Guest editorial

New frontiers in comfort research: Integrating human needs and design in future mobility

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Abstract

Comfort is a pivotal construct in human-centered design, connecting technical functionality with well-being across products, services, and systems. The 2023 International Comfort Congress (ICC2023) brought together researchers and practitioners to explore how new contexts of use, predictive approaches, and user diversity are reshaping this field. Contributions in this special issue address comfort in automated driving and turboprop aviation, where physical, psychological, and environmental factors converge. Advances in predictive comfort science demonstrate how objective measures, physiological sensing, and modeling complement traditional self-reports. At the same time, inclusive design approaches—ranging from XR-based co-creation to analyses of posture and movement variability—highlight the importance of accounting for heterogeneous user needs and comfort trade-offs. Together, these studies illustrate a shift toward more adaptive, accessible, and sustainable systems, underscoring comfort as a multidimensional construct that evolves with technological innovation and societal change.

Keywords

comfort research, human-centered design, predictive modeling, automated driving, accessibility, user diversity

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Comfort remains a central concern in designing and evaluating human experiences across products, services, and systems. From early ergonomics research to today's innovations in transportation, workplace design, manufacturing plants and digital ecosystems, comfort has consistently served as a bridge between engineering functionality and human well-being. However, comfort cannot be defined in isolation. It is not merely a property of a product; rather, it is an experience shaped through interaction and judged by the user.[1] This user-centered perspective has given rise to a growing body of theoretical models, including those by de Looze et al.,[2] Vink and Hallbeck,[3] Naddeo et al.,[4] and Mansfield et al.,[1] which continue to shape and evolve the field.

Building on this knowledge foundation, the 2023 International Comfort Congress (ICC2023), following the momentum of the Salerno Congress in 2017, the Delft Congress in 2019, and the Nottingham Congress in 2021, was held in the vibrant city of Amberg, Germany. This special section captures insights from the conference, reflecting on how new contexts of use and predictive approaches are converging with user diversity to shape the future of comfort research.

Humans in the emerging contexts of use

ICC2023 was convened at a time of transformation in how people engage with new contexts. While the physical design of products, such as seats, continues to evolve, it is the broader ecosystem of change, driven by advances in artificial intelligence and the growing demand for sustainability, that is now redefining comfort.

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One key area of focus is automated driving, where the gradual removal of driving responsibilities allows users to engage in non-driving-related activities (NDRAs),[5] such as working, relaxing, or socializing. This context demands new interior layouts to accommodate different postures and enable accessibility for a wide range of user groups, including persons with reduced mobility (PRMs) and other special populations. This is reflected in the paper "*Special Users with Special Needs in Autonomous Vehicles"* in this issue.[6] Beyond physical design factors, psychological aspects such as trust in the automated system are crucial. This dimension is represented by "*Dive into a trustworthy trip: Developing a multi-dimensional questionnaire to evaluate trust in autonomous vehicles"*.[7]

Another key area is the in-flight passenger experience. Environmental impacts have brought renewed focus to turboprop aircraft, which are expected to incorporate lower-emission and possibly hydrogen-powered technology.[8] Despite their advantages in reducing fuel usage, turboprops introduce new challenges such as limited space, cabin noise and vibration. Several contributions in this special section address these challenges, including noise cancellation strategies,[9] in-flight vibration exposure studies,[10] and predictive modeling of passenger comfort based on objective measurements.[11]

From measurement to modeling: advancing predictive comfort science

ICC2023 reflects the shift from traditional subjective assessments toward data-driven, predictive models of comfort. Several studies highlight how comfort can be measured with increasing precision using objective measurements and machine learning. For instance, Vanheusden and Ogilvie apply EEG and skin conductance to investigate how prolonged seating and task difficulty affect discomfort and stress in an eRacing simulation, revealing the potential of using physiological signals to track real-time comfort under demanding conditions.[12]

Meanwhile, in real-world aviation contexts, Song et al. propose a quantitative model of passenger comfort in turboprop aircraft.[11] By integrating anthropometric data, seat position, noise, and duration, the model achieves reliable prediction of comfort and discomfort trajectories across different passenger profiles. These insights are complemented by Mansfield et al., who provide empirical vibration data from actual flights, calling for revised comfort metrics that can better account for tonal vibration patterns unique to turboprops.[10]

Designing with diversity: trade-offs and posture

Comfort can no longer be considered in isolation from the diversity of users and their evolving roles in future mobility systems. ICC2023 featured several studies addressing how users manage discomfort and how design trade-offs influence perceived comfort.

Understanding posture and movement variability is essential. Kruithof et al. review in-chair movements (ICM), showing how users manage discomfort through dynamic posture changes.[13] They highlight inconsistencies in definitions and call for coherent methods that link movements to design, especially in long-duration contexts such as aviation and automated vehicles.

Attention to user diversity also informed research into comfort trade-offs. Eversdijk et al. examine how reclining seat backs affect perceived comfort and legroom, revealing no clear preference across users.[14] This underscores the subjective and context-dependent nature of seating comfort and the need for flexible solutions that accommodate different user expectations.

Together, these contributions reflect an integrated design approach, where methods and trade-offs evolve to serve a more heterogeneous user base—spanning age, gender, ability, posture, and use cases.

Envisioning the future of comfort research

The studies presented in this special section demonstrate how theoretical frameworks and applied research are coming together to create more responsive, accessible, and sustainable comfort systems. As comfort research expands into new domains, including autonomous vehicles and next-generation aircraft, technological developments such as real-time sensing, predictive modeling, and analyses of posture and movement are enabling systems to adapt dynamically to users' needs. These approaches not only enhance interaction but also make systems more accessible to PRMs. Meanwhile, the drive for sustainability is encouraging more creative and efficient design solutions, especially in areas like space use and material selection. Several contributions in this issue reflect this shift, emphasizing accessibility, psychological trust, and user diversity. These are essential steps toward broader acceptance and more equitable comfort experiences in future mobility systems.

We extend our sincere gratitude to the contributing authors, reviewers, and editorial team whose efforts made this special section possible. As the comfort research community continues to explore new frontiers, the intersection of technological innovation, societal development, and human empathy will remain essential. Together, we can turn today's challenges into tomorrow's opportunities, shaping a future of mobility where comfort, accessibility, sustainability, and technology progress together.

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