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DOI
10.1145/3581961.3609836

Publication date
2023

Document Version
Final published version

Published in
Proceedings of the 15th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI 2023

Citation (APA)
Pöhlmann, K. M. T., Al Taie, A. J. S., Li, G., Dam, A., Wang, Y. K., Wei, C. S., & Papaioannou, G. (2023). 2nd Workshop on Multimodal Motion Sickness Detection and Mitigation Methods for Car Journeys - Finding Consensus in the Field. In *Proceedings of the 15th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI 2023* (pp. 223-226). Association for Computing Machinery (ACM). https://doi.org/10.1145/3581961.3609836

2nd Workshop on Multimodal Motion Sickness Detection and Mitigation Methods for Car Journeys - Finding Consensus in the Field

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ABSTRACT

The adoption of automated vehicles will be a positive step towards road safety and environmental benefits. However, one major challenge that still exist is motion sickness. The move from drivers to passengers who will engage in non-driving related tasks as well as the potential change in the layout of the car interior that will come with automated vehicles are expected to result in a worsened experience of motion sickness. The previous workshop [18] highlighted the need for consensus on guidelines regarding study design for motion sickness research. Hence, this workshop will develop a guide for motion sickness research through reflection and discussions on the current methodologies used by experts in the field. Further it will build on the knowledge collected from the previous workshop and will thereby facilitate not only new research ideas and fruitful collaborations but also find a consensus in the field in regard to study design and methodologies.

CCS CONCEPTS

• **Human-centered computing** → **User studies**.

KEYWORDS

Motion Sickness; Comfort; Automated Vehicles; Mitigation; Detection

ACM Reference Format:
Katharina Pöhlmann, Ammar Al-Taie, Gang Li, Abhraneil Dam, Yu-Kai Wang, Chun-Shu Wei, and Georgios Papaioannou . 2023. 2nd Workshop on Multimodal Motion Sickness Detection and Mitigation Methods for Car Journeys - Finding Consensus in the Field. In *15th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '23 Adjunct), September 18–22, 2023, Ingolstadt, Germany*. ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3581961.3609836

AutomotiveUI '23 Adjunct, September 18–22, 2023, Ingolstadt, Germany

ACM ISBN 979-8-4007-0112-2/23/09.
https://doi.org/10.1145/3581961.3609836

1 INTRODUCTION

We spend large part of our lives travelling, such as commuting to and from work, as well as for longer journeys, such as holidays or visiting friends and family. With the introduction of automated vehicles (AVs) into our lives, drivers will turn into passengers allowing for not only a redesign of the car interior, but also opening up more free time for the now passengers to engage in non-driving related tasks (NDRTs; e.g. watching movies, reading, working). Passengers often experience a heightened sensation of motion sickness compared to drivers [23] and engaging in such NDRTs can further increase these adverse symptoms [3, 6]. Motion sickness results in a multitude of symptoms, such as, dizziness, sweating, headaches, drowsiness, nausea and in extreme cases vomiting [5]. Such symptoms, once experienced, often persist for the entire journey and are slow to diminish, with even mild symptoms negatively affecting passengers engagement in NDRTs [1, 20, 22], and in the worst case resulting in people having to terminate their journey prematurely. Highlighting the need for research that can successfully detect motion sickness symptoms and identify mitigation strategies that will ensure a comfortable travel experience of AV occupants.

Motion sickness research spans across a multitude of domains, which is why it is not surprising that the methodologies used vary strongly (e.g. [13, 17, 19]). The length of conditions can vary between a few minutes up to over half an hour, with all experimental conditions being performed on the same day, or in separate sessions [19, 21]. The tasks that are being performed while immersed in the sickness inducing environment include anything from simple counting tasks, to reading tasks, and even video games [7, 10, 15, 19, 24].

Studies are being performed on motion simulators in the lab with varying motion profiles, in AVs on test tracks, and even in cars in everyday traffic [2, 9, 10, 19, 21]. However, not only does the way motion sickness is induced vary strongly between studies, but also the way it is measured. Various types of subjective and objective measures, from questionnaires to physiological sensors, are employed to measures the passengers sensation of motion sickness. In addition to the measures being inconsistent between studies, the way a specific measure can be employed also often varies from study to study. Mitigation methods also vary strongly between studies, they are generally either passenger- or vehicle-centric. Motion sickness can for example be reduced by optimising the velocity or acceleration profile of the vehicle [8, 12] or by optimising seat configurations [11, 16] but can also be mitigated independent of the type of car journey by manipulating the sensory information the passenger perceives during their journey (e.g., visual input through a virtual reality headset or a displays placed in the car interior) [2, 4, 14]. This strong variation in the methodologies makes it often impossible to compare findings of different studies with each other, and can impede the process of designing a successful motion sickness study. This highlights the need for clear guidelines on how to design a motion sickness study.

This workshop will bring together experts in the field of motion sickness who will discuss the methodologies used in their own work, highlighting the benefits and disadvantages of each. These discussions will form the basis to finding consensus in the field, and providing well-informed guidelines for researchers allowing them to easily design research studies that are not only more reliable in their nature, but also more easily replicable, and allow for easy comparison between findings of different groups. At the same time this workshop will strengthen the multi-disciplinary motion-sickness community by bringing together researchers from Automotive, Neuroscience, Human-Computer-Interaction, Psychology and others.

2 WORKSHOP GOALS

This workshop will build on the goals defined in the previous workshop [18], (1) highlighting the need for motion sickness research in the future of AVs, (2) strengthen the community of motion sickness researchers by facilitating collaboration across research domains, institutions and industry to further contribute to the success ad progression in the field, and most pressingly (3) this workshop will form the basis for a consensus in the research field regarding methodologies used and will aid the development of guidelines for motion sickness researches to improve and speed up the design stage of research studies allow for direct comparison between studies between research groups and allow for easy replication of findings. In this workshop the organisers will bring together members of the AutoUI community and beyond as well as researchers from the industry with a background in motion sickness research.

First, the workshop organisers will introduce the topic and aim of the workshop to participants; they will give a quick overview of the outcomes of the previous workshop which inspired the focus of the current. Following, participants that chose to submit a short abstract prior to the workshop will present the methodologies used in their current studies. This will build a foundation and common knowledge for the discussions later on in the workshop, which are expected to identify advantages and disadvantages of commonly used methods in the field and find a consensus of what methods are best suited depending on the aim on focus of each study.

The workshop will build the foundation of a shared review paper as well as guidelines that will help researches conduct the most successful work bringing us one step closer to solving motion sickness in AVs.

3 WORKSHOP OVERVIEW AND TENTATIVE SCHEDULE

This workshop will include participant presentations focusing on the methodologies used in their motion sickness studies, group discussion on benefits and disadvantages of different methodologies used in motion sickness research as well as a keynote. The workshop will last 3 1/2 hours with a 20 min break. Participants will leave this workshop with a broader knowledge of the current methods used in motion sickness research, their individual benefits and recommended use settings as well as new collaborators that will help advance the motion sickness research field even further. Participants will be able to submit their own work by submitting short abstracts prior to the workshop with some of them being selected by organisers for presentation. Submission of such short abstracts is, however not mandatory to participate in the workshop. A main goal of the workshop is to discuss the current methodologies used in motion sickness research, discuss the study design, the measures used and the tasks performed by users. Based on these discussions, we aim to find consensus in the these methods that will allow for better replication and comparability of motion sickness research. We are expecting around 30 participants to take part in this workshop.

3.1 During the Workshop

At the beginning of the workshop, organisers will introduce themselves as well as the aims of the workshop; additionally, a short summary of the findings from the first workshop will be provided to participants who did not attend it. This will be followed by participant presentations and short Q&A sessions. These presentations will focus on providing an overview of the current methodologies used in motion sickness research and the Q&A sessions will not only allow participants to ask questions but also to discuss their own methodologies used; this will motivate engagement of all participants and will guide further discussions later on in the session. After the presentations, a short introduction to the aim of the group discussions will be given. The discussions will focus on the methodologies used in motion sickness research with the main aim being to find a consensus in the field that can guide future study designs. This is done to give participants the chance to contribute to the topics that will be discussed and to allow them to make a decision regarding which group discussion they want to participate in. These topics will include but are not limited to:

(1) The NDRTs chosen
(2) The motion profiles chosen to induce motion sickness
(3) The measurements chosen to detect motion sickness and how and when they are being applied

Timeline	
Before Workshop	**During Workshop**
Submission of short abstracts by participants to present at the Workshop	Introduction of Organisers (10 min) Introduction to the Workshop and Workshop goals (10 min) Pre-selected Participant Presentations (30 min) Introduction to Discussion Topics and forming smaller Discussion Groups (30 min) **Break (20 min)** Group Discussions (40min) Final Discussion in entire Group and Group Presentations (40 min) Keynote (30 min)

Table 1: Workshop Timeline

(4) The interpertabilty of findings based on different motion sickness theories (such as sensory-conflict or postural instability theory)
(5) Passenger-centric vs. vehicle-centeric methodologies
(6) Potential differences between carsickness and simulator sickness

Following, a 20 min break is planed to allow organisers and participants to recuperate before the second half of the workshop. The second half of the workshop will focus on group activities, discussing the current methodologies used in motion sickness research an possible ways to find a consensus in the field. Participants will form groups to discuss their chosen topic. Each sub-group will focus on one part of the methodology identified earlier on in the session. The subgroups will also prepare short presentations about the outcome of their discussions. After the discussions in the smaller groups have finished the entire workshop will come back together for a final discussion allowing each group to present their outcomes and initiate further discussion of those with all participants. This final group discussion will summarise the outcomes of the workshop, which will guide and improve future motion sickness research. The workshop will conclude with a keynote by a leading motion sickness researcher.

4 WORKSHOP OUTCOMES

Based on the outcome of the first workshop, the organisers predict that this workshop will facilitate even more fruitful collaborations between attendees and organisers, and will be the basis of finding a consensus in the research field regarding the methodologies used and design choices made when designing motion sickness studies. Our overall goal is to allow for motion sickness free travel of all occupants of AVs and make their journey as comfortable and pleasant as possible. Furthermore, we expect the outcomes of both this workshop and the previous one to result in an overview paper on currently used detection and mitigation methods for motion sickness in AVs as well as form the basis for a guide that will help researcher chose the most suitable methodologies and study designs for the motion sickness research.

5 AUTHOR BIOGRAPHIES

Katharina Pöhlmann is a Post-doctoral Researcher Fellow at the KITE Rehabilitation Institute in Toronto and is an affiliate researcher at the University of Glasgow working on the ViAjeRo project (https://viajero-project.org/). She earned her PhD in Psychology at the University of Lincoln. Her research focuses on using multisensory motion cues to reduce motion sickness.
Ammar Al-Taie is a PhD student in the School of Computing Science at the University of Glasgow. His area of research is Autonomous Vehicle-Cyclist interaction. This often involves utilising unconventional technologies, such as new displays on the car's exterior. Ammar is a "hands-on" researcher; most of his work is conducted in real-world settings using new technologies such as eye-tracking. **Gang Li** holds a PhD in Electronic Engineering from Pukyong National University, South Korea. Gang's expertise is the design and implementation of the closed-loop EEG-based brain-machine interface system coupled with brain stimulation (tDCS/tACS) techniques. He is a research associate of translational neuroscience leading a VR motion sickness mitigation project funded by the UK Medical Research Council.
Abhraneil Dam is a third year PhD candidate at the Mind Music Machine Lab in Virginia Tech. Abhraneil is conducting research on the topic of motion sickness in passengers of AVs as his dissertation work; he also worked on the topics of audio augmented reality, and safety of distracted pedestrians at unsignalized crosswalks. Prior to his PhD program, he earned his MSE degree in Automotive Systems Engineering from the University of Michigan-Dearborn.
Yu-Kai Wang is currently a Senior Lecturer and core member of the Australia Artificial Intelligence Institute within the Faculty of Engineering and Information Technology at University of Technology Sydney, Australia. His current research interests include computational neuroscience, human performance modelling, artificial intelligence, brain-computer interface and human-AI teaming.
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ACKNOWLEDGMENTS

The opinions and conclusion of this announcement and the workshop are not necessarily those of the associated organisations. This research is sponsored by European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 835197).

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