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Enhancing Work and Entertainment Experience During Automated Driving: A Study in Interior Design

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Abstract

As vehicles integrate driving automation, the driver's role evolves into that of a passenger. During highly automated driving (SAE Level 4), the driver is no longer responsible for driving but can engage in non-driving related tasks (NDRT), such as working or consuming entertainment. Hence, highly automated driving changes user needs and their requirements for interior design. As part of the RUMBA research project, the authors developed an innovative vehicle interior concept to support both work and entertainment during highly automated driving by applying a user-centered design process. The innovative interior concept was evaluated against a classic vehicle interior in a static driving simulator. The study applied an experimental 2 × 2 factorial within-subjects research design. Forty-eight participants performed two non-driving activities (Factor 1: completing work tasks versus watching a movie) in each of the two vehicle interiors (Factor 2: innovative versus classic). Testing took place during four approximately 15-min automated drives. The vehicle's interior UX was measured as a dependent variable. According to the results, the innovative vehicle interior leads to a significantly more positive hedonic UX while working and a significantly more positive hedonic and pragmatic UX while watching a movie. It seems that a redesign of the interior of vehicles to enhance passengers' UX during highly automated driving has a promising future.

Keywords

User-centered design, highly automated driving, vehicle interior, user experience, autonomous vehicle, driving simulator

Introduction

Research Project RUMBA and User-Centered Design of the Vehicle Interior

RUMBA is a German acronym that means "Achieving a positive user experience through the user-friendly design of the vehicle interior for automated driving." It is a joint research project publicly funded by the German Federal Ministry for Economic Affairs and Climate Action (funding code 19A20007D). The research project RUMBA aims to redesign the UX of vehicle occupants during highly automated driving (SAE level 4) (SAE International, 2021) by developing innovative interior and interaction concepts. Therefore, research partners from industry and science are working on new vehicle concepts by applying a user-centered design process.

The human-centered approach, following ISO 9241-210:2019 (International Organization for Standardization, 2019), aims to develop products or systems by focusing on users and considering their needs and requirements in all phases of development.

We developed a vehicle interior concept for highly automated driving (SAE level 4) following the iterative steps of the human-centered design process of ISO 9241-210:2019 (International Organization for Standardization, 2019):

1. **Plan the human-centered design process**: The project objective was defined as the user-friendly redesign of the vehicle interior as well as the displays and controls for the occupants during highly automated driving in a question-zero workshop with the project consortium.
2. **Understanding and specifying the context of use**: We investigated changes in user requirements during highly automated driving in an empirical simulator and diary study. The results, qualitatively identified user requirements, can be found in Haar et al. (2021, 2022).
3. **Specifying the user requirements**: We conducted a synthesis workshop within the project consortium to compile our research results on user requirements, extract key learnings, and derive opportunity areas that seemed effective for improving the UX.
4. **Producing design solutions**: We developed ideas and initial prototypes during a design-thinking workshop. Then, we refined the results into five user narratives (paper prototypes) (Teicht et al., 2022).
5. **Evaluating the design**: We gathered qualitative feedback on the five user narratives using focus groups of heterogeneous users. The results (qualitative user feedback from the focus groups) can be found in Teicht et al. (2022).
6. **Developing design solutions**: Besides another prototype to support social interaction, we designed a prototype to support individual occupation (relevant to our findings in this paper) in the driving simulation environment.
7. **Evaluating the developed design**: In a laboratory study, we evaluated our driving simulation prototype, which supports individual occupation.

The vehicle interior concept supporting individual occupation focused on work and entertainment during highly automated driving (Figure 1).

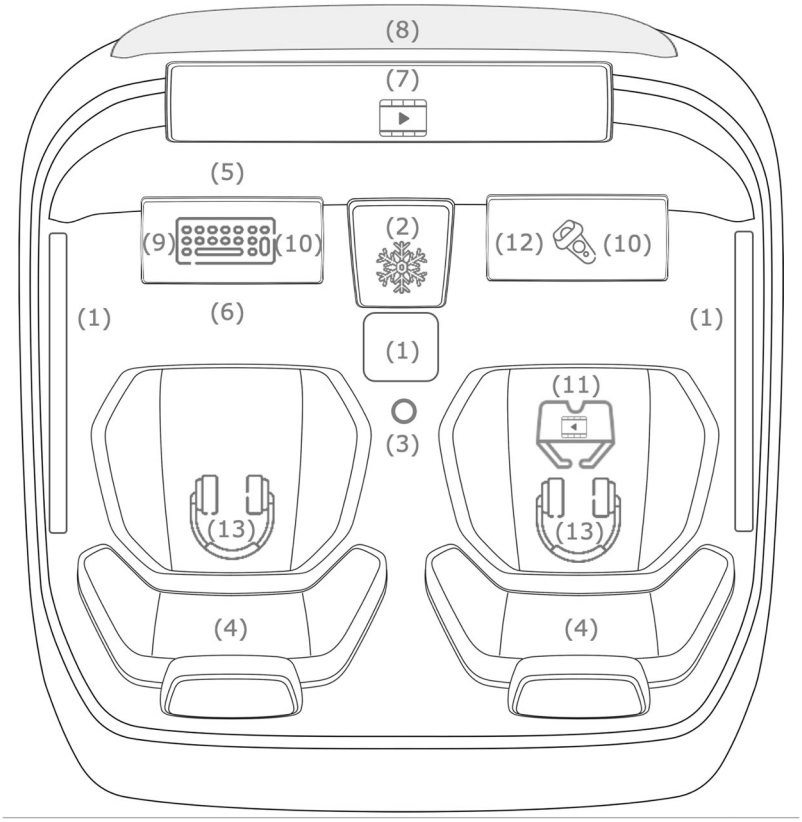

Figure 1. Concept of the Innovative Vehicle Interior (graphic templates from Seitz & Reichelt, 2021; icons from Eucalyp, n.d.; Freepik, n.d.a, n.d.b, n.d.c; Icons 8 (n.d.).

Side and center storage areas (1), a refrigerator (2), and an emergency button (3) that would autonomously bring the vehicle to a safe stop were available for both seats in the innovative interior concept. The flexible seats (4) could be pushed forward or backward and rotate slightly around their own axes. No steering wheel (5) or pedals (6) were present during highly automated driving.

Figure 1 shows the environment for working in the left seat and watching a movie in the right seat. However, in the experimental setting both environments were realized in both seats. Work tasks were performed on a large, retractable screen (7) in front of a milky windshield (8). A keyboard (9), integrated into a retractable tabletop (10), was used for control. Films could be watched through virtual reality glasses (11) in a virtual cinema. In a cinema-like environment, the film was operated via a controller (12) that could be placed on a retractable tabletop (10). Noise-canceling headphones were used to work and watch movies (13).

User Experience

The International Organization for Standardization defines UX in ISO 9241-210:2019(en) as "user's perceptions and responses that result from the use and/or anticipated use of a system, product or service" (2019). By this definition, UX focuses on realizing high-quality emotional experiences instead of avoiding functional usability problems (Hassenzahl & Tractinsky, 2006).

In this study, two different models were taken into account in order to consider UX comprehensively. The first model (Hassenzahl, 2018) that we integrated was already validated. The second model is still under development but considers UX in a more differentiated manner.

The validated model of UX by Hassenzahl (2018) categorizes the apparent product character into pragmatic and hedonic attributes. Pragmatic attributes refer to usability and usefulness

aspects, whereas hedonic attributes consist of non-task-related features like originality and beauty (Hassenzahl et al., 2000; Hassenzahl et al., 2003).

According to Engeln (2013; Engeln & Engeln, 2015), the facet model of UX structures UX along six facets: task including interaction, self-expression, learnability, convenience of use, joy of use, and aesthetics. Based on other constructs and empirical validation efforts, the six main facets are subdivided into sub-facets (Engeln et al., 2020). Figure 2 illustrates the current state of the model.

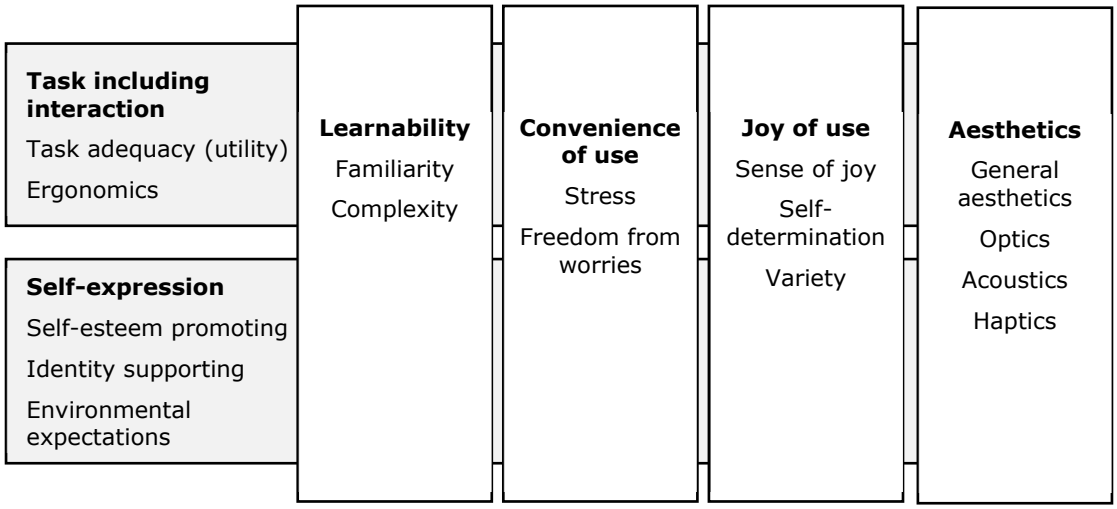

Figure 2. Facet Model of UX (based on Engeln, 2013; Engeln & Engeln, 2015; Engeln et al., 2020).

The six facets are briefly described below:

- **Task including interaction:** Does the product effectively help me accomplish the task it is designed for? The product's task adequacy (utility) and ergonomic aspects are relevant factors in answering this question.
- **Self-expression:** Does the product suit me, or would I prefer not to be associated with it? Self-expression is based on the product's ability to promote self-esteem, support identity, and meet environmental expectations.
- **Learnability:** Can I use the product intuitively, or how much effort do I have to spend learning it? Learnability is determined by one's familiarity with a product and the complexity of it.
- **Convenience of use:** Does the product support the feeling of relaxation or stress? A product's convenience of use is defined by the degree to which it causes or avoids pressure and its influences on the amount of worry produced while using it.
- **Joy of use:** Does the product affect the experience of fun or boredom? In this context, it is important whether the user experiences a sense of joy while using the offer, the extent to which the user is self-determined, and whether the product use provides variety versus monotony.
- **Aesthetics:** Do I find the product beautiful or unattractive? Aesthetics encompass not only the general perception of aesthetics but also the experience of all senses, including optics, acoustics, and haptics.

The six facets are not understood as distinct. Rather, the model emphasizes the mutual influence of the facets on each other. In particular, the first two facets—task including interaction and self-expression—are influenced by the design of the other four facets. Although the model does not explicitly differentiate between pragmatic and hedonic qualities, the facets for task, including interaction, learnability, and convenience of use, tend to be assigned to pragmatic qualities, and the facets for self-expression, joy of use, and aesthetics tend to be assigned to hedonic qualities.

Research Objectives

The main objective of this study was to evaluate our innovative vehicle interior concept against a classic vehicle interior in a standardized experimental setting. We compared the influences of the concepts on the UX of users completing work tasks or watching a movie. An additional objective was to identify qualitative design information to further the user-centered design of the innovative vehicle interior concept.

Methods

The method used in this study is summarized below. For more details, refer to Teicht et al. (2023a). The method was reviewed and approved in advance by the ethics committee of the RUMBA project. Measures had been defined to deal with the risks of simulator sickness, such as the exclusion of persons susceptible to motion or simulator sickness, an intercom for emergency communication during the test phases, and an observation system in the simulator. We obtained the informed consent of the participants beforehand in each case.

Participants

A total of 48 participants (26 females) participated in the study. Figure 3 shows the distributions of the age and their kilometers of car driving per year in our study's sample.

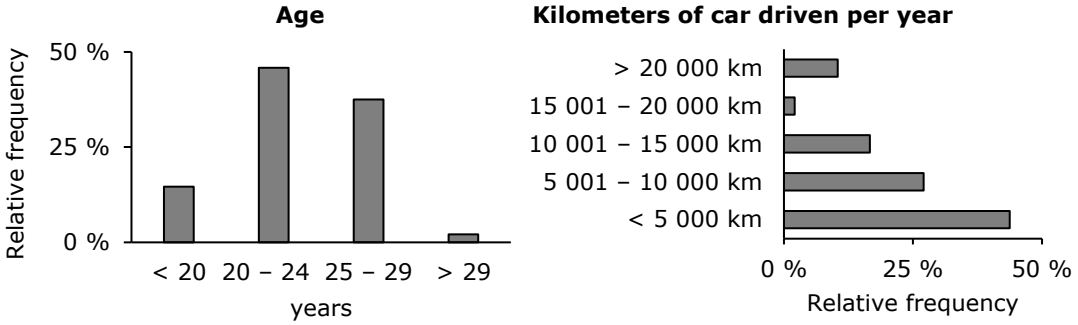

Figure 3. Sample distribution of age (left) and miles driven per year (right).

The average age was 23.25 years (*SD* = 3.68, ranging from 18 to 31 years), and the majority of the sample had a low mileage per year.

Experimental Design

The experimental 2 × 2 factorial, within-subjects research design included two independent variables: vehicle (innovative versus classic interior) and non-driving activity (completing work tasks versus watching a movie). Working was simulated by four different tasks including text input, addition, proofreading, and creative thinking, whereas the movie shown was "Interstellar," a science-fiction film. The task sets were created based on Foldbjerg and Reimann (2001), Wargocki et al. (2000), and Witterseh et al. (2004). Figure 4 shows the vehicle interior and equipment elements available for non-driving activities in the driving simulator environment.

Classic interior Innovative interior

Figure 4. Vehicle interiors and non-driving activities (Teicht et al., 2023a). The equipment for completing work tasks was on the left seat, and the equipment for watching a movie was on the right seat. The vehicle interior mockup was built by Fraunhofer™ IAO.

Procedure

Two participants participated simultaneously in a single trial.

After an introduction and answering a pre-questionnaire on sample characteristics, participants completed four approximately 15-min experimental test drives. Each participant performed both non-driving activities twice (completing work tasks versus watching a movie), once in the innovative interior and once in the classic vehicle interior. The experimental conditions were counterbalanced. Figure 5 shows snapshots of the innovative interior concept captured by the cameras used to observe the test drive.

Figure 5. Snapshots of the Test Drive Observation.

Participants completed an interim questionnaire after each of the four test drives. After the fourth test drive, they also completed a final questionnaire and took part in an interview regarding their experience with the two vehicle interiors.

Materials

In the interim questionnaire, two tools were used to measure the UX of the vehicle interior. One tool was the German version of the User Experience Questionnaire-Short (UEQ-S) with eight items, a previously validated method for measuring UX at the level of pragmatic and hedonic quality (Schrepp et al., 2017). The second tool was a questionnaire to measure UX along the

facet model of UX. This questionnaire was based on the questionnaire by Engeln and Engeln (2015) and further developments by Engeln et al. (2020). The version of the questionnaire used in the study, which is still under development, consists of 70 items (see Appendix A).

Results

Effects of the Vehicle Interior on Pragmatic and Hedonic UX

To compare the UX of the vehicle interiors, we performed paired sample *t*-tests (SPSS® Statistics 28). Figure 6 provides an overview of the mean values and standard deviations of the pragmatic and hedonic UX qualities of the vehicle interiors. Statistical values can be found in Appendix B.

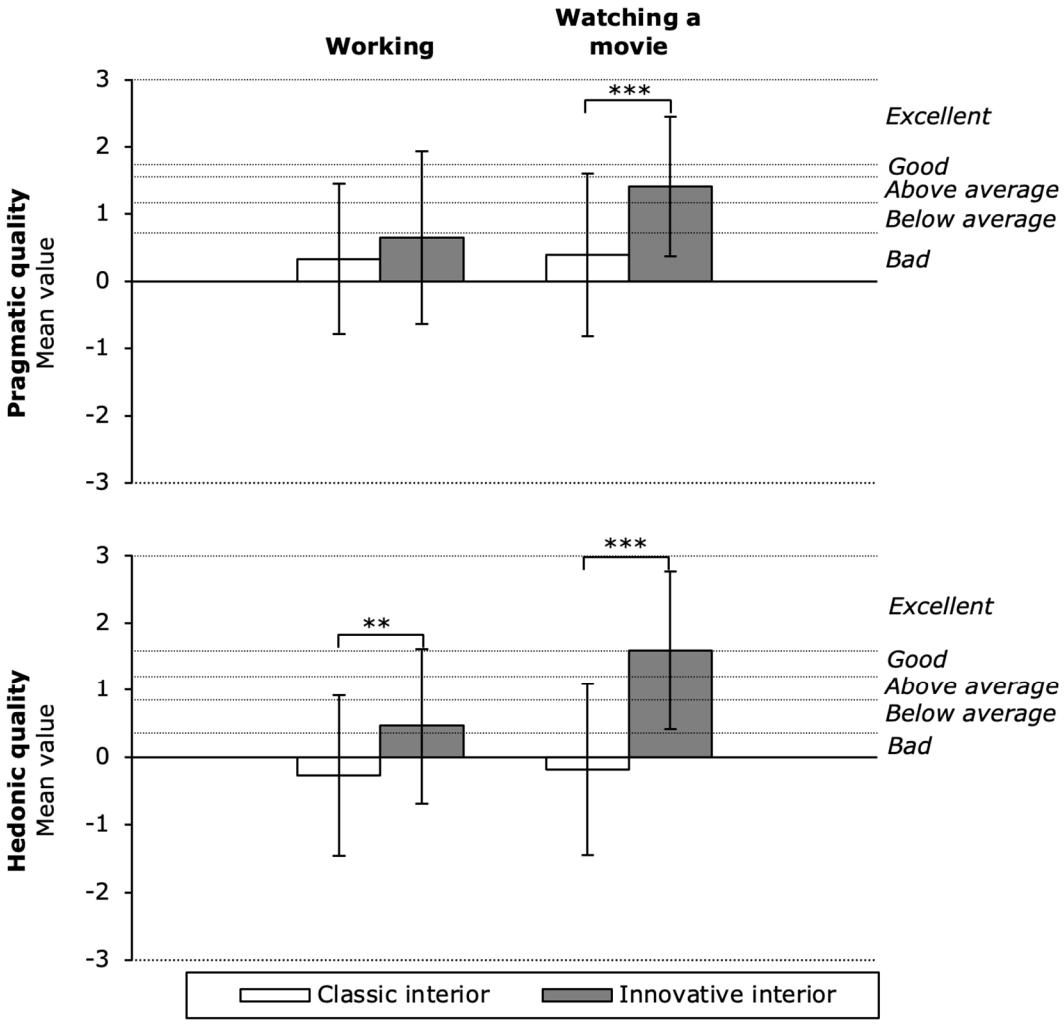

Figure 6. Pragmatic and Hedonic Quality of UX. The mean values for pragmatic and hedonic quality are shown for working and watching a movie, separated for the classic and innovative interiors (error bars show standard deviation).

Note: In Figure 6, a value of -3 indicates a negative UX and +3 a positive UX on the scale (N = 48). The mean difference (2-sided) was highly significant ($p < .01$) for the hedonic UX while working and ***very highly significant ($p < .001$) for the hedonic and pragmatic UX while watching a movie. Dotted horizontal lines form the areas of the UEQ-S benchmark *excellent*,

good, *above average*, *below average*, and *bad* (Hinderks et al., 2018). The values currently available in the UEQ-S data analysis tool on the UEQ website were used as reference data for the benchmark. The benchmark was derived from a dataset of 21,175 persons from 468 studies (Schrepp, n.d.).

For users working, the hedonic UX rated significantly more positive in the innovative interior concept, whereas there was no significant improvement in the pragmatic UX. According to the benchmark data of the UEQ-S (Hinderks et al., 2018; Schrepp, n.d.), the average UX (both pragmatic and hedonic qualities) within the classic interior was *bad*. In the innovative car interior, the pragmatic quality continued to be *bad*. The hedonic quality was better but still classified as *below average*.

For users watching a movie, the innovative vehicle interior led to a significantly more positive hedonic and pragmatic UX. The classification of the mean values based on the UEQ-S benchmark again showed that the UX (both pragmatic and hedonic qualities) in the classic interior was *bad*. In the innovative car interior, the pragmatic quality improved and classified as *above average*. In addition, the hedonic quality improved and classified as *excellent*.

Effects of the Vehicle Interior on Facets of UX

We performed paired sample *t*-tests to compare the UX of the vehicle interiors (SPSS Statistics 28). Figure 7 provides an overview of the mean values of the sub-facets of the UX of the vehicle interiors compared to users working or watching a movie. Appendix C provides the standard deviations and other statistical values.

Figure 7. Facets of UX. Mean values for the sub-facets (named on the right side) of the six facets of UX (named on the left side) are shown for working and watching a movie, separated by classic and innovative interiors.

Note: In Figure 7, a value of -3 indicates a negative UX and +3 a positive UX on the scale (N = 48, except identity supporting at work, which is N = 47). The mean difference (2-sided) was significant ($p < .05$) for environmental expectations and a sense of joy while working in the innovative interior. It was highly significant ($p < .01$) for self-esteem promoting and optics while working in the innovative interior and for task adequacy, ergonomics, (low) stress, and optics while watching a movie in the innovative interior. It was very highly significant ($p < .001$) for general aesthetics and acoustics while working in the innovative interior and for self-esteem promoting, environmental expectations, sense of joy, general aesthetics, acoustics, and haptics while watching a movie in the innovative interior.

While users were working, there was no significant difference in pragmatic quality, as was found when using the UEQ-S. The only exception was the sub-facet familiarity, which was not considered in the UEQ-S. Familiarity was significantly more positive when working with the classic interior concept. Similar to the UEQ-S, the hedonic quality was significantly more positive in some hedonic sub-facets, including self-esteem promoting, environmental expectations, sense of joy, and the three aesthetic sub-facets general aesthetics, optics, and acoustics. The other sub-facets, identity supporting, self-determination, variety, and haptics, showed no significant improvement through the innovative interior concept.

While users were watching a movie, the innovative vehicle interior led to a significantly more positive UX for most UX sub-facets, which was consistent with the results of the UEQ-S for both pragmatic and hedonic qualities. Exceptions were the sub-facets of identity-supporting, complexity, freedom from worries, and self-determination, for which no significant improvement was found. Lower familiarity with the innovative interior was stated again.

Qualitative Design Information

A total of 13 concept ideas were evaluated from the users' perspectives. Selected user feedback relevant to further work is described in Table 1. Each idea is illustrated with an exemplary interview quote.

Table 1. Qualitative Hints for Further Design of the Innovative Vehicle Interior Concept (Teicht, 2023b)

Concept idea	Ranking	User feedback	Exemplary interview quotes
Flexible seats	2.85 (1.89)	Adjustability too little	"I thought it was a pity that you couldn't recline them." (test duo 04, line 229)
Emergency button	4.27 (3.75)	Design too prominent	"Maybe a slightly simpler design, because it really looks like 'Oh God, we're all going to die.'" (test duo 09, lines 295f.)
Retractable screen	5.48 (2.54)	Position unergonomic	"I think the position is a bit unsuitable. I think I would have preferred to have it centrally in front of me [...]" (test duo 10, lines 94f.)
Storage area	5.71 (3.24)	Cup holder missing	"[...] cup holder was a deficit here." (test duo 07, line 157)
Extendable table tops	5.77 (3.17)	Height not ergonomic	"Yes, well, I always bumped my knees on this table [...]" (test duo 14, line 78)
Disappearing steering wheel	7.15 (3.09)	Lack of option for intervention	"[...] if you still have the option of driving yourself [...] I think that's still good." (test duo 04, lines 260ff.)
Noise-canceling headphones	7.35 (3.65)	Uncomfortable to wear	"Well, the headphones were exhausting. [...] Simply the wearing comfort. [...] The noise canceling probably more as a [...] function of the car." (test duo 07, lines 283ff.)

Concept idea	Ranking	User feedback	Exemplary interview quotes
Transparent/milky windshield	7.50 (3.95)	Distraction through side windows, lack of sense of control	"I would even consider it for the side windows [...]" (test duo 01, line 115) "[...] I [would] like to see what is happening and that I have at least some control [...]" (test duo 13, lines 104f.)
Integrated keyboard	8.50 (2.86)	Unfamiliar key and keyboard size	"In contrast to the laptop, I really had problems not mistyping because the keys were very close together." (test duo 13, lines 76f.)
Disappearing pedals	8.67 (3.20)	Lack of option for intervention	"[...] it was always fixed [or not fixed] with us, but if you can make it flexible, I think that's good." (test duo 16, line 158)
VR glasses	8.69 (3.64)	Too heavy	"I always pressed against it with my cheekbones [...] it was very heavy." (test duo 13, lines 67ff.)
Refrigerator	9.19 (3.19)	Not necessary	"A fridge is just nice to have." (test duo 01, line 170)
Controller for VR	9.88 (2.89)	Uncomfortable for text input	"Complicated things could perhaps be difficult, so of course a touchpad is better [...]" (test duo 03, lines 204f.)

Note: We asked the test participants: "Imagine you were equipping your own vehicle. Which equipment elements would you like to have in a fully automated vehicle?" The ranking reflects the average rank (and standard deviation). Therefore, Table 1 ideas are ranked in descending order of importance. Interview quotes are translated from German by the authors.

Discussion

Methodological Learnings

Most participants were under the age of 30. Young adults are potential customers of automated systems in the future, and homogeneous samples are well suited for estimating causality in experimental testing. However, we must mention that this study's sample does not represent all potential future user groups.

An experimental test setting in a laboratory environment helps to identify and evaluate the strengths and weaknesses of the innovative design in direct comparison to the classic interior. In conclusion, this simulation-based evaluation is helpful in identifying and quantifying the differences in UX of the two interior concepts as well as raising relevant hints and feedback for further concept development. In addition, the results can be applied to other modes of transportation when not driving oneself, for example, work and entertainment environments installed in buses, trains, planes, or shuttles. Our results may differ from those obtained during natural driving in real traffic, not at least due to the lack of movement in the simulator and due to different experiences of safety. Hence, for absolute rating of the UX and more ecological validity, additional driving tests in natural environments must be conducted for future concept development, in which passive safety systems must also be taken into account.

As we do not find an improvement of the pragmatic value while users are working, per the UEQ-S, the measurement of the pragmatic UX facets task including interaction, complexity, and convenience of use, does not change. The significant improvements of the UEQ-S according to hedonic values and pragmatic values while watching a video are replicated by the UX facet measures. So, similar results of the UEQ-S and the measurement of the UX facets indicate a valid measurement of UX using this tool. However, the sub-facets that are consistent with the general evaluation of UX by the UEQ-S may explain this general evaluation in more detail; sub-facets that do not show significant improvement may provide starting points for improving the UX of the innovative interior concept.

Influence of the Vehicle Interior on UX and the Developed User-Centered Design

This study shows that the innovative interior may have a positive effect on UX in general. When users are working, the hedonic UX is significantly more positive. When users are watching a movie, the innovative interior leads to a more positive hedonic and pragmatic UX.

The result that the innovative interior does not improve the pragmatic UX while working may be explained by two facts: The less important one may be caused by the short working period in the simulation (15 min in each condition). Habituation in longer test trials could lead to higher familiarity and, thus, to different results. Even more important may be the insufficient ergonomics of the working environment realized in the simulator environment. The design of the keyboard, as well as the display, in the innovative interior environment seems to be suboptimal. This is indicated by the qualitative oral feedback provided by the participants; for example, the keyboard with the touchpad integrated into the innovative concept is smaller than a typical keyboard. Moreover, the tabletop is not adjustable in height, as intended in the initial concept; therefore, taller participants bump their knees. In addition, a smaller work screen directly in front of the person working (instead of a screen that stretches across the entire windshield surface), or simply working on a laptop placed on an extendable table, is desired by participants.

Furthermore, the feeling of control is an important experiential variable: This is indicated, for example, by the desire for self-determined availability of the steering wheel and pedals and by the heterogeneous feedback on the transparency of the windshield. Finally, an optimized concept and revised prototype, which are intended to be realized as the next step in user-centered design, could improve the pragmatic values of an innovative interior design.

Conclusion

This study aimed to examine the influence of the vehicle interior on the UX in highly automated driving. Overall, the study suggests that it is worthwhile to modify the vehicle interior to improve the UX for occupants enjoying entertainment and partially for occupants working in the car. Besides the ergonomic improvements of the prototype tested, care should be taken in further development to use long-term studies when habituation effects are particularly important. User feedback should be obtained to develop the vehicle interior concept further iteratively. Therefore, the results of this study should be validated under real environmental conditions in a field study. Finally, this study provides helpful methodological learnings for a more detailed, but standardized measurement, of UX using UX facets and sub-facets. This will help to develop quantitative evaluation methods for an improved and more effective user-centered design process.

Tips for Usability Practitioners

Based on our experimental study of the UX of vehicle interiors during automated driving, we identified these recommendations to assist UX practitioners:

- Use long-term studies when habituation effects could be particularly important.
- Validate results of simulation-based studies under actual environmental conditions of a field study.
- Consider specific ergonomic design and the feeling of control as important aspects relevant for success, especially when designing working environments for automated driving.
- Use the UX-facets questionnaire in standardized prototype user testing to evaluate the six UX facets and the 16 sub-facets. A thorough evaluation provides a detailed view of the strengths and weaknesses of the UX of your prototypes on a standardized level.

The current version of the questionnaire can be requested from the authors (please email engeln@hdm-stuttgart.de). Usage is free, but in return, we hope to get back the anonymous data from your testing for further evaluation of the questionnaire.

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Appendix

Appendix A

Table 2. Items to Measure the UX Along the Facets (in German)

Sub-facet	Items
Task adequacy	nutzlos – effektiv
	zielführend – ungeeignet*
	unbrauchbar – brauchbar
Ergonomics	unergonomisch – ergonomisch
	äußerst bedienungsfreundlich – nicht bedienungsfreundlich*
	schlecht handhabbar – sehr gut handhabbar
	bedienungsfreundlich – unergonomisch*
	schlecht handhabbar – ergonomisch
	gut handhabbar – wenig bedienungsfreundlich*
Self-esteem promoting	schadet meinem Image – fördert mein Image
	imageförderlich – imageschädlich*
	geringgeschätzt von anderen – wertgeschätzt von anderen
	verschafft mir Respekt – führt zu Geringschätzung*
	vor anderen peinlich – vor anderen Eindruck machend
	Eindruck machend – peinlich*
	peinlich – Bewunderung hervorrufend
	verleiht mir ein höheres Ansehen – verringert mein Ansehen*
	erregt bei anderen keinen Neid – erregt bei anderen großen Neid
	großen Neid erregend – keinen Neid erregend*
	nicht vorzeigbar – Bewunderung hervorrufend
Identity supporting	optimal zu mir passend – nicht zu mir passend*
	nicht für mich gemacht – wie für mich gemacht
	mir völlig entsprechend – mir widersprechend*
Environmental expectations	von anderen abgelehnt – von anderen befürwortet
	andere würden es befürworten – andere würden es ablehnen*
	meine Freunde würden es schlecht finden – meine Freunde würden es toll finden
	widerspricht der Erwartung meiner Freunde – entspricht der Erwartung meiner Freunde
	entspricht der Vorstellung meiner Freunde – widerspricht der Vorstellung meiner Freunde*
	von anderen akzeptiert – von anderen abgelehnt*
	andere mögen es – andere mögen es nicht*
	andere würden es nicht mögen – andere würden es mögen
	möchten andere nicht haben – wünschen sich andere
	sollte ich nutzen – sollte ich nicht nutzen*
Familiarity	äußerst vertraut – unvertraut*
	ungewohnt – gewohnt
	sehr gut bekannt – unbekannt*
Complexity	extrem einfach – kompliziert*
	verwirrend – sehr eingängig
	optimal verständlich – schwer verständlich*

Sub-facet	Items
Stress	sehr entlastend – belastend*
	stressig – höchst entspannend
	vollkommen mühelos – anstrengend*
	stark beanspruchend – nicht beanspruchend
Freedom from worries	völlig unbedenklich – bedenklich*
	nicht sorgenfrei nutzbar – sorgenfrei nutzbar
	äußerst verlässlich – besorgniserregend*
Sense of joy	langweilig – interessant
	begeisternd – enttäuschend*
	ist langatmig – macht viel Spaß
Self-determination	fremdbestimmt – in hohem Maß selbstbestimmt
	völlig unabhängig – abhängig*
	das System/es entscheidet – ich entscheide
Variety	sehr abwechslungsreich – monoton*
	eintönig – enorm vielfältig
	extrem vielseitig – einseitig*
General aesthetics	missgestaltet – wohlgestaltet
	scheußlich – geschmackvoll
	höchst ästhetisch – unästhetisch*
Optics	hässlich – extrem schön
	sehr schön anzusehen – unansehnlich*
	optisch abstoßend – optisch besonders ansprechend
Acoustics	sehr schön anzuhören – schrill*
	lärmend – leise (UEQ+)
	wohlklingend – missklingend* (UEQ+)
	dröhnend – gedämpft (UEQ+)
	sanft – schrill* (UEQ+)
Haptics	schlecht anfühlend – sehr gut anfühlend
	unhandlich – extrem handlich
	äußerst angenehm anzufassen – unangenehm anzufassen*
	handschmeichelnd – nicht handschmeichelnd*

Reversed items are marked with an asterisk. Adjectives were based on the questionnaire of Engeln and Engeln (2015) and the further developments of Engeln et al. (2020). Adjectives of the sub-facet acoustics were taken from the User Experience Questionnaire Plus (UEQ+) (Schrepp & Thomaschewski, 2019). The items were asked in randomized order on a seven-point scale from -3 = very over 0 = neither to +3 = very.

Appendix B

Table 3. Results of the Evaluation of the Pragmatic and Hedonic Quality of UX

Measure	**Classic interior**		**Innovative interior**				
	M	***SD***	***M***	***SD***	***t***	***df***	***p***
Work							
Pragmatic quality	0.33	1.12	0.65	1.29	-1.493	47	.142
Hedonic quality	-0.27	1.19	0.46	1.15	-3.485	47	.001**
Movie							
Pragmatic quality	0.39	1.21	1.41	1.04	-4.316	47	< .001***
Hedonic quality	-0.18	1.27	1.59	1.18	-10.036	47	< .001***

Mean difference is (2-sided) *significant (p < .05), **highly significant (p < .01), ***very highly significant (p < .001).

Appendix C

Table 4. Results of the Evaluation of the Facets of UX

Measure	**Classic interior**		**Innovative interior**				
	M	***SD***	***M***	***SD***	***t***	***df***	***p***
Work							
Task adequacy	0.98	1.09	1.10	1.03	-0.569	47	.572
Ergonomics	0.34	1.12	0.52	1.14	-0.830	47	.411
Self-esteem promoting	0.22	0.60	0.53	0.69	-3.100	47	.003**
Identity supporting	0.44	0.98	0.22	1.16	1.273	46	.209
Environmental expectations	0.24	0.81	0.54	0.83	-2.324	47	.025*
Familiarity	0.81	1.31	-0.24	1.36	4.793	47	< .001***
Complexity	1.14	1.02	1.01	1.06	0.862	47	.393
Stress	0.07	1.05	0.13	1.19	-0.307	47	.760
Freedom from worries	0.42	1.09	0.60	1.04	-1.026	47	.310
Sense of joy	0.18	0.95	0.58	0.94	-2.136	47	.038*
Self-determination	-0.30	1.18	-0.57	1.16	1.476	47	.147
Variety	-0.31	1.10	-0.13	1.03	-0.971	47	.337
General aesthetics	0.07	0.81	0.56	0.91	-3.557	47	< .001***
Optics	0.19	0.63	0.54	0.86	-2.949	47	.005**
Acoustics	0.13	0.92	0.89	1.06	-4.922	47	< .001***
Haptics	0.30	0.81	0.23	0.89	0.524	47	.603
Movie							
Task adequacy	0.73	1.09	1.36	0.82	-3.408	47	.001**
Ergonomics	0.53	1.29	1.26	0.91	-3.372	47	.002**

Measure	Classic interior		Innovative interior				
Self-esteem promoting	0.21	0.57	0.84	0.71	-6.346	47	< .001***
Identity supporting	0.28	1.05	0.72	1.26	-1.977	47	.054
Environmental expectations	0.43	0.93	0.96	0.79	-3.825	47	< .001***
Familiarity	0.69	1.33	-0.41	1.33	4.438	47	< .001***
Complexity	1.23	0.98	1.21	1.04	0.093	47	.926
Stress	0.53	1.03	1.16	0.97	-2.889	47	.006**
Freedom from worries	0.56	1.11	0.69	1.11	-0.688	47	.495
Sense of joy	0.40	1.06	1.47	0.93	-7.163	47	< .001***
Self-determination	-0.24	1.11	-0.26	1.24	0.136	47	.893
Variety	-0.42	1.29	0.83	1.12	-5.529	47	< .001***
General aesthetics	0.24	0.78	0.90	0.96	-4.593	47	< .001***
Optics	0.25	0.66	0.65	0.94	-3.071	47	.004**
Acoustics	0.24	0.95	1.03	1.04	-4.830	47	< .001***
Haptics	0.25	0.83	0.88	0.89	-3.552	47	< .001***

Mean difference is (2-sided) *significant ($p < .05$), **highly significant ($p < .01$), and ***very highly significant ($p < .001$).

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