Goldsmiths
UNIVERSITY OF LONDON

User Experience Engineering

Academic Supervisors : Nicolas Hine

Guanqun Hou
33751736

Exploring the performance of different displays presenting driving information and the degree of visual distraction

Abstract

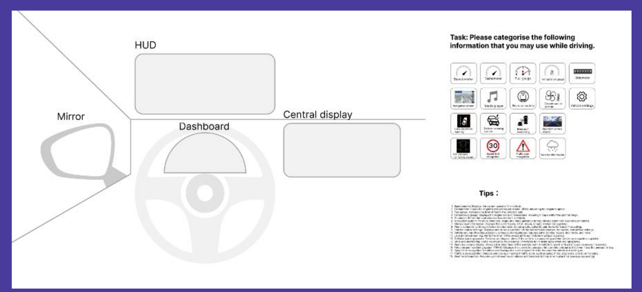
The purpose of this study was to investigate the performance of different displays presenting driving information and the degree of visual distraction.The study utilized a mixed-method approach of qualitative and quantitative analyses, with data collected through a card sorting test, an eye tracker, and biosensors to collect a large amount of data. The results showed that the HUD and the center control had the best ability to present information, while the right mirror had the worst ability to present information and was almost unusable. In addition, I found that the center control and dashboard lead to the most number of sweeps and the longest visual dwell time, which can easily cause driving distraction. This study enriches the research on in-vehicle information systems in terms of driver information presentation and provides insights into the design of in-vehicle information.

Introduction

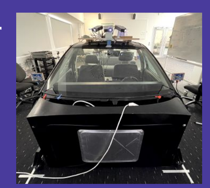
Driving is a complex task that requires physical, sensory, mental and cognitive synergy from the driver. Therefore, the design of in-cab information display systems is critical to safety, comfort and driving experience. With the development of Advanced Driver Assistance Systems (ADAS), in-vehicle functionality is increasing and information displays are evolving from traditional mechanical instrument clusters to digital display systems such as dashboards, center screens, HUDs, and mirrors. These designs affect the driver's ability to access information such as vehicle status, navigation, and entertainment. However, distraction may reduce driving safety when accessing multiple pieces of information. Based on human-computer interaction, cognitive psychology and ergonomics, this study explores the relationship between the design of the information display area and the efficiency of information transfer, driver distraction, and analyzes its effect on cognitive load. It aims to reveal the effects of information display methods on driver behavior and performance under different information types, in order to gain insights into the advantages and disadvantages of cab information display design. This study is expected to provide guidance for improving driving safety and experience.

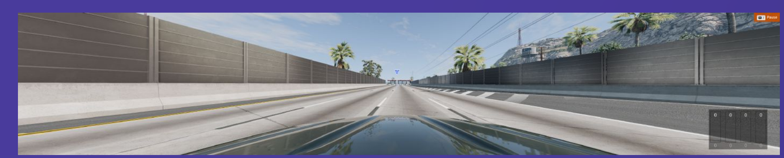
Diagram

Card sorting



Car Simulator

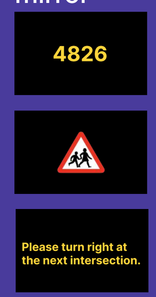




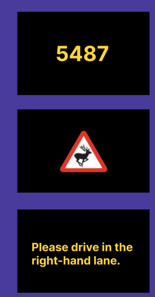
Simulator screen

HUD

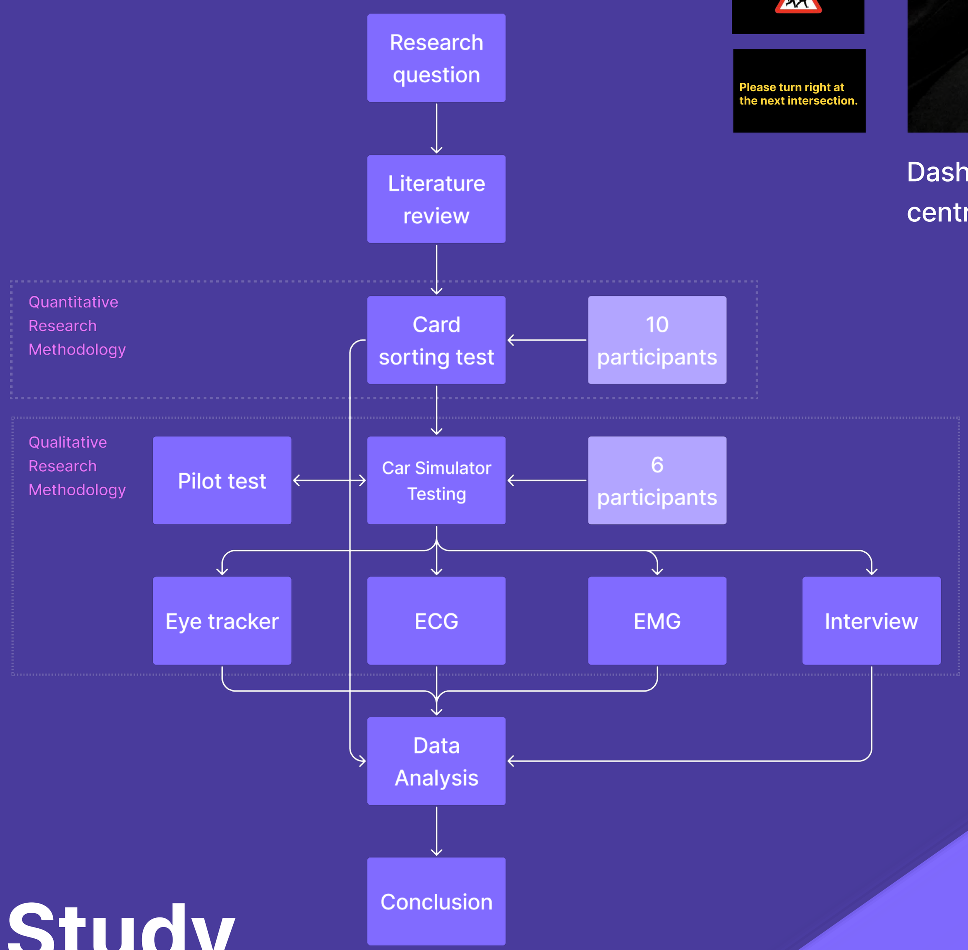
Left mirror



Right mirror

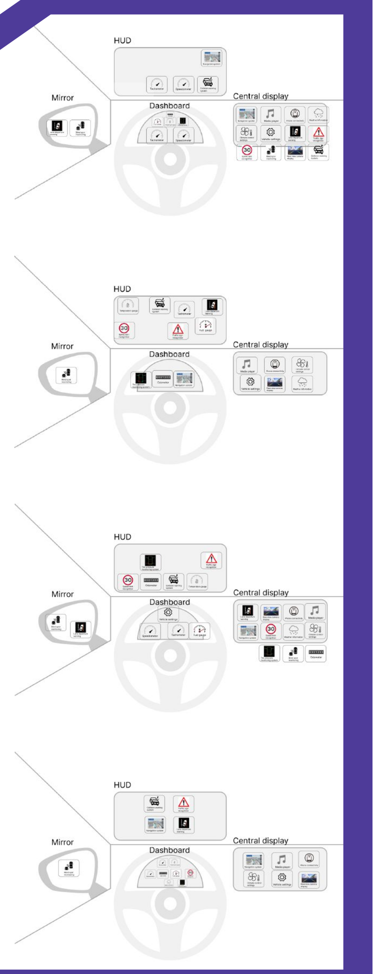


Dashboard & central control



Study Methodology

Test sample



Testing & Evaluation

1 This test simulated a 2D view of the driver's seat and divided the categorized areas into HUD, dashboard, center console and one side mirror. Eighteen pieces of common driving information were used as cards. Participants were required to categorize these cards into 4 display areas.

2 Participants will drive normally in a driving simulator, five displays will randomly drop three different types of information (number, image, text), and participants need to talk about what they see, during this process, Eye tracker, ECG and EMG will also record the participant's vision changes and bioelectrical signals at the same time.

The results matrix

	HUD	Dashboard	Central display	Mirror	unsorted
Speedometer	6	4			
Tachometer	1	9			
Fuel gauge	3	7			
Temperature gauge	2	5	3		
Odometer	1	6	3		
Navigation system	7	1	2		
Media player information	1		9		
Phone connectivity	1		9		
Climate control settings			10		
Vehicle settings		2	8		
Lane departure warning	6	1		3	
Collision warning system	6	1		3	
Blind spot monitoring	2			8	
Rearview camera display	1		7	2	
Tire pressure monitoring system (...	1	6	2	1	
Speed limit recognition	7	2	1		
Traffic sign recognition	8	1	1		
Weather information	1	1	8		

Research Results

Card sorting analysis

From the Results Matrix (right), it can be seen that the center control is the area that carries the most information messages (63), followed by the HUD (54) with the dashboard (46), and the mirror carries the least information (17). In terms of the type of information, although the center control carries the most information, it is mostly information that is not directly related to driving safety, such as multimedia and temperature adjustment. Instead, users chose to put most of the information directly related to driving safety in the HUD, such as speed, warning alerts, and so on. The instrument panel carries most of the information that does not require the user's constant attention during normal driving, such as odometer, fuel level, etc. The mirrors carry very little information and only a few warning messages, the largest percentage of which is blind spot monitoring.

Correct rate analysis

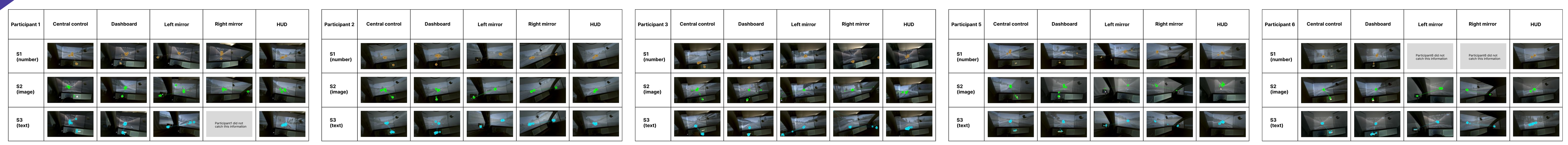
	Total	True	False	Miss	Correct rate
Central control	18	18	0	0	100%
Dashboard	18	15	3	0	83.33%
Left mirror	18	16	1	1	88.89%
Right mirror	18	13	1	4	72.22%
HUD	18	18	0	0	100%

	Total	True	False	Miss	Correct rate
S1 (number)	30	27	1	2	90%
S2 (image)	30	30	0	0	100%
S3 (text)	30	23	4	3	76.67%

Comparing displays, HUD and center console performed best with 100% accuracy across 18 messages for all 6 testers. The LEFT mirror and dashboard followed at 88.89% and 83.33% respectively, with few errors. RIGHT MIRROR scored lowest, at 72.22%, misreading 1 message and missing 4. Regarding information types, graphics achieved 100% accuracy, numbers scored 90%, and text performed least at 76.67%, with 4 inaccuracies and 3 omissions.

After tracking and analyzing the incorrect or missing information, it was found that the RIGHT mirror performed extremely poorly in presenting the TEXT information. 3 out of 6 participants missed this information, 1 did not accurately understand the meaning of the information, and only 2 accessed it correctly, which is only 33.33% correct. However, the left mirror performed much better than the right mirror, with only one participant answering incorrectly and no information missed in the presentation of text information. It is hypothesized that the reason for this is that the left mirror is closer to the driver, which reduces visual eccentricity. The information appeared closer to the driver's central field of view, compared to the poor performance of the right mirror, which was farther away and had a higher visual eccentricity. In addition, the dashboard performed poorly, with one numeric message and two text messages answered incorrectly, although no messages were missed. Or because it is the closest display to the driver, close to the driver's visual center. During normal driving, the driver's focus is in the distance, and suddenly turning to the dashboard requires adjusting the focus, which may result in not being able to recognize the information clearly when scanning, and thus answering incorrectly.

Eye tracker analysis



In the eye-tracker data analysis, I intercepted the visual movements of 6 participants who acquired 3 different types of information in 5 different displays, totaling 90 visual movements, and generated a visual kinematic map of each visual activity. It presents the participants' visual motions, visual dwell positions, and the amount of visual allocation. In the end, out of the six groups of participants, a total of five sets of complete and valid data were collected.

In the scan path map, the more sweeping, the higher the number of circles, and the longer the visual dwell time, the bigger the circles. From the analysis of the laws of different information types, the text type of information leads to longer visual dwell time than number information and image information. The shortest visual dwell time is for image information, most users can get the image information only by one sweep. Number information is second only to image information, which also does not lead to long visual dwell time. From the analysis of the pattern of different displays, the longest scanning and visual dwell time is in the center control and dashboard, followed by the HUD. Left mirror and right mirror account for very little scanning and visual dwell time compared to other displays.

ECG EMG analysis

In the biosensor, the data of 6 participants were complete and valid. However, the data in both ECG and EMG fluctuated and undulated more smoothly and did not change much, as shown in the figure. Only in EMG it can be seen that when the participant went to the right rearview mirror, a slight fluctuation ups and downs were recorded.

Conclusions

1. The HUD and center control have the best information presentation capabilities, the right mirror has the worst information presentation capabilities and is almost unusable.
2. The center control and dashboard will lead to the most number of sweeps and the longest visual dwell time, which will easily cause driving distraction.
3. Image information is easier to be acquired and understood by drivers in the driving environment, followed by digital information, text type information will acquire more attention and lead to driving distraction.
4. In normal driving behavior, the driver will not be nervous and other psychological pressure when acquiring information from various displays.
5. With the exception of the right mirror, the driver can only move his/her eyes to see all the information on all the displays without having to turn his/her head.

Limitation & Future Work

1. The sample size is small and the results may be biased due to the personal habits of the participants.
2. Driving simulators are somewhat different from real driving, and conclusions may differ from real driving situations.
3. This study only explored the visual distraction of driving, and could be expanded in the future to explore other distraction situations such as auditory distraction and cognitive distraction.