And in the bus I usually listen to podcasts or music."*



Behaviour in AV:

DENNIS: *"Actually, I don't think I would (sleep in the AV). I like what and where I am doing right now. (...) If I compare with PT or a bus I would do the same thing, I would listen do a podcast or read a book. I don't think I would work more. So, I think for me it doesn't really change much. It's not transferring something I do at home to something which I do in a car."*

A.30

MAARTEN: *"Yes, it is like, I cannot really say how I would use that time. (...) I do not immediately see what things I could do, look at my phone, but that is of course not very useful. So for that matter, it is not like: I can now spend my time much more useful. But now it feels as completely lost time."*

RENATE: *"It is so difficult to think about what you would want different, you are just used to it. It is therefore difficult to think differently. Yes, what would you like differently?"*

A.31

NIEK: *"Yes, look, in my case if I would use an automatic car, I would see it more as a moment of relaxation. It is not that I am going to do things like: preparing my work, it is purely for relaxation. You do not have to pay attention to the road by yourself. It is not that I am going to do all sorts of stuff in the car, brushing teeth, working, mailing or something."*

JOHANNA: *I like sewing in my free time, which takes a lot of time. Sometimes I'm busy for 3 hours, it's going very fast. But, I would also like to do that in the AV.*

A.32

LAURENS: *"I would like to have multiple choices. Suppose I have a stressed day, then I want a massage chair and just my favourite music in the background. But indeed, another day I still have energy left, and then I want to exercise."*

Petra: *"Sleeping will not apply to me. The nice thing is that you can do something active or something passive, that you can make the choice. That you can determine this per day or per time."*

PAULIEN: *"It is for me also more impulsive. Not pre-planned. (...) I never actually plan anything in advance, it is just spontaneous."*

A.33

PETRA: *"Or if you actually finish your work inside the car. Then you come home and then you do not have to finish it. Then you have more time for your children or other important things."*

A.34

PAULIEN: *"When you leave the AV you are done, (...) just leave it there and at home is at home. (...) That last hour is used differently, you are more productive. And then just feet in the air at home, watching TV, music, knitting, reading."*

ERIC: *"I think it is nice to close the office door behind you and really be ready, so to say."*

MAARTEN: *"It can go two ways, on the one hand I think, I sometimes stay late on my work, but then I am working on something and then I want to finish it. It might be that at the moment you know, I do not want to go home yet because I want to finish something, I could catch up on the way home. (...) So if I have something like that, I want to finish something for half an hour, because I will forget it before the next day, then I can do that in the AV."*

A.35

CAROLINE: *"I won't do the work in my AV. But busy people may do this."*

PAULIEN: *"Or if you do business, you can have a business meeting on a large screen. Then you can give a presentation somewhere on the way."*

LAURENS: *"I would meet with my customers more easily outside the office. If I want to meet outside the office now, before I have made an appointment, then I have to sit in a car for an hour and a half, one and a half hour back then I think: I am not going to do that."*

A.36

"DANIEL: *I think one of the disadvantages for me, if I replace my bike and train with an AV, I will become fat really fast. (...) Because I will be too lazy to go for a run in the evenings or go to the gym afterwards to burn extra calories. I also could not resist eating the same, less.*

MODERATOR: *Isn't there a gym in your AV? Or not in yours?*

DANIEL: *But it still takes the willpower to use the gym. It's only a resource for me."*

"BART: *People are busy, it is all. I feel that people do not spend time, which is essential, for casual interaction or not about work. Spending time with people with good colleagues. It is very important. Spending some time to work in the car will liberate, make available some time for this kind of interaction. (...) Yeah of course the time would be used to have this interaction.*

ANDRÉ: *You think people will? I think when people have more time, they just spend more time on their own."*

CAROLINE: *"After a while people will not travel anymore. It is not interesting anymore."*

KOEN: *"I think I'm going to get bored at a certain moment. Then I think: yes, everything is already done, then I am back on the couch. Then after months or years, yes, life was better in the past, back then I was just busy."*

ELISABETH: *"I think that too many new things of which you think at the beginning: I go a lot more time but at one point it's just normal and then you think yes... The novelty is off. And then it's no longer necessary. I can imagine, yes your travel range just gets bigger."*

A.37

FELIX: *"I actually have exactly this, I work for four and a half day and every Wednesday afternoon I pick up my son from school. (...) And if he goes out by himself or something. That car can also pick up your children at night. Then you do not have to stay awake for it. (...) I like that a lot, my son is 10 now, but if he's going to go out, and I feel like I do not want him to go over the streets alone. Then I do not have to pick him up but then the AV can."*

A.38

"KATRIEN: *Can you also send the AV by itself?*

LAURA: *I like to take a look at my children, at their preparations. When my son plays football I always go there and look at the training. I am one of the few mothers who never misses a training but I think it's important to see that they play together and that things are going well.*

KATRIEN: *That's nice for your child when he sees: Mom is interested in me.*

LAURA: *I feel really sorry if I have to make a deadline but then I just say goodbye to my boss: I go to my child."*

A.39

"NORA: *We have to bring my daughter to her internship two evenings a week, so we do not have to take her to an internship anymore. Now, she can get in that car and the car will take her there. And that car comes back to us, so that would save time. So that would be nice, if I trusted it. But I have to trust that thing first. I'm not really going to put my child in such a car on his own.*

NIEK: *Yes, so do I, how do you know that the right person is getting in your car?*

NORA: *Yes, exactly. It is my daughter, so I do not just do that.*

MODERATOR: *But imagine that it is completely safe.*

NORA: *Yes, then I would do it."*

PAULIEN: *"But, when it comes to picking up children, I do not really think that is an advantage. You do not know how old they are. Maybe they sit in the car with a group. No, I think that's too risky."*

RENATE: *"I would just stay with my children if I bring them to school, that may also have something to do with age. If they get older then I would (let them travel alone)."*

A.40

LAURA: *"If I have to park my car in Amsterdam, Rotterdam you have to pay a lot of parking fees. Does this remain? Is that different?"*

LAURENS: *"I actually combine it, we have an office in The Hague, where I have to be two days a week. Then I go partly by car to <location removed>, then I get on the Randstad Rail again, because I have to pay parking fees."*

MAARTEN: *"I mainly use the bicycle for things in the city center. I think it's already mentioned, but if you have to park your car there, it will cost you a lot. That is why I think I would still take the bike, because you have to park your car somewhere."*

A.41

RENATE: *"Let the AV pick up your groceries at the pick-up point of Albert Heijn, I do not have to go anymore."*

A.42

"Maarten: If I have to drive for more than two hours, I have completely lost my concentration. I would never make a car trip to Paris, but in this (AV) case, you do not have to take it into account.

Norbert: Exactly, and you have the comfort of your own room, no noise, no people who are calling, you do not have that."

A.43

PIETER: *"I often have the fight against sleep, while I still have to drive a long distance. But, I don't want to go off the highway, I want to go home as soon as possible. But actually I am really tired. It would be great if you could sleep. Even if others ride along with me, I am the one who has to stay awake, they can turn their chair backwards, I would like to do that myself."*

CAROLINE: *"Hotels will not be happy with this because if it is allowed people will spend the night in their AV. So for them traveling is cheaper, because they do not need to pay for the hotel. You have a good bed. So traveling is cheaper so maybe I will travel more."*

A.44

PIETER: *Well look, your freedom, you are in your own cocoon which does the work for you, maybe it will take longer but you will travel in a very relaxing way to your destination. Airport is stressful, already in the arrival hall, but also in the plane itself. There are incredibly many people in a very small space.*

PAULIEN: *All the carrying with suitcases and waiting.*

PIETER: *It can be very cheap, but that is not a pleasant way of traveling. While this will be a very nice way of traveling.*

PAULIEN: *"Now, I will perhaps realize everything (travel plans), with holidays and travel. If you take a look at France and Germany, if you have to go by plane, first 2 hours to Schiphol, then you might go by AV as well."*

A.45

RENATE: *"Yes family trips, to the zoo, amusement parks, that are the things I would do, I'm not going for a daytrip to a zoo in Arnhem now, I really have to go during holiday or weekend away when I would like to do that."*

A.46

"MODERATOR: So for example you would travel further for vacation?"

LAURA: *But also just for myself, a day in Groningen is great fun. A day in Haarlem is also fun.*

LINDA: *3 hours to your destination, so 6 hours in total, that remains the same.*

KATRIEN: *Yes, but less intensive. It is a difference whether you drive yourself or whether you can sit back or play a game with your family, whatever you do in that car.*

LAURA: *That is nice, monopoly in the car.*

KATRIEN: *Exactly."*

PAULIEN: *"But suppose you have younger children, then you go to a theme park, then you can be busy on the go, quality time with the children."*

A.47

"GABRIELLE: (Would travel) further away, yes. (...) You are less tired. You do not have to account for a ride back, you do not have to go back in the evening, if I go so far away, I want to eat and drink, but that's not possible again. In this way, you can easily go to Brussels or Paris or so.

MODERATOR: To eat out there?

GABRIELLE: Yes

FELIX: That would be an invention, to Paris, God.

GABRIELLE: Yes, nice right? Eat there and then go back and sleep in your car.

ELISABETH: Then you are not talking about commuting anymore, but really about fun trips."

A.48

"PIETER: I would also travel further. I would also go on vacation much easier, instead of going by plane.

PAULIEN: Yes, I also travel by car to Italy, Spain, that kind of places but I also go by plane. Now, I would take the AV rather than the plane. I am more a person that really does things on the go. Just stop on the way and eat something. Exploring the neighbourhood, that's what I like more. My children are of course also a bit older. They don't want to only go swimming in the hotel."

A.49

LINDA: "If I have to move it is indeed, the time you have to travel back and forth is less decisive than now. Now it is like: it shouldn't be more than an hour otherwise it is really a waste of your time, but, if you can use this hour useful, then it makes sense."

CHRIS: "It makes the decision easier. If you live in a place where your work is far away. If I have AV I would be more comfortable."

JELMER: "But there is one possibility (otherwise would not move), if I can work more, want to work elsewhere, other boss, career opportunities, a job offer in Paris, I would do it. I would not do it for the moving part, but I would make other choices because I can travel further."

DENNIS: "But when you have your own private car or AV I think it would definitely be so much easier, you don't have to think so much. I know people that commute from Leiden or Amsterdam to Delft, it is a bit strange that you want to travel a lot, but if you have other constraints, for example my wife, then it makes the decision quite easy."

A.50

NORA: "No, if I had to move for my job, I would travel a bit further to my job, I would travel a bit further. I would not move for that. I would travel a bit further, that does not matter to me, but I'm not going to move."

A.51

ELISABETH: "No I would not work at all in Groningen, even if I still live in Delft. You still have the travel time. I can use that as well for other things."

CAROLINE: "There is no difference for me. I don't want to change my city. I don't want to spend time commuting every day."

LINDA: "About moving? No, I would not move because I have an AV. If I have to move it is indeed, the time you have to travel back and forth is less decisive than now. Now it is like: it should not be more than an hour otherwise it is really a waste of your time, but, if you can use this hour useful, then it makes sense. However, I still think I will get bored at a certain moment, you are still locked up. You get some more degrees of freedom, but you're still trapped."

A.52

LINDA: *"About moving? No, I would not move because I have an AV."*

NIEK: *"I see it as a nice addition, but I certainly would not move for it."*

PAULIEN: *"Yes, I want to move anyway, but not because of that car. That is different. (...) So that basically will not be the cause for a move."*

RENATE: *"It does not affect me either. I would not move for it."*

A.53

PETRA: *"No, I would not move. I do not see myself living in a village or in a rural area. It is of course nice that you can perform a trip more often to go there. I need people around me."*

JELMER: *"I feel like this: my house is my house. I am a Rotterdammer now. I have nice neighbours who will not move for me. I like it there. If my son is home, we'll go outside. There really cannot be a car that is better than that."*

JOHANNA: *"Now, I see myself living in Delft in the future, I think it is such a cute little town. That you walk into town, a pub for example. I think I would not move for that. Because it is cozy, the atmosphere, (...) social events. Friends, going out. In that case: no (to relocation)."*

NIEK: *"No, for me it is more dependent on the location, not whether I have an automatic car."*

A.54

BART: *"Yeah, it would influence my decision. In Delft rents are very high, so we may decide to rent a flat elsewhere. In a place with better housing and a nicer for weekends. And commute in AV."*

DANIEL: *"I think it is also depends on how expensive the living there is in the region. If there is a big advantage in price by living outside the city and you don't have a choice then it is an option."*

GABRIELLE: *"Yes, I would do that too (move somewhere else). Wherever there is less regional tax."*

KOEN: *"But suppose you have to move, suppose I would get a job in Amsterdam and I have to move there, so I would want to live outside of Amsterdam. Because if you want to live in Amsterdam, you have to be really rich."*

Appendix B: FG participants

Group number		1	
Name		Arjun	
Age		24	
Occupation		Student	
Current way of travelling		bike/earlier car	
Current travel time		used to be up to 2h (in a car)	
Usual travelling activities		nothing, gets frustrated because of congestion	
Current satisfaction with travel time		Unsatisfied: it's completely unproductive	
Time perception category (now)		Time wasted	
Time pressure		No time for breakfast	
Activities inside AV		Morning: breakfast, newspaper	
Activity transfer		Transfer of morning preparations	
Daily plan rearrangement/ use of extra time		Extra sleep in the morning; Otherwise, no clear idea ('maybe' read or study)	
Travel choices		Unknown	
Location choices		Unknown	
Name		André	
Age		26	
Occupation		Student	
Current way of travelling		bike/PT	
Current travel time		Unknown	
Usual travelling activities		play on phone, read book, music	
Current satisfaction with travel time		Rather satisfied: it's an unavoidable burden to be accepted with positive attitude	
Time perception category (now)		Time to kill	
Time pressure			
Activities inside AV		Sleeping	
Activity transfer		Sleeping	
Daily plan rearrangement/ use of extra time		Staying awake in the evening for a longer time; Otherwise, no clear idea ('probably' hobbies or sleep)	
Travel choices		Would travel more often to friends and family	
Location choices		Unknown	

			Chris	Caroline	Bart
38	Student	32	34	Student	
	now bike/PT, used to drive	Researcher	Student	mostly PT	
	Unknown	now bike/earlier PT	Unknown	Unknown	
	PT: nothing, observing; car:radio/nothing	usually nothing (phone/talking to someone/staring), but time can be used for work if needed		read; look at landscape	
	Satisfied: Likes driving	Unknown: it is unproductive though		Satisfied: travelling is productive and stimulating	
	Time to relax	Time to kill/Time for action (if needed)		Time for action/Time to relax	
		No time for certain leisure activities she would like to do		"People are busy"; therefore no time for social interaction	
	Sleeping; eating; email	Things she never has time for: e.g. Karaoke		Checking news; work (checking emails)	
	Breakfast	No transfer of activities		Work transfer (in PT it's impossible to work on laptop)	
	Extra sleep in the morning			More social interaction	
	Would travel more; would travel more to destinations with parking problems	Would use AV for long travels (e.g. going back home to Iran); for touristic purposes		Would travel more overnight (like in a night bus)	
	It would have influence on hypothetical decision	AV would not make difference, doesn't like commuting anyway		AV would have influence on hypothetical decision; would move to a nicer and cheaper place further away	

2		Daniel	
Elisabeth	Dennis	Daniel	
42	33	32	
Independent consultant	Student	Student	
train+subway/car	bike/PT	train	
PT:40min; car: 40min-75min	bike:30min; PT:20min	Unknown	
phone calls/emails (work-related)/radio	cycling: nothing; PT: music/podcasts/audiobooks	music/audiobook/staring	
PT: unsatisfied, would use it differently but can't due to crowding and lack of comfort and travel continuity, car: satisfied, it's a resting moment	Rather satisfied: productive if performing activities (e.g. Travelling with wife/listening to podcast), unproductive otherwise	Difficult to assess: it's 'between productive and unproductive'	
Time wasted (PT); Time to relax (car)	Time for action	Time to kill	
House administration			
Read newspaper; watch TV; doing errands (house administration)	Same as now: podcast;book	Playing computer games	
House administration	No transfer of activities ("I like what and where I'm doing now")	Unknown	
	Self-development (learning to code/Dutch); living healthier		
Would maybe go more often for leisure trips far away but that would end as soon as "novelty is off"; Also only for irregular trips ("I wouldn't work in Groningen")	Unknown	Would travel less because of using AV as a courier for people and things	
Would maybe move a bit but not too far away; Commuting time is still a burden because you're "trapped inside AV"	AV would make relocation decision easier	Financial aspect would be important for location choice	

Eric		
Gabrielle	Felix	Eric
65	33	30
Teacher (retired)	Sales agent	Storage company owner
car	car/sometimes subway	train
40min	car: 20min; PT: 40min	30min
car: talking on the phone; PT: work	car: music/whatsapp; PT: music/surfing on the Internet	nothing; rest; mobile phone; no ritual (spontaneous decisions)
Satisfied: It's time to do things which otherwise would be lost time	Rather unsatisfied: Would organize the time differently with an AV	Satisfied if travel time is as expected, if it is different it leads to disruptions of daily plan (unsatisfied)
Time for action	Time to kill	Time to kill
	Can't relax when having leisure time at home (watches TV series "in a rush"): it's not relaxing; also some house administration/letters which have to be done	Many appointments during the day; doesn't prepare breakfast in the train anymore because he's too busy; sleep shortage
Do make-up	Watching TV series; rest; using AV as a courier for his child	Relax: do nothing, eat or have a conversation
Transfer some morning preparations (make-up)	Watching TV series; house administration	
When leaving work earlier and finishing it in AV, she could go to gym earlier than usually and save time	Would not have to pick up child from school or during the night; would use this time for himself or for sleep	
Would travel further; e.g. leisure trips to Paris		
AV would influence relocation decision; would move to a place with less regional tax	Would hypothetically move further away to a cheaper location and bigger house: ravel time no longer a problem	

ω		
Koen	Jelmer	Johanna
33	44	24
Business consultant	Contractor	Catering assistant
car	car	car
1h-2,5h (multiple destinations for work, all over NL)	travels all the time for work	20min
pay attention to traffic; radio/music	whatsapp/phonecalls (for work); eating in the car	music/singing/makeup
Not satisfied at all; is frustrated, could answer mails/phone calls/sleep in that time	Unsatisfied: It's stressful	Satisfied: enjoys driving a car, it is relaxing
Time wasted	Time for action	Time to relax
	Constant work pressure: often no time to even eat outside the car; Stressful traffic; Takes the work home which is bad for family life	
Work (AV as a workstation); possible transfer of morning preparations	Would do his work in AV (e.g. phoncalls): "AV would be my office"	Knitting
	Work transfer	Cutting food
Extra sleep; starting work earlier (in AV): use extra time for social life	Extra time with family	
Car would travel more often (as a courier), but the participant would travel less		More travel for leisure/abroad
If the participant had to move, would move to a more quiet area, further away because no driving is needed financial considerations would also play a role	Would consider moving when offered a much better job (then AV would impact the decision), otherwise the value of nice neighbourhood and people is too high for AV to influence relocation decision	AV would rather not influence the choice; neighbourhood and cosy environment is most important ("social events, friends, going out")

Katrien			Laura			Laurens		
46	38	46	38	46	46	38	46	46
Bus driver	Administration at insurance company	Credit controller	Administration at insurance company	Credit controller	Credit controller	Administration at insurance company	Credit controller	Credit controller
car	car/train	2 days a week: car+rail/3 days: car	car/train	car/train	2 days a week: car+rail/3 days: car	car/train	car/train	car+rail/3 days: car
1h (morning); 30 mins (evening)	train:30 min; car: 1h	car+rail: 1h; car: 30min-1h	train:30 min; car: 1h	car+rail: 1h; car: 30min-1h	car+rail: 1h; car: 30min-1h	train:30 min; car: 1h	car+rail: 1h; car: 30min-1h	car+rail: 1h; car: 30min-1h
radio; planning the day; phone calls; music	radio	car+rail: newspaper; phone, car: music; smoking; planning the day	radio	car+rail: newspaper; phone, car: music; smoking; planning the day	car+rail: newspaper; phone, car: music; smoking; planning the day	radio	car+rail: newspaper; phone, car: music; smoking; planning the day	car+rail: newspaper; phone, car: music; smoking; planning the day
Rather unsatisfied because of long time and congestion; other car users make it more enjoyable	Satisfied: It's time to relax	Rather satisfied: it's an unavoidable burden to be accepted with positive attitude	Satisfied: It's time to relax	Rather satisfied: it's an unavoidable burden to be accepted with positive attitude	Rather satisfied: it's an unavoidable burden to be accepted with positive attitude	Satisfied: It's time to relax	Rather satisfied: it's an unavoidable burden to be accepted with positive attitude	Rather satisfied: it's an unavoidable burden to be accepted with positive attitude
Time wasted	Time to relax	Time to kill	Time to relax	Time to kill	Time to kill	Time to relax	Time to kill	Time to kill
Killing time (movie, music, mail, WhatsApp); 'I don't believe I'll do much'	Staring outside the window; No transfer of activities; Difficult to find things to do inside AV	Depends on the day and mood: stressful->relax with a massage chair; if still energy left->exercise(sport), AV good for business people: videoconference,	Staring outside the window; No transfer of activities; Difficult to find things to do inside AV	Depends on the day and mood: stressful->relax with a massage chair; if still energy left->exercise(sport), AV good for business people: videoconference,	Depends on the day and mood: stressful->relax with a massage chair; if still energy left->exercise(sport), AV good for business people: videoconference,	Staring outside the window; No transfer of activities; Difficult to find things to do inside AV	Depends on the day and mood: stressful->relax with a massage chair; if still energy left->exercise(sport), AV good for business people: videoconference,	Depends on the day and mood: stressful->relax with a massage chair; if still energy left->exercise(sport), AV good for business people: videoconference,
No rearrangement (maybe if you can remotely control devices at home)	No rearrangement	Using extra time for more social interaction (thanks to better work/life balance), possible to schedule day more efficiently	No rearrangement	Using extra time for more social interaction (thanks to better work/life balance), possible to schedule day more efficiently	Using extra time for more social interaction (thanks to better work/life balance), possible to schedule day more efficiently	No rearrangement	Using extra time for more social interaction (thanks to better work/life balance), possible to schedule day more efficiently	Using extra time for more social interaction (thanks to better work/life balance), possible to schedule day more efficiently
Would not travel more, because already travels a lot (enjoys driving)	Travel further (it's more comfortable); also for touristic purposes	Travelling more often for meetings outside the office, because travel is less burden in AV; visiting family far away more often	Travel further (it's more comfortable); also for touristic purposes	Travelling more often for meetings outside the office, because travel is less burden in AV; visiting family far away more often	Travelling more often for meetings outside the office, because travel is less burden in AV; visiting family far away more often	Travel further (it's more comfortable); also for touristic purposes	Travelling more often for meetings outside the office, because travel is less burden in AV; visiting family far away more often	Travelling more often for meetings outside the office, because travel is less burden in AV; visiting family far away more often
Would possibly move further away, to countryside	Would rather stay in the current place because the neighbourhood is great; if move, then only for a job	Even with AV still good access to a highway is important to not get stuck in a city	Would rather stay in the current place because the neighbourhood is great; if move, then only for a job	Even with AV still good access to a highway is important to not get stuck in a city	Even with AV still good access to a highway is important to not get stuck in a city	Would rather stay in the current place because the neighbourhood is great; if move, then only for a job	Even with AV still good access to a highway is important to not get stuck in a city	Even with AV still good access to a highway is important to not get stuck in a city

4		
Nicole	Maarten	Linda
		48
Freelancer (image coaching)	Software developer	Policy researcher
car	car/bike	cycle+train+train+tram
Currently travels all the time for business	bike: 45mins; car: 25mins	1h
phone calls/music (short travel); studying audio courses (longer travel)	radio/podcasts	social media; reading news; sometimes movie
Depends on how much the respondent can do in the vehicle	Unsatisfied: Unpleasant necessity, both for a bicycle and a car	Unsatisfied: lack of travel continuity and crowding make activities impossible
Time for action	Time wasted	Time wasted
Broad possibilities: quality time with children; business meeting, etc.	Possibly morning preparations (brushing teeth, lenses, etc.)	Morning preparations (also for work): make-up; breakfast; email; news, On the way back relax, e.g. Movie, AV as an extension of workplace/home
	Possible transfer of morning preparations; peeling potatoes	
Would rearrange her day to be more efficient; as an entrepreneur her lifestyle is pretty dynamic and unpredictable (travelling to various places and clients constantly)	Would transfer work to save time and be more at home; transfer of morning preparations (breakfast) in the AV would be used for more sleep	AV an extension of work/home, depending on time pressure; finishing work inside AV possible, giving more free time
Would travel further and more often, because of more flexibility	No travelling further: lives already close to everywhere and doesn't enjoy holidays	Would travel further, but not more often; There is still limit to travel distance though
Would not move because of AV: would not have hypothetical impact either (travelling a bit further is no problem)	Would not move because of AV: would have impact if moving is needed (travel time becomes less important)	Would not move because of AV; However, in case of moving AV would have impact on the decision (up to certain extent: 'you're still locked up')

Niek		
Norbert	Nora	Niek
Institution for entrepreneurial NL		Teacher and student
subway+train+train	car	car/bike
45min-1h	15min	30min
morning: newspaper (also for work); afternoon: killing time (phone/music/doing nothing)	Paying attention to traffic; radio	car: usually nothing; occasionally music; train: phone
Satisfied: Doesn't know how it could be more pleasant	Satisfied: it's an unavoidable burden, it's 'in the system'	Unsatisfied when congestion: would rather relax during this time
Time for action (morning); Time to relax (afternoon)	Time to kill	Time to kill
		Lack of time for breakfast (hypothetically)
Would not change travel habits	Cell phone; Movie; TV; using AV as a courier for children (if it can be trusted)	Relax, e.g. on a comfortable chair or with mobile phone, especially when stuck in congestion, less important for shorter distances
		Possible to eat breakfast in AV if no time in the morning (hypothetically)
Not able to change a lot of daily routine and save time with AV; impossible to transfer activities	Impossible for the participant to transfer work outside workplace, would watch more TV; could also use extra time for extra sleep; use time	Would not transfer any activities; use AV only for relaxation
Would travel more on weekends	Going further for holidays far away	Travel more for holidays
Would maybe move to countryside when older	Would not move because of AV: would not have hypothetical impact either (travelling a bit further is no problem)	Would not move because of AV: would not have impact if moving is needed (location is more important)

5		
Pieter	Petra	Paulien
Salesman	Funeral care	Pedicure specialist
car	car	car
30-45min; twice a week 2h (a lot of travel for work)	20min, depends on traffic (irregular working time)	30min-1h (travel back and forth to clients all day)
eating; talking on the phone; mail; whatsapp; work (in a notebook)	radio; morning:(getting in the mood for work) afternoon:(clearing mind of work)	radio; eating
Unknown	Satisfied: useful and relaxing and the same time (when listening to the radio for example)	Unsatisfied if congestion
Time for action	Time to relax	Unknown
		Currently eats in the car because of lack of time
In the evening when a lot of driving (long distances): sleeping; otherwise watching news, movie; before leisure time: work	Varies by mood and time of day; something active or passive	Would do work and relax in the car; driving the car between clients would no longer be so exhausting; when not working decisions on what to do would be spontaneous: either
		Would transfer her business into the AV
Would use the AV as a courier for picking up people/things	No rearrangement (no family, thus less hectic life and less room for gaining time efficiency)	Unknown
Going further for vacation (AV instead of plane)	Unknown	More often travel (unclear where to)
Would not move because of AV: AV makes it easier to live further from workplace, can play a role when moving	Would not move because of AV: likes to have people around	AV would play a role in case of hypothetical moving; could move further away to a more peaceful area

Renate
Coordinator in an institution for people with dementia
car
30mins (travelling a lot everyday to various places for work)
eating; talking on the phone; whatsapp
Satisfied: it's relaxing; Unsatisfied if congestion (annoyed)
Time to relax
Difficult to find time for a speech therapy with her daughter
When on a leisure trip with family: spending quality time with them (e.g. board game) On a daily basis: preparation for work in the morning
Speech therapy with her daughter
No rearrangement
More long-distance travel to family/leisure/vacation
Would not move because of AV

Appendix C: List of codes

Code	Example
Alcohol in AV	“I think another behavioural change could be, sitting in the car, watch a movie, drink some beers or some other alcohol, not worry about how you are going to drive home. So basically more people will be drunk inside these cars.”
AV as a courier	“Let the AV pick up your groceries at the pick-up point of Albert Heijn, I do not have to go anymore.”
AV for rent	“Maybe cars that are available for rent. A collection of cars with different functions. They may be available for rent. There are cities where there are programs for car sharing. You rent the car when you need it, when you go away for the weekend, they tell you the position of the car in the city.”
AV interior	“I think it has to do with how the design of the car will look like, it will become a relaxation room or it will become a working space.”
AV seen as PT	“I really see it (AV) as a kind of individual PT, individual automated transport. The two conveniences of the current means of transport are combined, in PT you do not have the worry about the fact that you have to pay attention in traffic, you have the freedom of: I get into the car when it suits me and that car is ready for me at front of my door.”
AV size	“ KOEN: No, it does not necessarily have to be a desk. But if you have your door, you can for example slide a table out. That you can stand in a kind of way in your car, that would be nice. LAURA: Then it becomes a very big car. KOEN: That does not matter.”
AV vs. other modes	“I think that such AV can be a formidable competitor for the aircraft to a certain range. So up to Spain or within Europe.”
AV: comfort	“Yes, better, because now you do everything quickly, you can do it more relaxed by then. It is freer, you are comfortable, you do not have to pay attention to traffic.”
AV: <activity>	Code for activities people declared to perform in the AV. Activities include: relaxing, staring, sport, gaming, sleeping, knitting, etc. Example: AV: staring – “If I can sit in it, I just sit and look outside and I think, enjoy nature.”
Burden of driving	“I am not happy at all with the travel time that I have. (...) So, if I have to be somewhere at 8 o'clock, and it's a two hour drive, I have to leave at 6 o'clock. Then I think, in that time I could easily answer my e-mail, make phone calls, things like that. (...) At the end of a working day it would be nice if you could relax, instead of being annoyed and still have to go all the way home.”
Business inside AV	PETRA: You can make a studio in your car. PAULIEN: Yes, just a collapsible treatment chair. (...)Yes and you have everything with you. That would be very ideal.
Children	“Yes, and yet he can be with his child. I don't want to think about that, well my children are already much older, already grown up now, such a young child who is 8 or 10 years old, I would not just put it in the car and say: you have to go there, the door opens and get inside yourself. I would also like to know if he actually arrives there.”
Congestion	“At first I don't think that it is lost time. But as soon as you stand still it is a lot more annoying yes. That gives a very different feeling.”
Considering travel as working time	“If your employer also takes into account that your travel time is also your working time then you can also stop earlier. Then you take that into the car so you do not have a disadvantage at all from the travelling.”

Difficulty to imagine	“Then it is so difficult to think about what you would want different, you are just used to it. It is therefore difficult to think differently. Yes, what would you like differently?”
Enjoying driving	“Yeah, I like driving. Then I listen during the driving to music or radio or just nothing, just take care of driving.”
Extension of workplace/home	“It will also be an extension of home, because at home you just do what you feel like doing. This will also be like that.”
Extra: <activity>	Code for activities people declared to do in extra time thanks to AV: sleeping, self-development, social interaction, etc. Example: Extra: sleeping - “Well I can sleep longer. Imagine that you can do your make-up in the car, wash yourself or name it, you can sleep longer, you can change clothes when you go to work in the car, do your hair, you name it all. I really see time saving.”
Health deterioration	“I think one of the disadvantages for me, if I replace my bike and train to an AV, I will become fat really fast.”
Illusion of extra time	“Nice to be home and doing nothing. This time is of course very short, so to say, I fill it in, but you get used to is very fast, so you do not even appreciate having that extra time.”
Leisure trips	“Those leisure trips, that is always very early somewhere to collect all the people, that is not needed anymore. Because if you arrive somewhere at 9 o'clock you have to collect all the people at 6 o'clock.”
Long trips	“I often have the fight against sleep, while I still have to drive a long distance. But, I do not want to go off the highway, I want to go home as soon as possible. But actually I am really tired. It would be great if you can sleep. Even if others ride along with me, I am the one who has to stay awake, they can turn their chair backwards, I would like to do that myself.”
Mood and activities	“I would like to have multiple choices. Suppose I have a stressed day, then I want a massage chair and just my favourite music on the background. But indeed, another day I still have energy left, and then I want to exercise.”
Motion sickness	“I must say something about reading, I think I would do that? So, I cannot actually read a book inside the car because I will get sick. Watching a movie is still possible, I would still do that. But, I hope that I will not suffer from it anymore. I never tried that behind the computer.”
No activity transfer	“No, I was just thinking about that. I do not think so. Ideally, you could do everything, in such a car. Brushing your teeth, putting on your lenses, everything. You cannot take a shower, that's a little over-enthusiastic. So for me personally the difference would not be that big. I do not have to concentrate at all in the morning. I'm just going to sit down.”
Now: <activity>	Activities people declare to do now during travel time. Example: Now: radio – “Listen to radio, listen to traffic information”
Old habits prevail	“But after some time I'll find some easier ways of gratification of myself like watching some more YouTube or more television more entertainment. Than the time will be wasted anyway.”
Overcrowding in PT	“I do not know if it is a clear question for me, I would like to use my time in the PT differently. But I often travel in the peak hours, I do not like to open my laptop, then you're on your cellphone for a bit, just on the internet doing nothing.”
Own choice	“But yes, I do not think the responsibility lies with the car to live healthy. That lies with you.”
Parking	“If I have to park my car in Amsterdam, Rotterdam you have to pay a lot of parking fees. Does this remain? Is that different?”

Policy	“If this really happens, rules will also change. So many cars can use the road today, or something like that. You cannot just say, families who are going on vacation on black Saturday, I don’t know what they call it. But, that's just not allowed, to go all together at the same time, that is what I think at least. It really cannot be the case that they are all allowed at once on the roads, now that is allowed, on one hand, that is an advantage, however, we will not have this freedom anymore.”
Predictability	“I am afraid that if we use AV’s all the time we will find ourselves in bubbles. We go from point A to destination in an isolated way. So there may be no be much room for interaction and unpredictable things. Like it may be to deterministic, less exciting.”
Pressure in daily life	“It also works the other way round, if you want to go home, at 6 o'clock 7 o'clock, and I have such a pile of work, I can do it in a rush, or I can take it too.”
Pressure to work	“That's what I am wondering about, because I also think people will work more because of this. So people can use that time to relax or to work even more.”
Privacy	“I would say it will different from PT, because in PT I don’t put my laptop out. Well I have a smartphone. I will take the AV as a mini office space, movable office space, and do office work that does not need any interaction with people. So it is different because it is confined environment where I can concentrate.”
Relocation: financial aspect	“I think it is also depends ow how expensive the living there is in the region. If there is a big advantage in price by living outside the city and you don’t have a choice than it is an option. But in the Netherlands almost all places are the same expensive.”
Relocation: moving further away	“Yes, such AV makes it a little easier, that you do not have to live very close to that place or in that place itself. The AV makes it easier to move, to live further away.”
Relocation: neighbourhood	“I feel like this: my house is my house. I am a Rotterdammer now. I have nice neighbours who will not move for me. I like it there. If my son is home, we'll go outside. There really cannot be a car that is better than that.”
Relocation: hypothetical AV impact	“It would not really be a reason to move, but if I were already considering moving, this would make it easier.”
Relocation: no hypothetical AV impact	“There is no difference for me. I don’t want to change my city. I don’t want to spend time commuting every day.”
Satisfied with travel time	“Well at the moment I think it, I also drive at times that it is generally not busy, then I find it, if it does not take too long, I also find it a kind of relaxing to drive. If it all just goes nice then I just think, good. Music on, my cappuccino. Then I do not think it's all that bad.”
Seatbelts	“I have another question: are there any belts in those cars?”
Social aspect of travel	“There is always the fact that you are in a traffic jam with several people and not alone. And you can look around you at what the rest is doing.”
Social aspect: children	“I can remember when I was a child, sometimes my father came to my school, and he picked me up and during the ride he asked me, hey Chris what did you do? What was fun in school, or you had some discussion in between. Now sometimes you cannot find the time because your father is more busy most of the time. So this (AVs) will take that opportunity for the families”

Social aspect: irregular trips	“If I went for a day out with my family to a theme park far away, I would spend time with my family during the trip. Do something together, like a game.”
Social equity	“Not everyone drives a car, you obviously have elderly people without a driver's license, my husband does not have a driver's license. They can also get into such a car.”
Social isolation	“No one seems to look at you anymore. You all have your own world in that car. So nobody is looking at each other anymore. Once you get in, you're doing something. (...) It will be a completely different dimension.”
Time continuity and activities	“It would be an alternative for me if I had to take the bike and change to the bus and the metro, 2 times or 3 times. That is not a direct connection. Then you are on the road for one hour instead of 20 minutes. Then I take the car. If I have to cycle for 10 minutes, I will take the bike.”
Time ownership	“Of course, your employer may also expect that you work inside the car. You have an AV, so you can work in the car for 3 hours.”
Time pressure	“But what I do on the way is often eating a sandwich, because otherwise I do not have time for it.”
Tourism	“I can imagine that it is easier to go to Paris or to Berlin, because you do not have to wait at an airport. You get in at your front door, sit down, you have movies you want to see with you, books you want to read, then you just go there. That, you do not have that you're on the plane, I can imagine that that can be extraordinarily pleasant. That also makes it more accessible to go somewhere.”
Transfer: <activity>	Activities which people declare to potentially transfer into the AV. Example: Transfer: morning preparations – “I would like to prepare myself for my work in the morning. Just like you sometimes do your make-up in the train nowadays, I would definitely want to do that too. Refreshing you can do still at home, nice inside the shower.”
Trapped inside AV	“Because you're just locked up. I mean you can do a lot, you can have a lot of contact, but of course not really. Of course you can shop on the web or cut your stuff. You're just locked up in a small physical space. It's nice if it's more efficient, but I would not want to live much further from my work. Maybe a little further. But I don't feel like traveling 2 hours for work.”
Travel as necessary burden	“For me, travel time is really loss of my time. I think car driving is not really relaxed, especially when it is busy, then I notice that I do need a lot of focus to look at the road. The same holds for cycling, it is not like: I do it for relaxation. It is more that you have to do it to get to work. But to really say that I find it relaxing, or that I think I spent that time useful: no. I would certainly spend my time more efficiently if that would be possible.”
Travel duration	“We are talking about a travel time of 20, 40 minutes. It is not that you can do miracles in such a time. Half an hour longer in the car and then your work is complete.”
Travel further	“If I go on vacation now, I prefer to go within one and a half hour, two hours, that is the limit for me. So in this case I would say: I sit down and drive to France for a few days.”
Travel less often	“I think I would drive less myself. I live in Rotterdam but I live quite in the middle of nowhere. There is no PT, I always have to pick up people in that neighbourhood. Then I would send that car, so that would mean less driving.”
Travel overnight	“You may also travel more during the night. If you can really organize your rhythm in such a way that you can actually sleep inside it.”

Travel time perception	"I think for me it is something in between productive and unproductive. I can't say it is totally unproductive, because if I have this time at home, I have wasted this time completely even worse when driving train. It is not totally unproductive as well because at least I can at least check the internet. Sometimes it is also not good because it feeds my internet addiction further. It seems that all this internet is finished."
Travelling as stimulation	"Yeah, well, quite productive actually in PT I used to read quite a lot, more than when I am at home. So yeah, when I travel, I used to, I don't know, maybe psychological, I used to read a lot."
Travelling more often	"I see my friends twice a year now, but then probably way more often. Yeah big change for me."
Unsatisfied with travel time	"No, I don't think it is productive, it is totally unproductive. So, even if I can work on my laptop I would prefer to send some mails, which can be short tasks, I can finish when travelling."
Work/life balance	"Or if you actually finish your work inside the car. Then you come home and then you do not have to finish it. Then you have more time for your children or other important things."
Work transferability	"I must also mention that the work I do is not really suitable for working at home. So at the moment, it is of course a cultural thing, that not all people are in the system yet, it is being encouraged to work at home."
Work regularity	"Well, I am satisfied one day, then I get everything done. The other day I am not satisfied, because I do not have a permanent working place. I travel everywhere, for me, every day is different. Every day is a surprise."
Work as an option	"But something that came to my mind that there was a time that I used PT regularly and I used to have a presentation, so I could use that time for getting ready for the presentation. And it was very useful. (...) Yeah, but I prefer to do nothing."

Appendix D: Process of content analysis

Below a process of coming from the specific to the general is shown based on one example from the results of the study.

One of the preconceptions made before the analysis of the results was to find the mechanism behind travel time perception, that is find the factors which determine how this time is currently perceived.

In the process of **open coding** a number of codes was identified, all of which are listed in the Appendix D. Similar list of codes, but including all the relevant quotations, was prepared after coding all the data and used as a **coding sheet**. That served the purpose of easy access to all the codes and quotations, and allowed for quick access and comparison, which facilitated the analysis.

Among the identified codes are (with exemplary quotations):

- "Enjoying driving"

CHRIS: *"Yeah, I like driving. Then I listen to music or radio or just do nothing, just take care of driving."*

- "Burden of driving"

KOEN: *"I am not happy at all with the travel time that I have. (...) So, if I have to be somewhere at 8 o'clock, and it's a two hour drive, I have to leave at 6 o'clock. Then I think, in that time I could easily*

answer my e-mail, make phone calls, things like that. (...) At the end of a working day it would be nice if you could relax, instead of being annoyed and still have to go all the way home.”

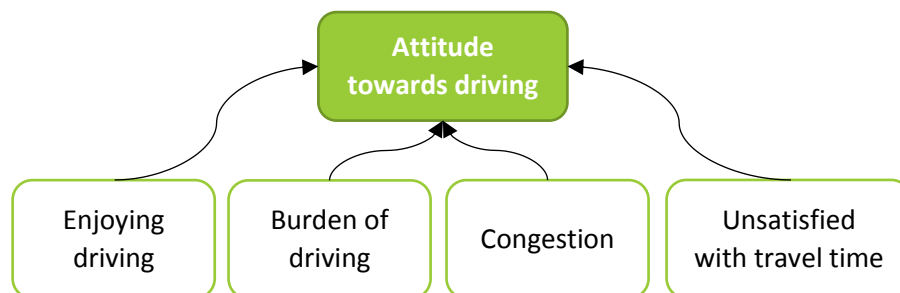
- “Congestion”

LINDA: “Yes, another disadvantage: driving itself can also be quite nice, if you are not in a traffic jam. I also know people who, on Sundays, not the typical Sunday driver, but who just drive a bit on Sunday, just for fun.”

- “Unsatisfied with travel time”

ARJUN: “I don’t think it (traveling by car) is productive, it is totally unproductive. So, even if I could work on my laptop I would prefer to send some mails, which could be short tasks, that I could finish when travelling.(...) For me, travel time is really loss of my time. I think car driving is not really relaxed, especially when it is busy, then I notice that I do need a lot of focus to look at the road. (...) I would certainly spend my time more efficiently if that would be possible.”

By identifying that these codes are all related to the attitude towards driving, they can be grouped together in the process of **categorization**.



Among the applied the codes are also the following (with exemplary quotations):

- “Social aspect of travel”

KATRIEN: “There is always the fact that you are in a traffic jam with several people and not alone. And you can look around you at what the rest is doing.”

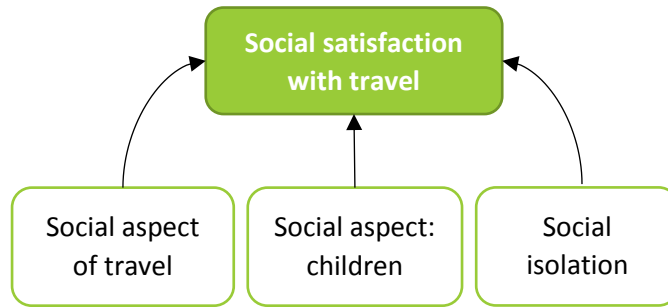
- “Social aspect: children”

CHRIS: “I can remember when I was a child, sometimes my father came to my school, and he picked me up and during the ride he asked me, hey Chris what did you do? What was fun in school, or you had some discussion in between. Now sometimes you cannot find the time because your father is more busy most of the time. So this (AVs) will take that opportunity for the families”

- “Social isolation”

GABRIELLE: “No one seems to look at you anymore. You all have your own world in that car. So nobody is looking at each other anymore. Once you get in, you're doing something. (...) It will be a completely different dimension.”

Similar as in the previous example, the codes can be grouped together into a category “social value of travel”.

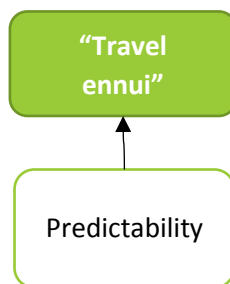


During the stage of open coding also a code was used to mark statements about the life possibly becoming too deterministic due to AV:

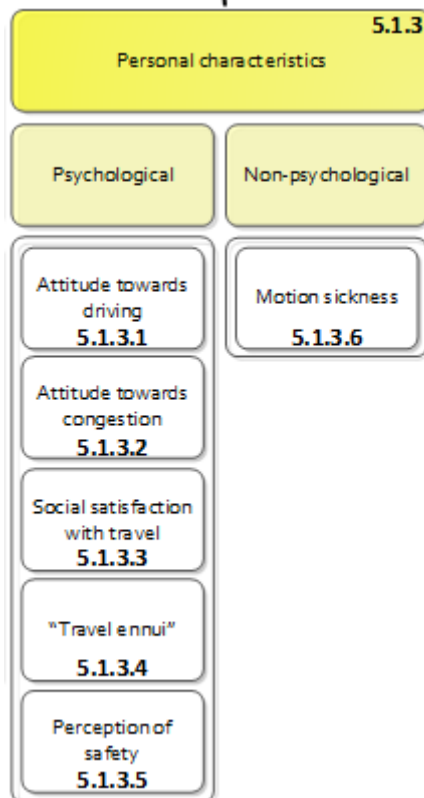
- "Predictability"

NORBERT: *"If you have to travel by PT, like me, sometimes you encounter unexpected moment right? How should I say this, if you have the same trip every day in that AV, then every day is the same. What you see, whether it rains, if the sun shines, or you see how people walk, what people say, what people look like, all those things. It becomes monotonous. Then you are no longer surprised either in a positive or in a negative sense."*

Because this code is unique and considered relevant it can constitute a category on its own.



By continuing this kind of reasoning, it is eventually possible to combine similar categories into one general category: "psychological characteristics", which together with "non-psychological" characteristics constitute a broad category: "Personal characteristics".



In the process of further **abstraction**, the category "Personal characteristics" was conceptualized as one of the three large groups of factors constituting the input for travel time use mechanism.