Activity-travel Behaviour in the Automated Vehicle-era: A Focus Group Study and a Time-use Model

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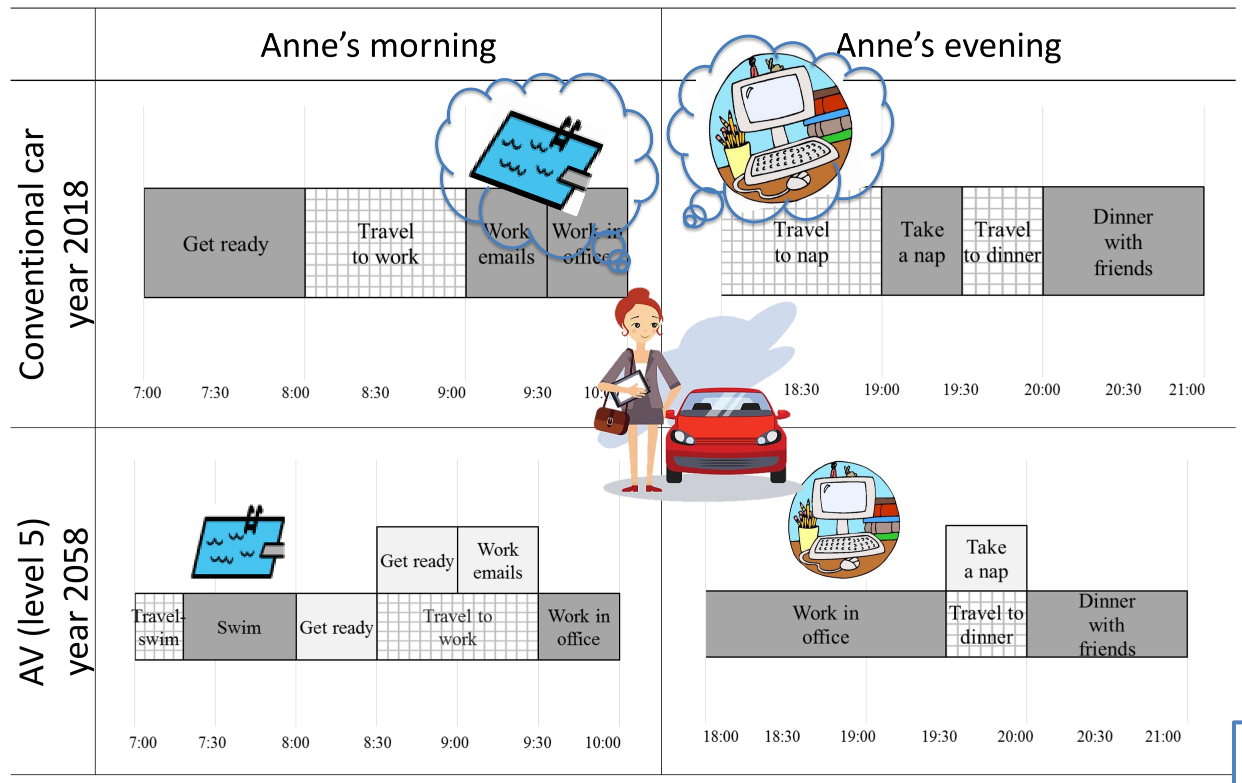
Anne's story

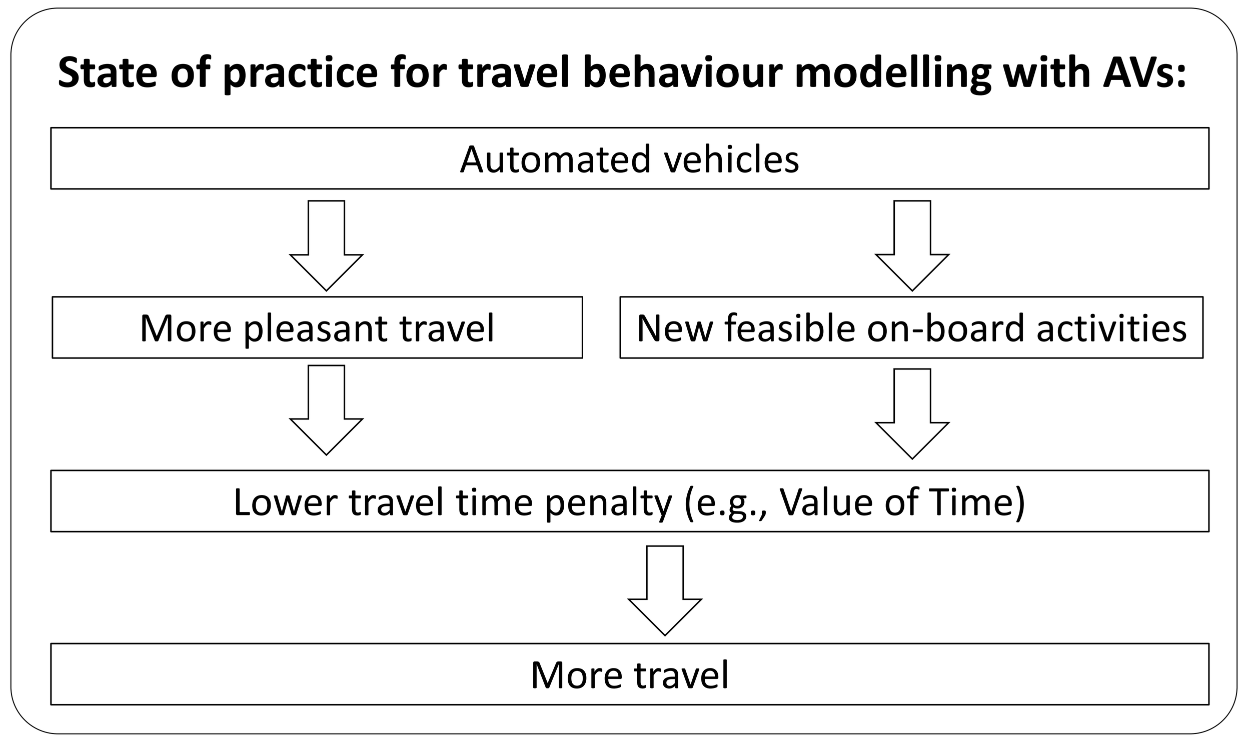
Before purchasing her AV, Anne used to wake up at 7:00 to get ready (dress, eat breakfast), depart at 8:00, and reach work at 9:00. She contemplated visiting a swimming pool in the morning, but did not want to get up earlier to do so. In the evening, she used to leave her work at 18:00, head home for a 30-minute nap, and drive to meet her friends at 20:00. She often felt like working longer, but did not want to miss out on her evening activities.

Now, Anne's company allows employees to do their morning work in their AVs. Anne leaves home at 8:30 and arrives at the office at 9:30. About 30 minutes of her journey she spends eating breakfast; in the remaining 30 minutes she replies to work emails. She uses the gained hour in the morning to visit a swimming pool. In the evening, Anne stays an extra hour and a half at work. She naps in her AV, while it drives her straight to the meeting with friends.



Hypothesis

AVs may cause re-arrangements in activity schedules.



Travel time penalty cannot model activity re-arrangements as in the example of Anne:

- Activity 'transfers' from stationary locations (home, work) to AV are not accounted for;
- The potential of on-board activities to 'save time' is not considered;
- Travel time penalty-approach would always predict more travel. But this is not the case for Anne's evening.

Gather qualitative evidence about potential re-arrangements

Derive quantitative models that can capture & estimate re-arrangements

Focus Group Study

How many: 5 groups, 27 participants in total
Who: TU Delft students and employees (1 group), Dutch working population who commute with car or PT (4 groups)
Scope: fully automated vehicles, mostly privately used. 100% safe, secure, available, customisable

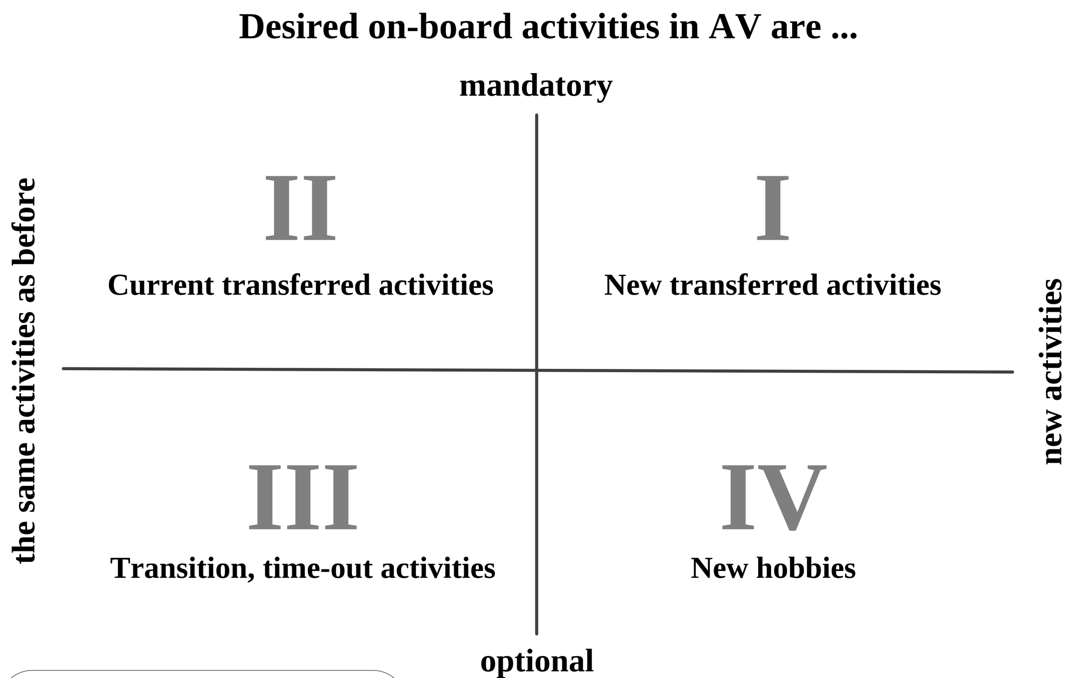
Focus group participants expected that...

1. ... travelling in an AV would change
   a) the **pleasure of travel** – for better or for worse,
   b) the **feasibility of on-board activities**, which would probably increase.

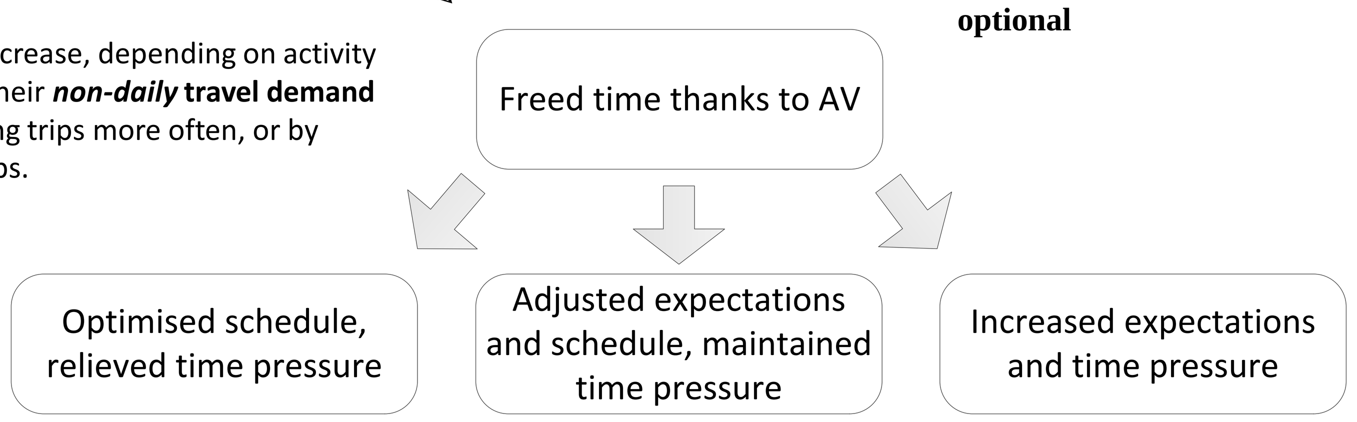
   The exact characteristics of AVs and travel in it will determine the size and magnitude of these changes.

Characteristics of travel in AV	Influence of the characteristics on ...	
	pleasure from travelling in AV	feasibility of on-board activities
Fully automated driving	+/–	+
Availability, little planning needed	+	0
Travel continuity (no transfers)	+	+
Comfort	+	+
Equipment, storage possibilities	0	+
Privacy, isolation	+/–	+
Predictability, reliability of travel time	+/–	+
Movements of AV, position of the traveller (possible motion sickness)	–	–

2. ... given the feasibility of new on-board activities, they **may or may not perform new activities on-board**. In addition, the chosen on-board activities may have different **priority levels** – mandatory activities (work, sleep, meals, personal care, scheduled appointments) or optional activities (e.g., hobbies without appointments, time to contemplate). Four types of on-board activities emerge.



3. ... transferring mandatory activities to the AV (type I) could save time and relieve **time pressure**. However, the possibility to use travel time productively could also create/increase the expectations and pressure to work during travel. This pressure could be either formal (from a manager) or informal (peer pressure). Alternatively, the expectations and saved time could balance out and restore the initial, pre-AV level of time pressure.

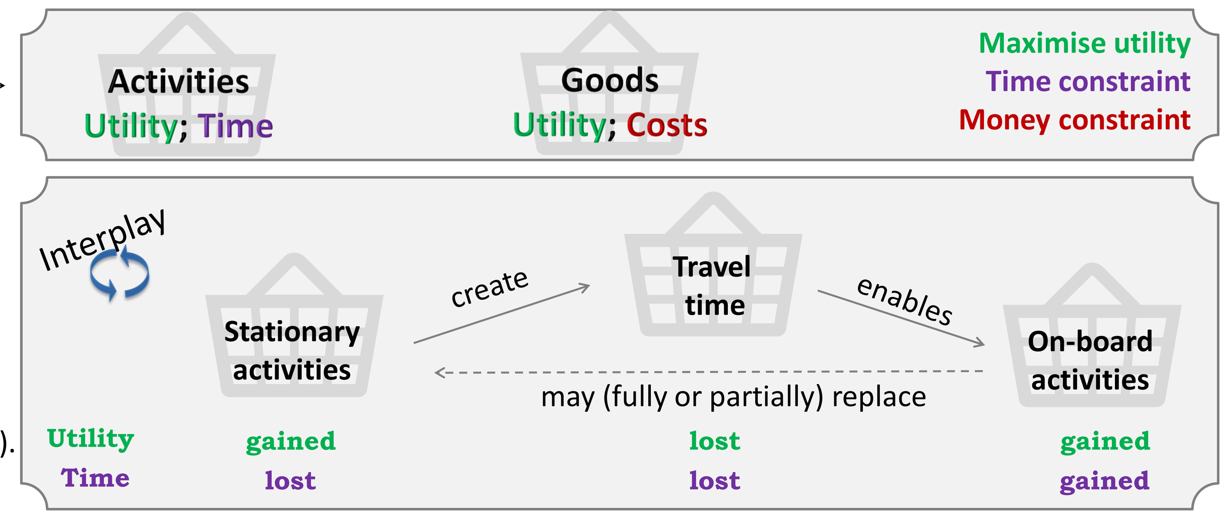


4. ... their ***daily* travel demand** may increase, remain unchanged, or even decrease, depending on activity needs and current feasibility. However, many participants indicated that their ***non-daily* travel demand** might increase by accepting further locations for activities, performing long trips more often, or by switching their travel mode from plane or train to AV for long-distance trips.

Time-use Model

Time-use theory (started by Becker 1965) postulates that individuals allocate their time to activities so that the utility is maximised while respecting time and money constraints.

We use this framework to build a model that incorporates the activity transfer, saved time and re-arrangement effects (see Anne's story above). To do so, we split the 'activities' component from the time-use theory into three parts: stationary activities, on-board activities and travel. The three parts relate and interplay with each other as shown:



Activity transfers are inherent in this interplay: on-board activity may 'replace' stationary activity and 'gain' time. The gained time is optimally assigned to other activities (and/or travel).

Our model:

$$\max \sum_{i\in I}\left(\sum_{l\in L}\left[y_i^l U_i^l + \sum_{m\in M}\left(z_{il}^m V_{il}^m + \sum_{j\in I} y_{ijl}^m U_i^m\right) + \psi_i\left(r_i^l + \sum_{m\in M}\sum_{j\in I} s_{ijl}^m\right)\right] - \psi_i x_i\right), \quad (1)$$

(1) Maximise Utility of Stationary and on-board activities (+), Travel (-), Fragmentation (-)

subject to:

$$\sum_{i\in I}\sum_{l\in L}\left(y_i^l T_i^l + \sum_{m\in M} z_{il}^m H_{il}^m\right) \le T, \quad (2)$$

(2) Time of Stationary activities + Travel < Total time

$$\sum_{i\in I} y_{ijl}^m T_i^m \le z_{jl}^m H_{jl}^m \qquad \forall j\in I, \forall l \in L, \forall m \in M, \quad (3)$$

(3) Time of On-board activities during any trip < Trip time

$$\sum_{l\in L}\left(y_i^l + \sum_{m\in M}\sum_{j\in I} y_{ijl}^m\right) = x_i \qquad \forall i \in I, \quad (4)$$

(4) Shares of each activity (in different locations) sum up to 1 or 0

$$y_i^l \le r_i^l \qquad \forall i\in I, \forall l\in L, \quad (5)$$

$$r_i^l \le G y_i^l \qquad \forall i\in I, \forall l\in L, \quad (6)$$

(5)–(6) Define flag: activity is at least partly performed stationary

$$y_{ijl}^m \le s_{ijl}^m \qquad \forall i\in I, \forall j\in I, \forall l\in L, \forall m\in M, \quad (7)$$

$$s_{ijl}^m \le G y_{ijl}^m \qquad \forall i\in I, \forall j\in I, \forall l\in L, \forall m\in M, \quad (8)$$

(7)–(8) Define flag: activity is at least partly performed on-board during a specific trip

$$\sum_{m\in M} z_{il}^m = r_i^l \qquad \forall i\in I, \forall l\in L, \quad (9)$$

(9) Shares of each trip (in different modes) sum up to 1 or 0

$$x_i, r_i^l, s_{ijl}^m \in \{0,1\},\ y_i^l, y_{ijl}^m, z_{il}^m \in [0,1] \qquad \forall i\in I, \forall j\in I, \forall l\in L, \forall m\in M, \quad (10)$$

(10) Define variables

Short answers to FAQ

1. Are our modelled effects of activity transfers identical in the behaviour of PT users?
- We believe not (although data is necessary to verify that). AVs are expected to facilitate activities better, especially mandatory activities (e.g., work, sleep), which may lead to more activity transfers. Hence, it is especially crucial to apply our model for predictions of travel behaviour in the AV-era.

2. Should our model be added to models of higher-order choices, such as residential location and vehicle type in the AV-era?
- Yes. The activity transfer effects (represented in our model) are crucial for location choices, including the residential location. E.g., longer, further travel may be preferred for certain activities, such as for taking a nap in the example of Anne. Activity transfers are conditional on activity facilitation and therefore potentially an important factor in the choice of vehicle type (for purchase/ rental).

Ask me for more!

TU Delft TU/e

Spatial and Transport Impacts of Automated Driving