

Rethinking the road ahead – generation Z's perspectives on AI-based mobility services

Márk Miskolczi^{*}, László Kökény, Melinda Jászberényi

Institute of Sustainable Development, Department of Tourism, Corvinus University of Budapest, Kozraktar utca 4-6., Budapest 1093, Hungary

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ABSTRACT

Empirical studies project that autonomous vehicles (AVs) with SAE Levels 4/5 will become widely available for passenger transport by the early 2030s. However, consumer expectations and perceived risks related to this technology remain insufficiently understood. This study addresses this gap by exploring how Generation Z – arguably the most receptive segment to Industry 4.0 innovations – perceives highly automated vehicles. Focus group interviews ($n_{\text{discussions}} = 5$, $n_{\text{subject}} = 25$) were conducted and analysed following the three-stage Grounded Theory method developed by Corbin – Strauss (1990). The resulting conceptual model – **TRACE** (*Technology-related Repertoires of Attitudes, Control, and Engagement*) – identifies critical yet under-researched factors such as *alternative vehicle usage patterns, AI-scepticism, and shifting human-machine (AI) interdependence* that may significantly shape AV acceptance. This research offers a theoretical contribution to the field of human-technology interaction and practical insights for stakeholders aiming to accelerate the socially responsible diffusion of AVs.

1. Introduction

The rapid advancement of artificial intelligence (AI) is transforming nearly every aspect of life – from content creation and decision-making to personal mobility. With the mainstream adoption of large language models (LLMs, e.g., ChatGPT) (Kasneji et al., 2023) and AI-driven automation systems, society is grappling with questions of trust, human agency, and machine control. These concerns are particularly salient in the context of AI-based mobility services, such as autonomous vehicles (AVs), which are quickly moving from experimental phases to public road deployment (Khan et al., 2024).

AVs equipped with SAE Level 2 and 3 techniques are already commercially available in private vehicles (e.g., Khan et al., 2024) and shared mobility platforms (e.g., Waymo, Uber, Lyft). Prototypes of SAE Levels 4 and 5 – capable of operating without human intervention under defined or unrestricted conditions – are currently being tested across urban environments globally (Rahmani et al., 2024). While technical readiness is advancing, social readiness remains a key barrier to adoption. Scholars (Bakti et al., 2025, Naiseh et al., 2025) emphasise that overcoming technical shortcomings (e.g., AI errors, network reliability) must be matched by efforts to understand and shape technology-acceptance.

Although AV acceptance has been widely examined from

engineering and economic perspectives, its psychological and social dimensions remain underexplored, particularly in Central and Eastern Europe (CEE). This study addresses that gap by focusing on Generation Z, a digitally native cohort expected to become a primary user base for AV technologies in the coming decade. Our aim to uncover the *latent, psychosocial perceptions and concerns of this generation*, particularly those that may influence intention to use. For this, we conducted five focus group interviews ($n = 25$) and analysed the data using grounded theory (GT) methodology. The resulting model (**TRACE – Technology-related Repertoires of Attitudes, Control, and Engagement**) identifies drivers of intention to use and key barriers of AV acceptance (e.g., loss of personal control and driving experience, social status). These dimensions are largely absent in current mobility research and offer novel insights into the social conditions for AV diffusion.

The structure of the paper is as follows: Section 2 presents a literature review that integrates technological, social, and generational perspectives on AVs. Section 3 outlines the methodology and analytical approach. Section 4 discusses the findings and introduces our conceptual model. Section 5 highlights theoretical and practical implications, study limitations, and future research directions.

^{*} Corresponding author.

E-mail addresses: mark.miskolczi@uni-corvinus.hu (M. Miskolczi), laszlo.kokeny2@uni-corvinus.hu (L. Kökény), jaszberenyi@uni-corvinus.hu (M. Jászberényi).

2. Literature review

2.1. Technological overview of autonomous vehicles

Autonomous vehicles (AVs) represent a technological shift in which human control over driving tasks is progressively reduced and eventually eliminated (Grosso et al., 2021; Eyssartier et al., 2023). The Society of Automotive Engineers (SAE) defines six levels of vehicle automation, ranging from Level 0 (no automation) to Level 5 (full automation without geographic or infrastructural constraints). As of 2025, SAE Level 2 and 3 vehicles are commercially available, while SAE Level 4 AVs are being introduced via shared mobility services such as Waymo. Although vehicles with partial automation rely on Advanced Driver Assistance Systems (ADAS), human supervision remains essential (Freudendal-Pedersen et al., 2019). This study focuses on SAE Level 4 and 5 AVs – systems that can operate without human intervention – and examines how potential users, particularly Generation Z, perceive this technology.

2.2. Social perceptions toward AVs

While technical progress in AV development is well documented, the social implications remain underexplored, especially in Central and Eastern Europe (Miskolczi et al., 2021; Ásványi et al., 2022; Jászberényi et al., 2022). AV adoption raises complex issues around *trust, safety and control* – core themes in sociological studies of technology (Braidotti, 2016; Randell 2017; Raats et al., 2020).

In the era of Industry 4.0, human-machine relations are becoming increasingly complex. Scholars argue that individuals are reshaping their identities through interactions with technological systems (Randell 2017). Car ownership has long served as a form of *self-expression and social status* (Gardner and Abraham, 2007; Epley et al., 2007), particularly in Central and Eastern Europe, where it is often viewed as a key life goal (Duffy, 2003). However, the rise of AVs and shared mobility services may challenge these traditional notions. While automation promises safety and efficiency (Nuriyana et al., 2023), it reduces the role of the human driver, potentially diminishing feelings of control, autonomy and pleasure (Berberian et al., 2012; Menon et al., 2019).

A growing body of research has examined AV-related attitudes among specific groups such as seniors, people with disabilities, and visually impaired individuals. These studies typically highlight optimism around *increased independence and concern about safety, affordability, and overreliance on machines* (Hwang et al., 2020, Brinkley et al., 2020; Hwang et al., 2020; Ghasrodashti et al., 2021; Zhu et al., 2024). However, broader social concerns – including the erosion of agency, cyber risks, and reduced human interaction – remain understudied in everyday mobility contexts.

2.3. Generation Z and AV-acceptance

Generation Z (born between 1995–2010, McCrindle and Wolfinger 2009) is projected to be a key user group for SAE Level 4 and 5 AVs by the 2030s (Eyssartier et al., 2023, Mutzenich et al., 2024). As digital natives, they are familiar with seamless technological integration (Mohr and Mohr, 2017). However, fluency does not imply uncritical acceptance. Research suggests that Gen Z is defined by hedonistic, experience-driven behaviours (Leggatt, 2017, Grénman et al., 2024), high online engagement (Nugroho et al., 2020), and nuanced attitudes toward innovation (Bińczycki and Dorocki, 2022). While they may embrace the convenience and novelty of AVs, concerns around privacy, control, and dependency on digital systems may temper their enthusiasm (Surat et al., 2021). Moreover, Gen Z may associate driving not only with practical mobility but also with independence and emotional gratification – values potentially undermined by full automation. Understanding how they perceive the shift from driver to passenger is therefore critical in anticipating the social trajectory of AV-acceptance.

2.4. Research gaps

Despite growing interest in AVs, several critical gaps remain in the literature:

- *Limited understanding of the psychological effects of full automation:* Existing research largely overlooks how automation affects autonomy and identity (Berberian et al., 2012; Randell 2017).
- *Underrepresentation of Generation Z:* Although expected to be early adopters, Gen Z's perspectives remain understudied, especially in non-Western contexts (Ásványi et al., 2022; Bińczycki and Dorocki, 2022).
- *Lack of qualitative, theory-building approaches:* Most studies rely on quantitative surveys or technology acceptance models (e.g., TAM- or UTAUT-extensions), neglecting inductive, exploratory methods.
- *Neglect of ambivalence and perceived trade-offs:* Existing models often assume linear acceptance, ignoring the contradictory perceptions linked to AI dependence.

This study contributes to addressing these gaps by exploring how Generation Z evaluates the trade-offs posed by highly automated vehicles, with particular attention to psychosocial constructs in machine-mediated mobility.

3. Methodology

Fig. 1 represents the key steps of data collection and analysis.

3.1. Data collection

3.1.1. Immersion in data

To ensure methodological transparency, the research began with a systematic literature review (SLR – see section 2) conducted in accordance with PRISMA guidelines (Page et al., 2021). This preliminary phase served as both conceptual orientation and as a basis for defining the initial sampling strategy for qualitative fieldwork. Prior to SLR, the following research question (RQ) was formulated:

RQ: What **latent psychosocial factors** shape Generation Z's intention to use highly automated vehicles (AVs)?

- o *1.1.A Platform Selection and Search Criteria:* Database searches were conducted using Google Scholar and ScienceDirect. Keyword combinations ($n = 5$) were applied, prioritising peer-reviewed English-language articles published between 2015 and 2025.
- o *1.1.B Final Selection Based on Abstracts and Full Content:* The review yielded 65 records. After removing duplicates and screening titles and abstracts, 30 papers were excluded for not meeting inclusion criteria (e.g., lack of AV-focus, irrelevant populations). A final set of 35 papers was retained for conceptual analysis.

3.1.2. Theoretical sampling

- o *1.2.A Research Design:* The empirical phase was designed in line with the Grounded Theory (GT) methodology as outlined by Corbin and Strauss (1990).
- o *1.2.B Recruitment*
 - Participants were recruited via *purposive sampling based on age* (born 1995–2010). *Recruitment* was conducted through social media and the internal newsletter of Corvinus University of Budapest – Hungary's *top-ranked private university* specializing in business and social sciences (QS World University Rankings, 2025) – to effectively reach Generation Z respondents.

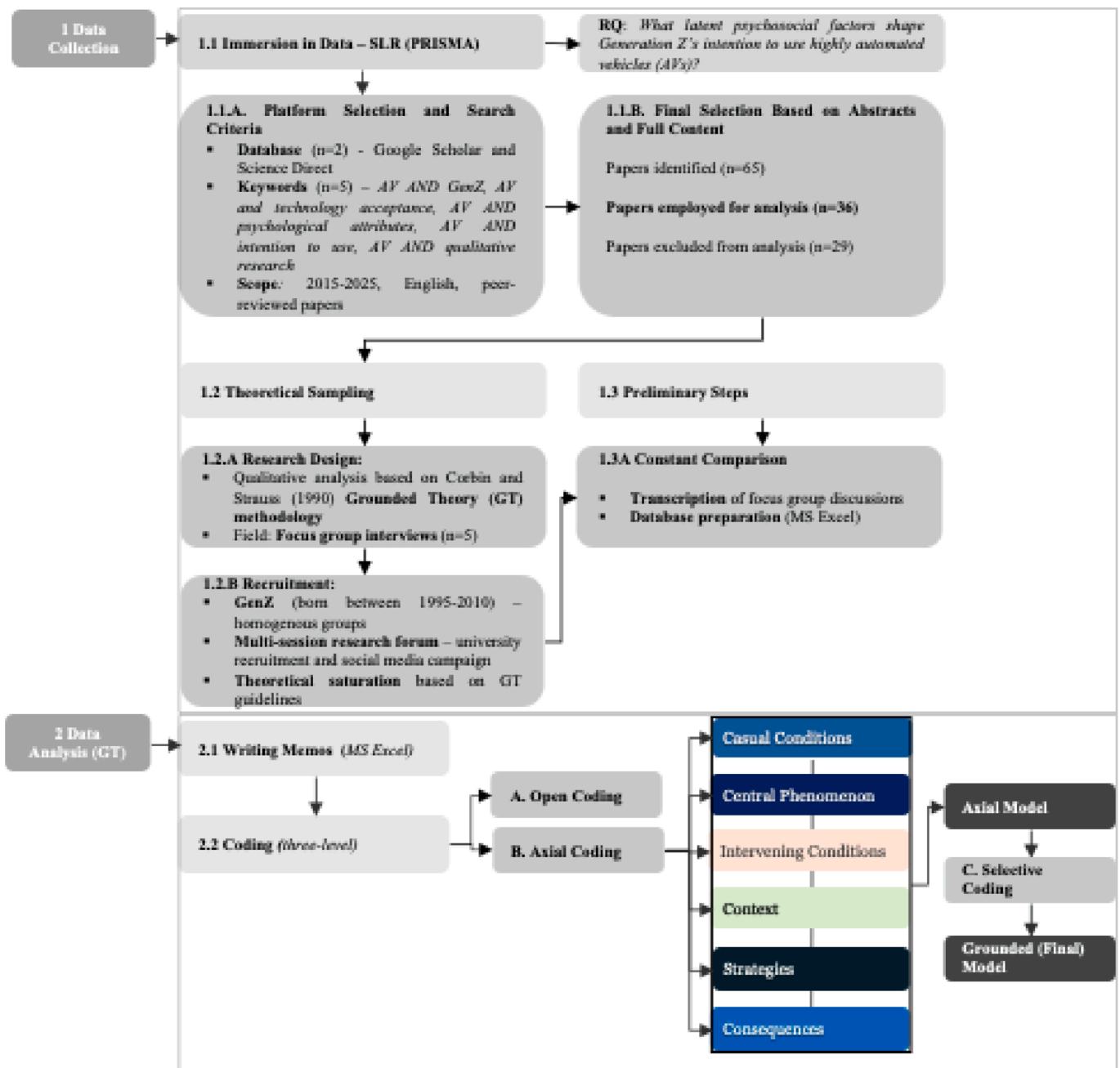


Fig. 1. Research design. Source: Authors' own editing, based on Corbin and Strauss (1990).

- Focus group interviews were organised as part of a *multi-session research forum*, allowing for flexible scheduling and iterative reflection. Following each session, the research team assessed the *theoretical saturation* based on audio transcripts and memo writing. In line with GT principles, data collection was concluded once recurring patterns and no new categories emerged in the final two groups.
- While the number of groups may appear modest, prior studies emphasise that small, *thematically focused focus groups are effective in exploring generational narratives* and shared cultural meanings (Malhotra et al., 2020).

Table 1 presents anonymised sociodemographic characteristics of the sample.

3.1.3. Preliminary steps

Before coding, a series of preparatory activities ensured methodological rigour and traceability:

- o **1.3.A Constant comparison**: All focus group sessions were audio-recorded, transcribed verbatim, and organised in matrix format using Microsoft Excel. A unified data structure was created to support line-by-line coding, theme clustering, and traceability of each quotation to individual participants.

3.2. Data analysis

Although classical GT discourages prior literature review (Glaser and Strauss, 1967), we followed the evolved framework of Corbin and Strauss (1990), which supports the development of theoretical sensitivity through engagement with relevant literature. In line with this, we

Table 1
Subjects' socio-demographic characteristics.

N	Code number ¹	Age	Gender ²	Residence ³	Education ⁴	Driving license ⁵
1.	#1a	24	1	1	4	3
2.	#1b	22	2	1	2	1
3.	#1c	21	2	1	2	1
4.	#1d	24	1	1	2	1
5.	#1e	16	2	1	2	2
6.	#1f	18	2	1	2	2
7.	#2a	18	2	1	2	2
8.	#2b	20	2	1	2	1
9.	#2c	19	2	1	2	2
10.	#2d	20	1	1	2	1
11.	#2e	19	2	3	2	2
12.	#3a	20	2	3	2	1
13.	#3b	20	2	3	2	2
14.	#3c	21	2	4	2	1
15.	#3d	22	2	4	2	2
16.	#3e	20	1	1	2	2
17.	#4a	18	1	1	2	2
18.	#4b	24	1	1	3	1
19.	#4c	23	1	1	3	2
20.	#4d	24	2	1	3	1
21.	#5a	21	2	3	3	1
22.	#5b	24	1	1	4	1
23.	#5c	25	2	1	4	1
24.	#5d	18	2	1	2	1
25.	#5d	25	1	1	4	1

Source: Authors' own editing.

Note: 1.: Combined code number from focus group number (#1–5) and subjects individual code (a-f); 2.: Male = 1; Female = 2; 3.: 1=Capital city (Budapest); 2=County seat city; 3=Other city; 4 = Village; 4.: 1=Primary; 2=Secondary; 3 = Tertiary (BA, BSc); 4 = Tertiary (MA, MSc); 5=PhD; 5.: 1 = Yes; 2=No, but they want it; 3=No, and they do not want it.

adopted a *constructivist grounded theory* approach (Charmaz, 2017), which acknowledges the researcher's interpretive role and is particularly well-suited to examining how individuals construct meaning in dynamic, technology-mediated contexts. The overall analysis was conducted in two main phases: (1) memo writing for analytical organisation and reflexivity; and (2) multi-level coding.

3.3. Writing memos

Throughout the research process, analytical memos were used to document emerging insights, theoretical reflections and coding-related decisions. Memos served as a bridge between raw data and theory development, supporting both transparency and analytical depth. The transcripts from the five focus groups were manually analysed using Microsoft Excel, enabling constant comparison of statements across participants and sessions. Key themes and recurring perceptions were documented in tabular format to prepare for coding.

3.3.1. Coding

The coding process followed the three-stage GT procedure developed by Corbin and Strauss (1990): open, axial, and selective coding. The steps are summarized as follows:

- **Open coding:** Initial categories were generated by labelling recurring ideas in participants' narratives.
- **B. Axial coding:** Categories were refined and interconnected using a coding paradigm, consisting of the following components:
 1. *Causal conditions:* Factors that initiate or shape the central phenomenon (e.g., previous beliefs, experience with AI-based services).
 2. *Central phenomenon:* The core concern or concept around which the data is structured. *In this case:* the intention to use highly automated vehicles.
 3. *Strategies:* Actions or responses resulting from the central phenomenon (e.g., potential forms of AV usage).

4. *Context:* Specific conditions influencing how strategies unfold (e.g., vehicle features and preferred functions).
5. *Intervening conditions:* Broader social or personal factors that moderate strategies (e.g., driving licence, sociodemographic characteristics).
6. *Consequences:* Short or long-term outcomes of action strategies (e.g., acceptance or rejection of AVs).
 - **C. Selective coding:** Synthesis of axial codes and restructuring them into a theoretical framework to reveal attitudes towards AV-usage.

4. Results

The results are presented along with the three-level coding process.

4.1. Open coding

During the open coding phase, transcribed focus group data were analysed using a line-by-line approach. At this stage, coding was intentionally open-ended and unstructured, with no pre-defined categories. When multiple statements conveyed similar underlying attitudes, they were grouped under a common initial code to avoid redundancy. For instance, comments such as „I can take back control at any time” and „It is important to keep the opportunity to lead” were both linked to the code „possibility to have/take back control”. The main objective of open coding was to generate a broad and diverse set of conceptual elements to capture latent variables influencing AV acceptance. Although GT does not require quantification at this stage, approximately 200 initial codes were created, representing a wide range of perceptions, motivations, and concerns.

4.2. Axial coding

In the axial coding phase, open codes were reinterpreted and clustered into higher-order categories. This process enabled the development of a structured framework that connects individual attitudes to broader conceptual domains. Fig. 2 illustrates the coding paradigm developed through axial coding. Key insights from each axial code category are presented below.

4.2.1. Causal conditions

- *Perceived flexibility of AV usage:* Participants highlighted that AVs offer a more versatile mode of transport, enabling a range of activities – such as working, relaxing, or socializing – beyond the traditional task of driving.
- *Usability without driving license as a motivator:* Respondents suggested that AVs could enable mobility for those without a driving license, framing automation as a tool for enhanced social inclusion.
- *Relief of driving tasks:* The elimination of manual driving responsibilities was perceived as a reduction in stress and a key factor increasing the appeal of AVs for routine commuting.
- *Reduced cognitive load:* Many respondents believed that AVs would lessen the mental demands of travel, allowing users to preserve cognitive energy for other purposes.
- *Perceived loss of driving skills:* Concerns emerged that reliance on AVs may lead to a gradual decline in traditional driving competencies, particularly among younger users.
- *Decreasing role of human driver:* Participants expressed ambivalence about the diminishing role of human agency in mobility, with some viewing it as a loss of personal freedom and others as a practical evolution.
- *Fear of cyberterrorism:* The risk of hacking or cyberattacks targeting AV systems was perceived as a significant safety concern, particularly among digitally literate users.

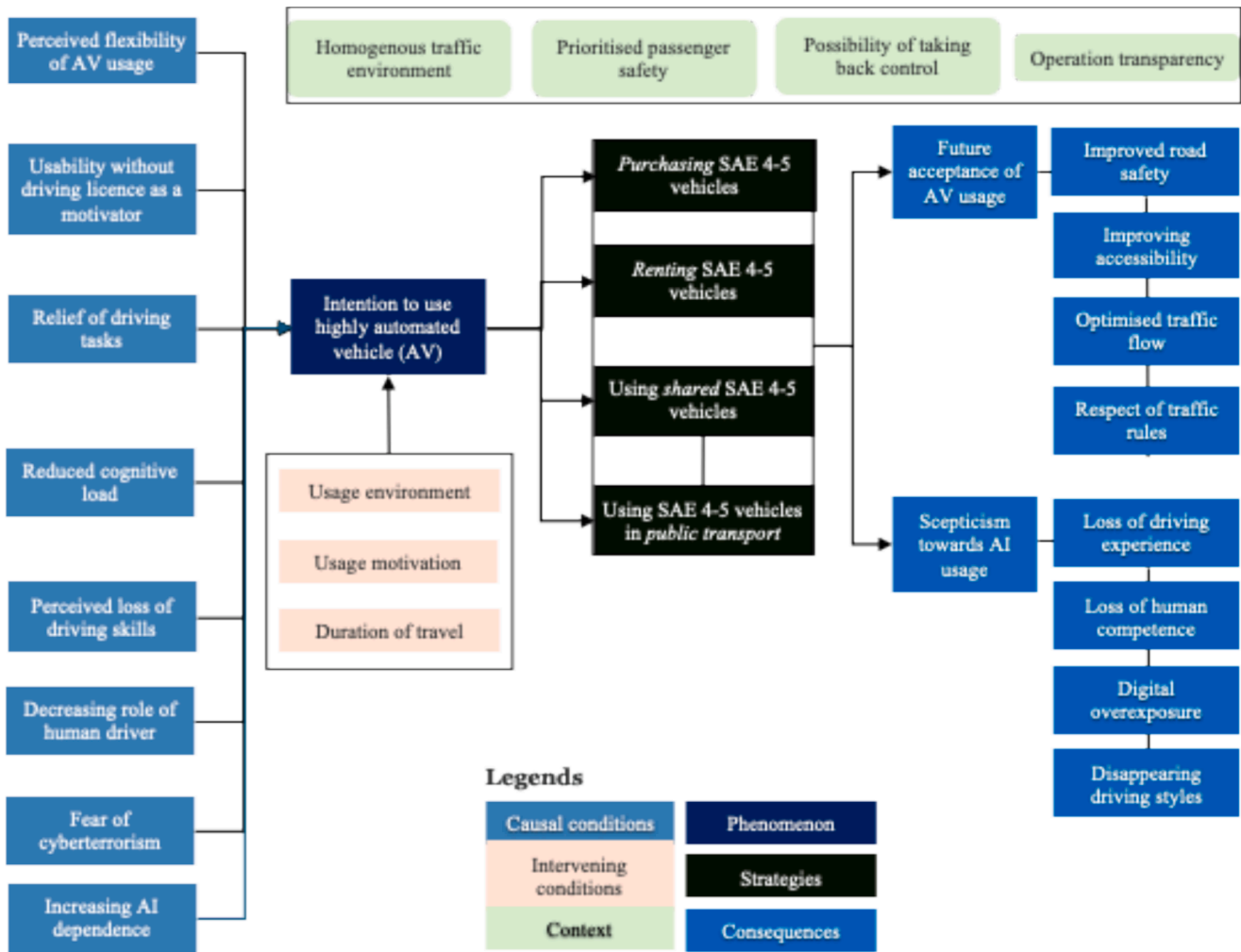


Fig. 2. Result of axial coding process. Source: Authors' own editing.

- **Increasing AI dependence:** Several respondents voiced fears about over-reliance on AI systems, highlighting potential vulnerabilities if machine decision-making becomes pervasive and unchecked.

4.2.2. Phenomenon

The central phenomenon emerging from the axial coding process is the *intention to use highly automated vehicles*, shaped by a dynamic interplay of perceived benefits and potential risks/barriers of AV-usage.

4.2.3. Intervening conditions

- **Usage environment:** Participants emphasised that the acceptance and practical use of AVs would strongly depend on environmental conditions, such as urban versus rural settings, traffic complexity, and infrastructure readiness.
- **Usage motivation:** Respondents cited a variety of motivations for AV use, particularly commuting, leisure travel, and short-distance convenience.
- **Duration of travel:** Perceptions of AVs were found to be highly sensitive to trip length, with longer journeys intensifying concerns about comfort, system reliability, and perceived loss of control.

4.2.4. Strategies

- **Purchasing SAE 4–5 vehicles:** Participants were open to purchasing highly automated vehicles if affordability, trust in safety systems, and usability were adequately demonstrated. Ownership was closely associated with independence and control.
- **Renting SAE 4–5 vehicles:** Short-term rental was considered a flexible option for occasional use – for travel, trying out the technology, or replacing conventional vehicles without committing to ownership.
- **Using shared SAE 4–5 vehicles:** Many respondents expressed willingness to use shared AV fleets, particularly in urban contexts, where shared mobility was seen as more cost-effective and convenient.
- **Using SAE 4–5 vehicles in public transport:** Several respondents envisioned AVs as part of public transportation systems, such as driverless shuttles or last-mile solutions, highlighting convenience, accessibility, and environmental benefits.

4.2.5. Context

- **Homogenous traffic environment:** Participants noted that a uniform traffic environment dominated by AVs could improve predictability and reduce accidents, in contrast to hybrid human-AV traffic systems.

- **Prioritised passenger safety:** Safety was identified as a non-negotiable condition for AV acceptance. Participants stressed that AVs must demonstrably prioritise passenger protection.
- **Possibility of taking back control:** There was a recurring expectation that users should retain the option to manually override the AV system if needed, as a safeguard and to maintain a sense of control.
- **Operation transparency:** Respondents highlighted the importance of clear communication about how AVs function – including their decision-making logic and system limitations – as essential to building trust.

4.2.6. Consequences

Aspects enhancing AV-acceptance:

- **Improved road safety:** Participants anticipated that widespread AV adoption could significantly reduce accidents caused by human error, contributing to overall traffic safety.
- **Improving accessibility:** Respondents emphasised that AVs could improve mobility for people with disabilities, older adults, and those without a driving license, supporting more inclusive transport systems.
- **Optimised traffic flow:** Participants suggested that AVs’ ability to communicate and coordinate with each other could optimize traffic flow, reducing congestion and travel times.
- **Respect of traffic rules:** AVs were expected to comply consistently with traffic regulations, reducing rule violations and promoting more orderly road behaviour.

Aspects limiting AV-acceptance:

- **Loss of driving experience:** Respondents expressed concern that the enjoyment and emotional value associated with manual driving could be diminished or lost entirely with AV usage.

- **Loss of human competence:** There were fears that reliance on AVs may erode essential driving skills and situational awareness over time.
- **Digital overexposure:** Several respondents suggested that freed-up travel time could increase screen-time and deepen existing patterns of digital dependency.
- **Disappearing driving styles:** Participants noted that culturally specific or individualised driving habits might disappear, leading to more homogenised, standardised travel experiences.

4.3. Selective coding – The TRACE model

Selective coding synthesises the *key categories identified during axial coding* into a unified conceptual framework (Fig. 3) centred around the central phenomenon: the intention to use highly automated vehicles (AVs). This integrative step links causal conditions, contextual factors, intervening conditions, user strategies, and their perceived consequences.

We refer to the resulting grounded theory model as **TRACE** – the -*Technology-related Repertoires of Attitudes, Control, and Engagement*-framework – which captures the complex and ambivalent factors influencing Generation Z’s intention to use highly automated vehicles. The model provides a conceptual lens through which symbolic, emotional, and experiential dimensions of AV acceptance can be understood.

While many of the perceived impacts of AVs were clearly interpreted as either facilitating or constraining acceptance, some themes elicited ambivalent responses. For instance, extended availability and disappearing personalised driving styles were viewed by some participants as benefits (e.g., greater efficiency, traffic standardisation), while others perceived them as losses (e.g., overconnectivity, erosion of driving identity). These dual-coded categories are represented in grey in the TRACE model to reflect their context-dependent nature. Their placement outside the core “benefit” or “barrier” domains underscores the nuanced, multidirectional character of AV perceptions among

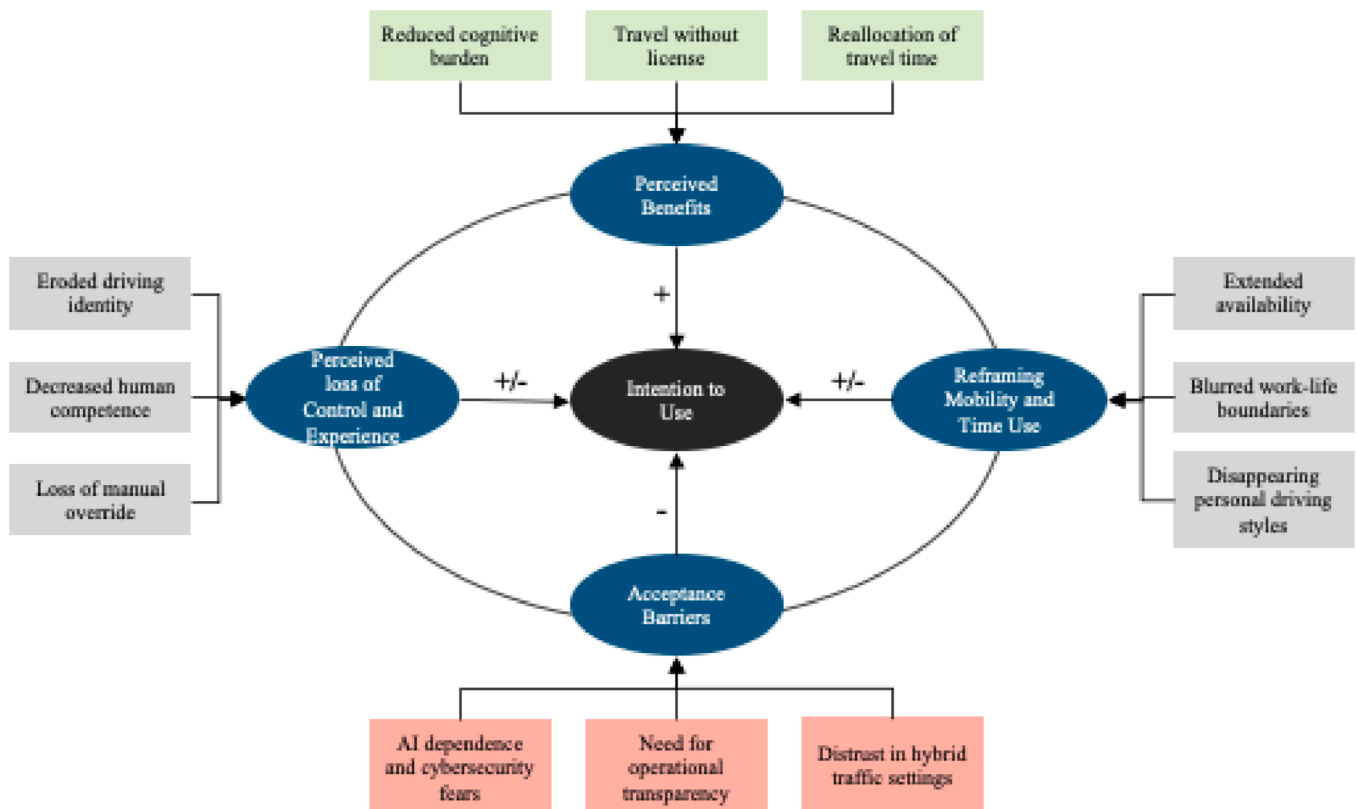


Fig. 3. Selective coding result – TRACE model. Source: Authors’ own editing.

Generation Z users.

4.3.1. Loss of control and the elimination of driving experience

Participants consistently reflected on how AVs would redefine traditional driving experiences and reshape personal identity. The prospect of reduced manual control was seen as a double-edged sword: it alleviates the burden of driving but may also diminish driver competence. As manual skills become obsolete, the figure of the “good driver” risks losing symbolic value.

“You do not necessarily need as much driving skill as you would for a manual car. A lot of the functions in these are already autonomous, so it is enough to concentrate on the basics while driving.” (#3d).

This perceived erosion of driving ability may also undermine the social meaning of car use, weakening its role as a status symbol and a marker of competence, especially within micro-communities.

4.3.2. Perceived benefits

In contrast, many participants emphasised the potential advantages of AVs, including ease of use, reduced cognitive load, and the elimination of driver training requirements. The prospect of using AVs without a driving licence was especially appealing for both practical and financial reasons.

“It is simple for sure. It might be good, but it is going to make our brains even more addicted to technology, perhaps, which is going to be dangerous.” (#1e).

The potential to repurpose travel time for rest, productivity, or leisure emerged as a key motivator.

“The car user can have a better time if the car can actually navigate to the destination. This time could be better spent on work, maybe sleep or relaxation.” (#4a).

4.3.3. Acceptance barriers

Trust in AV technology was closely tied to operational transparency and safety. Participants emphasised the importance of retaining manual override functions, especially in unfamiliar or malfunctioning situations.

“For me, it would be important to be able to switch to manual mode at any time. Humans are not perfect and faultless, but viruses and hackers are probably one of the main risks with machines these days.” (#1c).

A fully automated traffic environment was viewed as a prerequisite for AV safety. Mixed traffic scenarios involving both human-driven and autonomous vehicles were widely regarded as riskier.

“If everyone had one autonomous vehicle, it would be safer traffic. I think that by sharing manual-self-driving cars, both parties could be unsafe to drive.” (#5b).

Operational simplicity and transparent AI decision-making were perceived as critical for trust-building, particularly in the early phases of adoption.

4.3.4. Reframing mobility and time use

Participants envisioned AVs as potentially transforming the meaning of travel time. The shift from active driver to passive passenger was seen as creating space for new forms of engagement – both productive and recreational – while also raising concerns about deepening digital dependency.

“It will improve [travel time efficiency]. Remaining work or tasks can be completed while travelling.” (#3e).

However, concerns were raised about the blurring boundaries between work and leisure, as increased availability and automation might reinforce expectations of constant connectivity and availability.

Standardisation of driving behaviour was perceived as a safety benefit, contributing to smoother traffic flow. Yet it was also viewed as a potential loss of personal freedom and driving identity.

“...there would be no different driving styles and no ‘Sunday drivers (uselessly slow drivers)’ on the roads. Although, along with this, it would not be so easy to drive fast (over the speed limit).” (#3a).

5. Discussion and conclusion

5.1. Main findings and theoretical implications

This study provides a novel insight into how Generation Z perceives highly automated vehicles (AVs), considering identity, emotions and symbolic meaning in addition to rational evaluation. The main theoretical contributions are:

- **Psychological framing of AV adoption:** Our findings demonstrate that the intention to use AVs is shaped not only by utilitarian evaluations but also by symbolic, emotional, and identity-related factors – such as *perceived autonomy, loss of control, and driving as self-expression*.
- **Extension of technology acceptance frameworks:** The TRACE model introduces latent constructs (e.g., *reduced cognitive burden, fear of AI-dependence, distrust in hybrid traffic*) that are not currently represented in TAM, UTAUT, or similar models.
- **Ambivalence and dual perception:** Participants expressed both enthusiasm (e.g., for ease and flexibility) and scepticism (e.g. over loss of control or digital overload), highlighting the non-linear nature of AV acceptance.
- **Context-sensitive adoption:** Acceptance varies by travel context, purpose, infrastructure, and use-case, suggesting AV uptake is contingent, not generalisable.
- **Reframing the driver role:** The symbolic meaning of the “good driver” is seen as diminishing, replaced by passive system reliance and functional depersonalisation.
- **Generation-specific motivational structures:** Generation Z appears to frame AVs as digital, customisable spaces that enable lifestyle continuity, rather than simply as transport modes.

The TRACE model provides a conceptual scaffold for understanding these psychosocial dynamics in AI-mediated mobility. It bridges transport research with identity, affect, and control – dimensions often overlooked in traditional AV studies.

5.2. Practical relevance and stakeholder insights

To promote socially acceptable AV uptake, we propose the following strategies for developers, marketers, and policymakers:

- **Design for cognitive relief:** AVs should emphasise features that reduce driver mental load, such as adaptive automation, intuitive interfaces, and stress-reducing cabin environments.
- **Preserve manual override options:** Retaining user agency via optional steering or braking can foster trust during the adoption phase.
- **Increase transparency:** Clearly communicating how AVs make decisions and handle critical situations can increase perceived safety and reduce resistance.
- **Mitigate AI-related fears:** Address concerns over cyber risk and system opacity through secure-by-design protocols and visible safety features.
- **Align branding with identity:** Avoid portraying AVs solely as rational tools – **acknowledge their impact on self-expression, freedom, and status**, especially for younger consumers. For this, the following strategies are suggested to follow:
 - *Position AVs as lifestyle enablers* rather than technical solutions, emphasizing autonomy, creativity, and digital integration.
 - *Use influencer-based campaigns* and user-generated content to showcase how AVs can reflect individual identity and values.

- **Highlight design personalization options** (e.g., customizable lighting, infotainment, interior mood settings) to reinforce **the vehicle as an extension of self**.
- Create **brand associations with emotional values** like trust, curiosity, and control rather than just efficiency or safety.
- **Support digital boundaries:** Provide features that allow users to designate travel time as leisure, rest, or disconnection—not only productivity.
- **Prepare policy and infrastructure:** Regulators should facilitate the rollout of homogeneous AV traffic environments and invest in infrastructure to reduce human–AV interaction complexity.

This study presents one of the first grounded theory models—TRACE (Technology-related Repertoires of Attitudes, Control, and Engagement)—to explore how psychosocial dimensions influence AV perceptions. It advances AV research by embedding symbolic, emotional, and generational meaning-making into the acceptance process. TRACE thus offers a multidisciplinary platform for future inquiry into socially sustainable AI-driven mobility.

5.3. Limitations and future research directions

This study is exploratory and qualitative; therefore, its findings are not statistically generalisable. While focus groups enabled rich and nuanced insights, the sample size and gender imbalance may have influenced the relevance of themes such as safety, trust, and emotional engagement with driving. Future studies should aim to address this imbalance and examine how gender moderates AV perceptions and adoption intentions. Further research is needed to test the TRACE model in diverse cultural and demographic contexts. Quantitative studies, including large-scale surveys and structural modelling, could help validate and refine the model's key constructs. Longitudinal research would also be valuable in tracking how attitudes evolve with increasing AV exposure and technological maturity. Finally, examining the roles of socio-economic status, digital literacy, and urban–rural differences may reveal additional moderators influencing AV acceptance.

CRedit authorship contribution statement

Márk Miskolczi: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **László Kökény:** Writing – original draft, Formal analysis, Data curation, Conceptualization. **Melinda Jászberényi:** Supervision, Project administration.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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