Research and Practice of Intelligent Cockpit Interaction Design Based on Women's Car Scenarios

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Abstract

Automotive seating and controls have traditionally been designed with a male-centric approach, reflecting technologies and ergonomics established over a century ago, which may not meet the needs of today. Car cockpits have been tailored primarily for male users, often overlooking the preferences and requirements of women drivers. While car design has begun to work on safety questions for women's bodies in the cockpit, this project focuses on comfort and enjoyment. This research project identifies the specific problems of women in cockpits to offer design solutions for their scenarios. This research includes a design project to redesign the heating controls in car seats so that they are divided to be more modular and controllable to the needs of women drivers. I use interviews and field visits, gendered design research, and continuous literature reviews to identify the most pressing problems and needs for women drivers. The findings led to my design project Modular Heated Seat using multimodal interaction and focusing specifically on how it interacts with the driver. This project is developed on a digital platform with specific context and physical prototypes. Human-centred design incorporates gender-specific considerations in cockpit design to significantly enhance women drivers' comfort. This research contributes substantially to automotive industry change by documenting a design probe into the challenges of rectifying gendered design.

Land Acknowledgement

I want to acknowledge that the research presented here was conducted primarily on the Coast Salish peoples' unceded territories, including the Musqueam, Squamish, and Tsleil-Waututh Nations. The term "unceded" is crucial to understand; it signifies that these lands were never surrendered, relinquished, or transferred in any form.

It is essential to recognize that most of British Columbia remains unceded, sovereign Indigenous lands. This reality underscores that neither the Canadian nor the British Columbia governments possess legal or moral authority over these territories.

In conducting and sharing this research, I aspire to contribute to a deeper understanding of how we, as settlers and uninvited guests, can support Indigenous sovereignty. I sincerely hope our endeavors in this field can foster new relationships with the Original Peoples of these lands—relationships rooted in honor, respect, and mutual recognition.

Keywords

Intelligent Cockpit Design, Human Centered Interaction Design, Gender Inclusivity, Modular Design, Driver-Machine Interaction, Driver Pain, Women Driver

Introduction

Topic and Context

Since researching intelligent automotive cockpit design, I have been fascinated by its potential. The industry is growing fast, focusing on creating more intelligent and more intuitive designs (Automotive Smart Cockpit Design Trend Report, 2022). I noticed a recurring theme during a casual conversation with my close woman friends, discussing their driving experiences. They expressed concerns over how some car cockpit features could have been more intuitive for them. There is no storage space for putting their makeup, or the controls' positioning is slightly out of reach. It made me wonder, "In an era where customization and intelligent devices are the watchwords, why are we still missing the mark on something as integral as the in-car experience for women?"

I have realized that while intelligent cockpit design offers infinite opportunities, there is an evident gap – the experience design tailored for women's needs. Most designs seem to be developed either with a male-centric perspective or, worse still, based on male ideologies,

completely sidelining women's needs. In the worst case, this gap can result in life danger. Caroline Perez's (2019) book "Invisible Women: Data Bias in a World Designed for Men" discusses how gender data gaps can lead to fatal consequences for women. Car crash-test dummies have historically been designed around the male physique, making cars less safe for female occupants, potentially leading to more severe injuries or fatalities. When the safety features were being developed, their measurements and tests were based on a male average. Women drivers are killed because of this ignorance. (Atwood et al., 2023) Research by the Insurance Institute for Highway Safety (IIHS, 2021) has shown that, while crash testing programs have helped improve safety for both men and women, women are still 20-28% more likely than men to be killed and 37-73% more likely to be seriously injured in crashes. However, this increased risk is primarily related to the types of vehicles women drive and the circumstances of their crashes rather than physical differences. Once factors like vehicle size and crash circumstances are accounted for, the discrepancies in injury risks between men and women narrow dramatically. The study also found that crashworthiness improvements have benefited men and women equally when comparing similar crashes.

Focus and Scope

This research focuses on advancing the field of intelligent automotive cockpit design, particularly for vehicles equipped with advanced interactive systems. These systems promise to offer a user-centric experience that adapts to the needs and preferences of the driver. The scope is intentionally narrowed to intelligent vehicles, bypassing those with essential interaction features that need more sophistication for this study. Specifically, the research studies the

experiences of women drivers who commute regularly, a demographic selected for their likelihood to engage with and provides insights into intelligent cockpit functionalities.

Relevance and Importance

The relevance and importance of this thesis are in the dichotomy within automotive design—a field historically tailored to male specifications, ignoring the needs and preferences of female drivers. Who is addressing the needs of female drivers? The lack of scholarly research addressing women-centric design in automotive cockpits highlights a significant gap that my thesis intends to bridge. Theoretically, this work challenges the prevailing gender-neutral approach in design, which often defaults to male-centric norms, and questions the biases that have led to this industry-wide oversight (Reuther, n.d.).

Research Questions and Objectives

There are three core research questions that guide this project. These are:

1. What are the gaps between acknowledging gender inclusivity in cars and designing applications to address women drivers' needs?
2. What are pain points and ignored needs, and how do women become aware of them?
3. How can multimodal interaction design be implemented in an intelligent automotive cockpit to cater to the needs of women drivers?

The objective is to cultivate an intelligent cockpit design that resonates with the comfort and enjoyment of women, acknowledging their unique scenarios and experiences. By emphasizing the 'humanness' of the driver, this study aims to foster a design that grants women more control and a sense of belonging within the automotive space, transforming the cockpit into an intuitive, responsive environment that respects and reflects the diverse drivers it serves.

Thesis Structure

This thesis is a structured exploration of the design of automotive cockpits, focusing on women drivers' needs and preferences. The Introduction section provides a preliminary overview, leading into the Topic and Context to ground the research into the broader conversation of intelligent car design. Focus and Scope sections clarify the study's parameters, with Relevance and Importance underscoring the work's significance. Research Questions and Objectives pinpoint the study's guiding inquiries and aims. A Literature Review critically examines the existing academic field, identifying a Research Gap seeks to address. The Methods section delineates the research approach, data collection and analysis, ethical considerations, and limitations. Fieldwork, case studies, and interviews constitute the Primary Research section, with the Findings section presenting data through descriptive statistics and software analyses. The Design Output section translates research into actionable design strategies. Discussions engage with the reflection and limitations, evaluating the results' validity. The thesis culminates in a Conclusion that summarizes the research, reflects on its implications, and suggests directions for future studies, rounded off with a comprehensive list of References and Appendices, including

ethical board approvals and interview questions, ensuring the study's integrity, and facilitating further inquiry.

Literature Review

Research Gap Contribution

As I embarked on my master's thesis, focusing on the research and practice of intelligent cockpit interaction design specifically for women's scenarios, the initial phase was dedicated to scouring existing literature. However, one of the most surprising and, in many ways, disconcerting findings was the sheer lack of publications directly related to this field. It is a disappointment. It was perplexing to realize that this area has been markedly under-researched in academics despite addressing concerns relevant to half the population just in the U.S., with about 117.6 million female licensees compared to 115.2 million male licensees (Arthur, 2024). This gap in literature underscored a significant oversight in automotive research and pointed towards a broader issue of gender disparity in design practices.

Literature Review: Women in Automotive Industry

Styhre, Backman, and Borjesson's academic paper published in 2005 on Gender, Work, and Organization explored the area of gender and automotive industry practices. It remains relevant, as evidenced by its presence in the Wiley Online Library, providing valuable insights into the challenges of addressing gender differences in the automotive industry. The paper focuses on

Volvo's Your Concept Car (YCC) project, the first in the industry to be managed entirely by women. The authors use critical discourse analysis to examine the media coverage of the YCC project, revealing how gender differences were articulated. Even in projects that aim to move beyond “gendered” — recognizing specific needs of a gender without resorting to stereotypes — the language that reconfigures the social reality remains stuck in a mode of expression that opposes such an ambition. The authors also discuss 'male irrationalities' in car buying preferences, which could be seen as an untapped resource in the industry. The paper's conclusion emphasizes the need for subtle strategies to undermine dichotomous modes of thinking (such as "male/female") in the automotive industry. They suggest that speaking about gender differences can inadvertently reinforce them because gender stereotypes are challenging to eliminate. While refusing to acknowledge them can leave existing disparities unaddressed. This creates a double-bind situation, making it challenging to step outside the language of gender differences.

The article "Made in Patriarchy: Toward a Feminist Analysis of Women and Design" by Cheryl Buckley was published in 1986. The author delves into how patriarchal ideologies have historically influenced design principles, often relegating women to roles defined by their biology and traditional societal expectations. Buckley (1986) highlights the pervasive influence of advertising in shaping and reinforcing these gendered stereotypes. Advertising reinforces design meanings as envisioned by predominantly male designers or manufacturers. It consistently employs and amplifies gendered stereotypes, often casting women in traditional, limiting roles such as mothers, cleaners, and cooks. The article underscores how advertising crafts not only an ideal use for products but also an "ideal" user, often sidelining women's actual needs and complexities. Further, the article suggests that women in advertisements emphasize

the commodification of their bodies to cater to a dominant male gaze. Through this lens, women are often reduced to passive entities, valued primarily for their aesthetic appeal. Buckley's (1986) article provides a comprehensive feminist critique of design history, emphasizing the need to understand and challenge the patriarchal assumptions that have shaped design practices and perceptions of women in the field. It suggests that the feminine design in the market is shaped under the male gaze, which explains why intelligent cockpit designer needs to research more on the relationship between "vehicles and drivers" (Zhang and Zhu, 2019) to meet the needs of women drivers.

Literature Review: Approach to Intelligent Cockpit Interaction Design

Caizhong Zhang and Aijun Zhu from the School of Visual Communication Design at Shandong University of Art and Design wrote this paper in 2019, which provides an in-depth analysis of the current state and future potential of automobile human-computer interaction, with a specific focus on Head-up Display (HUD). The authors argue that the automotive HUD industry has been relatively backward compared to the mobile phone industry and propose using the smartphone industry's advanced experience and design concepts to bring new inspiration to the current automotive industry, especially HUD design. The paper highlights the existing problems in the field, such as car manufacturers needing to fully understand users' needs and investing more energy in exploring the relationship between vehicles and drivers. The authors present a practical project to improve driving safety by designing a panoramic HUD. They discuss the design principles, differences between automotive interaction design and mobile phone interaction design, and the HUD’s design goals. They also present the target user portrait and the

information architecture of the Panoramic HUD. This paper is a valuable resource for anyone interested in automobile technology and interaction design – especially for HUDs. Connecting to Styhre, Backman, and Borjesson's (2005) suggestion of finding subtle strategies to undermine the dichotomous modes of thinking, Zhang, and Zhu (2019) provided a comprehensive overview of the field's current state. They offered innovative solutions for improving user experience and safety.

Literature Review: Modular System

Manuel E. Sosa, Steven D. Eppinger, and Craig M. Rowles' article "Designing Modular and Integrative Systems" delves deep into product architecture, particularly emphasizing modular design. Modular design is about creating distinct, independent components that can be combined in various ways without affecting each other's functionality. The authors introduce the 'Resultant Matrix' (p.5), a pivotal tool that visually maps design interfaces to team interactions, providing insights into how modular components align with team collaborations. The research explains the benefits of modular systems, such as flexibility, scalability, and ease of updates. By designing modules, teams can work on different components simultaneously, leading to efficient development processes. However, the article also touches upon the challenges of organizational boundaries, which can sometimes act as barriers to effective modular design. These boundaries, determined by team groupings, can create communication barriers, potentially hindering the integration of modular components. This article focuses on the collaboration aspects of modular design, while "Atomic Design" by Brad Frost introduces the design methodology in design systems. They both inspired me for my research project on women's intelligent cockpit design,

and they provided insights on how to implement gender-inclusive design in cars by providing potential solutions for different users using modular design systems.

"Atomic Design" by Brad Frost introduces a methodology for creating design systems. Just as everything in the universe comprises atomic elements, Frost (2016) posits that all interfaces comprise a combination of distinct components. He breaks down user interfaces into a hierarchy: atoms (the foundational building blocks like buttons and input fields), molecules (combinations of atoms that function together like a search form), organisms (complex UI sections like headers), templates (page-level objects that place components into a layout), and pages (specific instances of templates). This approach allows designers and developers to construct user interfaces methodically and with a clear structure. By focusing on the smaller, reusable components (atoms and molecules), designers can assemble larger, more complex structures with consistency and scalability in mind. Frost's (2016) methodology emphasizes the importance of creating a robust design system that can adapt and evolve, ensuring that digital products remain consistent and user-friendly across different platforms and devices. The book provides a comprehensive guide for me to implement this design methodology in my project, which is an inspiring guideline for potential design practice for women drivers' needs.

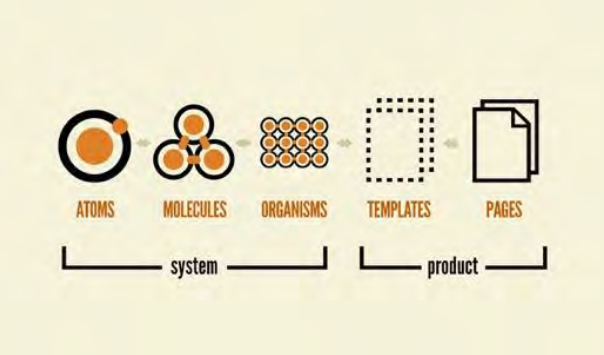

Figure 1. Frost, B. (2016). Extending Atomic Design | Brad Frost. https://bradfrost.com/blog/post/atomic-web-design/

Literature Review Conclusions: A Shocking Lack of Research

Although the above authors do address the topic of women's experiences in automobile cockpits, these publications are the few exceptions to the ubiquity of using male-centric perspectives in automobile design. In other words, these publications are much rarer than they should be. The literature around women's experiences in the vehicle cockpit is severely lacking. It is shockingly rare to find automotive research papers that address any aspect of the female experience. **For example, in searching through 23,700 papers on Google Scholar (Google *Scholar Search on "Women, Intelligent Car Cockpit Design," as of January 26,* 2024), only ONE paper that studied gendered experience and needs were found.** In other words, the scientific publication domain is woefully lacking in reflecting the in-car experience millions of users. It is alarming. This lack of research is a reminder that much work needs to be done in this field. This project is a start at addressing this lack of automotive research.

Methods

This research employs a comprehensive and ethical methodological approach to explore the experiences of women drivers about intelligent cockpit design. This study is grounded in an ontological philosophy and interpretivism; the study combines qualitative research methods, including in-depth interviews, observational studies, and a case study, to gain a nuanced understanding of women's unique perspectives and needs in automotive design.

Methodological Approach

The research philosophy guiding this thesis is ontological and focused on women drivers' real-life scenarios. The research methodology is anchored in interpretivism, focusing on understanding individuals' subjective experiences and interpretations. This approach begins with an extensive literature review to frame the research within existing knowledge. Qualitative methods, interviews and observational studies are central to this methodology, allowing for a deeper exploration of individual perspectives and meanings. A design project utilizing the research findings contributes back to my thesis. They emphasize the context in understanding these perspectives, recognizing women drivers' experiences and interpretations shaped by their unique backgrounds and environments. This methodology is iterative, and the research remains flexible and responsive to the complexities of human experiences.

The research methods are primarily qualitative, chosen due to the limited academic publications and reviews on the topic. This scarcity of existing literature requires a direct engagement with primary research methods to gather firsthand insights. The approach includes conducting in-depth interviews, allowing for a detailed exploration of individual experiences and perceptions. Field visits and observations are integral, allowing one to witness and understand user interactions and behaviours in car cockpit settings. Additionally, a case study of a specific car brand is undertaken to delve into practical applications and real-world implications. This case study offers a focused examination of how the brand addresses the needs and preferences of its users, providing a concrete example to critique and learn from. The rationale behind these methods is to communicate directly with end-users – women – in capturing their experiences and viewpoints, which are ignored in traditional research approaches. This user-centric methodology ensures a rich, grounded understanding of the subject, directly informed by those most affected.

Data Collection and Analysis Method

The data collection and analysis method of this research primarily followed the principle of qualitative research. The focus was to gather and analyse non-numerical data to understand the experiences, attitudes, feelings, and behaviours of research participants. The objective of qualitative research in smart cockpit design was to gain a deeper understanding of users' perspectives and experiences in specific contexts. This was achieved through various methods such as interviews, field visits, observation, and case studies. The insights obtained came mainly from the direct feedback provided by research participants, which included their opinions on the effectiveness of the research, the struggles they face, and suggestions for improvement.

The interviews, aimed at uncovering the specific needs of women drivers, were initiated through a targeted recruitment strategy on social media. I successfully enlisted eight participants, aged between 20 and 35. To explore their unique experiences and perspectives, I carefully prepared interview questions, focusing on understanding the nuances of driving from a woman's viewpoint. This research was approved by Emily Carr University's Research Ethics Board. To ensure the research is done ethically, planned studies followed the rules of Emily Carr's REB and were approved in July 2023. (See the complete Consent Form and Research Invitation in Appendix C).

Based on the participants ' convenience, these interviews were conducted via Zoom or in-person to ensure a comfortable environment for open and honest discussions. Each interview was recorded and then transcribed to capture the full extent of the conversations. This process was completed over two weeks, allowing for a concentrated and thorough data collection phase. The analysis of these interviews involved a systematic grouping of key words in Fig Jam. (Figure 2.) This technique enabled her to extract significant insights and patterns from the responses, thereby forming a comprehensive understanding of the needs and experiences of women drivers.

Figure 2. Qiao. Y, 2023, Grouping of interview findings.

I had a field visit to the Shanghai Auto Show in April 2023. This visit provided a unique opportunity to observe various car brands and models firsthand. While there, I focused on understanding how the interior interactions within these vehicles are designed and utilized. I watched the layout design, ergonomics, and interactive features of various car interiors, noting how they catered to or neglected the specific needs of women drivers. This immersive experience allowed me to gather real-world data and insights that could not be captured through secondary research methods. My observations at the Auto Show were crucial in identifying trends, innovations, and gaps in current car designs, particularly from the perspective of female drivers. This field visit enriched this research with practical, tangible examples of how car interiors are conceptualized and executed in the automotive industry, providing a solid foundation for my analysis and conclusions.

In this thesis, a case study was conducted on Ora (Figure 3), a car explicitly marketed as a women's car. This involved visiting and test-driving the Ora on a non-busy urban road to gain firsthand experience of its features and performance from a woman driver's perspective. The analysis focused on critiquing how the design of the model Ballet Cat from Ora presenting itself as a car for women. Central to this evaluation was the question, "How is the experience as a woman driver?" Pictures and videos were taken during the test drive to document the experience, capturing the car's interior and exterior features. Online reports and videos were also used for analysis. These resources complemented the detailed analysis, providing a comprehensive understanding of Ora suggesting the current automobile industry.

Figure 3. Photo of trying Beauty Cam feature on center console in Ora's driving cockpit. 2022.

Limitations

In this research method, several limitations are important to acknowledge. Firstly, the sample size of participants could have been larger, since 8 participants do not fully represent all women drivers' diverse experiences and needs. Additionally, the focus on a specific age group and the recruitment through social media could introduce a selection bias, potentially overlooking the perspectives of older or less technologically engaged women. While insightful, the case study of the Ora car represents just one brand and model, limiting the generalizability of the findings to other vehicles and brands. Furthermore, the field visit to the Shanghai Auto Show, although valuable for direct observation, might not capture the full range of global automotive design trends. Moreover, this study does not extensively explore the ergonomics of automotive design, a critical aspect that affects drivers' comfort and safety. This indicates a gap in research that warrants further investigation. Lastly, the subjective nature of qualitative research, particularly in interpreting participants' responses and observations, could influence the objectivity of the findings. These limitations suggest the need for caution in generalizing the results and highlight areas for future research to build upon and expand the understanding of women's experiences in automotive design.

Methods Conclusion

This research employs qualitative methods, such as in-depth interviews, observational studies, and a case study, to understand women's specific perspectives and needs in automotive design. It

focuses on aspects beyond ergonomics, which remains under-researched. Despite some limitations, the insights garnered offer valuable contributions to the field.

Findings

This section introduces the interview participant information, case study analysis and the findings to the three research questions of:

1. What are the gaps between acknowledging gender inclusivity in cars and designing applications to address women drivers' needs?
2. What are pain points and ignored needs, and how do women become aware of them?
3. How can multimodal interaction design be implemented in an intelligent automotive cockpit to cater to the needs of women drivers?

This approach, highlighting the necessity for personalization and psychological consideration in intelligent vehicle interaction design, underscores the urgent need for more gender-specific research in automotive design, especially focusing on women's unique preferences and requirements.

Interview Participant Information

For my interview sessions, the study involved six women participants, all regular drivers aged between 22 and 30 years, each with at least two years of driving experience. The interviews,

aimed to uncover women's unique challenges and preferences in car cockpits, were either online via Zoom or in person. The more detailed fourteen interview questions can be found in the Appendix D.

The choice of participants was strategic, ensuring a diverse range of experiences while maintaining a specific focus on women who spend a considerable amount of time driving daily (at least cumulative 40 minutes per day). The interviews were designed to explore the physical aspects of cockpit interaction and the psychological impact on women drivers.

Each interview was recorded and later transcribed, creating a comprehensive dataset for analysis. This methodological rigor was essential for capturing the depth and breadth of the participants' experiences and insights. Transcribing these interviews into textual data is a critical step in the next analysis process, which will be discussed in the results section.

I collected 300 minutes of interview audio recordings and compiled eight pages of notes. These were then organized into grouping activities to identify the most recurring patterns. During my field visit, I gathered approximately 40 minutes of audio recordings, capturing my immediate reactions to the designs and scenarios.

Ora Case Study Analysis

In my thesis case study on Ora, a brand leading the change in China's electric and intelligent car market for women—a demographic rapidly increasing its purchasing power. Ora has positioned itself as a women-centric brand, targeting what it calls the "She Economy (Ren, 2019)."[1] Ballet Cat (Figure 4) launched in 2022 as their latest model introduced new concepts and I had a field study to test drive this model. I visited the Shanghai Auto Show in April 2023 and got to test out how it feels in person and gain a different perspective of this research problem.

Figure 4. Official marketing photo of Ora Ballet Cat Model. (Zhang, 2022)

This vehicle stands out in the auto show with pastel colours like pink and pale violet, offering a refreshing alternative to conventional automotive colours. These choices have been well-received by women who appreciate the personalized touch.

1 SHE Economy: the term for the women-targeted market in China. Women are also key influencers for traditionally male-oriented products such as liquor, automobiles, and sports.

However, during my evaluation in the test drive, I found some quirky choices in the user interface. The climate control feature, for example, is named “Warm Guy Mode”[2] or “暖男模式”. (Figure 5.) In Chinese, this term “Warm Guy” or “暖男” refers to a pleasant man with a cute and caring personality (La, 2019). “Warm Guy Mode” or “暖男模式” is suggesting that the heating climate is warming the driver like a “Warm Guy”. In the press release for their upcoming car model, Ballet Cat (released on May 20, 2022) on May 16, 2022, Ora acknowledged the specific needs of women drivers by stating, "开车手冷、生理期不用慌" which means "Don't panic if you have cold hands while driving or if you're on your period." (Ora, 2022) While this statement indicates an awareness of women's unique concerns, the actual features of the car may not fully address these issues. Indeed, the feature is no different from standard climate systems except for the naming. Despite the car's aim to appeal to the persona of an independent professional woman, this naming suggests an unnecessary male presence.

Figure 5. A Photo of "Warm Guy Mode”or “暖男模式” on center console in Ora Ballet Cat’s cockpit.

2 Warm Guy: a guy with a warm and caring personality, is an example that describe males that have a more ‘cute’ or warm personality/presence towards women.

Progressively, Ora has pioneered the first female crash dummy test in China, indicating a commitment to women's safety—a notable stride in the right direction. In June 2023, they ran a test with a female dummy as the driver, affirming the vehicle's safety for women (Figure 6). Despite this advancement, it was paradoxical that the testing team, car crash experts and reporters were all male (Figure 7 & Figure 8), and the media coverage was framed with an optimistic outlook for women drivers, subtly guiding public perception. Despite these contradictions, Ora's initiatives are a significant step forward in an industry that is still catching up to such inclusive practices and doing better than other brands.

国内首次主驾女性假人十字路口连环碰撞挑战

主驾女性假人	假人部位	评价指标	评价阈值	试验结果	评价
	头部	HIC15	500	481	GOOD
		罚分项：头部碰撞触	无碰撞触		
	胸部	胸部肋骨位移	31mm	13.47mm	GOOD
		罚分项：粘性指标	1	0.1	
	腹部	腹部肋骨位移	38mm	14.85mm	GOOD
		罚分项：粘性指标	1	0.09	
	骨盆	骨盆位置合力	3.5KN	2.79KN	GOOD
	主驾女性假人碰撞挑战		成功		

*表中为关键试验结果

Figure 6. Ora's crash test report concluding the successful performance of female crash dummy. Sohu, 2023. 碰撞测试+硬核拆车，欧拉闪电猫双管齐下打好纯电轿跑安全组合拳! (n.d.). https://www.sohu.com/a/681699332_121139435

Figure 7. Testing scene of Ora Lightning Cat Model. (Ora High Speed Spinning Crash Test, 2023)

Figure 8. Expert evaluating the Crash Test during an interview. (Sohu, 2023).

Analyzing Ora provided a practical lens through which to understand how current industry players are addressing, or failing to address, the specific needs of women drivers in cockpit design. This shift from theoretical to practical exploration allowed me to delve deeper into the nuanced realities of intelligent cockpit design, moving beyond what is written to what is experienced and implemented, thus filling a critical gap in both academic literature and industry practice.

Finding 1: Gaps in Gender Inclusivity

Recognition vs. Implementation: There is a notable gap between the acknowledgment of the need for gender inclusivity in car design and the actual implementation of design features that address women drivers' specific needs. Research by Deloitte in collaboration with Automotive News has highlighted (Bowman & Robinson, 2020) that woman, comprising about half of the general labour force, represent only a quarter of the automobile industry workforce. The study suggests that increasing diversity within the industry could provide a competitive advantage by bringing a wider variety of ideas and perspectives to the table, which is crucial for innovation

and growth. However, a significant gender discrepancy persists, indicating that more needs to be done to include women in the workforce and in the consideration of automotive design processes . While many automotive companies recognize the importance of inclusivity, this often translates into something other than tangible design changes.

Stereotypical Assumptions: Some existing designs are based on stereotypical assumptions about women's preferences, leading to superficial changes rather than addressing functional needs. Ora has branded them.

Finding 2: Pain Points of Women Drivers

Ergonomic: Emphasizing the indispensable role of ergonomics in automotive design, particularly for women drivers, the study highlights the profound impact of interior design on comfort and usability. Interviews with participants illuminated the critical nature of ergonomic considerations, as every participant (100%) articulated issues with the spatial arrangement within the vehicle's cockpit. A notable account from one participant vividly illustrates this ergonomic challenge: "To see what's behind my car, I always have to lean forward to adjust the mirror position." This vividly underscores the pervasive issue of visibility and control accessibility for women drivers, accentuating the urgency for inclusively designed vehicle interiors that cater to diverse body types and needs.

Furthermore, an overwhelming 80% of the participants disclosed experiencing significant discomfort during long drives, particularly when menstruating. The lack of adequate lumbar support in current car designs was pinpointed as a notable deficiency, inadequately addressing the discomfort from menstrual cramps. This revelation underscores a pivotal opportunity for innovation in car seat ergonomics, emphasizing the need for designs that offer more substantial support and comfort during such sensitive times.

These findings compellingly argue for the critical examination of ergonomics in automotive design, underscoring that overlooking ergonomic affordances in vehicles is no longer viable. The data lays bare the explicit need for a paradigm shift towards more ergonomically inclusive design principles that prioritize and accommodate the distinct requirements of women drivers, thereby enhancing the driving experience for all.

Storage and Practicality: A frequently overlooked aspect is the lack of practical storage solutions for items commonly used by women. During the interview, one participant demonstrated the variety of personal items she stores in her car's central compartment. This included her perfume, hand sanitizer, a makeup bag, and, notably, a bunny stuffed toy. She explained, 'I keep my bunny in the car as it gives me a sense of security when driving alone.' This insight highlights a car design gap concerning female drivers' storage needs.

Awareness through Comparison: Women often become aware of these pain points when comparing their experiences with other vehicles or through discussions with other women

drivers. For example, one participant noted that drivers waiting behind her often become impatient and resort to rude comments or yelling when she takes time to parallel park. In contrast, when her boyfriend takes a similar amount of time to park, those drivers tend to honk and drive away without further confrontation.

Finding 3: Implementing Multimodal Interaction Design for Women Drivers

Human-centred Design: Using human-centred design methods, researching women drivers. Enhance features that are tailored for scenarios more commonly encountered by women. This requires more testing participants that are women drivers.

Personalization: Implementing personalization features in car design, such as adaptable seats and customizable lighting, addresses the unique preferences of women drivers. According to interviews, most participants (80%) desired enhanced personalization options within their vehicles. By incorporating principles of atomic design (Frost, 2016), initially used in web development, into the user interfaces of smart cars, automakers can create more flexible and user-centred experiences. This approach allows for the modular and scalable design of car interiors and technology systems, making adjusting elements to suit different driver needs and preferences easier.

Include Woman in Testing: Testing is the key process of human centered design and in intelligent cars. This requires teams to invite more women participants as well as more women testing teams.

Findings Conclusion

These insightful studies have directly informed the development of my design project, the 'Modular Heated Seat,' which I will detail in the next section. The findings have significantly influenced my approach, steering me towards a more human-centred design that mainly addresses the needs of women during their menstrual periods. This approach emphasizes the importance of personalization in the user's interaction with the car's features. It becomes evident that intelligent vehicle interaction design should not only focus on functional aspects but also consider the psychological impact of the interface on the user. There's a pressing need for more comprehensive, gender-specific research in automotive design. There needs to be more understanding of women's unique needs and preferences in vehicles.

Design Output

Eighty percent of the interview participants highlighted a specific challenge they faced while driving - the discomfort and pain associated with menstrual cramps. While general advice and products, such as heating pads, are available for menstrual cramp relief, more information is needed on integrated car design solutions focused on this issue. This underscores the importance

of my research in pushing the boundaries of automotive design to be more attentive to the needs of women drivers, particularly in designing elements like heated seats with adjustable zones for targeted relief. The automotive industry has made strides in offering heated seats to alleviate discomfort, the current design often needs to address the unique needs of individuals experiencing period-related discomfort. The prevalent design heats both the seating pad and the back simultaneously. This becomes particularly problematic when considering that, for many, applying heat to the seating pad, especially during active bleeding, intensifies discomfort rather than alleviates it. However, the warmth in the lower back area can be a crucial relief for cramps. This disparity underscores a gap in truly human-centric design, where the broad application of technology might miss nuanced but significant needs. This research addresses such oversights and pushes the boundaries of what we consider when designing car interactions for women's specific scenarios.

Design Exploration: Modular Heated Seat

My design exploration's central assumption is that current car seats lack adequate modularity. In revisiting the design of heated car seats through the lens of Frost's (2016) atomic design philosophy, this exploration pivots on the critical observation that existing car seat configurations lack essential modularity. Presently, the dominant model for seat heating functions in a uniformly extensive manner; upon activation, it indiscriminately heats a substantial portion of the seat, affecting the back, buttocks, and thighs in a sweeping gesture. This broad application of heat, while beneficial up to a point, can become a source of discomfort during prolonged periods of driving. Specifically, this generalized approach fails to meet the

nuanced comfort requirements of drivers and passengers—most notably, women drivers experiencing menstrual cramps.

> Imagine yourself on a 40-minute journey along the highway while experiencing menstrual discomfort. You're grappling with intense lower back cramps, a condition where warmth often brings relief. However, the seat's heating function, though comforting for your lower back, causes the seating area to become overly warm, leading to discomfort, especially during menstruation. Meanwhile, your upper back feels slightly too heated, unlike the lower back, where the temperature feels just right.

This common experience, shared by nearly half the world's population, led me to reimagine car seats with a more modular design. My design offers a tailored solution by segmenting the heating system into distinct zones (upper back, lower back, buttocks, and thighs). Users can select specific areas for heating through the touchscreen interface I developed. This approach provides targeted relief and enhances overall comfort, especially for women drivers during their menstrual cycle. The aim is to transform a standard car journey into a more comfortable and personalized experience, aligning with the diverse needs of all drivers and passengers.

Conceptual Development

Modular Design

By applying atomic design principles, the proposal is to deconstruct the car seat heating system into its most fundamental unit of cushions (atoms) and reassemble them into more complex, adaptable systems of a full seat (molecules and organisms) that can offer targeted heat control. See Figure 9. This modular approach would allow for the heating mechanism to be activated selectively, focusing warmth where it is most needed for comfort and relief—such as the lower back area for menstrual cramp alleviation—without unnecessarily heating other areas of the seat that might exacerbate discomfort, particularly during active menstrual periods. This nuanced, human-centric design reimagines the car seat heating system as a collection of interconnected elements that can be personalized to individual needs, thereby enhancing the driving experience for everyone, especially for women in specific scenarios.

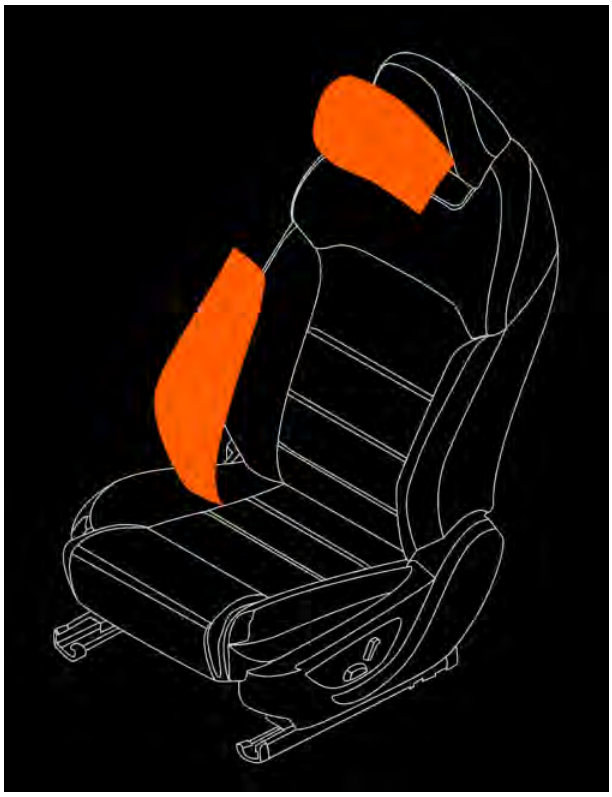

Figure 9. A sketch of modularized driver seat with separated unit.

Considering the challenges above highlighted by my participants, I sought inspiration from various domains to approach a design solution. A key inspiration was the concept of modular website design[3], which emerged as a promising strategy to address the unique demands of my context. At its core, modular website design advocates for creating distinct modules, each with a singular responsibility, which can be combined to craft a cohesive and complex system. This methodology promotes flexibility and specificity, ensuring each system component serves a unique and well-defined purpose. This source provided comprehensive insights into how modular systems can be designed to cater to specific user needs while maintaining an integrated user experience – and these concepts were useful in rethinking how automotive cockpits can be rethought.

Technical and Material Development

To build this prototype, I prepared a digital interface design with a physical prototype and video narration. I crafted an interface design in Figma that allows users to interact with a touchscreen and select the specific area they wish to heat. For the physical prototype, I prepared a chair sectioned into thighs, buttocks, and lower and upper back. I used red LED lights to represent the heat is on. At the same time, I put heating pads in these areas.

[3] "Modular Web Design: Creating Reusable Components for User Experience Design" (2010).

My modular heated seat design offers expansive benefits for diverse users. This innovation is especially advantageous for individuals with chronic pain in their back or buttocks. The design allows for the selective activation or deactivation of heating modules, providing targeted relief and personalized comfort. See Figure 10. This feature mainly benefits those requiring focused heat therapy for localized pain areas, enhancing the experience of long drives or prolonged sitting. Incorporating ventilation into specific seat sections further elevates the design's utility. This system balances the seat's temperature, preventing overheating—a common issue with traditional heated seats. The ventilation works alongside the heating elements to maintain an optimal and comfortable environment, reducing sweat and promoting hygiene.

This modular heated seat design transcends its initial purpose, offering a versatile and customizable solution that enhances comfort and well-being for many car users.

Figure 10. Modular Heated Seat center console touch screen design mock up. 2024.

Affordable Adaptation of Modular Heated Seats

Building on the modular heated seat design for smart cars, there is a compelling opportunity to extend its benefits to economically disadvantaged groups by adapting the system for broader accessibility. This design can be turned into an affordable add-on product by recognizing the financial barriers associated with purchasing new smart cars equipped with advanced features. Individuals can retrofit their existing vehicles without significant financial investment by transforming the sophisticated seat design into detachable seating cushion pads. These cushion pads, equipped with a standard power outlet connection, can be easily installed, and removed, offering flexibility and convenience.

A simple remote control can be provided to accommodate users who may need access to integrated touchscreen controls. This remote would allow users to turn individual heating modules on or off, targeting specific areas for heat therapy as needed. Such an approach democratizes access to personalized comfort technologies and ensures that the benefits of such innovations are not confined to those who can afford high-end vehicles. By repackaging the modular heated seat into a cost-effective, universal accessory, this design can significantly enhance the driving experience for a wider audience, mainly benefiting those who spend extended periods in their vehicles and need customized heating solutions to manage pain and discomfort. This strategic pivot expands the market reach and aligns with broader inclusivity goals, making advanced car technologies accessible to all, irrespective of economic status.

Discussion

Reflection and Insights

This research has made significant strides in addressing the unique needs of women drivers in automotive design. To alleviate menstrual pain experienced while driving, I have developed a modular heated seat that offers three distinct modes of interaction, each designed to cater to the driver's specific needs. First, buttons on the screen allow the driver to turn various seat sections on or off as required. This provides immediate and customizable relief. Second, the system includes a feature for drivers to set up times and schedules, enabling the seat to turn on or off automatically – a convenient solution for regular pain relief. Lastly, the most advanced aspect of this system is the integration of multimodal sensors. These sensors can detect signs of pain and automatically adjust the seat settings, offering a seamless and intuitive experience for the driver.

Despite the rapid advancement of AI in automotive technology, sometimes the most effective solutions are the simplest. In this case, adding a button offering more choices represents a straightforward yet highly effective approach. This highlights a crucial principle for designers: the importance of directly engaging with and understanding the needs of our target users. By asking the right questions and focusing on user-centred design, we can develop practical and innovative solutions that significantly enhance the driving experience for women.

Limitations

This thesis's core revolves around exploring and developing intelligent cockpit interaction designs tailored specifically for women's scenarios. However, as with all research endeavors, it is pivotal to delineate the boundaries of this study to ensure a focused and meaningful discourse.

The primary ambit of this research centers on vehicles equipped with advanced interaction mechanisms. Cars that possess the capacity for smart interactions are the focal point, as these vehicles promise to offer a more adaptable and user-centric experience. The thesis deliberately does not deal with vehicles with limited interaction capabilities, as they may offer more adaptability than intelligent cockpit designs require. Furthermore, the primary demographic under consideration comprises women with a higher income bracket and commuting daily. This demographic is chosen because they are more likely to possess or aspire to own cars with smart interaction capabilities. Hence, they can provide valuable insights into the user experience.

This exploration operates within subjectively qualitative design research rather than quantitative ergonomics design research. It's crucial to recognize the intrinsic limitations accompanying this approach. Car design is inherently complex, intersecting with multiple domains such as engineering, human-machine computing, psychology, and ergonomics. While efforts have been made to comprehend the subtleties of these disciplines as they intersect with cockpit interaction design, my investigation needs to encompass exhaustive expertise across these vast areas.

Consequently, specific technical, psychological, or ergonomic considerations may need to receive the detailed examination they warrant. Additionally, by focusing on a particular demographic—higher-income women who commute daily—this research may not fully encapsulate the diverse range of experiences and needs among women from varied socioeconomic backgrounds or with different commuting habits. This delineation underscores the subjectively qualitative nature of the study, aiming to illuminate rather than define the spectrum of design considerations within automotive interiors.

Conclusion

Summary

This thesis studies the challenges women drivers face in car cockpits, aiming to devise design solutions tailored to their unique needs to improve their comfort and enjoyment. The study breaks new ground in the relatively unexplored area of automotive design for women, utilizing qualitative research methods, including literature reviews, interviews, field visits, and a case study. It uncovers substantial gaps in gender inclusivity within the industry, highlighting a disconnect between recognizing these issues and their actual implementation. The research identifies key areas of concern for women drivers, such as ergonomic design, storage solutions, and psychological comfort. A significant contribution of this thesis is the development of a modular heated seat designed to address women's menstrual pain, exemplifying the practical application of human-centred design principles, and advocating for greater woman participation in testing participants and industry roles.

Implications

The automotive industry and the academics have largely overlooked the specific needs of women drivers, and it is time for that to change. It is surprising and unacceptable that such research is so rare that only ONE out of 23,700 publications studies women as drivers. People should be aware and concerned about this oversight. The solutions to making cars more comfortable for women don't have to be complicated or expensive. A simple change, like adding a button, can make a big difference. It is more about listening to what women need than about high-tech solutions.

This thesis research has taught me about the significant lack of research on women as drivers – and I hope it inspires others to continue this work. The message is simple: we must start including women's perspectives in car design. It is not just a technical issue; it is about understanding and valuing the experiences of women drivers. My goal is for future designers and researchers to see this issue's importance and build on the foundation this research has laid, creating cars that are truly designed for everyone.

Future Research

A future area of research to ensure that the Modular Heated Seat design works well would be to conduct a field study where people can try a prototype while driving. This way, its effectiveness can be tested with feedback from real users. This step is essential to ensure that the technology

works in theory and is also helpful and comfortable for drivers in their daily lives. Other than my own research interests, more areas can be explored, like safety, smart driving and passenger interactions. Menstrual pain detection not only can be largely explored in cars, but also has the potential to succeed in medical examination, human computer interaction, neural network studies and psychological studies. The end research goal should be to make cars not just a way to get around but a space that understands and responds to the driver's health and comfort needs. More research is needed in this field: it desperately needs design attention, engineering attention, social studies attention, and is a significant business opportunity for those willing to listen.

Glossary

Intelligent Cockpit:

In automotive design, an intelligent cockpit refers to the integrated control center of a vehicle that features advanced technological elements such as interactive displays, voice control systems, artificial intelligence, and connectivity solutions. This system is designed to enhance the driving experience by providing easier access to navigation, entertainment systems, vehicle diagnostics, and more.

Male-centric design:

This term refers to a design philosophy or approach that predominantly focuses on the male user's needs, preferences, and characteristics, potentially at the expense of other demographics. In product design, this can result in features, functionalities, or aesthetics that cater specifically to male users, which may only sometimes accommodate or appeal to female users or others.

Male ideology:

Male ideology pertains to the beliefs, norms, and values traditionally associated with masculine societal roles and behaviours. This ideology often emphasizes traits like competitiveness, stoicism, autonomy, and dominance. It can influence various aspects of culture and society, including workplace dynamics, leadership, decision-making practices, and social interactions.

Smart car:

A smart car generally refers to an automobile with advanced electronics, software, sensors, and connectivity features that facilitate autonomous driving, real-time traffic updates, cloud-based services like remote diagnostics, and energy management. These cars aim to enhance driver safety, improve the efficiency of vehicle operations, and provide a personalized driving experience.

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Appendix

A. REB Application

B. REB Approval

C. Participant Consent and Media Release Forms

D. Interview Questions

Application for Human Research Ethics - REVISED 2017, 2022

Project Info.

File No: 100551
Project Title: Research and Practice of Intelligent Cockpit Interaction Design Based on Women's Car Scenarios
Principal Investigator: Dr. Garnet Hertz (Faculty of Design + Dynamic Media)
Start Date: 2023/07/13
End Date: 2024/02/29
Keywords: Interaction Design

Project Team Info.

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Common Questions

1. Project Ethics Details

#	Question	Answer
1.1	Anticipated date that work with participants will begin.	2023/05/01
1.2	Anticipated date that work with participants will end.	2024/02/29
1.3	Type of Project	Graduate Thesis Project or Dissertation
1.4	If you have chosen "Other" in the selection above, please describe here	
1.5	Does the research fall within the jurisdiction of another research ethics board or body? If so, all approvals need to be in place before participant research can begin.	No
1.6	If you answer 'Yes' to question 1.5, please list the names of all of the Research Ethics Board(s) to which you have applied for this project.Include the approval date(s). These dates must match the dates in the certification documents that you attach to this application. Please follow this format: UBC GREB | January 15, 2017 to January 15, 2018	
1.7	Are you a student (graduate or undergraduate)applying for ethics approval for a thesis project?	Yes
1.8	If you answer 'Yes' in 1.7, ensure that the Principal Investigator in this application is your thesis supervisor and add your name to the "Other Project Member" category at the bottom of the page. Please click the info button for important instructions.	
1.9	Have all of the named researchers completed the TCPS2:CORE (Course on Research Ethics)? If yes, upload each of the certificates using the attachments tab of this application. No application will be processed until all of these certificates are supplied. If you have comparable certification from another site, please upload the certification with an explanation.	Yes

1.10	If you have uploaded comparable certification from a source other than the TCPS2:CORE, please describe here. (Provide a link to the program or an institutional description, if available)	
1.11	For student researchers(if you answered 'yes' in 1.7) - describe any potential conflicts of interest for the researchers such as non-academic benefits, (eg. financial remuneration, patent ownership, employment, consultancies, board membership, share ownership, stock options, etc.) expected by the researchers, partner organizations, or collaborators as a result of the research. Also describe any non-disclosure agreements or any other restrictions anticipated to affect the research	
1.12	Attachments checklist - Ensure that the following documents are attached to this application using the Attachments tab. Incomplete application will not be reviewed.- TCPS2:CORE certificates (or equivalent) for each of the researchers.- All Recruitment materials (also see 'Research Participants and Recruitment' tab)- All consent and release materials (also see the 'Consent' tab)- Other relevant documents	

2. Risk & Review

#	Question	Answer
2.1	(Optional) Would you like to determine the level of risk and review required for this project?	
2.2	From the 'Risk and Review' assessment, the proposed research project is expected to require the following (choose one). Do not attach the 'Risk and Review' assessment	Level 2 - Low Risk

3. Summary of Proposed Research

#	Question	Answer

3.1	Summary of Proposed Research: Describe the purpose of the proposed research project in non-technical language (200 words max, please see info button for details)	The Smart Cockpit Interaction Design Research for Women's Car Scenario aims to explore and identify design solutions that can improve the driver's experience in a car cockpit. The research focuses on the needs and preferences of women drivers, who often have different cognitive and technological demands. The research involves an integrated analysis of the current state of cockpit design through desk research, interviews, and field visits. The findings will be translated into design practice that can cater to the specific needs of women drivers. The goal of this research is to enhance the overall safety, and enjoyment of car cockpits and to promote gender consideration in the automotive industry.

3.2	Methodology (200 words max):Describe this project's methodological approach to participant research activities. Include details on what will be expected of participants. Attach survey, interview questions and other documents related to the research methods. Include a timetable for participant research activities.	Conducting user interviews allows for direct insights into the experiences and preferences of women drivers. There will a co-design sessions (asking for your design idea suggestions), and a prototype testing session when the design is completed. Here are some questions that I planned to ask: -How familiar are you with technology? Have you used CarPlay or Android Auto?-How comfortable are you with using technology in cars? -Are there any safety concerns you have that are specifically related to the car's cockpit design as a woman? -What measures or features make you feel more secure and confident while driving being a woman?-Are there any specific aspects of the car's cockpit design that affect your comfort negatively as a woman? -Are there any adjustments or features you'd like to see that would enhance your driving experience?-How important are personalization and aesthetics in a car's cockpit for you? Do you prefer a specific colour scheme, material, or interior design that reflects your style and preferences? -How would you like to see these aspects integrated into the intelligent cockpit design?-Are there any tasks or actions that you find difficult or uncomfortable to perform while driving or riding in a car as a woman?-Can you describe a time when you felt unsafe or uncomfortable while being in a car as a woman? What caused that feeling? -How do you typically interact with the dashboard, controls, and displays in a car? Are there any features or designs that you find confusing or difficult to use?-How does it empower you being a woman in a car?-What features do you think can be added in cars that will benefit you as a woman?-Do you have any final thoughts or suggestions you would like to

		share?Following the interviews, a co-design workshop will be conducted. In the workshop, participants will engage in the design process alongside researchers, contributing to idea generation and prototype development. Their input will inform the development of intelligent cockpit interaction designs that cater specifically to women drivers' needs.
3.3	Professional Expertise / Qualifications:If any of the research activities require professional expertise or recognized qualifications (eg. first aid certification, registration as a clinical psychologist or counsellor, health practitioner qualifications or expertise, etc), describe them here.	

4. Research Participants and Recruitment

#	Question	Answer
4.1	Participants: Indicate the groups that will be targeted for recruitment in the research project. Describe any specific inclusion or exclusion criteria (example: undergraduate students, specific age ranges, genders, etc)	The research project will target women drivers as participants. There are no specific age or educational criteria, but participants must have a valid driver's license and must have driven a car within the last 6 months. The study aims to include participants from diverse cultural and socio-economic backgrounds. There are no exclusion criteria based on race, ethnicity, religion, or sexual orientation. Participants will be recruited through online and personal referrals.
4.2	Number of Participants: What is the expected number of participants?	8-10 women drivers with driving experience. Preferably from different geographical locations.
4.3	Recruitment: Describe how participants will be recruited, and by whom. Attach any materials that might be used for recruitment (eg. email text, posters, fliers, advertisements, letters, telephone scripts).	Participants will be recruited through social media platforms (Facebook group chats, LinkedIn, Redbook community) and friends' referrals through invitations.
4.4	Incentives: Will participants be offered incentives to encourage their participation?	Yes
4.5	If yes to above, describe the incentive plans and the rationale for using incentives.	Monetary

4.6	Participants and vulnerability: Are there circumstances that cause the participants or participant group(s)to be vulnerable in the context of research?	No
4.7	If yes to above, describe the particular way participant vulnerability may be affected by the research and any measures that are planned to address potential risks associated with these vulnerabilities.	
4.8	Are people from First Nations, Inuit, Metis or other Indigenous backgrounds being specifically invited to participate in this research?	No
4.9	If yes to above, describe any additional reviews/approvals/consultations/cultural protocols required to complete this research. Ensure your rationale for engaging with specific individuals or communities is described in 3.1.	
4.10	Research Locations : Select all locations where participant research will occur.	Emily Carr University|Other (describe)
4.11	Provide details of the locations listed above	Online through Zoom.
4.12	Participant Access to Research Results: Describe your plans to provide or share results of your research with participants. This might include invitations to final presentations or exhibitions, or copies of publications produced. Content here should be consistent with descriptions in the consent forms provided.	The research data will be made accessible to participants upon their request. All participants will be invited to attend the final thesis presentation, and these invitations will be clearly communicated to them through verbal and written consent forms.

5. Risk vs Benefit

#	Question	Answer

5.1	Describe any known or anticipated direct or indirect benefits to the research community or society that may emerge from the proposed research.	The research will provide insights into the needs and preferences of women drivers, which will contribute to the design of more user-centred intelligent cockpits. The findings of this research can be used by automotive manufacturers, designers, and engineers to develop more gender-sensitive and inclusive designs for car cockpits, ultimately resulting in safer and more enjoyable driving experiences for all drivers, regardless of gender. It also can highlight the need to consider gender in technology design and development and promote awareness of the biases and stereotypes that exist in current technology designs. This can encourage more inclusive and equitable practices in technology design and development.
5.2	Risks of Research: Check any that apply - list all risks likely to be faced by participants in the proposed research.	Social Risks (including privacy issues, economic position, status, relations with others)
5.3	Describe the risks identified and contextualize them related to risks faced by participants in every day activities. See info button for details.	It might require the information of participants' current vehicle, which indirectly reflects their economic status.
5.4	Risk Mitigation: Describe how the researchers will mitigate the risks identified above. Describe whether the researchers have the skills to deal with identified risks or whether additional experts will be recruited. Describe any resources that will be made available to participants.	Participants have the right to decline to share any information that they consider confidential. Confidentiality will be maintained throughout the interview, co-creation workshop, and prototype testing. If participants feel uncomfortable or decide to withdraw from the research at any point, the activity will be stopped immediately. This will be clearly communicated to participants verbally and in writing during the activity.

6. Consent

#	Question	Answer
6.1	Consent Documents: Check all of the following consent and release documents that will be used in this project.	Combined Invitation and Consent Form

6.2	Describe any special consent provisions selected above	Participants will receive the research invitation and consent form.

7. Confidentiality and Security

#	Question	Answer
7.1	Confidentiality: Indicate the level of confidentiality built into the research design.	Anonymous - the research materials (data) is not collected in relation to any identifiers (for example: anonymous surveys) and the risk of identification is very low
7.2	Describe the rationale for the collection of identifiable research materials	The rationale for the collection of identifiable research materials is primarily to enrich the research quality and provide a comprehensive, personalized understanding of the experiences, preferences, and needs of women drivers. However, it's crucial to note that the project prioritizes participant privacy and confidentiality above all.For this reason, all identifiable research materials will undergo anonymization processes to eliminate any potential risks of identification.

7.3	Storage & Destruction of Confidential Material: Describe in detail how identifiable materials/data will be collected, stored, retained and destroyed at the end of the data lifecycle.	The information collected in this study may include the following: -Name, phone number and email for the purposes of contacting you only. Name and contact information will be kept separate from the interview data (interview recordings/transcripts of interviews). The interview data will be coded and then grouped with responses from other participants. Name and contact information will not be linked to the data set.- Responses to the interview questions which may include personal details and audio/video recording of the interview. If photos or recordings are used in the final reports or publications, identifying features will be made anonymous. For instance, if a photo is published, faces or other identifying features will be replaced with stock photos. All of the information that you provide to this study is considered to be confidential. During the course of the research and for 5 years following the conclusion of this study, the data and confidential materials will be securely stored on encrypted hard drives. These materials will only be accessible to Jocelyn Yue Qiao and Dr. Garnet Hertz. The confidential materials will be destroyed in a secure manner after 5 years. Results of this study may be published in various formats such as reports, graduate student thesis, design process books, as well as on digital platforms like websites and videos. The findings might be shared through presentations at conferences and colloquia.

7.4	Location of Data: Describe the location for long-term storage of confidential materials	During the course of the research and for 5 years following the conclusion of this study, the data and confidential materials will be securely stored on encrypted hard drives. These materials will only be accessible to Jocelyn Yue Qiao and Dr. Garnet Hertz. The confidential materials will be destroyed in a secure manner after 5 years.

8. Monitoring

#	Question	Answer
8.1	Once REB approval has been obtained, it is the responsibility of the PI to maintain the ethics file in up-to-date good standing and make appropriate reports (such as Severe Adverse Event reporting) and amendments (please see Info button for more details).Is it expected that the proposed research will require additional monitoring beyond the minimum annual requirement?	No
8.2	If you answered yes to the above, please describe your plans for this.	
8.3	Is it expected that the proposed research will continue beyond the conclusion of this project?	No
8.4	If yes to above, describe in detail.	

Attachments

Doc / Agreement	Version Date	File Name	Description
Consent Materials	2023/07/10	Consent and Research Invitation.pdf	Consent and Research Invitation
ECU-REB Approval Certificate	2023/07/13	20230713_Hertz_Qiao_Approval_Certificate.pdf	N/A
Recruitment Scripts	2023/07/10	Participant Recruitment Notice.pdf	Recruitment Notice

TCPS2:CORE certificate (or equivalent)	2023/06/09	Garnet Hertz's_tcps2_core_certificate.pdf	TCPS2: Dr. Garnet Hertz
TCPS2:CORE certificate (or equivalent)	2022/09/30	tcps2_core_certificate.pdf	TCPS2 Core Certificate

Emily Carr University Research Ethics Board (ECU-REB)
Research + Industry Office
520 East 1st Avenue
Vancouver, BC V5T0H2

ethics@ecuad.ca

CERTIFICATE OF RESEARCH ETHICS APPROVAL

The Emily Carr University Research Ethics Board approves the following project:

File #	Title	Principle Investigator:	Other Investigators
100551	Research and Practice of Intelligent Cockpit Interaction Design Based on Women's Car Scenarios	Dr. Garnet Hertz	Jocelyn Yue Qiao

The current approval dates are:

Approval Date	Expiration Date
July 13, 2023	February 29, 2024

The nature of the approval is as follows:

Type of Event	Type of Review	Approved Documents
New Approval Process	Delegated Review	ECU-REB application form; consent form; recruitment notice

It is the researchers' responsibility to meet all research ethics requirements in the jurisdictions in which the research takes place. The procedures and protocols described in this certification must be followed closely. Note the following conditions associated with this approval:

- For multi-site or partnered research, researchers are required to comply with all research ethics requirements that apply. Researchers are expected to share notice of this approval with partners, sites of research, or other research ethics review boards, as applicable.
- If changes to the approved application and documents are required by new partners, sites of research or other research ethics boards, researchers are required to inform the ECU-REB of these changes.

Researchers are required to report anticipated changes, adverse incidents, and project completion for further research ethics review. All reporting is managed through the research portal on the Research Management System Process Pathways Romeo - https://ecuad.researchservicesoffice.com/. Login and complete "event" reports for changes, adverse conditions, renewals, and the completion of this research ethics file.

This research ethics approval is in compliance with Tri-Council guidelines (TCSP2 2018) and Emily Carr University policies and procedures.

Nick Conbere
Chair, Emily Carr University Research Ethics Board
Emily Carr University of Art + Design

Research Invitation & Consent Agreement

Project Title: Research and Practice of Intelligent Cockpit Interaction Design Based on Women's Car Scenarios

Principal Investigator:

Dr. Garnet Hertz, Associate Professor

Faculty of Design + Dynamic Media

Emily Carr University of Art and Design

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Co-Investigator:

Jocelyn Yue Qiao, Graduate Student

Faculty of Graduate Studies

Emily Carr University of Art and Design

Phone: +1 778 798 6522

Email: yqiao@ecuad.ca

INVITATION

You are invited to participate in a research study. This research aims to explore and identify design solutions that can improve the driver's experience in a car cockpit. You are being invited to participate in this study because we are looking for participants whose experience reflects the needs and preferences of drivers who identify as women.

WHAT IS THE STUDY ABOUT?

The purpose of the Research and Practice of Intelligent Cockpit Interaction Design Based on Women's Car Scenarios study aims to explore and identify design solutions that can improve the driver's experience in a car cockpit.

WHAT'S INVOLVED?

As a participant, you will be asked to participate in interviews, co-design sessions (asking for your design idea suggestions), and prototype testing. The research methods include interviews, observations, co-designs, user-testing and the participation will include being audio recorded and photographed. Participants are invited to participate in three sessions at times that are convenient for you. Participation at each session will take approximately 1 hour including the introduction, discussion of the consent forms, and the actual research activities. The interviews will be conducted online through Emily Carr University Zoom or in person.

Due to the nature of this research, the researchers plan to collect recordings of you during the research, including recording your conversation with the researcher, your movements, and your gestures. The recording methods might include audio, video, photographs, and screen captures. The purpose of collecting recordings during the research is to transcribe the research findings into the form of a research summary. The transcripts will be available to participants upon request.

POTENTIAL BENEFITS AND RISKS

Participants are entitled to receive an incentive of $10 cash at the start of the research session. This is to compensate for the time spent and effort in assisting us with our research project.

Possible societal benefits of your participation in this research include generating new insights into the needs and preferences of drivers who identify as women. These insights are expected to contribute to the design of more user-centered intelligent cockpits. The findings of this research can be used by automotive manufacturers, designers, and engineers to develop more gender-sensitive and inclusive designs for car cockpits, ultimately resulting in safer and more enjoyable driving experiences for all drivers, regardless of gender. It also can highlight the need to consider gender in technology design and development and promote awareness of the biases and stereotypes that exist in current technology designs. This can encourage more inclusive and equitable practices in technology design and development.

There may be risks associated with participation. It might require the disclosure of private information, such as the participants' current vehicle, and other experiences which indirectly reflect economic status. Participants have the right to decline to share any information. Confidentiality will be maintained throughout the interview, co-creation workshop, and prototype testing. If participants feel uncomfortable or decide to withdraw from the research at any point, the activity will be stopped immediately. This will be clearly communicated to participants verbally and in writing during the activity.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. You are not obliged to participate. If you decide to take part in the research, you can decline to answer any questions or participate in any time in the research. You can withdraw from the study without giving a reason. You can also request the withdrawal of your contributions to the data. You can withdraw from the research without penalty or loss of benefits you were entitled to receive at the start of the research.

The researchers aim to provide information for you about what to expect at all stages of the research.

DATA MANAGEMENT

The information collected in this study may include the following:

- Your name phone number and email for the purposes of contacting you only. Your name and contact information will be kept separate from the interview data (interview recordings/transcripts of interviews). The interview data will be coded and then grouped with responses from other participants. Your name and contact information will not be linked to the data set.
- Your responses to the interview questions which may include personal details and audio/video recording of the interview. If photos or recordings are used in the final reports or publications, identifying features will be made anonymous. For instance, if a photo is published, faces or other identifying features will be replaced with stock photos.

All of the information that you provide to this study is considered to be confidential.

During the course of the research and for 5 years following the conclusion of this study, the data and confidential materials will be securely stored on encrypted hard drives. These materials will only be accessible to Jocelyn Yue Qiao and Dr. Garnet Hertz. The confidential materials will be destroyed in a secure manner after 5 years.

Results of this study may be published in various formats such as reports, graduate student thesis, design process books, as well as on digital platforms like websites and videos. The findings might be shared through presentations at conferences and colloquia.

DIRECT QUOTATIONS & USE OF NAMES

Due to the nature of this research, the researchers request that some direct quotations be included in the research. The purpose of including your name is to empathize with actual user data.

Although your decision can be changed during the course of this research, please indicate your preference for the use of direct quotations and the use of your name in the research:

☐ Yes, I consent to the use of direct quotations in this research.

☐ No, I do not consent to use of direct quotations in this research.

If yes,

☐

☐ Yes, I consent to the inclusion of my identity (name) in this research.

No, I do not consent to the inclusion of my identity (name) in this research. I choose to remain anonymous.

The researchers & I agree to the use of this alias: _____

CONTACT INFORMATION AND ETHICS CLEARANCE

If you have any questions about this research, you are invited to contact Jocelyn Yue Qiao by Email: yqiao@ecuad.ca or phone: +1 7787986522 or Dr. Garnet Hertz by Email: ghertz@ecuad.ca or phone: +1 604 789 6582.

This study has received ethics clearance through the Emily Carr University Research Ethics Board#100551, July 13, 2023. If you have any comments or concerns about ethical issues in the research, you are invited to contact - Research Ethics Board Coordinator, ethics@ecuad.ca.

CONSENT AGREEMENT

I agree to participate in the research described above. I have made this decision based on the information I have read here. I understand that I may ask for more information at any time.

I understand that my participation is voluntary, and that I may withdraw this consent at any time by contacting any of the people listed on this form.

By consenting to this research, I have not waived any legal recourse in the event of research-related harm.

Name: _____

Signature: _____Date: _____

Thank you for your assistance in this project.

EMILY CARR UNIVERSITY OF ART + DESIGN

Interview Questions

1. How familiar are you with technology? Have you used Carplay or Android Auto?
2. How comfortable are you with using technology in cars?
3. Are there any safety concerns you have that are specifically related to the car's cockpit design as a woman?
4. What measures or features make you feel more secure and confident while driving being a woman?
5. Are there any specific aspects of the car's cockpit design that affect your comfort negatively as a woman?
6. Are there any adjustments or features you'd like to see that would enhance your driving experience?
7. How important are personalization and aesthetics in a car's cockpit for you? Do you prefer a specific color scheme, material, or interior design that reflects your style and preferences?
8. How would you like to see these aspects integrated into the intelligent cockpit design?
9. Are there any tasks or actions that you find difficult or uncomfortable to perform while driving or riding in a car as a woman?
10. Can you describe a time when you felt unsafe or uncomfortable while being in a car as a woman? What caused that feeling?
11. How do you typically interact with the dashboard, controls, and displays in a car? Are there any features or designs that you find confusing or difficult to use?
12. How does it empower you being a woman in a car?
13. What features do you think can be added in cars that will benefit you as a woman?
14. Do you have any final thoughts or suggestions you would like to share?