Delft University of Technology

Changes in Non-Driving-Related Activities from Conditional to Full Automation and Their Implications for Interior Design

A Systematic Review and Meta-Analysis

Cai, Yujing ; Anjani, Shabila; Withey, Dave; Vledder, Gerbera; Song, Yu; Vink, Peter

DOI
10.3390/app14209442

Publication date
2024

Document Version
Final published version

Published in
Applied Sciences

Citation (APA)
Cai, Y., Anjani, S., Withey, D., Vledder, G., Song, Y., & Vink, P. (2024). Changes in Non-Driving-Related Activities from Conditional to Full Automation and Their Implications for Interior Design: A Systematic Review and Meta-Analysis. *Applied Sciences*, *14*(20), Article 9442. https://doi.org/10.3390/app14209442

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Copyright
Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy
Please contact us and provide details if you believe this document breaches copyrights.
We will remove access to the work immediately and investigate your claim.

This work is downloaded from Delft University of Technology.
For technical reasons the number of authors shown on this cover page is limited to a maximum of 10.

applied sciences

MDPI

Review

Changes in Non-Driving-Related Activities from Conditional to Full Automation and Their Implications for Interior Design: A Systematic Review and Meta-Analysis

Yujing Cai [1], Shabila Anjani [1], Dave Withey [2], Gerbera Vledder [1], Yu Song [1,*] and Peter Vink [1]

[1] Faculty of Industrial Design Engineering, Delft University of Technology, Landbergstraat 15, 2628CE Delft, The Netherlands; yujingcai750@gmail.com (Y.C.); s.anjani-1@tudelft.nl (S.A.); g.vledder@tudelft.nl (G.V.); p.vink@tudelft.nl (P.V.)
[2] JLR, Abbey Road, Whitley, Coventry CV3 4LF, UK; dwithey@jaguarlandrover.com
* Correspondence: y.song@tudelft.nl

Abstract: Automated driving frees users from the task of driving, allowing them to engage in new activities. Using keywords related to Non-Driving-Related Activities (NDRAs) and automated vehicles (and their variants), with reference to the Society of Automotive Engineers (SAE) levels 3, 4, and 5, the authors identified 2430 studies from various databases and sources. Of these, 47 were included in this study, with 39 included in the meta-analysis. The meta-analysis of the included studies shows a positive correlation between automation levels and the diversity of NDRAs. Communication and interaction with passengers are the most common activities, followed by media consumption, rest, and relaxation. Food and drink consumption slightly surpasses working and productivity, while personal habits and hygiene are less prioritized. Although some users still value vehicle monitoring, this need decreases with higher automation levels. Key activities such as communication, laptop use, and sleeping are highlighted as significant benefits of automation, as users transition away from situational awareness and are able to perform cognitively intensive tasks. The review also addresses potential design implications to support these NDRAs and discusses related regulatory challenges.

Keywords: automated vehicles; NDRAs; interior design

check for updates

Citation: Cai, Y.; Anjani, S.; Withey, D.; Vledder, G.; Song, Y.; Vink, P. Changes in Non-Driving-Related Activities from Conditional to Full Automation and Their Implications for Interior Design: A Systematic Review and Meta-Analysis. *Appl. Sci.* **2024**, *14*, 9442. https://doi.org/10.3390/app14209442

Academic Editor: Arkadiusz Gola

Received: 4 September 2024
Revised: 10 October 2024
Accepted: 11 October 2024
Published: 16 October 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Automated driving has been growing rapidly over the past decade. The Society of Automotive Engineering (SAE) has defined a widely accepted classification of automated driving, ranging from Level 0 (L0), fully manual driving, to Level 5 (L5), fully automated driving [1]. Among these levels, Levels 3 (L3) to L5 are generally considered automated vehicles. At L3 (Conditional Automation), the vehicle handles all tasks under certain conditions and a human must be ready to take over. At Level 4 (L4, High Automation), the vehicle manages all tasks in specific conditions without human intervention, though human control may be needed in other situations. At L5 (Full Automation), the vehicle can perform all tasks in all conditions without any human input. By 2030, 12 percent of new passenger cars are expected to be equipped with L3 or above automated technologies, and automated driving could create $300 billion to $400 billion in revenue by 2035 according to a McKinsey analysis [2]. The safety benefits, value of time, and resource optimization provided by self-driving cars are crucial drivers of this boom. Chao [3] reported that the major factor in 94 percent of all fatal crashes is human error, making it possible for self-driving cars to save lives and reduce injuries by reducing human error. Automated driving offers significant opportunities by relieving drivers of their responsibility for operating the vehicle, enabling them to engage in activities that were previously unfeasible during manual control. This shift allows travel time to be utilized efficiently, transforming it into productive time or leisure activities. Technologies such as environmental perception, navigation, and path planning empower self-driving cars to optimize resource allocation, enhancing road capacity, alleviating traffic congestion, and minimizing manpower and fuel waste [4].

However, achieving widespread deployment and commercialization of automated vehicles (AVs) presents several challenges that stakeholders must navigate, such as regulatory frameworks, public acceptance, infrastructure compatibility, cybersecurity risks, insurance and liability, and technological integration [5]. One of the major challenges is designing the interior layout of future self-driving vehicles to accommodate new user activities. As these vehicles reach higher levels of automation, users will increasingly have more time for non-driving-related activities (NDRAs).

Numerous studies using methods such as questionnaires, interviews, and Wizard-of-Oz experiments have explored different non-driving-related activities (NDRAs) during L3 and above automated driving. Given that L3 and above automated driving is a novel experience for most people, Schoettle & Sivak [6] found that participants expressed more concerns about fully self-driving vehicles compared to partially automated ones. Nearly half of the participants indicated they would prefer to watch the road, even when not driving. However, this behavior may change in the future. For instance, Large et al. [7] conducted a driving simulator study and discovered that as participants spent more time in an AV, their visual attention shifted away from the road and increasingly towards secondary activities over the course of a week.

The ability to perform secondary activities is one of the key factors influencing the acceptance of, and willingness to purchase, higher levels of automated driving [8], as it allows passengers to use their travel time more productively [9,10]. Moreover, Li et al. [11] found that as the level of automation increases, the frequency of engagement in nearly all secondary tasks also rises, particularly for potentially risky NDRAs such as sleeping and playing video games on a smartphone. Supporting this, Reimer et al. [12] noted that higher levels of automation quickly enhance driver comfort and willingness to engage in NDRAs. This shift is likely to significantly increase engagement in visually and physically demanding NDRAs in AVs compared to manually driven ones [13]. However, each study found different NDRAs due to varying participants, research methods, contexts, and other factors, and the evolution of NDRAs across Levels 3, 4, and 5 automation remains fuzzy as well.

A better understanding of NDRAs and their evolution across Levels 3, 4, and 5 is crucial for car interior design, as interiors will need to be adapted to align with these user activities [14]. For instance, the current car seat is optimized for driving [15], but as automation increases, new interior designs will be required to accommodate a broader range of activities. Large et al. [16] found that people adopt different postures in automated cars compared to traditional driving situations, highlighting the need for these adaptations.

This review examines the prioritization of NDRAs in which consumers wish to engage within self-driving vehicles at Levels 3, 4, and 5. Evidence from existing research was synthesized into a meta-analysis highlighting the importance of different NDRAs and the transition from L3 to L5. Potential changes needed in car interior design are also emphasized. The prioritized list aims to provide clear guidance for car manufacturers and designers, helping them create vehicle interiors that enhance user comfort and optimize the in-car experience in future AVs.

2. Methods

2.1. Information Sources, Search Strategy

The search followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA, [17]) guidelines. The study utilized "Scopus", "IEEE Xplore", "Web of Science", and "PubMed" to retrieve relevant literature, with the search terms detailed in Table 1. The search was restricted to English-language publications only. Additionally, the references cited within the retrieved literature were examined to ensure that no significant studies were overlooked. The search covered all publications up to 18 March 2023.

Table 1. Search terms.

Search Terms
("automated car" OR "automated cars" OR "automated vehicle" OR "automated vehicles" OR "self-driving car" OR "self-driving cars" OR "self-driving vehicle" OR "self-driving vehicles" OR "automated driving" OR "autonomous driving" OR "vehicle automation") AND ("non-driving activity" OR "non-driving activities" OR "non-driving-related activity" OR "non-driving-related activities" OR "non-driving-related task" OR "non-driving-related tasks" OR "ancillary activity" OR "ancillary activities" OR "secondary activity" OR "secondary activities")

2.2. Inclusion and Exclusion Criteria

The titles and abstracts of all eligible studies were imported into Rayyan [18] for selection via a Delphi process. The inclusion criteria required studies to investigate or experiment with various NDRAs that users might perform or have performed in the context of conditional, highly, or fully automated driving (L3, L4, and L5, referred to as automated driving). Participants in each study needed the freedom to choose or engage in natural NDRAs, rather than being limited to pre-designed activities. This analysis included all publications found up to the search date in the selected topic.

Excluded studies were those reporting activities in public transportation (e.g., trains, buses), those focused on consumer activities in manual or partially automated driving (L0, L1, L2), those requiring participants to perform mandatory pre-designed activities for other purposes (e.g., comparing takeover times after different NDRAs), and those not involving NDRAs.

2.3. Selection Procedure

Initially, 2421 articles were identified, with 2315 remaining after duplicate removal. These were screened against the inclusion criteria, resulting in the exclusion of 2097 articles. The full texts of the remaining 218 were reviewed, leading to the exclusion of 180 that did not meet the eligibility criteria, leaving a total of 38 articles. A review of their references and citations added nine more articles (19% of the total), bringing the total to 47. Of these, 39 studies dating from 2014 [6] to 2023 [9,11,13] were included in the meta-analysis, with one study excluded for not differentiating between target groups, markets, or automation levels. The Critical Appraisal Skills Programme (CASP) qualitative research checklist [19], designed to help researchers and practitioners evaluate the quality and rigor of qualitative research studies, was used to assess potential bias in the studies, and all included research was deemed valuable. Figure 1 outlines the selection process.

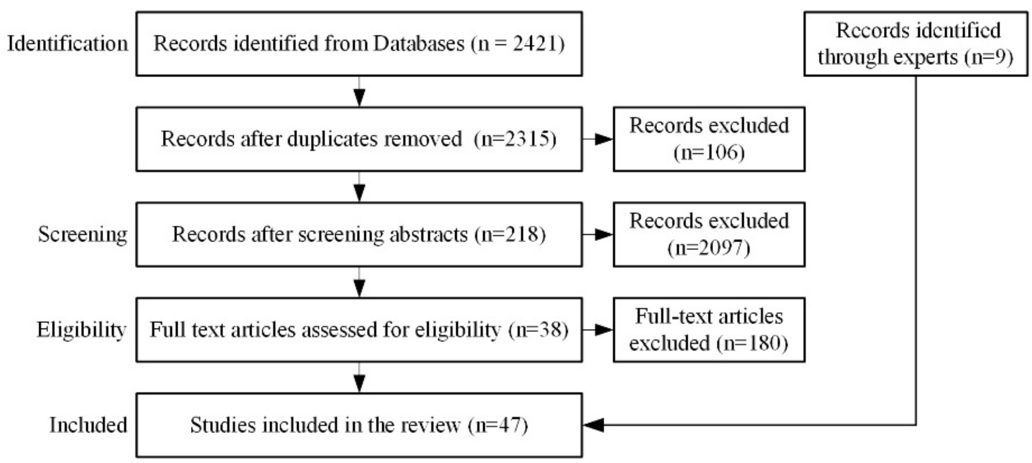

Figure 1. Study selection process.

2.4. Meta-Analysis

All selected studies were thoroughly reviewed, and the extracted data was organized into a table. A meta-analysis was then conducted using this tabulated data. In the meta-analysis, a categorization was performed, which is presented in Table 2. This classification was based on the various needs and setups required to accommodate different activities within the vehicle's interior. The findings are intended to guide the design of adaptable vehicle interiors that can support new postures and activities associated with automated driving cars, as discussed by Large et al. [16].

Table 2. Categories of different activity types.

No	Category
1.	Media Consumption and Online Activities (smartphone/tablet usage)
2.	Rest and Relaxation
3.	Work and Productivity (laptop usage)
4.	Communication and Interaction with Other Passengers
5.	Food and Drink
6.	Personal Hygiene, Grooming, and Beauty
7.	Personal Habits and Leisure
8.	Vehicle Monitoring Activities

The categories "doing nothing" and "other" were excluded from the meta-analysis due to the ambiguity in their definitions. For instance, Pudāne et al. [20] categorized activities such as watching scenery, thinking, and listening to music under "doing nothing", and included sleeping, shopping, service, and household tasks under "other". These activities overlap with those in other studies, leading to potential inconsistencies.

The data types considered in the meta-analysis include the percentage of frequency and percentage of duration. Since most studies reported percentages of frequency, only that type of data was included in this meta-analysis. If both quantitative and qualitative data were available in the literature, only quantitative data were considered. Data from the meta-analysis by Fitzen et al. [21] were excluded to avoid the potential duplication of results in this analysis.

3. Results

3.1. Automation Level and Research Methodology

The eligible 47 studies that were selected through this process were categorized based on their automation levels and research methodologies, shown in Table 3. The number of studies on L3 was greater than those on other levels, which might affect the meta-analysis.

Table 3. Eligible studies from which to extract outcomes.

Classification	Type	Number of Studies
Automation level	L3 (conditional automation in SAE, highly automated driving in VDA, highly automated driving in BASt, limited self-driving automation in NHTSA (National Highway Traffic Safety Administration))	24
	L4 (highly automation in SAE)	5
	L5 (fully automation in SAE, automated driving with train sets, driverless driving in VDA, driverless cars)	19
	L3 & L4 (SAE)	5
	L4 & L5 (SAE, completely self-driving automation in NHTSA, based on the scenario whereby vehicles can drive autonomously, fully automated driving in BASt, did not have any operator controls)	9
	L3 & L4 & L5 (Avs)	3
Research methodology	Online survey	29
	Driving simulator study	18
	Participatory Design (such as focused groups)	6
	Real-world Wizard-of-Oz study or simulated car or Pilot site	11
	Literature review with meta-analysis	1

3.2. Meta-Analysis Results

Preliminary analysis showed that the sample sizes in different studies were significantly different. Some studies had a large sample size of more than 3000 participants, e.g., [22,23], while others had only 20 participants, e.g., [24]. Additionally, some studies used surveys, while others employed experiments. To address the methodological differences and disparity in participant sizes across the studies, only the percentage of occurrences of NDRAs from each study was selected and averaged. This meta-analysis also distinguishes between different levels of automation. For studies that reported results across multiple automation levels, we included the data for each level separately. However, some studies combined automation levels (e.g., L3 & L4, L4 & L5). In such cases, we analyzed them as two distinct categories: L3 & L4 and L4 & L5. Table 4 presents the activities in each category along with their occurrence percentages.

Figure 2 shows the mean occurrence percentages of different NDRAs. The values increase from L3 (27% ± 17%) to L4 (41% ± 20%) and then decrease slightly at L5 (39% ± 15%). For group activities, the percentages are 33% ± 23%, 52% ± 8%, and 56% ± 10% for L3, L4, and L5, respectively. For personal activities, the percentages are 26% ± 16% for L3, 40% ± 21% for L4, and 38% ± 14% for L5. However, when L3 and L4 are combined, the mean occurrence percentage decreases to 27% ± 26%. Similarly, combining L4 and L5 results in a lower mean occurrence percentage of 28% ± 19%. This suggests that merging these levels in the study may reduce the observed mean values.

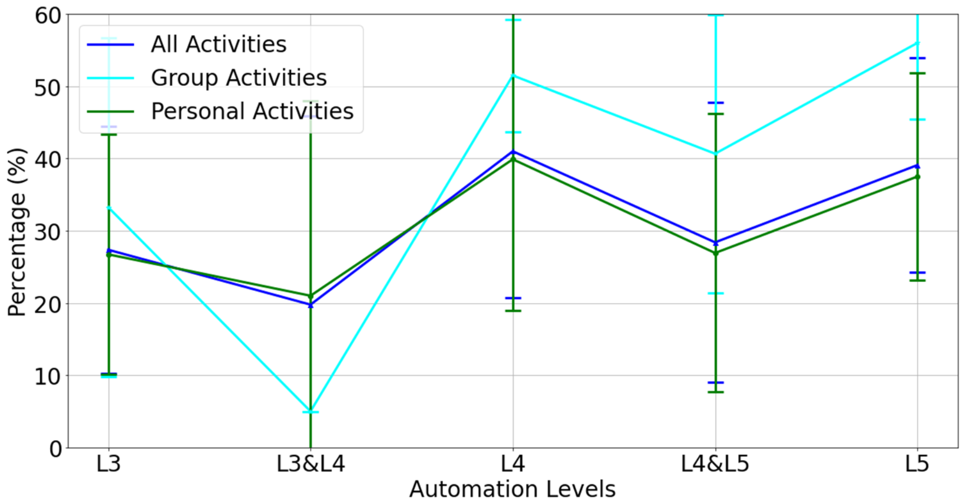

Figure 2. The mean occurrence percentages and standard deviation of different NDRAs regarding automation levels.

Figure 3 provides more details on personal activities. The mean percentages of different categories are 28% ± 7%, 38% ± 11%, and 36% ± 7% for L3, L4, and L5, respectively. While the results follow a similar trend to the occurrence percentages, it is notable that in L4, the variation in activities is the highest, and in L5, personal activities increase. It is worth mentioning that “Vehicle Monitoring Activities” and “Rest and Relax” decrease from L4 to L5. However, within the “Rest and Relax” category, “Rest and Relax—Looking at scenery” drops significantly at L5, whereas “Rest and Relax—Sleeping” continues to rise, as shown in Table 4.

Table 4. Occurrence percentages of NDRAs in L3, L4, and L5 automated driving cars.

Category	Average	Activity	Type §	L3	L3 & L4	L4	L4 & 5	L5
Communication and Interaction with Other Passengers	41%	Communication	G	29%		46%	56%	52%
		Interaction with other passengers	G	67%			47%	68%
		Taking care of children	G	13%				
		Games	G	24%	5%	57%	19%	48%
Media Consumption and Online Activities	37%	* Use smartphone	P	36%	100%	67%	4%	15%
		* Use tablet	P	31%	8%	24%		46%
		Take selfies	P	2%		15%	16%	
		Social media	P	35%	3%		39%	61%
		Passive entertainment (e.g., watch movies)	P	31%	9%	78%	20%	51%
		Online Shopping	P	32%				57%
		Texting/Messaging	P	45%	8%	44%	71%	65%
		Phone call	P	39%	2%	34%	37%	58%
		Listening to entertainment	P	65%	31%	38%	61%	33%
Rest and Relaxation	37%	Relax/rest	P	26%			44%	21%
		Sleep	P	24%		31%	28%	47%
		Looking at scenery	P	39%		80%	58%	26%
		Wellness/praying/meditation	P	17%				46%
Vehicle Monitoring Activities	34%	Watching the road/other vehicles	P	64%		46%	44%	23%
		Communicate with other vehicles	P	12%				
		Maintenance activity	P				18%	
Food and Drink	31%	Eating/drinking	P	46%	27%	36%	40%	41%
		Prepare meals	P	19%			8%	
Work and Productivity	29%	* Laptop use	P	12%	19%	26%		49%
		Work	P	33%	12%		20%	28%
		Learn language	P				12%	
		Analyzing/thinking	P	11%		64%	43%	12%
		Make to do list/writing/editing	P	4%		56%		
		Reading book	P	24%	29%	18%	29%	29%
		Video call	P	9%		24%		38%
		Trade stocks	P	2%				
		Product information	P	44%				45%
		Consultations	P	35%				39%
		Emails/browsing internet	P	40%			28%	48%

Table 4. *Cont.*

Category	Average	Activity	Type §	L3	L3 & L4	L4	L4 & 5	L5
Personal Hygiene, Grooming, and Beauty	27%	Personal hygiene	P	13%		46%	17%	29%
		Make up	P	12%		12%	17%	33%
		Change clothes	P	13%				35%
		Organizing/clean up	P	49%				47%
Personal Habits and Leisure **	19%	Smoking	P	13%		19%	6%	21%
		Knitting	P	1%			5%	
		Artistic activities	P	22%				30%
		Fitness	P	14%			5%	37%
		Play musical instruments	P				3%	6%
		Singing	P		4%			
		Health	P	39%				43%
		Training	P	36%				41%

* These activities may overlap with other activities. ** Scratching was mentioned in one study, but no specific numbers were provided. § G = Mainly group activities, P = Mainly personal activities.

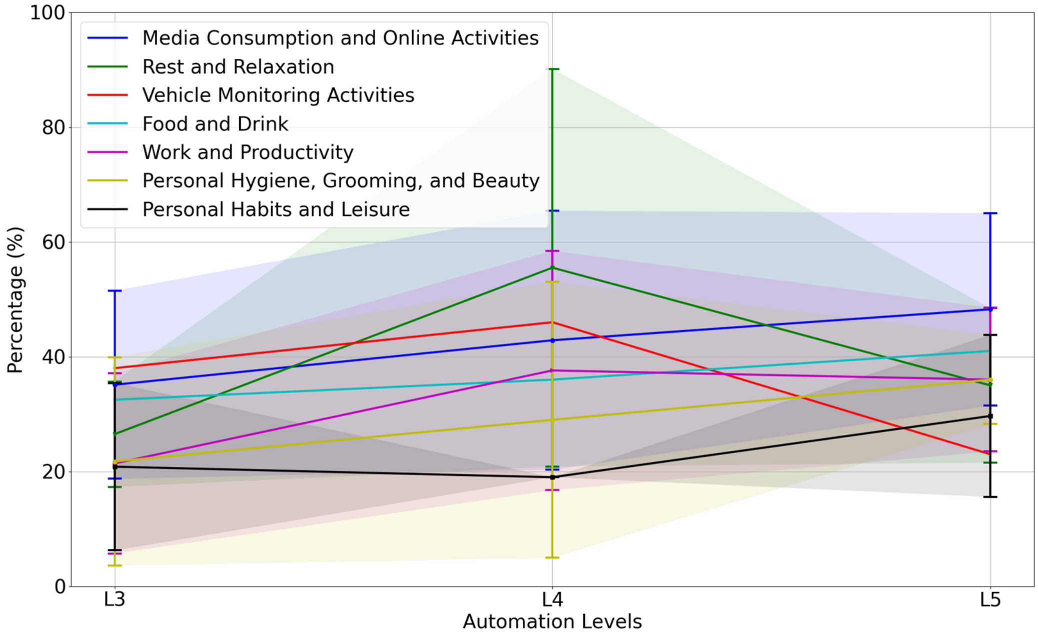

Figure 3. Changes in the occurrence percentages of personal NDRAs from L3 to L5, with shaded areas representing the standard deviation for each activity in the corresponding color.

4. Discussion

The automotive industry is driven by safety, automation, electrification, comfort, and sustainability within regulatory frameworks. As NDRAs become central in L3 and above vehicles, significant changes are reshaping car interior design, especially in seating support engineering to accommodate less driving and more NDRAs. There is also a growing focus on designing interiors that enable smooth transitions between automation levels L3 to L5. This underscores the importance of better understanding NDRAs and the transition process.

The diversity of NDRAs, represented by mean occurrence percentages (Figure 2), increased from 27% to 41% between L3 and L4, but remained nearly unchanged at 39% in L5, indicating significant changes from partial to full automation. As driving responsibilities are gradually removed from users, they have more time to engage in a wider range of activities, enhancing travel efficiency. Meanwhile, the variation in occurrence percentages is highest at L4 (Figure 3), reflecting the complexity users face in selecting NDRAs when both driving and full automation contexts coexist.

4.1. Group NDRAs

Among all activities, communication and interaction with other passengers, as a group activity, had the highest percentage, increasing from 29% in L3 to 46% in L4 and 52% in L5. While passenger car occupancy in Europe ranges from 1.20 to 1.90 persons [25], Yang et al. [26] found that the presence or absence of additional passengers, whether strangers or acquaintances, was the most influential factor in choosing an NDRA(s).

When an acquainted passenger is present, interacting with them becomes a highly preferred activity in self-driving cars [14,27–31], particularly during long-distance travel with family [32]. Users are also willing to pay more to fulfill this communication need in AVs [33]. For example, Cyganski et al. [34] found that when an acquaintance is present, users may overlook the value of productive time and prefer to converse with the other passenger. Besides verbal communication, AV users also prefer engaging in shared activities with fellow passengers, such as playing video games or board games [35]. This meta-analysis found a positive correlation between the prevalence of playing games and the levels of automation, with game-playing being much more common in L4 (57%) and L5 (48%) cars compared to L3 (5%), even with strangers.

4.2. Personal NDRAs

In the study by Wilson et al. [36], it was found that AV owners are more likely to be young, male, and early adopters of technology, primarily using their cars for personal travel. Unsurprisingly, the demand for media consumption and online activities in AVs is high, with 37% of users engaging in these activities. Popular NDRAs include smartphone features such as texting, calling, web browsing, reading, and using social media [24,37,38]. Consequently, users of automated cars prefer to freely use their smartphones during travel [39–42]. This meta-analysis also found that social media usage increased as the level of automation rose, from 35% in L3 to 61% in L5. Additionally, some users expressed a desire to watch movies on an onboard device, similar to in-flight entertainment systems in airplanes [43], which could be a potential focus for future car interior designs. This preference for "passive entertainment" was also found to be higher in L4 and L5 compared to L3.

Laptop use is also a popular need for working on the go. This meta-analysis found that the demand for laptop use grew from 12% in L3 to 49% in L5 cars. Productivity, such as working during daily commutes, was preferred by participants [10,44,45]. Working and writing emails require visual and manual resources, as well as a high cognitive load, making high-level AVs an ideal solution for these tasks [46]. Users are even willing to pay more if AVs enable them to enhance their productivity [47].

Many users still consider it important to monitor their vehicle. This study found that the percentage of participants needing to monitor their car's driving activity decreases as the level of automation increases, dropping from 64% in L3 to 23% in L5. This trend aligns with existing literature [48], though individual human characteristics remain the most influential factor.

Rest and relaxation are important activities that should be accommodated in AVs. This need is as prevalent as media use, with both activities occurring in 37% of cases. Resting, which involves being idle while gazing outside the car, is sought by many users [31,34,39,40,44,49–51]. This might be partly due to the strong need to monitor driving tasks to enhance situational awareness, as automated driving is a new experience for users [52], particularly for those driving alone [35] and for older drivers [53]. However, it is important to note the influence of L4 (High Automation) and L5 (Full Automation). While the steering wheel is present (L4), more than 80% of users select looking outside as a rest and relaxation activity, and this number drops to 26% in L5. Part of the reason is that while "Looking at scenery", users can still maintain situational awareness, while users develop trust at L5 and choose sleeping to make travel more efficient.

The percentage of users who prefer sleeping increased from 24% in L3 to 31% in L4 and to 47% in L5, reflecting a growing trend with advancing automation levels. In higher levels of automated driving, users are increasingly expected to fully engage in secondary activities. Li et al. [11] found that the frequency of sleeping, a NDRA that completely eliminates situational awareness, increases with higher levels of automation. In lower levels of automation, sleeping is considered dangerous. This finding aligns with Wörle et al. [43], who observed that sleeping is more common in L4 compared to L3. Additionally, Becker et al. [33] found that users were willing to pay 50% more for a fully automated car that allows for deep sleep.

Eating or drinking in an AV was selected by 31% of participants in this meta-analysis, which is higher than the percentage for working and varies with travel duration. For longer trips that include mealtimes, the need for eating and drinking in a car becomes more significant compared to short daily commutes. Additionally, mealtimes are relevant regardless of the presence of other passengers, whereas activities like working and communication are influenced by the number of passengers and their level of acquaintance [41,45].

Solitary leisure activities categorized under personal habits and leisure (19%), such as sports [28] and personal hygiene, grooming, and beauty (27%), including activities like applying make-up [10], were less frequently reported in this meta-analysis. Despite their lower initial prevalence, these activities do increase with higher levels of automation. This trend underscores the growing diversity of human needs and preferences as automation advances, highlighting the expanding role of NDRAs in high-level AVs.

4.3. Categorization Methods in Research

Different categorization methods were used to investigate NDRAs in automated vehicles. In Figure 2, it is evident that the mean occurrence percentages drop significantly when L3 and L4 are combined, as well as when L4 and L5 are combined. Humans remain central to NDRAs in automated vehicles. The key difference between L3 and L4 is that in L3, humans are required to take over control, while the difference between L4 and L5 is that in L4, the driving context is still present for users. Therefore, such combined categorizations may not be optimal, as participants in the research are navigating two distinct contexts rather than one. It is recommended that future research addresses each automation level separately.

4.4. Implications for Future Interior Design

Automotive interiors are designed to support various activities of drivers and passengers while ensuring safety. As automation levels advance from L3 to L5, these changes are shaping the way car interiors are designed. Below, we explore the key implications for interior design based on the trends of NDRAs.

Group activities: As passengers engage in social interactions, automotive interiors will need flexible seating arrangements. Studies show that a 140-degree seat angle is optimal for communication between passengers [54,55]. However, privacy and safety remain important, especially when traveling with strangers [14,56]. Although rotating seats enhance interaction, current safety standards address mainly frontal seating positions [57], making it challenging to ensure the safety of such seating configurations [58]. Therefore, interiors that support social interaction through adaptable seating layouts must balance passenger communication with privacy and safety, particularly in shared autonomous vehicles.

Smartphone usage: With the increasing prevalence of smartphones and tablets, vehicle interiors should integrate dedicated spaces for these devices to enhance media usage [59]. Features like angled armrests [60] may be beneficial in supporting comfortable smartphone use, allowing passengers to engage with their devices more easily during travel.

Working with laptops: As working becomes more common in higher levels of automation, vehicle interiors should be designed to accommodate laptop use. However, motion sickness remains a concern [61], though mitigation technologies are advancing [62]. Laptops up to 3 kg are often used in vehicles, but there are usually no specific fixtures to secure them, posing potential safety risks in collisions, particularly given current standards that focus on frontal seating. Future interiors should incorporate stable surfaces or fixtures for laptops while also addressing the issue of motion sickness.

Sleeping: Adapting the car interior to support sleeping is essential, especially for L4 and L5 cars. Although a small car space may not be as comfortable as a large bed, research indicates that sleeping in limited spaces is feasible [63,64]. Since up to 70% of people prefer side sleeping [65], vehicle interiors should be designed to accommodate this common posture. Recent research indicates that a backrest with a 50° recline angle might be the most comfortable position for sleep [66], though this could pose safety challenges for passenger restraint systems design, as reclined seating increases the occurrence of submarining (sliding underneath the lap belt) in case of a crash [67]. Future interior designs of automated vehicles, particularly for L5, should prioritize reclining options for various sleeping positions while integrating safety features to mitigate these risks.

Personalization: As automation advances, the variety of NDRAs increases, necessitating personalized and customizable car interiors for specific use cases [68,69]. However, considering the lengthy certification processes involved in vehicle design and production, the feasibility of full personalization becomes questionable. It may be more practical to adopt a standardized approach with limited customization options that still cater to user preferences while ensuring compliance with safety regulations. Since cars are costly, long-term assets, creating personalized designs without diminishing their value presents a significant challenge. This trade-off between personalization and practicality will be central in shaping the future of vehicle designs.

Special user groups: This study primarily focuses on NDRAs for adults, but elderly individuals, children, and special groups such as pregnant women, visually impaired people, and people with reduced mobility (PRM) may have different needs and activities in AVs. For example, Mosaferchi et al. [70] suggest that AVs could lower the driving age limit, while Park et al. [71] highlight the need for customizable in-vehicle support systems to assist cognitively impaired elderly users. The inclusion of these groups may introduce new activities and demands, warranting further research.

Safety: The meta-analysis results show a positive correlation between NDRA diversity and automation levels. As automation advances, the use of AVs by children, the elderly, and PRM users is expected to rise as well. This presents significant safety challenges in interior design to accommodate diverse activities, including both physical posture and the potential (full) reduction in situational awareness. Current safety standards focus on conventional driving environments, but flexible interior configurations for NDRAs will require updated regulations. New guidelines will be necessary for seat design, restraint systems, crashing tests, and advanced in-vehicle support systems, e.g., in-cabin monitoring systems [72] and human digital twins [73]. These guidelines will be crucial to ensure the safety of passengers, particularly vulnerable groups like the elderly, children, and PRM, especially regarding fall prevention during egress and ingress [74,75].

4.5. Limitations

This meta-analysis includes studies with diverse methodologies (interviews, observations, questionnaires), which may affect results [76]. Variations in activity categorizations, data collection methods (frequency counts vs. time percentages), and sample sizes might introduce inconsistencies. For example, assigning weights to different studies is challenging due to methodological differences. Socio-demographic characteristics such as region and age were not included because of inconsistencies across studies; for instance, not all studies accounted for older adults in their surveys or experiments. Additionally, special groups such as pregnant women, individuals with visual impairments, and PRM were often overlooked, as they were not included in many studies. Future research should address these methodological and sample size disparities, as well as differences in target groups, to achieve more accurate results. Additionally, the limited availability of L3 to L5 vehicles means that many participants are speculating about potential NDRAs, highlighting the need for ongoing research as these technologies become more prevalent. In terms of design implications, we highlighted key activities that require greater attention from future interior designers. However, a more in-depth review is needed to explore potential solutions that also consider safety concerns.

5. Conclusions

This review explores changes in Non-Driving Related Activities (NDRAs) across self-driving vehicle levels L3, L4, and L5. The meta-analysis indicates that as automation increases, both the range and occurrence percentages of NDRAs expand. The results show that communication and interaction with passengers are the most frequent activities, followed by media consumption, rest, and relaxation. Food and drink activities slightly exceed working and productivity, while personal habits and hygiene are less commonly prioritized. Although some users continue to value vehicle monitoring, this need decreases as automation levels rise. Major challenges for interior designers and regulatory bodies include accommodating communication, laptop use, and sleeping needs while ensuring safety. As automation advances and users place greater trust in the vehicle, they are more likely to engage in cognitive-intensive activities in the posture they were used to, potentially shifting their focus from situational awareness to leveraging the new advantages offered by the vehicle.

Author Contributions: Conceptualization, Y.S., D.W., P.V. and Y.C.; methodology, Y.S. and Y.C.; validation, Y.C., S.A., G.V. and Y.S.; formal analysis, Y.C. and S.A.; investigation, Y.C. and Y.S.; data curation, Y.C., S.A. and Y.S.; writing—original draft preparation, Y.C., S.A. and Y.S.; writing—review and editing, S.A., D.W., G.V., Y.S. and P.V.; visualization, Y.C. and Y.S.; supervision, Y.S., G.V., D.W. and P.V.; project administration, D.W. and Y.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: Author Dave Withey was employed by the company JLR. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. SAE International Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles—SAE International. Available online: https://www.sae.org/standards/content/j3016_202104/ (accessed on 28 December 2023).
2. Deichmann, J.; Ebel, E.; Heineke, K.; Heuss, R.; Kellner, M.; Steiner, F. Autonomous Driving's Future: Convenient and Connected; McKinsey & Company. 2023. Available online: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/autonomous-drivings-future-convenient-and-connected (accessed on 10 October 2024).
3. U.S. Department of Transportation. *Automated Driving Systems 2.0: A Vision for Safety Introductory Message*; Department of Transportation: Washington, DC, USA, 2017.
4. Bagloee, S.A.; Tavana, M.; Asadi, M.; Oliver, T. Autonomous Vehicles: Challenges, Opportunities, and Future Implications for Transportation Policies. *J. Mod. Transp.* **2016**, *24*, 284–303. [CrossRef]
5. Agrawal, S.; Schuster, A.M.; Britt, N.; Mack, E.A.; Tidwell, M.L.; Cotten, S.R. Building on the Past to Help Prepare the Workforce for the Future with Automated Vehicles: A Systematic Review of Automated Passenger Vehicle Deployment Timelines. *Technol. Soc.* **2023**, *72*, 102186. [CrossRef]
6. Schoettle, B.; Sivak, M. *A Survey of Public Opinion about Autonomous and Self-Driving Vehicles in the USA, the UK, and Australia*; University of Michigan, Transportation Research Institute: Ann Arbor, MI, USA, 2014.
7. Large, D.R.; Burnett, G.; Salanitri, D.; Lawson, A.; Box, E. A Longitudinal Simulator Study to Explore Drivers' Behaviour in Level 3 Automated Vehicles. In Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, Stanford, CA, USA, 21 September 2019; ACM: New York, NY, USA; pp. 222–232.
8. Kyriakidis, M.; Happee, R.; de Winter, J.C.F. Public Opinion on Automated Driving: Results of an International Questionnaire among 5000 Respondents. *Transp. Res. Part F Traffic Psychol. Behav.* **2015**, *32*, 127–140. [CrossRef]
9. Xing, Y.; Boyle, L.N.; Sadun, R.; Lee, J.D.; Shaer, O.; Kun, A. Perceptions Related to Engaging in Non-Driving Activities in an Automated Vehicle While Commuting: A Text Mining Approach. *Transp. Res. Part F Traffic Psychol. Behav.* **2023**, *94*, 305–320. [CrossRef]
10. Pudāne, B.; Rataj, M.; Molin, E.J.E.; Mouter, N.; van Cranenburgh, S.; Chorus, C.G. How Will Automated Vehicles Shape Users' Daily Activities? Insights from Focus Groups with Commuters in the Netherlands. *Transp. Res. D Transp. Environ.* **2019**, *71*, 222–235. [CrossRef]
11. Li, Q.; Wang, Z.; Wang, W.; Yuan, Q. Understanding Driver Preferences for Secondary Tasks in Highly Autonomous Vehicles. *Lect. Notes Electr. Eng.* **2023**, *941*, 126–133. [CrossRef]
12. Reimer, B.; Pettinato, A.; Fridman, L.; Lee, J.; Mehler, B.; Seppelt, B.; Park, J.; Iagnemma, K. Behavioral Impact of Drivers' Roles in Automated Driving. In Proceedings of the Automotive UI 2016—8th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, Ann Arbor, MI, USA, 24–26 October 2016; pp. 217–224. [CrossRef]
13. McKerral, A.; Pammer, K.; Gauld, C. Supervising the Self-Driving Car: Situation Awareness and Fatigue during Highly Automated Driving. *Accid. Anal. Prev.* **2023**, *187*, 107068. [CrossRef]
14. Koppel, S.; Octavio, J.J.; Bohman, K.; Logan, D.; Raphael, W.; Jimenez, L.Q.; Lopez-Valdes, F. Seating Configuration and Position Preferences in Fully Automated Vehicles. *Traffic Inj. Prev.* **2019**, *20*, S103–S109. [CrossRef]
15. Harrison, D.D.; Harrison, S.O.; Croft, A.C.; Harrison, D.E.; Troyanovich, S.J. Sitting Biomechanics, Part II: Optimal Car Driver's Seat and Optimal Driver's Spinal Model. *J. Manip. Physiol. Ther.* **2000**, *23*, 37–47. [CrossRef]
16. Large, D.R.; Burnett, G.E.; Morris, A.; Muthumani, A.; Matthias, R. Design Implications of Drivers' Engagement with Secondary Activities During Highly-Automated Driving-A Longitudinal Simulator Study. In Proceedings of the RSS2017—The Road Safety & Simulation International Conference, Near Delft, The Netherlands, 17–19 October 2017.
17. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *BMJ* **2021**, *372*, n71. [CrossRef]
18. Ouzzani, M.; Hammady, H.; Fedorowicz, Z.; Elmagarmid, A. Rayyan—A Web and Mobile App for Systematic Reviews. *Syst. Rev.* **2016**, *5*, 210. [CrossRef] [PubMed]
19. Critical Appraisal Skills Programme CASP Qualitative Research Checklist. Available online: https://casp-uk.net/casp-tools-checklists/ (accessed on 28 December 2023).

20. Pudāne, B.; van Cranenburgh, S.; Chorus, C.G. A Day in the Life with an Automated Vehicle: Empirical Analysis of Data from an Interactive Stated Activity-Travel Survey. *J. Choice Model.* **2021**, *39*, 100286. [CrossRef]
21. Fitzen, F.; Reimann, J.; Amereller, M.; Paetzold, K. Quantitative Characterisation for Non-Driving-Related Activities in Automated Vehicles. In Proceedings of the 22nd International Conference on Engineering Design (ICED19), Delft, The Netherlands, 5–8 August 2019. [CrossRef]
22. Stadler, R.; Brenner, W.; Hermann, A. *Autonomous Driving: How the Driverless Revolution Will Change the World*; Emerald Publishing: Bingley, UK, 2018; ISBN 9781787148338.
23. Nordhoff, S.; Louw, T.; Innamaa, S.; Lehtonen, E.; Beuster, A.; Torrao, G.; Bjorvatn, A.; Kessel, T.; Malin, F.; Happee, R.; et al. Using the UTAUT2 Model to Explain Public Acceptance of Conditionally Automated (L3) Cars: A Questionnaire Study among 9118 Car Drivers from Eight European Countries. *Transp. Res. Part F Traffic Psychol. Behav.* **2020**, *74*, 280–297. [CrossRef]
24. Naujoks, F.; Höfling, S.; Purucker, C.; Zeeb, K. From Partial and High Automation to Manual Driving: Relationship between Non-Driving Related Tasks, Drowsiness and Take-over Performance. *Accid. Anal. Prev.* **2018**, *121*, 28–42. [CrossRef] [PubMed]
25. Eurostat Passenger Mobility Statistics. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Passenger_mobility_statistics (accessed on 23 August 2024).
26. Yang, Q.; Ai, M.; Tong, X.; Liu, L. Demands Exploration of Future Interior Layout in Shared Mobility Using Design Fiction. *Lect. Notes Netw. Syst.* **2021**, *276*, 259–267. [CrossRef]
27. Ive, H.P.; Sirkin, D.; Miller, D.; Li, J.; Ju, W. "Don't Make Me Turn This Seat around!" Driver and Passenger Activities and Positions in Autonomous Cars. In Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive VehicularApplications, AutomotiveUI 2015, Nottingham, UK, 1–3 September 2015; pp. 50–55. [CrossRef]
28. Weber, H.; Hiller, J.; Eckstein, L.; Metz, B.; Landau, A.; Lee, Y.M.; Louw, T.; Madigan, R.; Merat, N.; Lehtonen, E.; et al. *L3Pilot: Pilot Evaluation Results*; L3Pilot Project: Wolfsburg, Germany, 2021.
29. Nordhoff, S.; Beuster, A.; Kessel, T.; Bjorvatn, A.; Innamaa, S.; Lehtonen, E.; Malin, F.; Madigan, R.; Lee, Y.M.; Merat, N.; et al. *L3Pilot: Annual Quantitative Survey about User Acceptance towards ADAS and Vehicle Automation*; L3Pilot: Wolfsburg, Germany, 2021.
30. Pfleging, B.; Rang, M.; Broy, N. Investigating User Needs for Non-Driving-Related Activities during Automated Driving. In Proceedings of the 15th International Conference on Mobile and Ubiquitous Multimedia, Rovaniemi, Finland, 12 December 2016; ACM: New York, NY, USA, 2016; pp. 91–99.
31. Bansal, P.; Kockelman, K.M. Are We Ready to Embrace Connected and Self-Driving Vehicles? A Case Study of Texans. *Transportation* **2018**, *45*, 641–675. [CrossRef]
32. Jorlöv, S.; Bohman, K.; Larsson, A. Seating Positions and Activities in Highly Automated Cars—A Qualitative Study of Future Automated Driving Scenarios. *IRCOBI Conf. Proc.* 2017. Available online: https://www.ircobi.org/wordpress/downloads/irc17/pdf-files/11.pdf (accessed on 10 October 2024).
33. Becker, T.; Stegmüller, S.; Herrmann, F.; Röckle, F.; Duwe, D.; Unger, N. *Enabling the Value of Time—Implications for the Interior Design of Autonomous Vehicles*; Fraunhofer IAO & Cordence Worldwide & Horváth & Partners: Stuttgart, Germany, 2018.
34. Cyganski, R.; Fraedrich, E.; Lenz, B. Travel-Time Valuation for Automated Driving: A Use-Case-Driven Study. In Proceedings of the 94th Annual Meeting of the Transportation Research Board, Washington, DC, USA, 11–15 January 2015; pp. 11–15.
35. Tang, P.; Sun, X.; Cao, S. Investigating User Activities and the Corresponding Requirements for Information and Functions in Autonomous Vehicles of the Future. *Int. J. Ind. Ergon.* **2020**, *80*, 103044. [CrossRef]
36. Wilson, C.; Gyi, D.; Morris, A.; Bateman, R.; Tanaka, H. Non-Driving Related Tasks and Journey Types for Future Autonomous Vehicle Owners. *Transp. Res. Part F Traffic Psychol. Behav.* **2022**, *85*, 150–160. [CrossRef]
37. Manchon, J.-B.; Bueno, M.; Navarro, J. How the Initial Level of Trust in Automated Driving Impacts Drivers' Behaviour and Early Trust Construction. *Transp. Res. Part F Traffic Psychol. Behav.* **2022**, *86*, 281–295. [CrossRef]
38. Fitzen, F.; Amereller, M.; Paetzold, K. Approximation of the User Behaviour in a Fully Automated Vehicle Referring to a Stationary Prototype-Based Research Study. In Proceedings of the DESIGN 2018 15th International Design Conference, Glasgow, UK, 21–24 May 2018; Volume 5, pp. 2187–2196.
39. Hecht, T.; Darlagiannis, E.; Bengler, K. Non-Driving Related Activities in Automated Driving—An Online Survey Investigating User Needs. In Proceedings of the Advances in Intelligent Systems and Computing; Springer: Berlin/Heidelberg, Germany, 2020; Volume 1026, pp. 182–188.
40. Shi, E.; Frey, A.T. Non-Driving-Related Tasks During Level 3 Automated Driving Phases—Measuring What Users Will Be Likely to Do. *Technol. Mind Behav.* **2021**, *2*. [CrossRef]
41. Metz, B.; Wörle, J.; Hanig, M.; Schmitt, M.; Lutz, A.; Neukum, A. Repeated Usage of a Motorway Automated Driving Function: Automation Level and Behavioural Adaption. *Transp. Res. Part F Traffic Psychol. Behav.* **2021**, *81*, 82–100. [CrossRef]
42. Detjen, H.; Pfleging, B.; Schneegass, S. A Wizard of Oz Field Study to Understand Non-Driving-Related Activities, Trust, and Acceptance of Automated Vehicles. In Proceedings of the 12th International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI 2020, Virtual Event, DC, USA, 21–22 September 2020; pp. 19–29. [CrossRef]
43. Wörle, J.; Metz, B.; Lutz, A.; Schmitt, M. Automated Driving on the Motorway: A Users' Perspective on Conditional Versus High Automation. *Adv. Intell. Syst. Comput.* **2020**, *1212*, 166–172. [CrossRef]
44. Stevens, G.; Bossauer, P.; Pakusch, C.; Vonholdt, S. Using Time and Space Efficiently in Driverless Cars: Findings of a Co-Design Study. *CHI Conf. Proc.* **2019**, *405*, 1–14. [CrossRef]

45. Jeon, M.; Riener, A.; Sterkenburg, J.; Lee, J.H.; Walker, B.N.; Alvarez, I. An International Survey on Automated and Electric Vehicles: Austria, Germany, South Korea, and USA. *Lect. Notes Comput. Sci.* **2018**, *10917*, 579–587. [CrossRef]
46. Teodorovicz, T.; Kun, A.L.; Sadun, R.; Shaer, O. Multitasking While Driving: A Time Use Study of Commuting Knowledge Workers to Assess Current and Future Uses. *Int. J. Hum. Comput. Stud.* **2022**, *162*, 102789. [CrossRef]
47. Dungs, J.; Stegmüller, S.; Duwe, D.; Schmidt, A.; Gaydoul, R.; Peters, P.L.; Sohl, M.; Herrmann, F. *The Value of Time—Potential for User-Centered Services Offered by Autonomous Driving*; Fraunhofer IAO & Horváth & Partners: Stuttgart, Germany, 2016.
48. Zhang, Z.; Tian, R.; Duffy, V.G. Trust in Automated Vehicle: A Meta-Analysis. In *Human-Automation Interaction*; Springer International Publishing: Cham, Switzerland, 2023; pp. 221–234, ISBN 9783031107832.
49. Pfleging, B.; Fekety, D.K.; Schmidt, A.; Kun, A.L. A Model Relating Pupil Diameter to Mental Workload and Lighting Conditions. In Proceedings of the CHI'16: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, San Jose, CA, USA, 7–12 May 2016. [CrossRef]
50. Hecht, T.; Feldhütter, A.; Draeger, K.; Bengler, K. What Do You Do? An Analysis of Non-Driving Related Activities during a 60 Minutes Conditionally Automated Highway Drive. In Proceedings of the Advances in Intelligent Systems and Computing; Springer: Berlin/Heidelberg, Germany, 2020; Volume 1018, pp. 28–34.
51. Metz, B.; Wörle, J. Technology Readiness Affects the Acceptance of and Intention to Use an Automated Driving System after Repeated Experience. In Proceedings of the 13th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, Leeds, UK, 9 September 2021; ACM: New York, NY, USA, 2021; pp. 165–172.
52. Sun, X.; Cao, S.; Tang, P. Shaping Driver-Vehicle Interaction in Autonomous Vehicles: How the New in-Vehicle Systems Match the Human Needs. *Appl. Ergon.* **2021**, *90*, 103238. [CrossRef]
53. Li, S.; Blythe, P.; Guo, W.; Namdeo, A. Investigation of Older Drivers' Requirements of the Human-Machine Interaction in Highly Automated Vehicles. *Transp. Res. Part F Traffic Psychol. Behav.* **2019**, *62*, 546–563. [CrossRef]
54. Kwon, J.; Ju, D. Spatial Components Guidelines in a Face-to-Face Seating Arrangement for Flexible Layout of Autonomous Vehicles. *Electronics* **2021**, *10*, 1178. [CrossRef]
55. Fiorillo, I.; Piro, S.; Anjani, S.; Smulders, M.; Song, Y.; Naddeo, A.; Vink, P. Future Vehicles: The Effect of Seat Configuration on Posture and Quality of Conversation. *Ergonomics* **2019**, *62*, 1400–1414. [CrossRef]
56. Meurer, J.; Pakusch, C.; Stevens, G.; Randall, D.; Wulf, V. A Wizard of Oz Study on Passengers' Experiences of a Robo-Taxi Service in Real-Life Settings. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference*; Association for Computing Machinery: New York, NY, USA, 2020; pp. 1365–1377.
57. Euro NCAP. *Assessment Protocol—Safety Assist Collision Avoidance, Implementation 2023*; European New Car Assessment Programme (Euro NCAP): Leuven, Belgium, 2024.
58. McMurry, T.L.; Poplin, G.S.; Shaw, G.; Panzer, M.B. Crash Safety Concerns for Out-of-Position Occupant Postures: A Look toward Safety in Highly Automated Vehicles. *Traffic Inj. Prev.* **2018**, *19*, 582–587. [CrossRef]
59. Clark, H.; Feng, J. Age Differences in the Takeover of Vehicle Control and Engagement in Non-Driving-Related Activities in Simulated Driving with Conditional Automation. *Accid. Anal. Prev.* **2017**, *106*, 468–479. [CrossRef]
60. Udomboonyanupap, S. Supporting Seat Design for Smartphone Use during Travel. Ph.D. Thesis, Delft University of Technology, Delft, The Netherlands, 2024. Available online: https://research.tudelft.nl/en/publications/supporting-seat-design-for-smartphone-use-during-travel (accessed on 18 September 2024).
61. Diels, C.; Bos, J.E. Self-Driving Carsickness. *Appl. Ergon.* **2016**, *53 Pt B*, 374–382. [CrossRef]
62. Pereira, E.; Macedo, H.; Lisboa, I.C.; Sousa, E.; Machado, D.; Silva, E.; Coelho, V.; Arezes, P.; Costa, N. Motion Sickness Countermeasures for Autonomous Driving: Trends and Future Directions. *Transp. Eng.* **2024**, *15*, 100220. [CrossRef]
63. Smulders, M.; Vink, P. Sleep Quality and (Dis)Comfort in Minimal Space Envelope. In Proceedings of the International Comfort Congress 2021, Le Mans, France, 2–3 September 2021; pp. 169–174.
64. Vink, P.; Vledder, G.; Smulders, M.; Song, Y. How Do We Sleep? Towards Physical Requirements for Space and Environment While Travelling. *Appl. Ergon.* **2025**, *122*, 104386. [CrossRef] [PubMed]
65. Gordon, S.; Grimmer, K.; Trott, P. Sleep Position, Age, Gender, Sleep Quality and Waking Cervico-Thoracic Symptoms. *Internet J. Allied Health Sci. Pract.* **2007**, *5*, 6. [CrossRef]
66. Vledder, G.; Compomanes, R.S.; Singh, U.; Kılıç, H.; Smulders, M.; Song, Y.; Vink, P. Experiences of Upright Sleeping in a Vehicle: The Preferred Back Rest Angle. *Adv. Hum. Factors Transp.* **2024**, *148*, ahfe1005258. [CrossRef]
67. Wang, X.; Grébonval, C.; Beillas, P. Effect of Seat Back Angle on Preferred Seat Pan Inclination for the Development of Highly Automated Vehicles. *Ergonomics* **2024**, *67*, 619–627. [CrossRef]
68. Minnoye, A.; Tajdari, F.; Doubrovski, E.L.; Wu, J.; Kwa, F.; Elkhuizen, W.; Huysmans, T.; Song, Y. Personalized Product Design through Digital Fabrication. Available online: https://asmedigitalcollection.asme.org (accessed on 14 August 2022).
69. Lee, S.C.; Nadri, C.; Sanghavi, H.; Jeon, M. Eliciting User Needs and Design Requirements for User Experience in Fully Automated Vehicles. *Int. J. Hum. Comput. Interact.* **2022**, *38*, 227–239. [CrossRef]
70. Mosaferchi, S.; Mortezapour, A.; Orlando, L.; Naddeo, A. Age Limit for "Driving" an Autonomous Vehicle: An Open Issue for Future Road Transport System. In *Proceedings of the Advances in Human Factors of Transportation*; AHFE International: Orlando, FL, USA, 2024; Volume 148.
71. Park, J.; Zahabi, M.; Zheng, X.; Ory, M.; Benden, M.; McDonald, A.D.; Li, W. Automated Vehicles for Older Adults with Cognitive Impairment: A Survey Study. *Ergonomics* **2024**, *67*, 831–848. [CrossRef]

72. Mishra, A.; Lee, S.; Kim, D.; Kim, S. In-Cabin Monitoring System for Autonomous Vehicles. *Sensors* **2022**, *22*, 4360. [CrossRef]
73. Song, Y. (wolf) Human Digital Twin, the Development and Impact on Design. *J. Comput. Inf. Sci. Eng.* **2023**, *23*, 060819. [CrossRef]
74. Montero-Odasso, M.; van der Velde, N.; Martin, F.C.; Petrovic, M.; Tan, M.P.; Ryg, J.; Aguilar-Navarro, S.; Alexander, N.B.; Becker, C.; Blain, H.; et al. World Guidelines for Falls Prevention and Management for Older Adults: A Global Initiative. *Age Ageing* **2022**, *51*, afac205. [CrossRef] [PubMed]
75. Song, Y.; van der Cammen, T.J. Electronic Assistive Technology for Community-Dwelling Solo-Living Older Adults: A Systematic Review. *Maturitas* **2019**, *125*, 50–56. [CrossRef] [PubMed]
76. Anjani, S.; Kühne, M.; Naddeo, A.; Frohriep, S.; Mansfield, N.; Song, Y.; Vink, P. PCQ: Preferred Comfort Questionnaires for Product Design. *Work* **2021**, *68*, S19–S28. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.