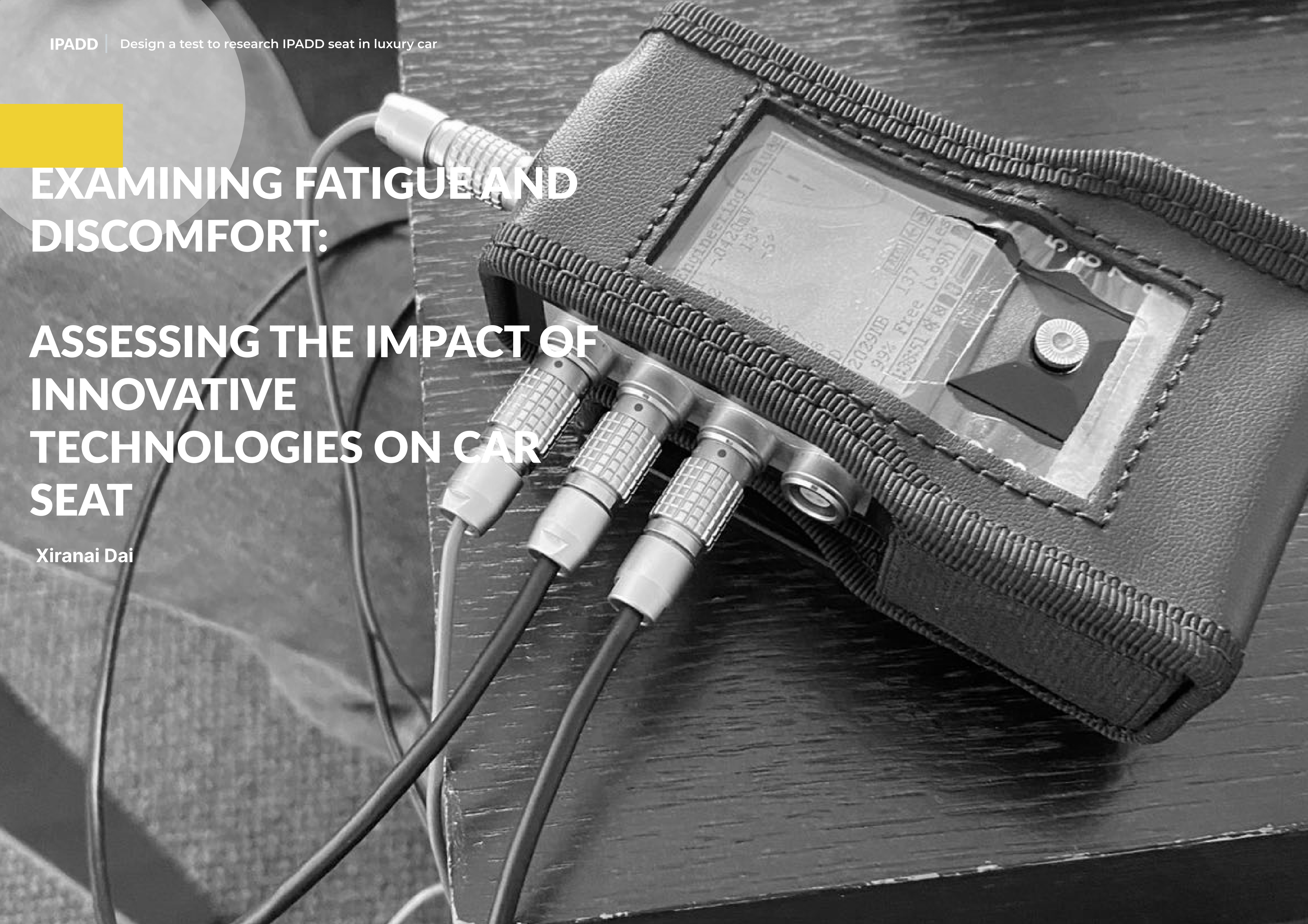

EXAMINING FATIGUE AND DISCOMFORT:

ASSESSING THE IMPACT OF INNOVATIVE TECHNOLOGIES ON CAR SEAT

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FORWORD

With the collaborative effort of numerous individuals, the culmination of this project has been made possible. The collective experiences shared throughout its duration have undoubtedly contributed to its evolution. This endeavor has served as a pivotal opportunity for me to assume the role of a researcher, granting me a wealth of invaluable experiences.

I extend my sincerest gratitude to Professor Vink, whose unwavering guidance and encouragement propelled me through this journey of exploration. Additionally, I am indebted to my mentor, Xinhe Yao, for offering me invaluable insights and constructive critiques that steered me towards the path of excellence.

The perspectives provided by Wim and Marco have proven to be instrumental in shaping the formulation of the project's progress. Their contributions have added layers of depth and refinement to the overall endeavor.

Lastly, I wish to express my heartfelt appreciation to my brother and Ahmin, whose unwavering support has been a constant source of motivation.

Summary

qumulus smart seating technology

ZIT werk

spark

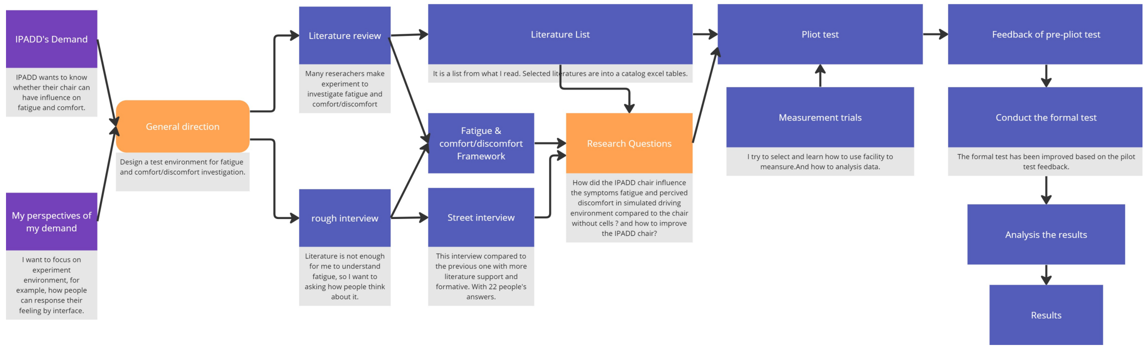
SUMMARY

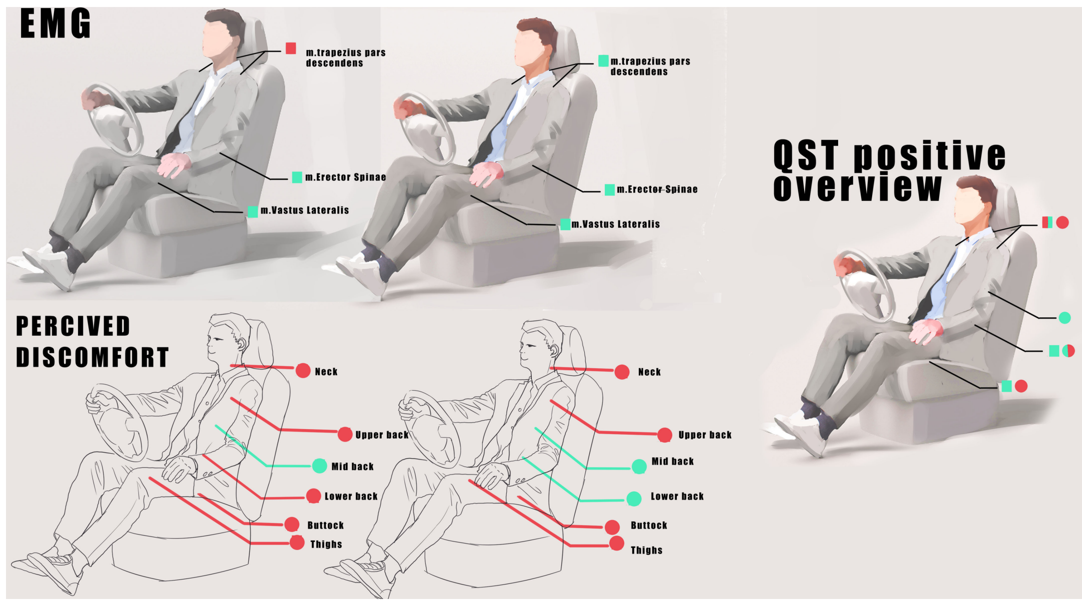
The objective of this project is to examine the effects of new technology in car seats on fatigue and discomfort. The first step involves defining the fatigue framework and selecting an appropriate assessment method. Since different studies suggest that the definition of fatigue can vary in different situations, a street interview was conducted to explore the type of fatigue relevant to the context of this project. The literature review and street interviews indicated subjective measurements of fatigue, including sleepiness, sore limbs, backaches, headaches, numbness, and stiff muscles. The objective measurements include Electromyography and Heart Rate Variability.

A pilot test was conducted which revealed certain drawbacks in the testing process. Subsequently, these issues were addressed in the formal test. The Visual Analogue Scale (VAS) form was introduced to assess discomfort in local muscles, comfort, and fatigue symptoms, in addition to the subjective measurements. Leg circumference was also measured to indicate blood flow.

The formal test took place over 150 minutes per person in Rotterdam, with 16 participants. Data were recorded while participants were seated in the chairs.

The data analysis indicates a clear conclusion regarding the evaluation of the seats: the technology integrated into the seats demonstrates a positive effect on fatigue and perceived discomfort in the shoulder, mid, and leg regions, as evidenced by EMG and VAS discomfort scores.





1 PROJECT OVERVIEW

The chapter describes the general background of the project, the individuals involved, the product being developed, and the project's overview workflow.

1.1 PROJECT BACKGROUND

The Qumulus Smart Seat Group has integrated cutting-edge technology into a car seat. The team is intrigued by its potential. (Figure 1).

The Cumulus Smart Seat group has integrated cutting-edge technology into a chair with the intention of testing the effect a car seat. Given that this chair represents an innovative invention, the team is intrigued by its potential impact on fatigue, comfort, and discomfort levels within the driving environment.

Figure 1: Qumulus Smart Seating Technology website

1.2 STAFF INTRODUCTION

Different parties involved in this project, so it is necessary to introduce the structure of the project group to facilitate the explanation of subsequent steps. As mentioned, the initial team involved in this project consists of Qumulus Smart Seating Technology, represented by Wim Tinke and Marco Pieterse. Spark Design & Innovation has been hired by Qumulus Smart Seating Technology to incorporate the chair into a luxury car.

Michel van Schie (Figure 2) served as the key liaison among the three stakeholders. I was affiliated with TUDelft and hold a research role in this project. Since the innovation device had not yet been assembled before June 2023. I had to wait for Spark Design & Innovation to complete the process. Once the chair was ready, I could conduct tests to assess how it influences fatigue and (dis)comfort, providing Qumulus Smart Seating Technology with a comprehensive report.

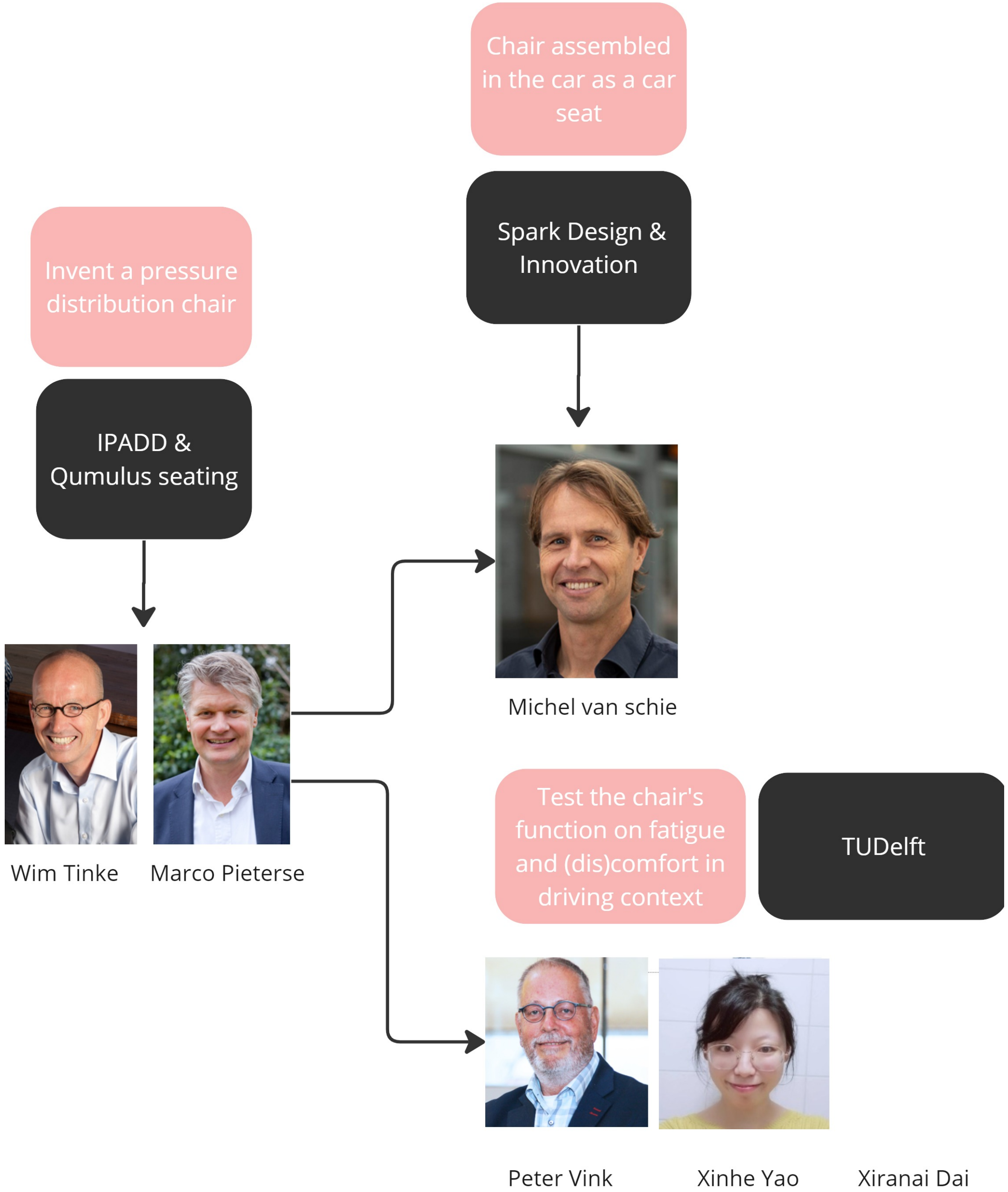


Figure 2 shows the staff members who are involved in the project.

1.3 STAFF INTRODUCTION

The primary focus of this project is the innovative chair, which incorporates 'cells' on the buttock and backside areas (Figure 3). These 'cells' have the capability to adjust the height creating small areas areas of force on the buttock, and mid back. These cells can change the pressure and modify the shape of the seat surface.

When a driver spends an extended period of time sitting on the chair, the 'cells' are automatically controlled by the car's internal system, making the adjustments imperceptible to the driver. It is important to note that the movement of these 'cells' should involve micro adjustments which is different from a traditional massage chair.

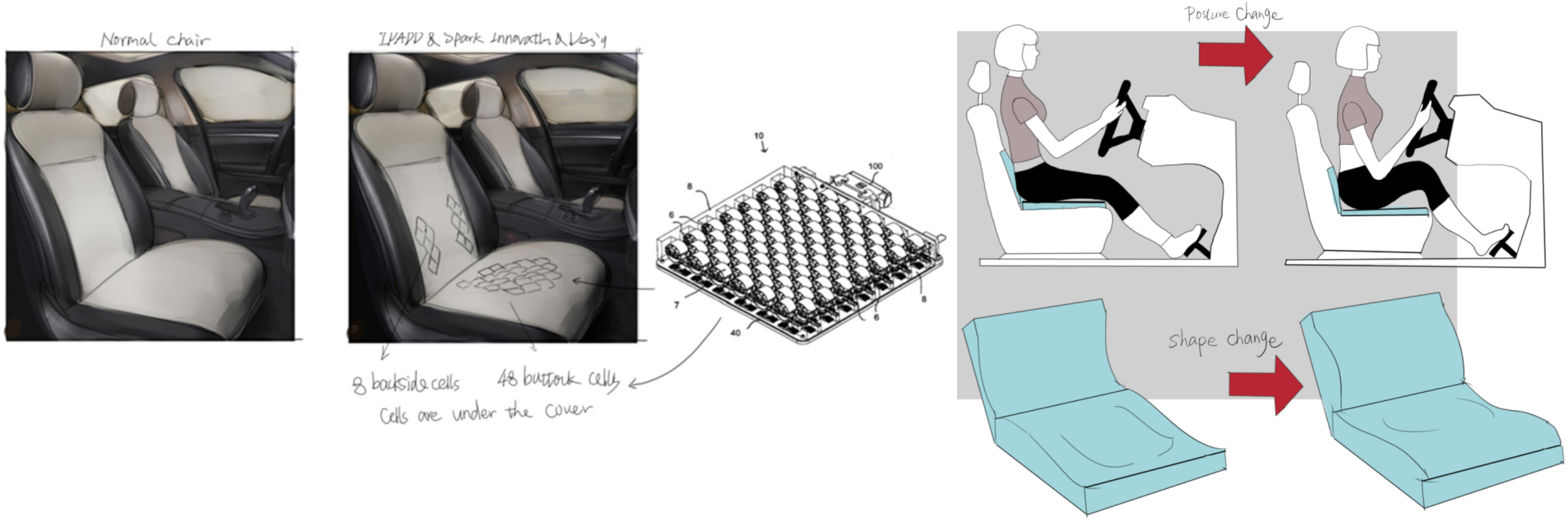


**Figure 3: Left side: normal chair
right side: Qumulus Smart Seating Technology's ideal car seat**

1 PROJECT OVERVIEW

1.3 PROCESS INTRODUCATION

Figure 4 provides an overview of the current process. The overall direction of the project combines IPADD's requirements with my perspective on the graduation project, which results on focusing on testing the user experience of Qumulus Smart Seat in scientific way. The research question is as follows: How does the IPADD chair, compared to the chair without Qumulus Seating technology (QSt), influence the symptoms of fatigue and perceived discomfort in a simulated driving environment?

The research question can be further divided into the following sub-questions:

1. What is fatigue?
2. How can fatigue be measured?
3. How can be (dis)comfort measured?
4. How can a scientific comparison be conducted between the QST seat and a regular seat in terms of (Dis)comfort and fatigue?

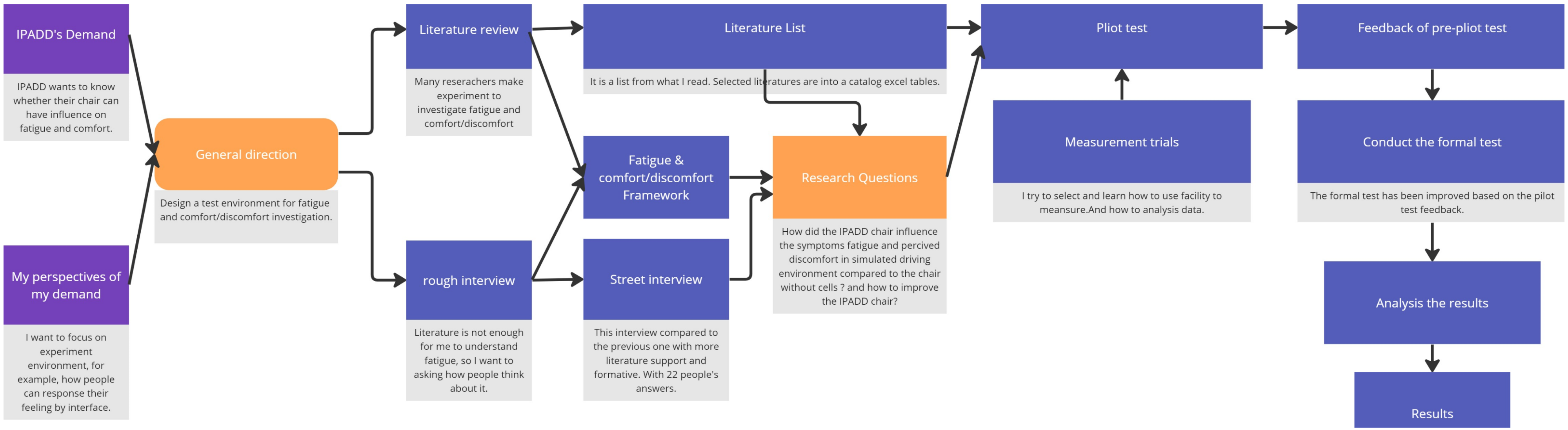


Figure 4: The process of IPADD project

1 PROJECT OVERVIEW

To address these questions, literature reviews are necessary to help gaining a deeper understanding of fatigue and (dis)comfort. There is a multitude of papers available on these topics, which can provide insights into how most researchers approach the subject. However, it is important to note that simply relying on existing research may not align perfectly with our project. Therefore, conducting interviews with individuals is chosen to gain insights in the fatigue experience in order to understand their firsthand experiences in driving conditions. These interviews yield valuable insights that assist in subsequent steps, such as developing a fatigue framework and determining appropriate measurements. The following chapter will explain these steps in detail.

2 REFINING FATIGUE & (DIS)COMFORT

2.1. FRAMEWORK OF FATIGUE AND (DIS)COMFORT

Nowadays, road accidents frequently occur as a result of driver fatigue, with drivers often experiencing drowsiness leading to accidents (Horne and Reyner, 1995; Pack et al., 1995). Despite their efforts to combat fatigue, drivers often find themselves unsuccessful to keep awake (Horne and Reyner, 1995; Pack et al., 1995). The existence of multiple definitions of fatigue across different domains complicates the situation (Hjollund et al., 2007). Therefore, in the context of the IPADD project, it becomes crucial to first establish a clear understanding of what fatigue entails.

This chapter focuses on the development of the fatigue framework for the IPADD project (Figure 5). To begin, it is crucial to establish a comprehensive understanding of fatigue. At this stage, the definition of fatigue can be initially broad and encompassing. However, the definition of (dis)comfort is clear and has enough evidences from pervious studies.

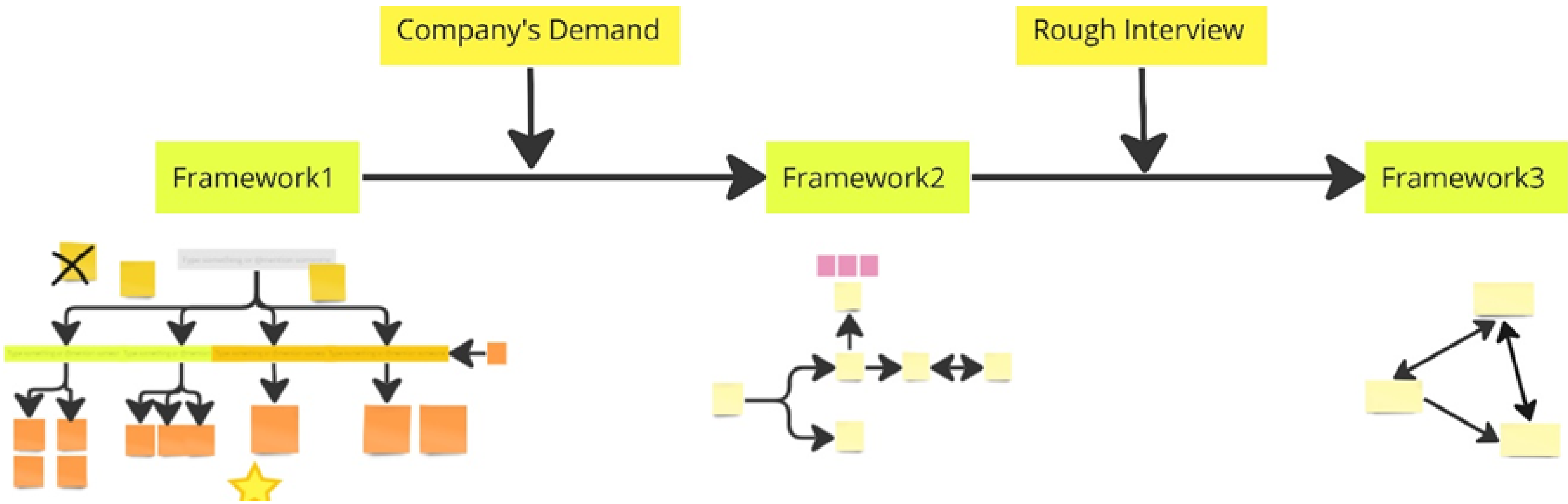


Figure 5 Progress of updating the fatigue framework

2 REFINING FATIGUE & (DIS)COMFORT

Considering the De Looze (2003) model (Figure 6), the definition of (dis)comfort becomes evident, with the product, the human, and the environment identified as key influencers. Previous studies indicate that discomfort primarily relates to the physical state, characterized by sensations of soreness and pain (Zhang, 1996; Helander and Zhang, 1997; Helander, 2003).

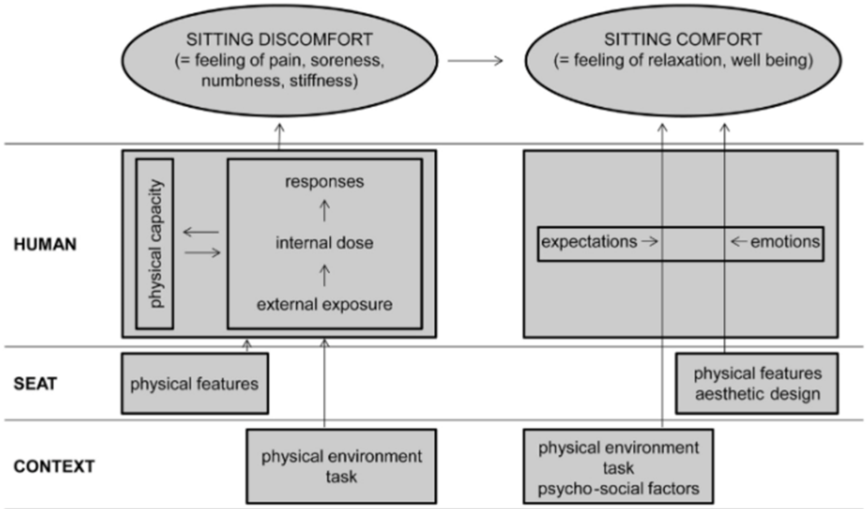


Figure 6 Models of Comfort and Discomfort of De Looze et al.(2003)

2.1 FRAMEWORK 1

A fatigue framework (Behrens, M., Gube, M., Chaabene, H., Prieske, O., Zenon, A., Broscheid, K., Schega, L., Husmann, F., & Weippert, M., 2022) was discovered and utilized to develop the framework for the IPADD project (Figure 7). The paper provides a comprehensive explanation of fatigue, dividing it into two general components: trait and state fatigue.

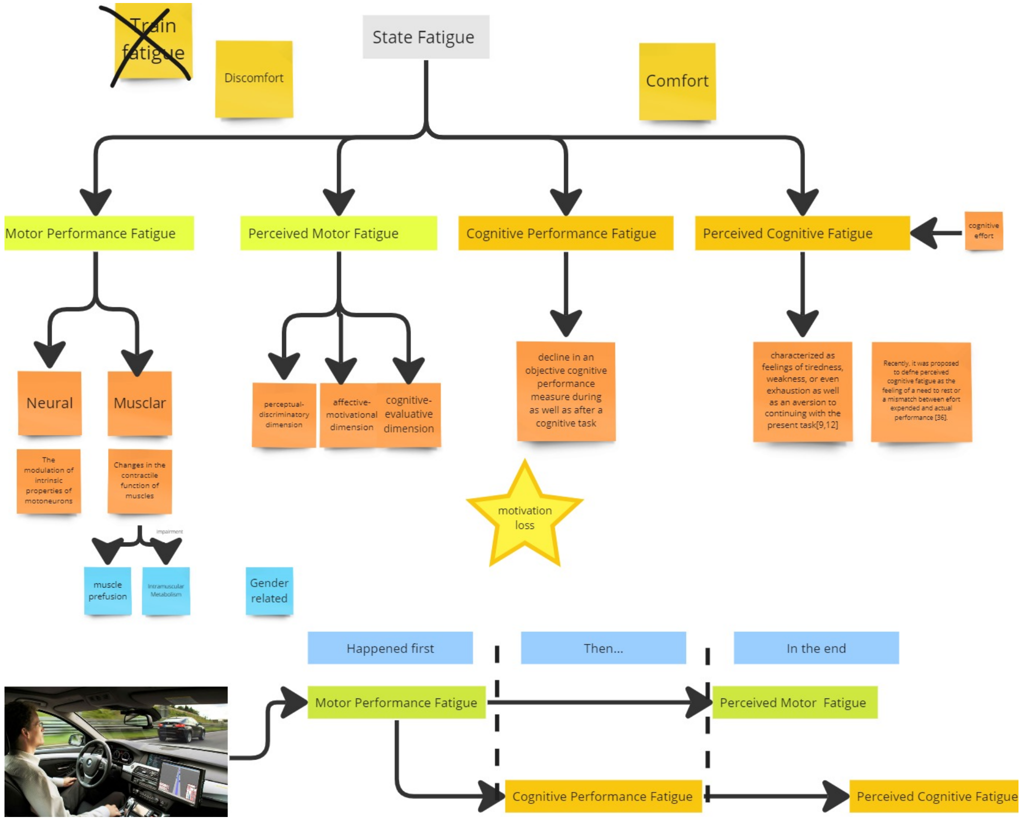


Figure 7 The Framework from Fatigue and Human Performance: An Updated Framework

2 REFINING FATIGUE & (DIS)COMFORT

Trait fatigue primarily stems from pathological factors, such as fever or other illnesses, and is typically experienced over an extended period (e.g., weeks or months). On the other hand, state fatigue is the primary focus of the IPADD project, representing a temporary change in human functioning. Figure 7 illustrates four sub-definitions within the realm of state fatigue: motor performance fatigue, perceived motor fatigue, cognitive performance fatigue, and perceived cognitive fatigue.

Motor fatigue, also known as muscle or neuromuscular fatigue, is traditionally associated with factors related to the musculoskeletal system. Cognitive fatigue, on the other hand, leads to decreased performance in cognitive tasks, including reaction time and other cognitive functions. These four types of fatigue are interconnected and may exhibit a sequential pattern in driving conditions. It is important to note that this project does not consider psychiatric disorders, disease symptoms, or treatment side effects. Additionally, the inclusion of all four types of fatigue may not be suitable for the scope of the project. Framework 2 aims to refine and narrow down the definition of fatigue within the IPADD project.

2.2 FRAMEWORK 2

Framework 2 (figure 8) shows the new perspectives on fatigue and (dis)comfort. The previous four definitions of fatigue merge into two, owing to the cause of car accidents. I shifted my perspective to the underlying issue, put the focus on car accidents, and identified two primary factors that cause them: fatigue and sleepiness (Davenne, D., Lericollais, R., Sagaspe, P., Taillard, J., Gauthier, A., Espié, S., & Philip, P. 2012b).

In this framework, physical as well as cognitive fatigue are subject of study(Davenne, D. et al. 2012). Physical fatigue is influenced by pressure distribution, muscle activity, and vertebral column curvature (De Looze et al., 2003). In some fields, fatigue is defined as feeling abnormally sleepy (Rahman, A., Hriday, M. B. H., & Khan, R. 2022) (Kocalevent, R., Hinz, A., Brähler, E., & Klapp, B. F. 2011). In this framework, vigilance decrement is regarded as cognitive fatigue. EEG is the primary method to investigate cognitive fatigue and detect vigilance.

However, in the article "Physical and cognitive consequence of fatigue: A Review" (Davenne et al., 2012) and in the study by Dittner, A., Wessely, S., & Brown, R. M. (2004), it was agreed that sleepiness and tiredness should not be considered as fatigue.

2 REFINING FATIGUE & (DIS)COMFORT

Besides, it has been challenging to establish a clear connection between fatigue and (dis)comfort thus far. However, there are commonalities between fatigue and (dis)comfort, particularly in terms of their symptoms (Wiker, S. et al., 1990). Wiker also concluded that there is a strong statistically significant intercorrelation within functional muscles.

As mentioned earlier, the current understanding of fatigue lacks clarity. Therefore, it is imperative to approach fatigue from another angle in order to gain a comprehensive understanding. Conducting interviews is used used in this study to redefine perspectives.

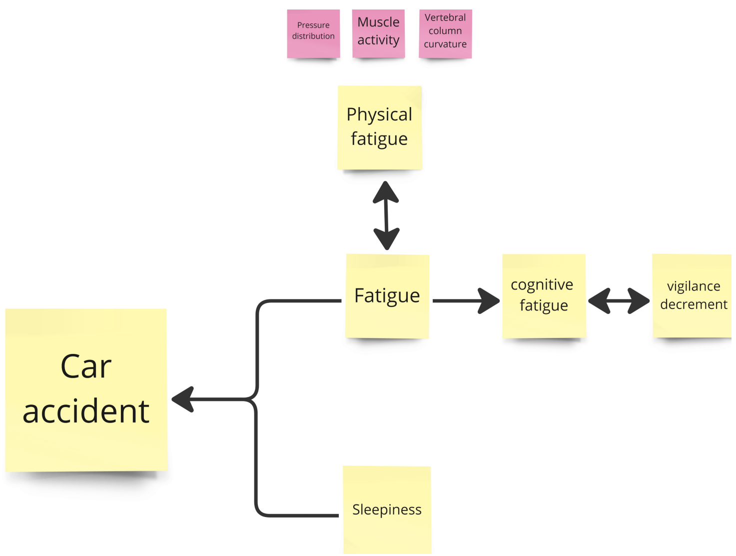


Figure 8 Framework 2

2.3 INTERVIEW

The literature review provides a limited perspective when it comes to understanding fatigue based on others' works. To supplement this, conducting interviews can offer valuable insights directly from drivers. The first interview was preliminary, while the second interview took place on the street.

A pre-street interview question list was prepared and can be found in Appendix II. Figure 9 displays the completed questionnaire, which was filled out by seven interviewees, providing valuable insights.

INSIGHTS FROM PRE-STREET INTERVIEW

1 One participant mentioned that the number of years of driving experience affects the duration of losing concentration. Less experienced drivers, lacking confidence, tend to stay nervous while driving, making them more prone to fatigue compared to experienced drivers.

2 Through careful observation of the interviewees' reactions and responses, it became evident that people use various symptoms to describe fatigue.

2 REFINING FATIGUE

2 Additionally, it was observed that individuals often unconsciously describe fatigue by referencing specific symptoms. This leads to the question of whether there exists a threshold at which individuals perceive and recognize fatigue.

3 Some questions were found to be less valuable and will be excluded in the next version of the interview. However, certain questions proved to be insightful, particularly those that explored the symptoms of fatigue in a chronological order. These questions helped shape perspectives and deepen our understanding.

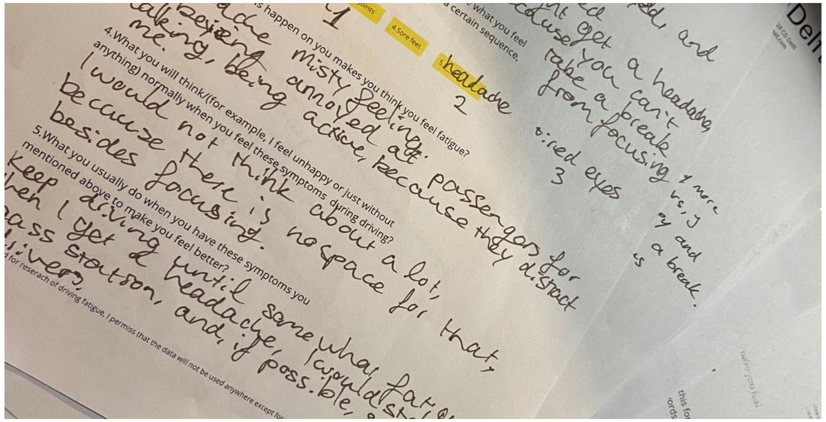


Figure 9: The street interview, the hand writing from participants

STREET INTERVIEW

Following the update of the previous questionnaire (Appendix II), a comprehensive structure (Appendix III) was formulated, incorporating relevant literature. This investigation was carried out through street interviews, university interviews, and online surveys.

As of 05/04/2023, a total of 22 individuals participated in the interviews, and the raw data can be found in Appendix V. From the analysis of the raw data, the following insights were derived:

1 The term "sleepiness" was the most frequently mentioned during the interviews.

According to the literature, sleepiness is identified as one of the contributing factors leading to road accidents.

2 The interviews revealed that individuals perceive sleepiness or a loss of concentration as a sign of their own fatigue.

Prior to conducting the interviews, it was my belief that individuals might not be able to clearly indicate when they feel fatigued.

2 REFINING FATIGUE

However, most interviewees were able to recognize and acknowledge their fatigue, leading them to stop driving. This self-awareness can serve as a fatigue threshold in my future research.

3 The interviews indicated that individuals tend to experience fatigue after approximately 2 hours of continuous driving.

4 Based on the interviews, it was found that 70% of individuals reported experiencing cognitive fatigue initially, while 30% reported experiencing physical fatigue first.

While I cannot definitively determine the exact factor responsible for the observed differences, I believe that the design of the chair may have a minor influence on the results. One valuable insight I gained from the interviews is the importance of understanding the sequence in which these fatigue symptoms manifest.

5 Participants reported that external stimuli have a refreshing effect on their fatigue levels.

Individuals tend to take certain actions when they perceive themselves to be fatigued. These actions can include singing a song, chewing gum, drinking coffee immediately, or simply enduring the fatigue for a short period of time.

2.4 FRAMEWORK 3

During the interviews, drivers described fatigue using symptoms such as sleepiness and soreness. The IPADD chair, designed by IPADD, aims to alleviate these fatigue symptoms by reducing the risk of pressure sore pain. Maintaining a static posture can decrease blood flow in local muscles (McGill, S. M., Hughson, R. L., & Parks, K., 2000). However, Bongers and Boshuizen (1990) demonstrated that seat vibrations could lead to neck, shoulder, and lumbar pain.

To determine if the IPADD chair's function is similar to that of seat vibrations, it is reasonable to focus on the fatigue symptoms. It is crucial to define which symptoms should be selected as measurable indicators. Nilsson, T., Nelson, T. R., & Carlson, D. R. (1997b) have provided a comprehensive list of all driving fatigue symptoms. Additionally, it has been discovered that these various symptoms exhibit different relationships with time and incidents (refer to figure 10).

2 REFINING FATIGUE

The symptoms in Cluster I and II show a linear increase over time. Additionally, during the interviews, several symptoms were mentioned. Therefore, the common symptoms observed in both Cluster I and II, as well as those mentioned in the interviews, were selected as significant indicators. These symptoms include ***sleepiness, sore limbs, backache, headache, numbness, and stiff muscles.***

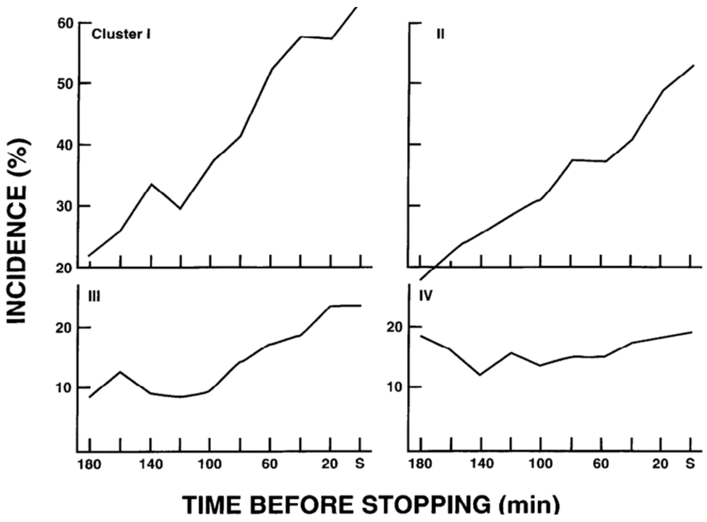


Figure 10: Mean occurrence ratings of various groups of physical symptoms as a function of driving time. (A) Cluster I: sore feet. Tired eyes and feeling drowsy. (B) Cluster II: backache. headache, chill. Stiff muscles and numbness. (C) Cluster III: ears ringing, upset stomach, and dizziness. (D) Cluster IV: tension, parched throat, clammy hands, heart pounding, and flushed face.

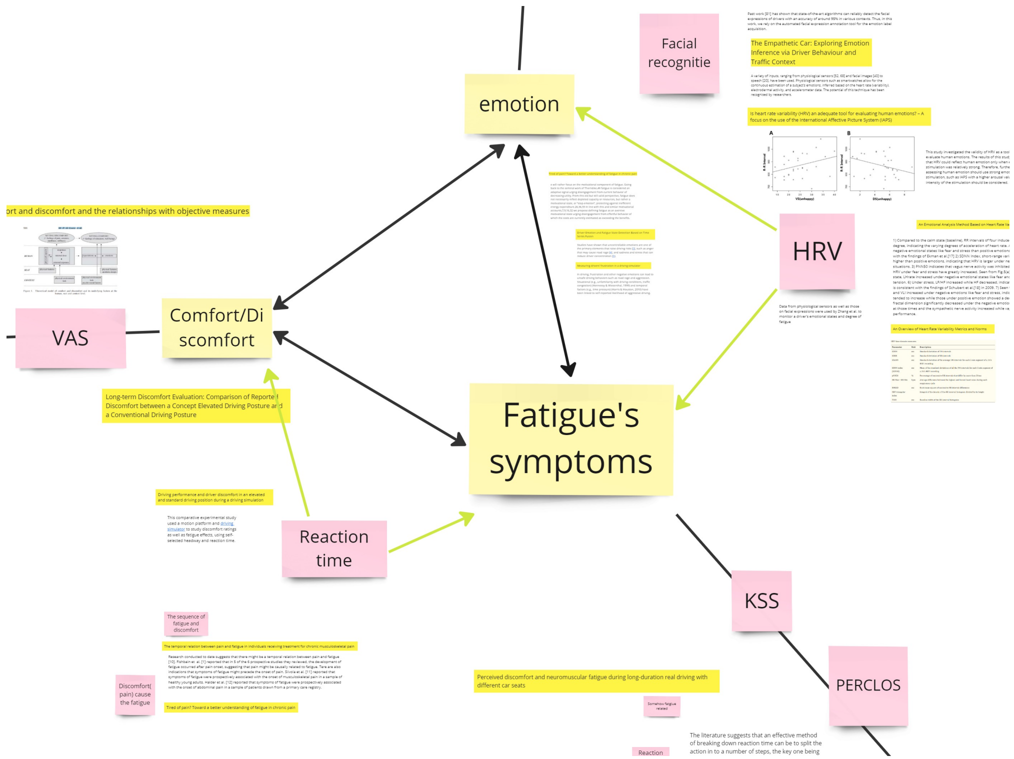


Figure 11 Framework 3

Framework 3 (Figure 11) has been developed based on fatigue symptoms and potential influencing factors. The measurements employed in this framework are not solely focused on fatigue symptoms but also encompass other factors such as (dis)comfort and emotion, which have an impact on the observed symptoms. These symptoms are considered as outcomes resulting from the interplay of these three factors during simulated driving (Shang et al., 2022). Emotion, as proposed by Shang et al., influences fatigue symptoms, with some drivers experiencing anger and sadness leading to decreased concentration.

2 REFINING FATIGUE

Moreover, Smith, J., Mansfield, N. J., & Gyi, D. E. (2015) concluded that musculoskeletal fatigue is correlated with discomfort scores obtained through the Visual Analog Scale (VAS). Additionally, Lecocq, M et al. (2022) suggested that neuromuscular fatigue could also contribute to an increased perception of discomfort.

The relationship between fatigue and discomfort is complex. However, discomfort can be perceived as a manifestation of fatigue, similar to the symptoms themselves. A study by Yamada K. et al. (2022) and Van Damme, S., Becker, S., & Van Der Linden, D. (2018) demonstrated a temporal relationship between pain and fatigue. Additionally, Fishbain et al. (2003) reported a potential association between pain and fatigue.

The pink stickers (Figure 11) represent the measurement method employed in this study. Heart Rate Variability (HRV) has been shown to be capable of detecting emotions based on various factors, as demonstrated by Wang, C., & Wang, F. (2012) and Choi, K. et al. (2017).

HRV can also reflect individuals' health, particularly in relation to fatigue, as highlighted by Escorihuela, R. M. et al. (2020). Emotion can be measured using different methods, such as the Self-Assessment Manikin (SAM) developed by Bradley, M. M., & Lang, P. (1994), as well as facial recognition techniques. Facial recognition studies often focus on the drivers' eye and lip movements, particularly the PERCLOS metric, which indicates levels of sleepiness and is utilized for predicting fatigue/sleepiness, as noted by Alioua, N., Amine, A., & Rziza, M. (2014) and Zhou, F. et al. (2020). (Dis)comfort measurement is primarily done through the use of the Visual Analogue Scale (VAS).

However, in other studies, reaction time has been proposed as a potential method for assessing discomfort and fatigue, as mentioned by Smith, J., Mansfield, N. J., Gyi et al. (2015). It is important to note that the mentioned measurement methods are not exhaustive, and a comprehensive list will be provided in the following chapter.

3 FORMULATING POLIT TEST

This chapter aims to outline the formulation of the pilot test. The central focus of the test involves identifying the most effective method for measuring fatigue symptoms. Therefore, it is crucial to evaluate and compare various measurement approaches. Additionally, this chapter will address the other necessary settings for the test.

3.1 POLIT SETTING

ENVIRONMENT

The pilot test was conducted at the Multisense lab, located at TUDelft. The lab provides space to carry out the test effectively. Figure 12 illustrates the positioning of the settings and participants, namely Wim Tinke, myself, and the EMG monitor. The HRV monitor will be implemented through a dedicated mobile application on my phone.

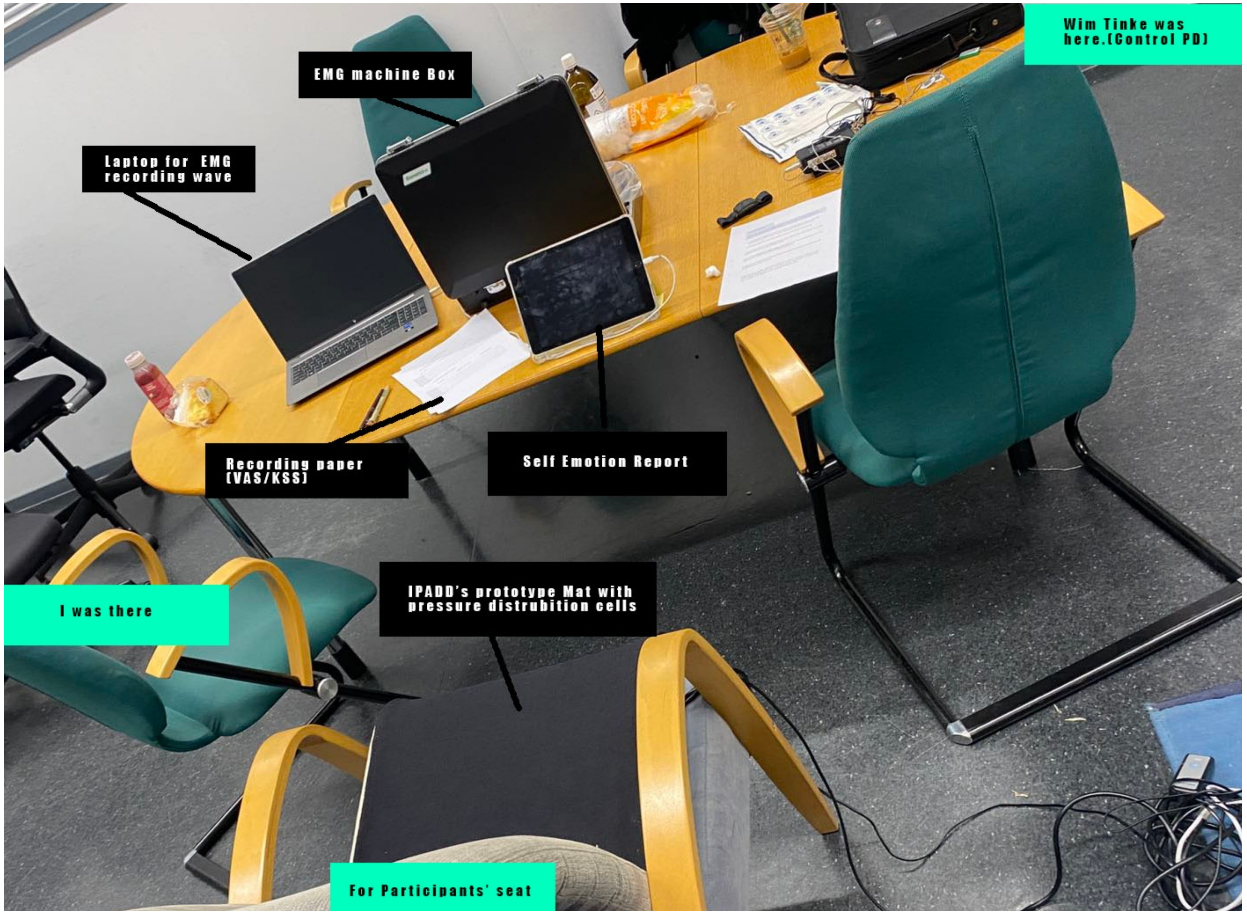


Figure 12: The environment of the pre-pilot test

3 FORMULATING POLIT TEST

MEASUREMENT

The chosen measurement methods for the project include EMG, VAS, KSS, and HRV. These methods were selected based on the literature list provided in Appendix I, which outlines standardized approaches for assessing fatigue and (dis)comfort in a driving context. Table 1 in the appendix highlights the advantages and drawbacks of each method.

These measurements are utilized for assessing the symptoms mentioned in the fatigue frameworks (refer to Figure 13). HRV is capable of detecting sleepiness and reflecting stress levels, while VAS is employed for evaluating discomfort in various body parts. EMG, as a physiological measurement, is combined with VAS to provide a comprehensive interpretation of the results.

Table 1 Comparison of measurements

Measurement	Drawbacks	Advantages
EEG	It is hard to control what people think during the experiment, the EEG only shows active area. the researchers need to find reasons why they are active.	The signal shows clear the active area in the brain, it is a physiological measurement.
EMG	It is hard to confirm the reason why these areas are active, the researchers need to find reasons.	It is a direct physiological measurement of localized muscle fatigue.
PERCLOS X	it can only measure sleepiness	It is a direct physiological measurement.
VAS	It is subjective scoring of discomfort or fatigue.	It is direcly from drivers' perspectives.
KSS	It is also a subjective scoring of sleepiness.	It is direcly from drivers' perspectives.
HRV	It can as a fatigue measurement but it is also influenced by emotion.	The signal shows clear the active area in the brain, it is a physiological measurement.

3 FORMULATING PILOT TEST

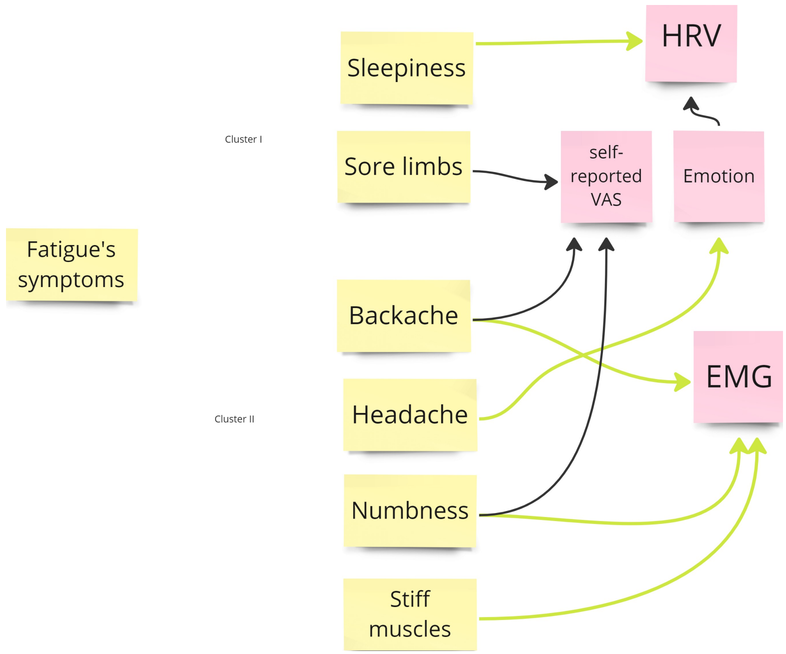


Figure 13: Measurement and Symptoms

SETTING

Due to time constraints, the development of the chair has not been completed. As an alternative solution, a prototype of the chair in the form of a mat will be tested. The mat focuses on distributing pressure specifically on the buttock area. According to Vergara and Page (2002), adjusting one's posture every 5 minutes can help reduce blood pressure. Therefore, the IPADD mat facilitates micro movements, with pressure distribution intervals lasting for 3 minutes.

EMG AND HRV

In the pilot test, the lumbar part was selected since backache is also the fatigue symptom in the VAS, which can help to interpret the EMG. The multifidus muscles(Zhou, F. J., Li, H., Song, G., & Wang, L. 2016) are selected in this pre-pilot test because the muscle reflects the low back pain and backache. (Figure 14) The commercial portable wireless EMG recorder is Biometrics DataLog. Moreover, the HRV is Scosche Rhythm 24+, and the recorder monitor is two apps: Rhythm Sync and Elite HRV. They are both for connecting the Scosche Rhythm 24+ to Elite HRV, Elite HRV for recording data, and Kubios HRV Standard for analyzing the data from Elite HRV. Participants need to wear Sosche Rhythm on their arms.(Figure 14)

Figure 14 Right :The muscle where EMG electrodes placed,Left one: Sosche Rhythm 24 band on participants' arm

3 FORMULATING PILOT TEST

PROCESS

The implementation of the test posed challenges due to the multiple tasks involved. However, with the valuable participation of Wim Tinke, who helped to control the pressure distribution during the Pilot test. The detailed flow of the test can be found in Appendix VII, while Figure 15 provides a graphical representation of the test progress for better understanding. To gather subjective feedback, self-report Visual Analog Scale (VAS) and Karolinska Sleepiness Scale (KSS) were used, and the corresponding tables can be found in Appendix VI. Additionally, an emotional self-assessment interface (Appendix VIII) was provided to allow participants to select the most suitable facial expression to describe their current mood. Participants were able to choose their emotional state during the testing period (sitting time).

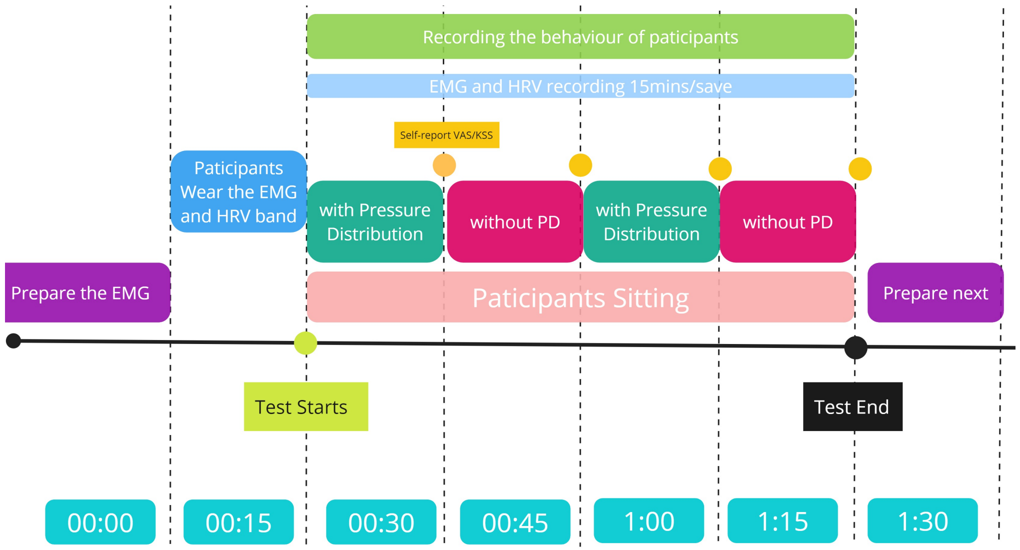


Figure 15 The process of the pre-pilot test

3.2 RESULTS

First, HRV, EMG, and VAS data were analyzed separately, then the findings were combined.

HRV

The raw data can be downloaded from the zip files. HRV (heart rate variability) is a measurement used to understand the balance between the parasympathetic and sympathetic systems. Heart rate variability refers to slight fluctuations in the time between heartbeats. It can indicate health problems in the long term, such as heart disease, among others. Additionally, it can provide insights into mental health issues like sleepiness, anxiety, and depression.

Generally, there are two domains used for analyzing HRV: time and frequency (Table 3). In the time domain, various measurements are considered (Table 2).

Table 2 HRV time domain measurement

Variable	Units	Description
Statistical measures		
SDNN	ms	Standard deviation of all NN intervals.
SDANN	ms	Standard deviation of the averages of NN intervals in all 5 min segments of the entire recording.
RMSSD	ms	The square root of the mean of the sum of the squares of differences between adjacent NN intervals.
SDNN index	ms	Mean of the standard deviations of all NN intervals for all 5 min segments of the entire recording.
SDSD	ms	Standard deviation of differences between adjacent NN intervals.
NN50 count		Number of pairs of adjacent NN intervals differing by more than 50 ms in the entire recording. Three variants are possible counting all such NN intervals pairs or only pairs in which the first or the second interval is longer.
pNN50	%	NN50 count divided by the total number of all NN intervals.

3 FORMULATING PILOT TEST

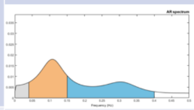
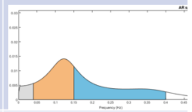
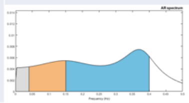
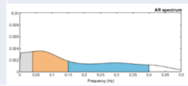
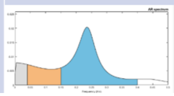
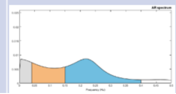
Kubios HRV Standard is utilized to obtain these time and frequency factors. Yugar, L. B. T. et al. (2023) have introduced Kubios HRV Standard as a research measurement tool. In our case, we specifically focus on the activity of the parasympathetic and sympathetic systems because their balance reflects the short-term condition of individuals.

Table 3 HRV frequency-domain measures.

r	Unit	Description
	ms^2	Absolute power of the ultra-low-frequency band (≤0.003 Hz)
	ms^2	Absolute power of the very-low-frequency band (0.0033–0.04 Hz)
	Hz	Peak frequency of the low-frequency band (0.04–0.15 Hz)
	ms^2	Absolute power of the low-frequency band (0.04–0.15 Hz)
	nu	Relative power of the low-frequency band (0.04–0.15 Hz) in norm
	%	Relative power of the low-frequency band (0.04–0.15 Hz)
	Hz	Peak frequency of the high-frequency band (0.15–0.4 Hz)
	ms^2	Absolute power of the high-frequency band (0.15–0.4 Hz)
	nu	Relative power of the high-frequency band (0.15–0.4 Hz) in norm
	%	Relative power of the high-frequency band (0.15–0.4 Hz)
	%	Ratio of LF-to-HF power

RMSSD is utilized for estimating the short-term components of HRV (Malik, M., Bigger, J. T., Camm, 1996). It is also used to assess individuals' health conditions, as lower RMSSD correlates with fatigue, stress, and increased risk of death (DeGiorgio, C. et al., 2010) (Shaffer, F., & Ginsberg, J. P., 2017). RMSSD is incorporated in Kubios HRV Standard and Elite HRV. Additionally, lower HF power (high frequency) in the frequency domain is associated with stress, panic, anxiety, or worry (Shaffer, F., & Ginsberg, J. P., 2017) (Table 3). Moreover, the RR-interval PSD (power spectral density) in the frequency range of 0.02-0.08 Hz shows a monotonic increase during regular sleep hours (Chua, E. C., Tan, W., Yeo, S. C., Lau, P., Xia, F., Mien, I. H., Puvanendran, K., & Gooley, J. J., 2012b).

Table 4 HRV RMSSD and HF graph

Participants	1st 15 mins (with PD)	2nd 15mins (without PD)	3rd 15mins (with PD)	4th 15mins (without PD)
Tester 1 of HRV RMSSD and HF	-	-	71.5ms 	56.3ms 
Tester 2 of HRV RMSSD and HF	-	-	83ms 	41.3ms 
Tester 3 of HRV RMSSD and HF	-	-	56.6ms 	56.1ms 

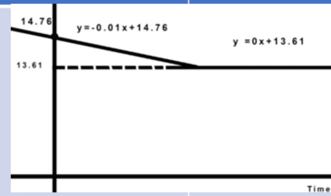
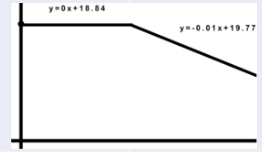
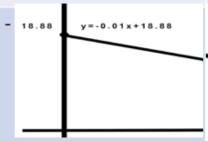
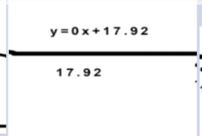
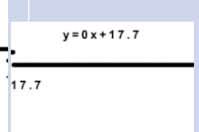
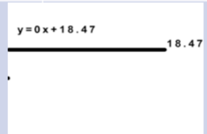
3 FORMULATING PILOT TEST

Based on the findings presented in Table 4, the first tester exhibited high RMSSD and high HF power when pressure distribution was applied. However, both the RMSSD value and HF power decreased when pressure distribution was removed. Similarly, the second tester showed a similar trend as the first tester. It is worth noting that the second tester's data may be unreliable due to continuous talking throughout the test. In the case of the third tester, the initial two HRV and EMG measurements were deemed unreliable as the tester ran to the lab. However, the RMSSD value from the third tester did not exhibit significant differences. Nevertheless, the HF power still demonstrated distinguishable variations between conditions with and without pressure distribution.

EMG

The raw data can be downloaded from the zip files, (Appendix VIIII)EMG was recorderd with a high filter at 2000Hz. EMG can indicate localized muscle fatigue by mean frequency when the mean frequency shifts to lower values, which means the muscle experience fatigue(Arendt-Nielsen, L., & Mills, K. I. 1985). From the raw data of EMG unnecessary DC and low frequency were removed, according to the tutorial from Biometrics DataLog.There is a selection of RMS and Mean Frequency. The linear function is the trendline of mean frequency each 15mins, representing muscle fatigue, which the EMG can interpret with VAS (backache). Sometimes accidents in recording happen which leads to drop outs and thereby data loss(Table 5).

Table 5 EMG and mean frequency

Participants	1st 15 mins (with PD)	2nd 15mins (without PD)	3rd 15mins (with PD)	4th 15mins (without PD)
Tester 1 of EMG MF	-	-		
Tester 2 of EMG MF	-	-		
Tester 3 of EMG MF	- 			

VAS WITH EMG & INTERVIEW

The Visual Analogue Scale (VAS) employed in this study serves as a self-report method specifically targeting fatigue symptoms. Additionally, during the subsequent interview, participants were asked to provide an overall assessment of the (dis)comfort level associated with the new chair compared to the regular chair. The scoring system ranged from 0 to 9, with 0 indicating no similarity and 9 indicating complete similarity in terms of symptoms experienced.

3 FORMULATING PILOT TEST

During the sitting time, I asked participants 1 and 3 each 15mins to answer the VAS form. Participant 2 was busy talking with others so these data were missing. Participant 1 had a personal issue: his head was hurt when he was entering the room. The overall score decreasing might be the reason for sitting is rest. His self-reported (backache)allocated with the EMG, the trendline of EMG stopped going downward(K value from -0.01 to 0) during the sitting 30mins (3rd 15mins) to 60mins (4th 15mins).(Table 4 and Table 6)

Participant 3 was running to the room as mentioned before, according to her description, she experienced a downward of sitting on the mat. In the first 15mins, her EMG was going down (k=-0.01), her backache was increasing. (from 0 to 3). For the next 15 mins, the VAS backache was at the same level. The EMG trendline is stable as well(K=0).In the 3rd 15mins, the mean value of the trendline decreased a bit. However, in the last 15mins, EMG mean value increased a bit, and the VAS backache kept the same.(Table 4 and Table 7)

The VAS backache and EMG the muscle around the spine have the possibility of validating each other when they correspond with each other.
After the sitting test, I interviewed two of participants about their comfort. Participant 1 said the comfort level of the IPADD chair (with a mat on the buttock) is 7.5, he said he needs the lumbar support. The mat with pressure distribution was attractive, Participant 2 said the regular chair would be 6 and the IPADD chair would be 7.5, she said the “massage” was comfortable, but it was not that smart enough. It did not stop immediately, and the lumbar part and feed needed more “massage.”

Table 6 Tester 1 VAS

Symptoms	0mins	15mins	30mins	45mins	60mins
Sleepiness	8	6	5	5	4
Sore Limbs	6	5	4	4	4
Backache	2	1	1	1	1
Headache	6	5	4	4	3
Numbness	2	2	1	1	1
Stiff muscle	3	3	2	2	2
Total score (except sleepiness)	19	16	12	12	11

Table 7 Tester 3 VAS

Symptoms	0mins	15mins	30mins	45mins	60mins
Sleepiness	5	1	5	7	7
Sore Limbs	0	0	0	0	0
Backache	0	3	3	5	5
Headache	5	0	3	2	2
Numbness	0	0	0	0	0
Stiff muscle	0	0	0	0	0
Total score (except sleepiness)	5	3	6	7	7

3.2 RESULTS

From an HRV perspective, the new technology has shown positive results. The vibration from QST induced a sense of physiological happiness and relaxation in participants, with no significant change in the emotions of participants 1 and 3, indicating that their moods did not influence HRV values. Regarding the EMG data, the duration of vibration and data loss have led to some uncertainties. However, certain hypotheses can be drawn: the vibration's impact on muscles tends to lower the EMG trendline, but the overall trendline remains stable, suggesting a potential delay in the effectiveness of the vibration (pressure distribution). The downward trendline typically indicates natural fatigue, but participants 1 and 3 exhibited stable trendlines, suggesting that the mat may somehow prevent the trendline from decreasing. Participant 2, being 65 years old, might be less affected by the muscle impact of the pressure distribution.

The test has a problem in that it is difficult to differentiate the effect of vibration on PD. It is challenging to determine whether the pressure distribution does not influence the time duration without DP, especially if the effect of pressure distribution is not immediate but delayed. The data from the only three participants do not provide any clues regarding this issue.

4. IMPROVEMENT

The movement of participants significantly influences the EMG. Due to the location of the electronic point on the participants' spine, it may come into contact with the back part of the seat.
Increasing the sitting time could be a solution, as a longer duration allows for better differentiation using the recorder. Due to recruitment difficulties, the pre-pilot test was limited to 1 hour. However, based on the literature, the duration should be 1 hour and 45 minutes or 2 hours. Hopefully, in the formal test, the duration can be extended to 1 hour and 45 minutes or 2 hours.

To compensate for the pilot test's inability to detect numbness through objective measurement, a method was implemented to measure the accumulation of blood in the leg veins and subcutaneous tissue fluid, as suggested by Saito and Muraki (2016). For assessing stiff muscles, only a self-reported VAS was used, as pressure distribution does not significantly help with stiff muscles. Additionally, since the experiment was conducted by myself, the number of ways to monitor symptoms was limited.
In conclusion, the following insights were gained:

3AND4 FORMULATING PILOT TEST & IMPROVEMENT

1 The duration should be 1 hour and 45 minutes

2 The recording for EMG and HRV has a time limitation, so in the formal test, only the middle 5 minutes will be recorded instead of the entire duration.

3 An observation form needs to be created to note the micro behaviors of participants.

4 The chair needs to be replaced with a real one.

5 Okino's study (2022) suggests that leg circumference reflects numbness, and prolonged sitting causes blood accumulation in the leg veins and subcutaneous tissue fluid (Saito and Muraki, 2016). It would be interesting to add leg circumference measurements to observe how the chair affects blood flow.

The flow of formal test settings (Figure 16) should be modified based on the insights gained (Figure 17). Additionally, Figure 16 illustrates the formative experiment setting, and Table 8 presents the list of items required for future testing.

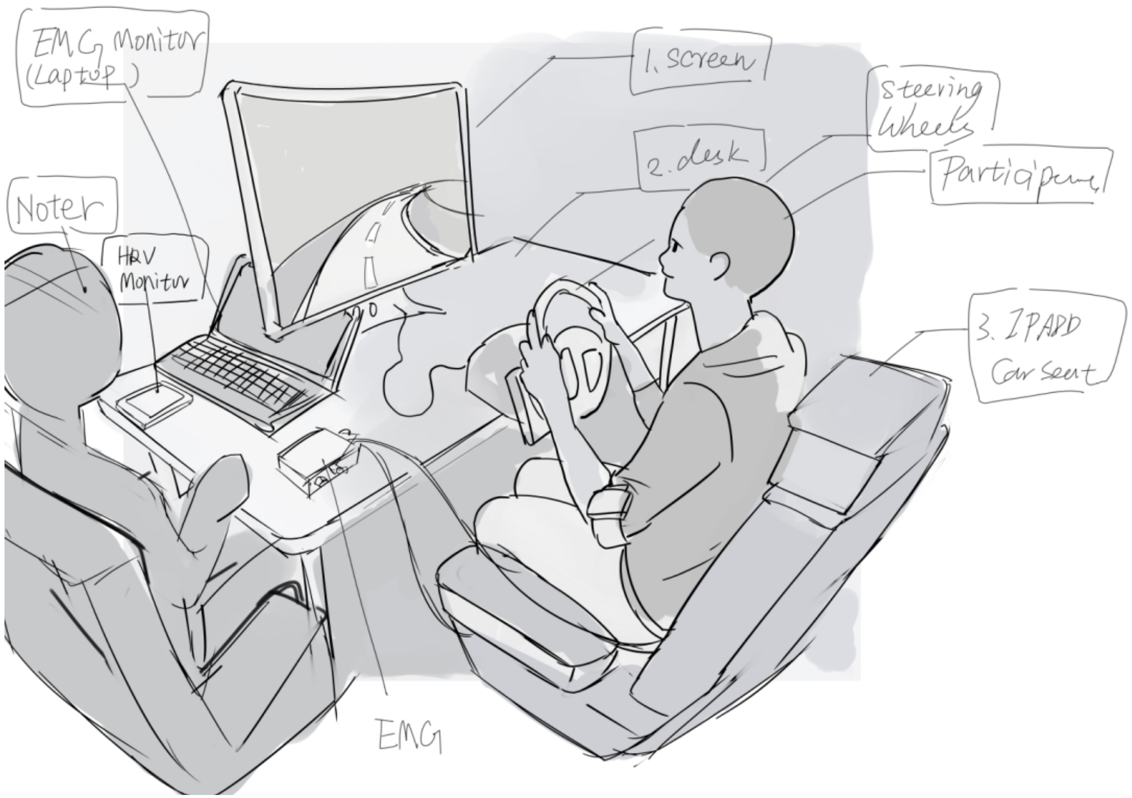


Figure 16 The formal test setting will be

5 THE FORMAL TEST SETTING

The formal test setup is improved based on the results of chapter 4. The overall flow has been updated for the formal tests, which consist of four sessions in the time domain. The test includes: a form that records people's body measurements, an EMG device for detecting localized fatigue and (dis)comfort, a self-report form for fatigue experienced symptoms and (dis)comfort, a comfort form, and an interview asking why they chose a specific option. The following text will describe the overall flow and these sessions in detail.

5.1REQUIRED TEST MATERIALS AND EQUIPMENT FOR TEST

An overview of the test will be described first:

There are 16 people participating in the formal test, whose ages range between 22 and 80 years old. A desk was used for placing the screens, steering wheel, and forms. The screen is for displaying a video that simulates the drivers' perspective to simulate the driving environment.

Items	Numbers	Price	Others
Participants (22years old -80years old)	16	Participating fee 50 € per person	-
Desk	1	-	borrowed from Spark
Screen	1	-	borrowed from Spark
Steering wheel	1	-	borrowed from Spark
EMG device and monitor	1	-	Borrowed from TUDelft
Self-emotion assessment Form	-	-	In Appendix XI Forms
HRV Scosche Rhythm24+	1	-	Borrowed from TUDelft
APP for HRV	1	-	My phone
Soft Ruler for leg circumference	1	-	Borrowed from somewhere
The discomfort and Fatigue form for each sessions	4	-	In Appendix XI Forms
The comfort form for each sessions	1	-	In Appendix XI Forms
The consent form	1	-	In Appendix XII
The checklist	1	-	In Appendix X
QST chair	1	Research object	From IPADD
Passive Pneumatic Seat	1	Research object	From IPADD

Table 8 Equipment used in the test

5 THE FORMAL TEST SETTING

The steering wheel is used to mimic driving postures. The EMG device will be attached to four parts of the participants' bodies: m.Left musculus pars descendens, m.Right musculus pars descendens, m.Erector Spinae, and m.Vastus Lateralis. The HRV device remains the same as in the pilot test. Due to the confidential contract, it is hard to present the pictures of the seats.

there are (Dis)comfort and Fatigue symptoms forms. better: forms had to be completed by the participants indicate (dis)comfort and fatigue.

According to previous research, the (Dis)comfort assessment will utilize the VAS form as a subjective measurement, where participants will score their (dis)comfort levels through self-assessment. Many researchers have shown that the VAS is a reliable method for assessing (dis)comfort (Klimek, L., Bergmann, K., Biedermann, T., Bousquet, J., Hellings, P., Jung, K., Merk, H. F., Olze, H., Schlenter, W., Stock, P., Ring, J., Wagenmann, M., Wehrmann, W., Mösges, R., & Pfaar, O, 2017), consistent with the results of Pearson's study (Pearson, E. 2009).

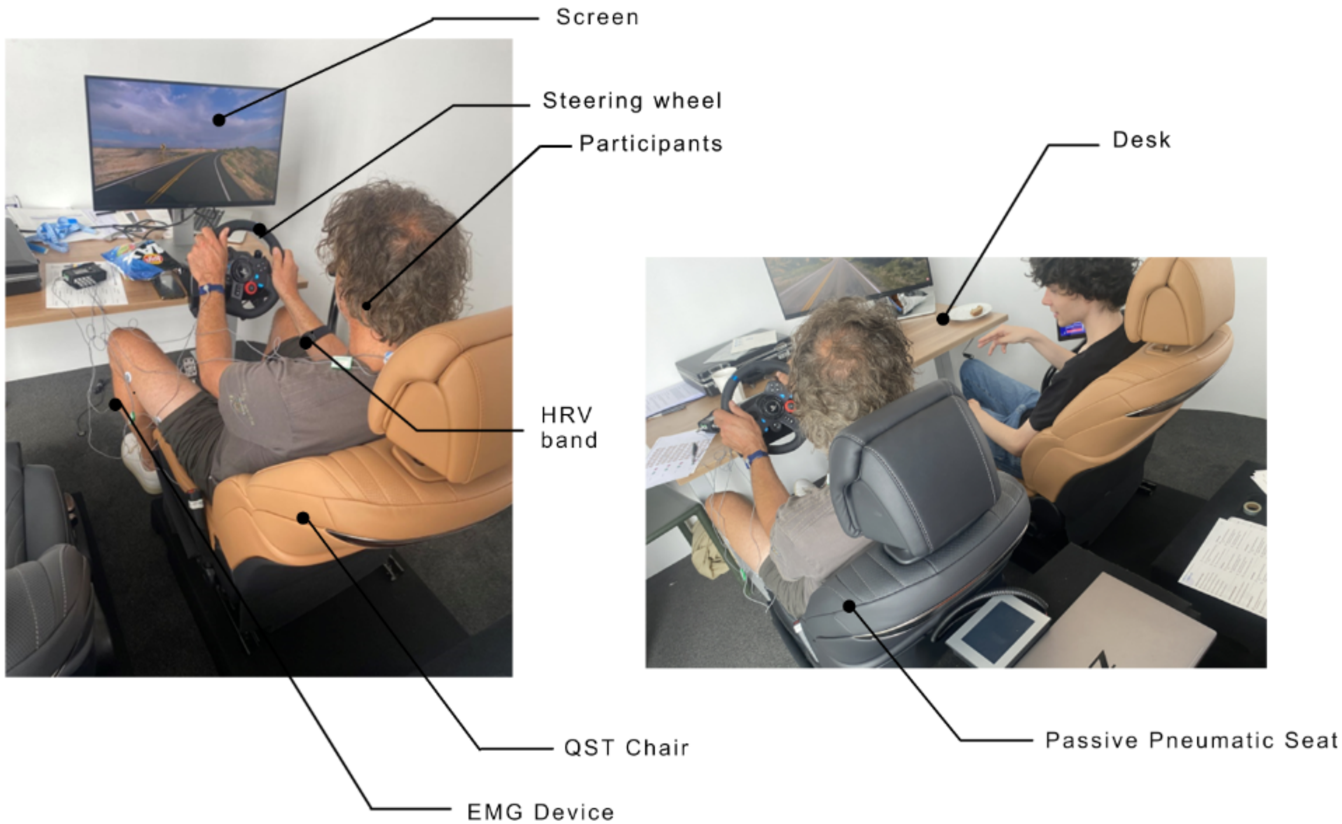


Figure 17 Test settings

5 THE FORMAL TEST SETTING

The form recording comfort allows participants to perceive precise comfort differences between different products by switching due to human sensors (Vink, P., 2014). Based on the evidence from this research, the comfort form must be filled out at the beginning of each session so that participants can clearly feel the difference compared to sitting for a while. Therefore, in this test, participants will fill out the comfort form at the beginning and at the end and also while switching chairs.

The body dimensions, including leg circumference, low leg length, upper leg length, upper body length, height, and weight, will be measured while participants are sitting on the chair and recorded by researchers.

5.2 TEST PROGRESS

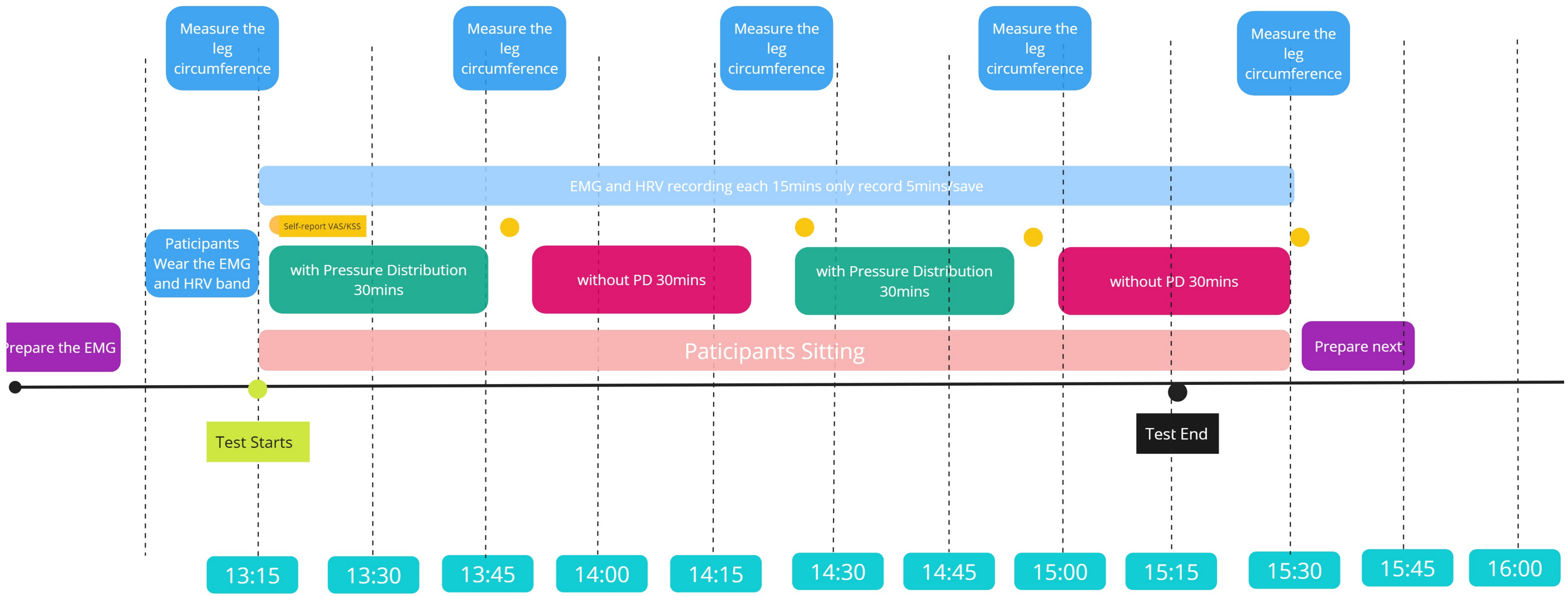


Figure 18 Activities in the test in the course of time

5 THE FORMAL TEST SETTING

The entire process consists of four sessions with two patterns (Figure 17). Before participants sit on the chair, they are required to sign the consent form, which introduces the test overview and informs them that their personal data will not be used without their permission. Once they have signed the consent form, researchers will assist them in wearing the EMG and HRV devices.

Researchers scrub the skin, place gel on the skin and than attach the electrodes by adhesive tape, and for the HRV, the HRV band should be placed on the wrist. The EMG electrodes need to be properly attached, and the HRV band should be placed around the elbow (Figure 18).

Subsequently, participants will sit on the chair and begin the test based on the assigned patterns. There are two patterns as mentioned before, In the first pattern, participants will first sit on the Qumulus Smart chair (QS chair)(The Brown one) for the initial 30 minutes, then switch to the PPS(Passive Pneumatic Seat) (The black one) for the following 30 minutes. Then switch again, each 30 minutes is called session. In the first pattern, there will be 4 sessions.(2hours)

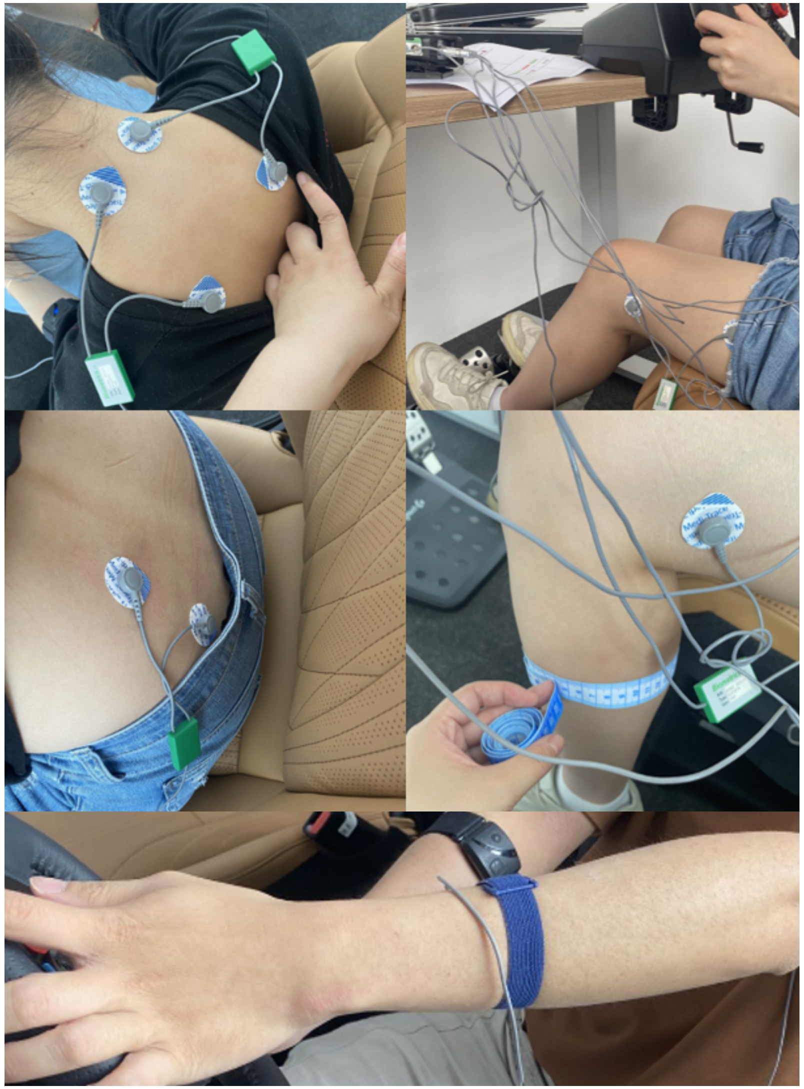


Figure 19 the upper four figures are EMG electrodes are positioned;the bottom figure is the HRV band placed.

5 THE FORMAL TEST SETTING

After each session, participants will fill out the discomfort and fatigue symptoms form and emotion self-assessment form to to gain data on the experience. The data are gathered while sitting to avoid that memory will play a role.

After the first pattern, the second pattern will be conduct(Without QS chair for 30mins -With QST chair for 30mins -Without QST chair for 30mins-With QST chair for 30mins), participants will first sit on the Passive Pneumatic Seat for 30 minutes and then switch to the Qumulus Smart chair. This second pattern also have four sessions.

During each session, the data of EMG and HRV will be recorded for 5 minutes, starting from the middle of the session. Additionally, the researchers will measure the leg circumference between each session (as indicated by the yellow dots in Figure 18).During each session switch, participants will be asked to fill out the comfort form.

In the end, as part of the research process, there was an interview conducted to understand the reasons behind participants' choices regarding the comfort score and discomfort score, the questions from the interview were original from IPADD. This interview will aim to gain insights into their preferences and perceptions regarding the chairs' comfort levels which is required from the company IPADD. The interview included some general questions about the chairs and how the participants feel while using them.

The interview served as a partially valuable qualitative component of the research, providing deeper understanding and context to complement the quantitative data collected from the forms and measurements.

5.3 RESULTS

In the end, a total of 16 participants(Figure 19 and Figure 20) took part in the test, with ages ranging from 20 years old to 70 years old. The group consisted of eight females and eight males, providing a balanced representation.

In the end, a total of 16 participants(Figure 19 and Figure 20) took part in the test, with ages ranging from 20 years old to 70 years old. The group consisted of eight females and eight males, providing a balanced representation.

5 THE FORMAL TEST SETTING

The data analysis will be divided into six key areas:
EMG (Electromyography)
HRV (Heart Rate Variability)
Discomfort Self-assessment
Fatigue symtopms
Comfort Self-assessment
Leg Circumference

The interview are in the Appendix XIV.

Due to the other five areas can make a sufficient conclusion, in this part, HRV are not going to be discussed, So by conducting thorough analyses in these five areas, the research aims to gain a comprehensive understanding of the participants' experiences and reactions to the different chairs. These data will contribute to the overall evaluation of the Qumulus Smart Seat in comparison to the non-massage chair, helping to draw meaningful conclusions about the chair's effectiveness and user satisfaction.

EMG

Analysis was conducted on four muscle parts utilizing the mean of median frequency: Right trapezius pars descendens, Left trapezius pars descendens , Erector Spinae, and Vastus Lateralis. Four hypotheses were formulated:
H0: There is no significant difference between QST technology and without QST technology on Right /

Figure 20 Participants from No.1 to No.10

5 THE FORMAL TEST SETTING

Figure 21 Participants from No.11 to No.16

Left trapezius pars descendens /Erector Spinae/ Vastus Lateralis by using t-test.

The t-test is a within subject design making paired comparison possible for the same subject in different conditions.The paired sample t-test showed a p-value below 0.05, rejecting H0. (The p-value shows in the table 9) The data supporting the t-test for paired samples showing the differences in localized muscle fatigue in the left m.trapezius pars descendens between the condition with Qumulus technology compared with a 'standard' seat (p=0.002).

During session 3-4 (driving after 1 hour), QST technology had a significant effect on Trapezius Left,p value is 0.002 (Table 9) with a strong correlation of 0.899 indicating that the localized muscle fatigue was lower in the Qumulus seat compared with the traditional seat.(Appendix XIII)

Table 9 Left m. trapezius pars descendens p-value Pair1: 0.941; Pair2:0.002

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	withQST1+2 - WithoutQST1+2	-.26625	16.92831	4.23208	-9.28671	8.75421	-.063	15	.951
Pair 2	WithQST3+4 - Without QST3+4	6.66937	7.23624	1.80906	2.81345	10.52530	3.687	15	.002

5 THE FORMAL TEST SETTING

Table 10 Right m. trapezius pars descendens p-value Pair1: 0.246; Pair2:0.023
m. erector spinae p-value Pair1:0.000; Pair2:0.000
m. vastus lateralis p_value Pair1:0.003; Pari2:0.001

Paired Samples Test

Trapezius right

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	withQST1+2 - WithoutQST1+2	4.85500	16.07026	4.01757	-3.70824	13.41824	1.208	15	.246
Pair 2	WithQST3+4 - Without QST3+4	5.57188	8.83003	2.20751	.86668	10.27707	2.524	15	.023

Etector spinea

					Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	withQST1+2 - WithoutQST1+2	30.01688	17.30700	4.32675	20.79463	39.23912	6.938	15	.000
Pair 2	WithQST3+4 - Without QST3+4	30.97438	18.13189	4.53297	21.31258	40.63617	6.833	15	.000

VastusLateralis

					Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed
r 1	withQST1+2 - WithoutQST1+2	21.23063	23.57945	5.89486	8.66602	33.79523	3.602	15	.00[illegible]
r 2	WithQST3+4 - Without QST3+4	21.04875	20.35915	5.08979	10.20013	31.89737	4.135	15	.00[illegible]

5 THE FORMAL TEST SETTING

Based on the analysis of Trapezius Right and Vastus Lateralis, similar to Trapezius Left, the results suggest that the QST technology's effect becomes evident over time. In the first two sessions (within 1 hour), there was no significant distinction between QST technology and without QST technology. However, during Session 3 and 4, the QST technology demonstrated a significant impact on the localized muscle fatigue in both Right m. trapezius pars descendens and m. Vastus Lateralis muscles. This indicates that the QST massage function is more beneficial during longer driving times (more than 1 hour).Regarding the Erector Spinae, positive effects were observed for both Session 1 and 2, as well as Session 3 and 4, regardless of the time duration.

The QST technology consistently showed beneficial effects on the m. Erector Spinae muscle in both shorter and longer driving sessions.
These findings suggest that there is an effect on localized muscle fatigue in various muscles, which could be caused by a better blood flow. In figure 22 the effects are shown in graphs.

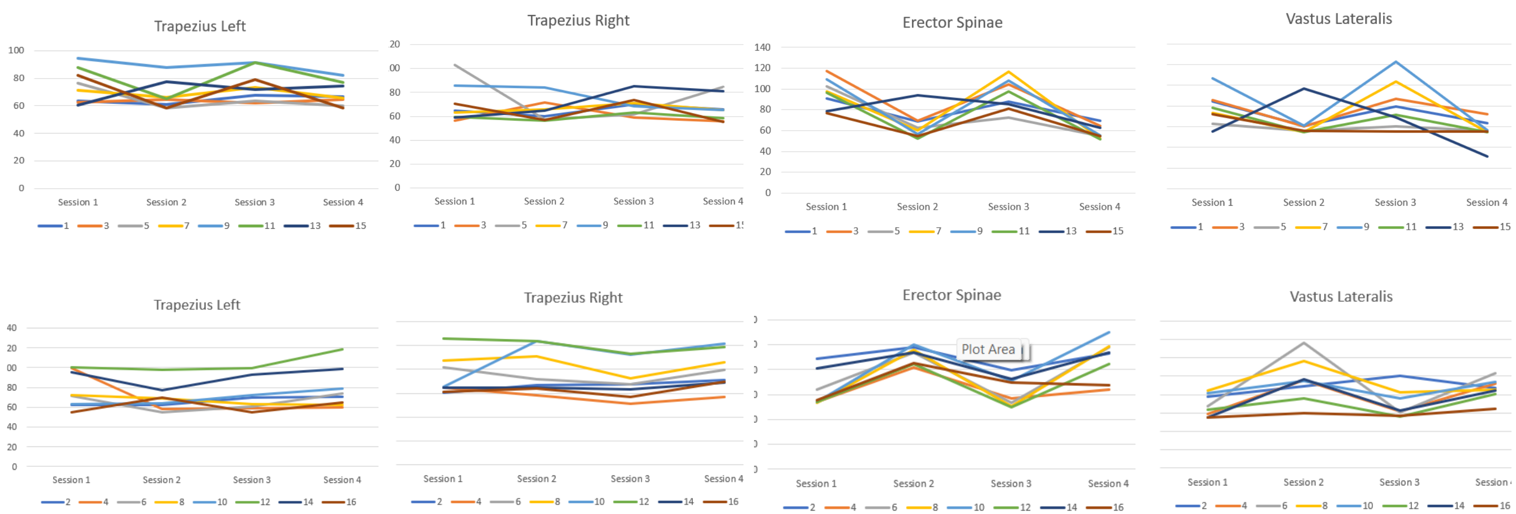


Figure 22 the upper graphes are showing the participant13579... The lower graphes are shown the participant 2468..

5 THE FORMAL TEST SETTING

COMFORT

Based on the Comfort form filled by participants' subjective feelings, the analysis involves conducting a Wilcoxon Test to compare the scores between the QST technology and without QST technology. The null hypothesis (H0) in this analysis states that there is no significant difference between the QST technology and without QST technology when evaluating the overall comfort experience. However, the Wilcoxon test results in a p-value below 0.05, which means that H0 is rejected.

Based on the p-values observed for Session 1+2+3+4 with QST and Session 1+2+3+4 Without QST, (Table 11) which are greater than 0.05, it suggests that there is no significant difference between the QST technology and without QST technology in terms of comfort.

However, the mean value of Session 1+2(7) with QST and Session 3+4 (7.25) with QST shows more comfortable than without QST(6.94 and 6.81). (Appendix XIII), according to the participants' subjective evaluation which mentioned that the hardness and dimension of the seat can significantly influence participants' comfort perceptions. Given that the QST seat is harder than the PSS (Black seat), these factors might indeed have impacted the participants' comfort experience and contributed to the lack of significant differences observed in the comfort form scores.

Considering these factors, it may be challenging to draw a clear conclusion about the comfort difference solely based on the subjective perspectives of the participants. Additional factors, such as the seat settings and individual preferences, could be influencing the overall comfort experience and need to be considered.

Table 11 Comfort Wilcoxon Test P-Value: 0.619

Test Statistics[a]

	Without1 + 2+3+4 - With QST1+2+3+4
Z	-.497[b]
Asymp. Sig. (2-tailed)	.619

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Ranks

		N	Mean Rank	Sum of Ranks
Without1 + 2+3+4 - With QST1+2+3+4	Negative Ranks	16[a]	13.09	209.50
	Positive Ranks	11[b]	15.32	168.50
	Ties	5[c]		
	Total	32		

a. Without1 + 2+3+4 < With QST1+2+3+4

5 THE FORMAL TEST SETTING

DISCOMFORT

The analysis method used for EMG is also applied to assess whether QST technology helps decrease perceived discomfort in various body areas (low back, buttock, mid back, thigh, and upper back). The hypothesis is stated as follows:

H0: There is no significant difference between QST technology and without QST technology in participants' perceived discomfort.

The Wilcoxon test results are presented in Table 12, providing insights into the potential impact of QST technology on participants' perceived discomfort in different body regions.Regarding the lower back, the results indicate that the QST technology seat has a positive effect, with a p-value of 0.035 observed during Session 3 and 4. This suggests that the QST technology helps decrease perceived discomfort in the lower back area during longer driving sessions.

Table 12 discomfort Wilcoxon test

Test Statistics[a]

Lowerback	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-1.700[b]	-2.105[b]
Asymp. Sig. (2-tailed)	.089	.035

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	4[a]	7.63	30.50
	Positive Ranks	11[b]	8.14	89.50
	Ties	1[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	3[d]	3.17	9.50
	Positive Ranks	8[e]	7.06	56.50
	Ties	5[f]		
	Total	16		

Test Statistics[a]

Buttock	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-.355[b]	-.717[c]
Asymp. Sig. (2-tailed)	.722	.473

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	6[a]	7.25	43.50
	Positive Ranks	6[b]	5.75	34.50
	Ties	4[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	5[d]	6.00	30.00
	Positive Ranks	7[e]	6.86	48.00
	Ties	4[f]		
	Total	16		

5 THE FORMAL TEST SETTING

Table 12 discomfort Wilcoxon test

Test Statistics[a]

MidBack	WithoutQST1 +2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-1.956[b]	-2.716[b]
Asymp. Sig. (2-tailed)	.050	.007

Test Statistics[a]

Neck	WithoutQST1 +2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-1.299[b]	-.719[b]
Asymp. Sig. (2-tailed)	.194	.472

Test Statistics[a]

Thight	WithoutQST1 +2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	.000[b]	.000[b]
Asymp. Sig. (2-tailed)	1.000	1.000

Test Statistics[a]

Upper back	WithoutQST1 +2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-1.535[b]	-.933[b]
Asymp. Sig. (2-tailed)	.125	.351

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	2[a]	7.25	14.50
	Positive Ranks	10[b]	6.35	63.50
	Ties	4[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	0[d]	.00	.00
	Positive Ranks	9[e]	5.00	45.00
	Ties	7[f]		
	Total	16		

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	4[a]	4.63	18.50
	Positive Ranks	7[b]	6.79	47.50
	Ties	5[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	4[d]	7.50	30.00
	Positive Ranks	8[e]	6.00	48.00
	Ties	4[f]		
	Total	16		

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	6[a]	5.50	33.00
	Positive Ranks	5[b]	6.60	33.00
	Ties	5[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	4[d]	4.50	18.00
	Positive Ranks	4[e]	4.50	18.00
	Ties	8[f]		
	Total	16		

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	1[a]	5.00	5.00
	Positive Ranks	6[b]	3.83	23.00
	Ties	9[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	2[d]	4.25	8.50
	Positive Ranks	5[e]	3.90	19.50
	Ties	9[f]		
	Total	16		

5 THE FORMAL TEST SETTING

Also p-value is 0.50 and 0.007 of session 1,2 and 3,4 in Mid back. Which means that the QST have the most effect for Mid Back area.

However, no significant difference was found for perceived discomfort in the buttock area between the QST technology and without QST technology seats.

On the other hand, the QST technology seat demonstrated a positive function on the mid back and lower back, indicating a reduction in perceived discomfort in these regions.

These findings contribute to understanding the specific areas where the QST technology seat is most effective in decreasing perceived discomfort during driving.

Figure 23 the right graphes are showing the participant13579... The left graphes are shown the participant 2468..

5 THE FORMAL TEST SETTING

Regarding the lower back, the results indicate that the QST technology seat has a positive effect, with a p-value of 0.036 observed during Session 3 and 4. This suggests that the QST technology helps decrease perceived discomfort in the lower back area during longer driving sessions.

However, no significant difference was found for perceived discomfort in the buttock area between the QST technology and without QST technology seats.

FATIGUE SYMPTOMS

The analysis method used for EMG is also applied to assess whether QST technology helps decrease fatigue symptoms(The hypothesis is stated as follows:Backache, Stiffness muscle, Sleepiness, Headache, Sore Limbs, Numbness.)

The QST did not show a positive effect on experienced fatigue based on p-value from Wilcoxon and t-test (Appendix XIII).

On the other hand, the QST technology seat demonstrated a positive function on the mid back and lower back, indicating a reduction in perceived discomfort in these regions.

These findings contribute to understanding the specific areas where the QST technology seat is most effective in decreasing perceived discomfort during driving.

LEG CIRCUMFERENCE

The leg circumference was recorded at beginning of the test, after each session and in the end. It could be that due to the massage the blood flow is improved. As a result the leg circumference could be lower after the QST seat. However, no significant differences could be found in Both Wilcoxon and T-test.

The result appears that the current data did not show a significant difference between the two conditions in terms of the sum of the Δ session values.

5 THE FORMAL TEST SETTING

However, the correlation analysis(The significant value is below 0.05) between with QST and without QST indicates a linear relationship, suggesting an improvement in blood flow. This improvement is not solely attributed to the massage from when the QST is in used, and the exact reason behind the enhanced blood flow needs further investigation.

To fully understand the factors influencing the blood flow improvement, additional research may be required to explore other potential variables and factors that could play a role in this observation.

Table 13 Test Overall

Measurement	Part	Method	QST seat positive effect
EMG	Left m. trapezius pars descendens	T-test	1 hour later
	Right m. trapezius pars descendens		1 hour later
	m. Erector Spinae		✓
	m. Vastus Lateralis		1 hour later
Perceived Discomfort	Lower Back	Wilcoxon	1 hour later
	Buttock		×
	Mid Back		✓
	Neck		×
	Thight		×
	UpperBack		×
Perceived Comfort	Overview	Wilcoxon	×
Leg circumference (Blood Flow)	Leg	Wilcoxon	×
Fatigue Symptoms	All symptoms	Wilcoxon & T-test	×
HRV	-	-	-

5.4 CONCLUSION

It was interesting to see that the discomfort in the lower back region reduced while using the QST active and at the same time the EMG of the lower back muscles show significantly less localized muscle fatigue. This indicated that subjective and objective data are in alignment with each other showing the positive effect in this region.Low back pain is one of the most common problems in humans and a system having a positive effect in this region is very welcome.

Figure 22 illustrates the positive effects of QST technology in a visual manner. EMG analysis demonstrates that the neck, back, and leg areas display positive effects due to QST. Additionally, the cells embedded in the backside of the chair and the seat parts indicate their effectiveness in preventing fatigue as per the EMG results. However, these EMG results might not be strong enough to definitively signify a reduction in discomfort. Therefore, some hypotheses have been formulated to explain the potential causes behind these outcomes.

5 THE FORMAL TEST SETTING

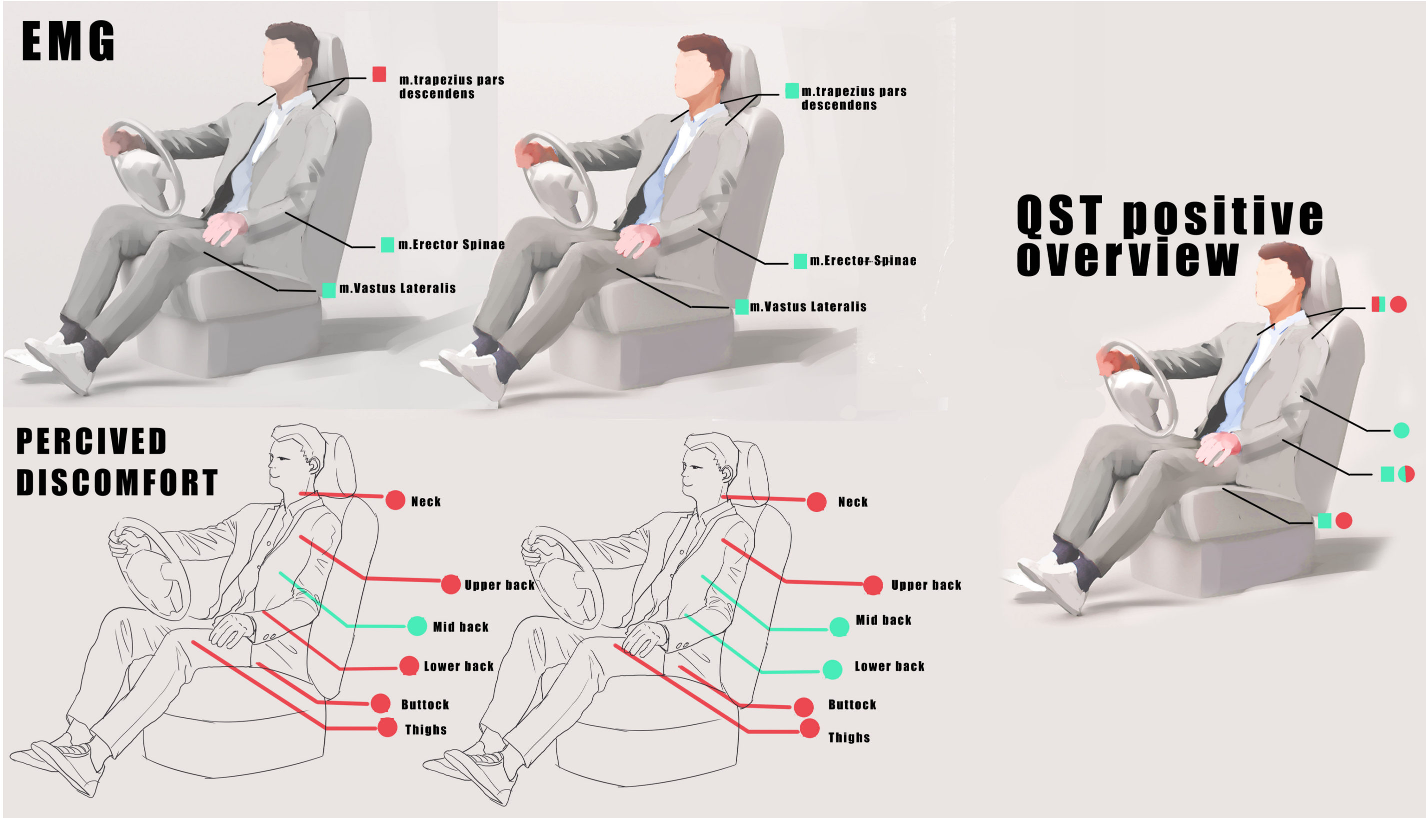


Figure 23 The overview of test results

The QST seat is not entirely identical to the PSS seat; notable differences exist in terms of texture and hardness. As perceived discomfort is subjective, these variations in hardness and texture significantly influence people's perceptions. This influence on perceived discomfort is reasonable, given the subjective nature of the assessment. The Wilcoxon results from leg circumference demonstrate that the QST seat has a positive influence on blood flow over time.

Overall, these results show that the QST seat has a beneficial effect in preventing fatigue. However, due to the differences in the test objects (hardness and textures), issues arise when evaluating comfort and discomfort. Despite this condition, the QST seat still exhibits superior performance in terms of backside discomfort.

5 THE FORMAL TEST SETTING

5.5 DESIGN PROPOSAL.

Based on the results from the previous chapter, certain design implications become evident. The QST technology on the backside has an effect on the shoulder and back areas, even with the upper leg areas. However, users are unable to recognize the functions in the shoulder, buttock, and leg regions. Here are further design suggestions:

1. The buttock section of the seat is firm; reducing this firmness could potentially result in a higher comfort score with QST.
2. The backside area of the QST can be made larger, and the simulation could be intensified.
3. The simulation for the buttock area of the seat can be enhanced.

REFERENCE

Behrens, M., Gube, M., Chaabene, H., Prieske, O., Zenon, A., Broscheid, K., Schega, L., Husmann, F., & Weippert, M. (2022). Fatigue and Human Performance: An Updated Framework. Sports Medicine, 53(1), 7–31. https://doi.org/10.1007/s40279-022-01748-2

Davenne, D., Lericollais, R., Sagaspe, P., Taillard, J., Gauthier, A., Espié, S., & Philip, P. (2012b). Reliability of simulator driving tool for evaluating sleepiness, fatigue and driving performance. Accident Analysis & Prevention, 45, 677–682. https://doi.org/10.1016/j.aap.2011.09.046

De Looze, M. P., Kuijt-Evers, L. F., & Van Dieën, J. H. (2003b). Sitting comfort and discomfort and the relationships with objective measures. Ergonomics, 46(10), 985–997. https://doi.org/10.1080/0014013031000121977

Rahman, A., Hriday, M. B. H., & Khan, R. (2022). Computer vision-based approach to detect fatigue driving and face mask for edge computing device. Heliyon, 8(10), e11204. https://doi.org/10.1016/j.heliyon.2022.e11204

Wiker, S. F., Chaffin, D. B., & Langolf, G. D. (1990). Shoulder postural fatigue and discomfort. International Journal of Industrial Ergonomics, 5(2), 133–146. https://doi.org/10.1016/0169-8141(90)90004-I

Chua, E. C., Tan, W., Yeo, S. C., Lau, P., Xia, F., Mien, I. H., Puvanendran, K., & Gooley, J. J. (2012). Heart Rate Variability Can Be Used to Estimate Sleepiness-related Decrements in Psychomotor Vigilance during Total Sleep Deprivation. Sleep. https://doi.org/10.5665/sleep.1688
Kocalevent, R., Hinz, A., Brähler, E., & Klapp, B. F. (2011). Determinants of fatigue and stress. BMC Research Notes, 4(1). https://doi.org/10.1186/1756-0500-4-238

Dittner, A., Wessely, S., & Brown, R. M. (2004). The assessment of fatigue. Journal of Psychosomatic Research, 56(2), 157–170. https://doi.org/10.1016/s0022-3999(03)00371-4

Abd-Elfattah, H. M., Abdelazeim, F., & Elshennawy, S. (2015). Physical and cognitive consequences of fatigue: A review. Journal of Advanced Research, 6(3), 351–358. https://doi.org/10.1016/j.jare.2015.01.011

Davenne, D., Lericollais, R., Sagaspe, P., Taillard, J., Gauthier, A., Espié, S., & Philip, P. (2012). Reliability of simulator driving tool for evaluation of sleepiness, fatigue and driving performance. Accident Analysis & Prevention, 45, 677–682. https://doi.org/10.1016/j.aap.2011.09.046

REFERENCE

Nilsson, T., Nelson, T. R., & Carlson, D. R. (1997b). Development of fatigue symptoms during simulated driving. Accident Analysis & Prevention, 29(4), 479–488. https://doi.org/10.1016/s0001-4575(97)00027-4

Shang, Y., Yang, M., Cui, J., Cui, L., Zizheng, H., & Li, X. (2022). Driver Emotion and Fatigue State Detection Based on Time Series Fusion. Electronics, 12(1), 26. https://doi.org/10.3390/electronics12010026

Smith, J., Mansfield, N. J., & Gyi, D. E. (2015). Long-term Discomfort Evaluation: Comparison of Reported Discomfort between a Concept Elevated Driving Posture and a Conventional Driving Posture. Procedia Manufacturing, 3, 2387–2394. https://doi.org/10.1016/j.promfg.2015.07.387

Lecocq, M., Lantoine, P., Bougard, C., Allègre, J., Bauvineau, L., González, D., Bourdin, C., Marqueste, T., & Dousset, E. (2022). Perceived discomfort and neuromuscular fatigue during long-duration real driving with different car seats. PLOS ONE, 17(12), e0278131. https://doi.org/10.1371/journal.pone.0278131

McGill, S. M., Hughson, R. L., & Parks, K. (2000). Lumbar erector spinae oxygenation during prolonged contractions: implications for prolonged work. Ergonomics, 43(4), 486–493. https://doi.org/10.1080/001401300184369

Bongers P.M., Boshuizen H.C. Beck (1990).Disorders and whole-body vibration at work. Thesis, University of Amsterdam

Wang, C., & Wang, F. (2012). An emotional analysis method based on heart rate variability. https://doi.org/10.1109/bhi.2012.6211518

Choi, K., Kim, J., Kwon, O. J., Kim, E. K., Ryu, Y. H., & Park, J. (2017). Is heart rate variability (HRV) an adequate tool for evaluating human emotions? – A focus on the use of the International Affective Picture System (IAPS). Psychiatry Research-neuroimaging, 251, 192–196. https://doi.org/10.1016/j.psychres.2017.02.025

Escorihuela, R. M., Capdevila, L., Castro, J. R., Zaragozá, M. C., Maurel, S., Alegre, J., & Castro-Marrero, J. (2020). Reduced heart rate variability predicts fatigue severity in individuals with chronic fatigue syndrome/myalgic encephalomyelitis. Journal of Translational Medicine, 18(1). https://doi.org/10.1186/s12967-019-02184-z

Bradley, M. M., & Lang, P. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. Journal of Behavior Therapy and Experimental Psychiatry, 25(1), 49–59. https://doi.org/10.1016/0005-7916(94)90063-9

Alioua, N., Amine, A., & Rziza, M. (2014). Driver's Fatigue Detection Based on Yawning Extraction. International Journal of Vehicular Technology, 2014, 1–7. https://doi.org/10.1155/2014/678786

Figure 9: Nilsson, T., Nelson, T. M., & Carlson, D. (1997). Development of fatigue symptoms during simulated driving. Accident Analysis & Prevention, 29(4), 479–488. https://doi.org/10.1016/s0001-4575(97)00027-4

REFERENCE

Chua, E. C., Tan, W., Yeo, S. C., Lau, P., Xia, F., Mien, I. H., Puvanendran, K., & Gooley, J. J. (2012b). Heart Rate Variability Can Be Used to Estimate Sleepiness-related Decrements in Psychomotor Vigilance during Total Sleep Deprivation. Sleep. https://doi.org/10.5665/sleep.1688

Zhou, F., Alsaid, A., Blommer, M., Curry, R., Swaminathan, R., Kochhar, D. S., Talamonti, W. J., Tijerina, L., & Lei, B. (2020). Driver fatigue transition prediction in highly automated driving using physiological features. X, 147, 113204. https://doi.org/10.1016/j.eswa.2020.113204

Yamada, K., Adams, H. R., Ellis, T., Clark, R., Sully, C., Larivière, C., & Sullivan, M. J. (2022). The temporal relation between pain and fatigue in individuals receiving treatment for chronic musculoskeletal pain. BMC Musculoskeletal Disorders, 23(1). https://doi.org/10.1186/s12891-022-05162-7

Van Damme, S., Becker, S., & Van Der Linden, D. (2018). Tired of pain? Toward a better understanding of fatigue in chronic pain. Pain, 159(1), 7–10. https://doi.org/10.1097/j.pain.0000000000001054

Fishbain, D. A., Cole, B., Cutler, R., Lewis, J. S., Rosomoff, H. L., & Fosomoff, R. S. (2003). Is Pain Fatiguing? A Structured Evidence-Based Review. Pain Medicine, 4(1), 51–62. https://doi.org/10.1046/j.1526-4637.2003.03008.x

Smith, J., Mansfield, N. J., Gyi, D. E., Pagett, M., & Bateman, B. (2015). Driving performance and driver discomfort in an elevated and standard driving position during a driving simulation. Applied Ergonomics, 49, 25–33. https://doi.org/10.1016/j.apergo.2015.01.003

Vergara, M., & Page, Á. (2002). Relationship between comfort and back posture and mobility in sitting-posture. Applied Ergonomics, 33(1), 1–8. https://doi.org/10.1016/s0003-6870(01)00056-4

Zhou, F. J., Li, H., Song, G., & Wang, L. (2016). Comparison between healthy subjects and low back pain patients based on surface electromyography features. https://doi.org/10.1109/icsp.2016.7878053

DeGiorgio, C. M., Miller, P. J. O., Meymandi, S., Chin, A. W., Epps, J., Gordon, S. M., Gornbein, J., & Harper, R. M. (2010). RMSSD, a measure of vagus-mediated heart rate variability, is associated with risk factors for SUDEP: The SUDEP-7 Inventory. Epilepsy & Behavior, 19(1), 78–81. https://doi.org/10.1016/j.yebeh.2010.06.011

Yugar, L. B. T., Yugar-Toledo, J. C., Dinamarco, N., Sedenho-Prado, L. G., Moreno, B. V. D., De Azevedo Rubio, T., Fattori, A., Rodrigues, B., Vilela-Martin, J. F., & Moreno, H. (2023). The Role of Heart Rate Variability (HRV) in Different Hypertensive Syndromes. Diagnostics, 13(4), 785. https://doi.org/10.3390/diagnostics13040785

REFERENCE

Malik, M., Bigger, J. T., Camm, A. J., Kleiger, R. E., Malliani, A., Moss, A. J., & Schwartz, P. J. (1996). Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. European Heart Journal, 17(3), 354–381. https://doi.org/10.1093/oxfordjournals.eurheartj.a014868

Shaffer, F., & Ginsberg, J. P. (2017). An Overview of Heart Rate Variability Metrics and Norms. Frontiers in Public Health, 5. https://doi.org/10.3389/fpubh.2017.00258

Arendt-Nielsen, L., & Mills, K. I. (1985). The relationship between mean power frequency of the EMG spectrum and muscle fibre conduction velocity. Electroencephalography and Clinical Neurophysiology, 60(2), 130–134. https://doi.org/10.1016/0013-4694(85)90019-7

Okino, K., Aoki, M., Yamane, M., Kataoka, Y., Nitta, A., & Kohmura, C. (2022). Prolonged Sitting Causes Leg Discomfort in Middle Aged Adults: Evaluation of Shear Wave Velocity, Calf Circumference, and Discomfort Questionaries. Journal of Clinical Medicine, 11(14), 4024. https://doi.org/10.3390/jcm11144024

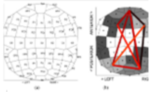
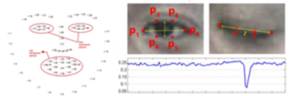
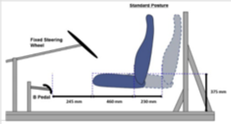
Saito J., Muraki S. (2016). Research of uncomfortable pain due to prolonged walking and standing. J. Biomech;40:121–130. doi: 10.3951/sobim.40.2_121. (In Japanese) [CrossRef] [Google Scholar]

Klimek, L., Bergmann, K., Biedermann, T., Bousquet, J., Hellings, P., Jung, K., Merk, H. F., Olze, H., Schlenter, W., Stock, P., Ring, J., Wagenmann, M., Wehrmann, W., Mösges, R., & Pfaar, O. (2017). Visual analogue scales (VAS): Measuring instruments for the documentation of symptoms and therapy monitoring in cases of allergic rhinitis in everyday health care. Allergo Journal International, 26(1), 16–24. https://doi.org/10.1007/s40629-016-0006-7

Pearson, E. (2009). Comfort and its measurement – A literature review. Disability and Rehabilitation: Assistive Technology, 4(5), 301–310. https://doi.org/10.1080/17483100902980950

Vink, P. (2014). The sweetness of discomfort : Designing the journey. TU-Delft. http://resolver.tudelft.nl/uuid:517db1ea-9e10-4ba7-9bae-f012698eddb3

APPENDIX I METHODOLOGY CONCLUSION (HAVENT FINISHED YET)

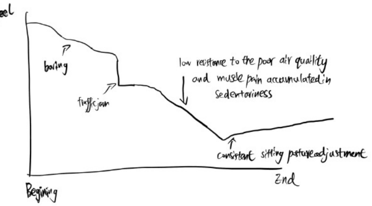
Article Name	Author	Publish Year	Participants	Thresh of defination fatigue	Instrument	Body Part Investigation	Duration	Environment setting	Method	Results
The Relationship Between Drivers' Cognitive Fatigue and Speed Variability During Monotonous Daytime Driving	Jinfei Ma1 , Jiaqi Gu1 , Huibin Jia2 , Zhuye Yao1 and Ruosong Chang1 *	Apr-18	21	increased EEG algorithm ($(\theta+\alpha)/\beta$ was an effective indicator for detecting drivers' fatigue (Jap et al., 2009). Therefore, this ratio was chosen as a factor that assessed drivers' fatigue state.	EEG	Head	60 mins			In this study, the psychological and physiological data confirmed that the 60-min prolonged monotonous driving task successfully elicited driver's cognitive fatigue, indicating an underload state (Desmond
Reliability of simulator driving tool for evaluation of sleepiness, fatigue and driving performance	D Davenne 1, R Lericollais, P Sagaspe, J Taillard, A Gauthier, S Espié, P Philip	Mar-12	20 drivers for simulated driving;14 people for real drive	VAS measure to define the results	VAS for fatigue(self report) and sleepiness,ILC	Whole body(self-report)	Last one hour		we only compared the ILC for the last hour of each drive, instead of the possible 2 h. Before starting to drive and at the end of each lap (i.e., every hour),	
Assessment of driving fatigue based on intra/inter-region phase synchronization	Wanzeng Kong a b, Zhanpe	Jan-17	15 healthy students participated	KSS &	 KSS+Fus	Head	3h		There are eight conditions in the experimental session and each of them includes a race of 2 laps.	We can conclude that the index of NASA_TLX is positively correlated with stimuli frequency (ρ=0.6939).
Computer vision-based approach to detect fatigue driving and face mask for edge computing device	Ashiqur Rahman, Mamun Bin Harun Hriday, Riasat Khan	Oct-22	x	 ERA definition+heart PERC	ERA+heart rate PERC	ERA+heart rate sensor+			including sociodemographic factors for associations between fatigue and perceived stress in the general	
Physical and cognitive consequences of fatigue: A review	Hoda M. Abd-Elfattah a, Faten H. Abdelazeim b, Shorouk Elshennawy b	May-15	x	Fatigue is different from normal experiences such as tiredness or sleepiness	x	x	x	x	x	x
Driving Fatigue and Performance among Occupational Drivers inSimulated Prolonged Driving	Kee Sze SeenShamsul Bahri Md TamrinShamsul Bahri Md TamrinYong Meng GohYong Meng Goh	Mar-10	25	alpha,beta and theta bands	. The EEG data was recorded with 16 bit quantitation at1024 Hz +Driving performance index (RORI and LSV)	Head+simulated driving error measure	3h		Simulated driving enivormnet, asking people to finish tasks within 3hrs, with EEG and task finished error as the measurements.	EEG/error,simulated driving is different from real driving, the vigilance
Perceived discomfort and neuromuscular fatigue during long-duration real driving with different car seats	Mathieu Lecocq 1 2, Pascaline Lantoine 2 3, Clément Bougard 3, Jean-Marc Allègre 3, Laurent Bauvineau 3, Damián	2022 Dec 12	21(mean age)	VAS+EMG	EMG+	soft-S1, firm-S2 and suspended-S3 + 8 muscle	3h	simulated driving environment	Ask participants join different experiment.Every twenty minutes, ask they discomfort score.	Overall, our results demonstrated that S3 could be considered as the most suitable seat to delay discomfort and NMF
Driving performance and driver discomfort in an elevated and standard driving position during a driving simulation	Jordan Smith a b, Neil Mansfield a, Diane Gyi a, Mark Pagett b, Bob Bateman b	2015 Feb 4	12	VAS scoring	VAS body discomfort assessment	Posture when driving, body parts,Driver performance, reaction time,discomfort	60MINS			software (XPI Simulation) allowed both steering and pedal inputs and provided visual (Samsung 50″ 1080p Screen) and audio outputs
Driver fatigue transition prediction in highly automated driving using physiological features	Feng Zhou a, Areen Alsaid b, Mike Blommer c, Reates Curry c, Radhakrishnan Swaminathan c, Dev Kochhar c, Walter Talamonti c, Louis Tijerina c, Baiying Lei d	1 June 2020	20	PERCLOS data		Eyes		The VIRTTEX (VIRtual Test Track EXperiment) driving simulator (see Blommer & Greenberg, 2003; Grant, Artz, Greenberg & Cathey, 2001for details) was used in the study to collect data		

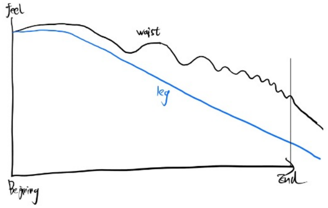
APPENDIX I METHODOLOGY CONCLUSION (HAVENT FINISHED YET)

Long-term Discomfort Evaluation: Comparison of Reported Discomfort between a Concept Elevated Driving Posture and a Conventional Driving Posture	Jordan Smith*, Neil Mansfield, Diane Gyi	2015	20	VAS scoring		13 different body parts,(left shoulder, right shoulder, upper back, middle back, lower back, buttocks, left thigh, right thigh, right ankle		 		
Heart Rate Variability Can Be Used to Estimate Sleepiness-related Decrements in Psychomotor Vigilance during Total Sleep Deprivation	Eric Chern-Pin Chua, PhD,1 Wen-Qi Tan, BEng,2 Sing-Chen Yeo, BSc,3 Pauline Lau, BSc,1 Ivan Lee, BSc,1 Ivan Ho Mien, BEng, MBBS,4 Kathiravelu Puvanendran, MBBS, MRCP, FRCP, FAMS,3 and Joshua J. Gooley, PhD1	2012 Mar 1								
Feelings and strategies of senior drivers:ways of coping with fear ?	Béatrice Cahour		12	Interview	Recording and coding	People's words	half an hour	 	Interview 12 people from paris, ask them to describe their emotion.	

APPENDIX II STREET INTERVIEW INITIAL VERSION RAW MATERIAL

This interview is a preliminary step toward conducting a formal interview that aims to address the research questions: "What is fatigue?" and "How can fatigue be measured?" At this stage, the goal is to gather quick insights from drivers regarding how they personally perceive fatigue. This input may serve as a preliminary threshold or indicator of fatigue for future steps. Seven people joined the interview, they shared their perspectives below:





I want to adjust the body to make myself feel comfortable. It is hard for me to say which comes first, drowsy or waist discomfort. My waist is the problem that people

"Half an hour (No much experience on driving)"

"If I feel fatigue, which means I fall asleep, When it happens, I will stop to have a coffee"

I feel I am tired after 2 hours, I feel drowsy, then I feel uncomfortable, when I feel fatigue, I will open the window and smoke for a while. If I feel my butts uncomfortable, I will move a bit to adjust the position. I cannot say the drowsy comes first or butts uncomfortable comes first.

I use my right leg to control the break, I feel that my leg has something wrong, I also feel drowsy, however, I think there is no any connections between drowsy and uncomfortable on body. Before my waist has some problems, I firstly feel drowsy, then waist was uncomfortable, Now, my waist now first uncomfortable, the uncomfortable keeps me feel awake!

I feel fatigue till 2 hours, I feel drowsy, I will somke to keep awake.

I cannot really concentrate after I drive for 4-5 hours, the long sitting and concentration makes me feel fatigue, I think the physical and mental influence is hard to define, (half and half?), normally, I feel that I cannot concentrate means fatigue, I maybe choose to stop and change another person to drive,

Fatigue

Fatigue is a feeling of weariness, tiredness, or lack of energy.

Considerations

Fatigue is different from drowsiness. Drowsiness is feeling the need to sleep. Fatigue is a lack of energy and motivation. [
feeling of not caring about what happens) can be symptoms that go along with fatigue.

Fatigue can be a normal and important response to physical activity, emotional stress, boredom, or lack of sleep. Fatigue
and it is usually not due to a serious disease. But it can be a sign of a more serious mental or physical condition. When fa
enough sleep, good nutrition, or a low-stress environment, it should be evaluated by your health care provider.

https://medlineplus.gov/ency/article/003088.htm

Physical activity

Emotional stress

Boredom

Discomfort

Discomfortable:

Synonyms of *fatigue* >

1 a : LABOR
b : manual or menial work (such as the cleaning up of a camp area) performed by military personnel
c **fatigues** plural : the uniform or work clothing worn on fatigue and in the field

2 a : weariness or exhaustion from labor, exertion, or stress
We were overcome by *fatigue* after the long hike.
b : the temporary loss of power to respond that is induced in a sensory receptor (s
RECEPTOR sense a) or motor (see MOTOR entry 2 sense 1) end organ by continu
stimulation
c : a state or attitude of indifference or apathy brought on by overexposure (as to
repeated series of similar events or appeals)
... a super PAC supporting Hillary Clinton launched within days of Barack Obam

Describe yourself

1-10

Drowsy sleepiness

Perceived cognitive discomfort (Drowsy, cannot focus or concentrate)

Time

Physical discomfort, lumbar part, thight uncomfortable

Perceived Fatigue

physical fatigue

Choose word to define fatigue.

Want to conduct a street interview

Rough interview question list

When do you feel fatigue during driving situation?

✓ How do you realize yourself or how do you define yourself "feel fatigue"?

✓ Are you more likely to feel hard to keep mind clear to finish the driving tasks or feel more discomfort of the physicals things?

x

how scale you agree, change it into a state. (easy to answer)

Which road makes you feel fatigue (Drowsy) or excited or scared?

What do you usually think or consider when you feel fatigue in the car?

✓ What actions you will do when you feel fatigue or uncomfortable during driving?

Can u image how you will be when you feel fatigue in the car? Facial movement, mental movement,etc?

fatigue和一些东西有个objective兼影响

有哪些symtons，让你觉得fatigue。

Theshold

Literature support

Write a question list to peter

driving experience

APPENDIX III STREET INTERVIEW VERSION 2

Gender:

Approximate age:

20+ 30+ 40+ 50+ 60+

Do you have any healthy problem (chronic illness)make you feel uncomfortable while you're driving?

How many year driving experience you have?

1 year 2 year

More confident ,less nervous,nervous cause fatigue.

CONFIDENCE IN, AND SELF-RATING OF, DRIVING ABILITY AMONG OLDER DRIVERS

Confidence scores were significantly correlated with driving frequency (r=0.31, p <0.0005), but were not associated with either age (r = - 0.13, p > 0.15) or education (r = 0.05, p>0.60). There was no association between confidence and gender, as women and men were equally confident in their abilities for those conditions under which they drove [t(123)=1.63, p>0.10]. However, men were more likely than women iskier conditions [t(123) = 2.97, p < 0.005].

Driving frenqucy influence the confidence

Acceptance of self-driving cars among the university community: Effects of gender, previous experience, technology adoption propensity, and attitudes toward autonomous vehicles

Our (economic) decision-making is affected by *familiarity*, not simply the experience, but rather the objective information we can gain (LaRiviere et al., 2014). Familiarity with AVs can reduce worries and have a positive effect on attitudes toward them, as shown in some studies (e.g. Dai et al., 2021). Drivers with prior knowledge of AVs are less concerned with AVs and more willing to relinquish driving control (Charness et al., 2018). Nees (2016) concluded that respondents who are familiar with self-driving technology and are exposed to articles on the topic had a greater acceptance of self-driving cars. However, Wicki (2021) found no effect of familiarity on acceptance or concerns in their research.

More experience makes less worries

How should I meansure the "experience"

OK, imagaine you are under figure's situation and doing this for a long time. What you will feel? would you mind using some words to describe ?

Which symptoms below is most similar to describe what you feel during driving? If these symptoms happen with a certain sequence, you can rearange them.

Dizziness | Drowsy,sleepiness | Stiff Joints | Sore feet | Or other thing

Development of fatigue symptoms during simulated driving

	Not	Uncertain	Somewhat	Definite
Dizziness	1	2	3	4
Chills	1	2	3	4
Back ache	1	2	3	4
Stiff joints	1	2	3	4
Numbness	1	2	3	4
Headaches	1	2	3	4
Flushed	1	2	3	4
Sore feet	1	2	3	4
Throat parched	1	2	3	4
Sore legs	1	2	3	4
Ringing in ears	1	2	3	4
Heart racing	1	2	3	4
Stomach upset	1	2	3	4
Clammy hands	1	2	3	4
Muscles tense	1	2	3	4
Drowsy	1	2	3	4
Heart pounding	1	2	3	4
Eyes strained	1	2	3	4

Can you draw a plot to describe symtoms happen in the whole process of driving in a car?

What you will think/(for example, I feel unhappy or just without anything) normally when you feel these symptoms during driving?

What you usually do when you have these symptoms you mentioned above to make you feel better?

APPENDIX IV STREET INTERVIEW VERSION 2

TU Delft
Mekelweg 5, 2628 CD Delft
Yaemokugo@gmail,com

Gender:

Approximate age:

20+ 30+ 40+ 50+ 60+

Do you have any healthy problem (chronic illness)make you feel uncomfortable while you're driving?

How many year driving experience you have?

1. imagaine you are under figure's situation and doing this for a long time. What you will feel? would you mind using some words/sentence to describe ?

2.Which symptoms below is most similar to describe what you feel during driving? If these symptoms happen with a certain sequence, you can rearange them.

1. Dizziness | 2.Drowsy,sleepiness | 3.Stiff Joints | 4.Sore feet | 5.________

3.Which symptoms happen on you makes you think you feel fatigue?

4.How many hours make you feel fagtiue?

5.What you will think/(for example, I feel unhappy or just without anything) normally when you feel these symptoms during driving?

6.What you usually do when you have these symptoms you mentioned above to make you feel better?

This form is used for reserach of driving fatigue, I permiss that the data will not be used anywhere except for this research.

APPENDIX V RAW MATERIAL OF INTERVIEW

01

F 50+ No 37y

Sleepy, left leg inative

2

Sleepiness and Impatience

2hr

Impatient

Move the hip and adjust the sitting posture slightly but frequently, and strench left leg.

02

M 40+ Diabat 25y

Less concentrate,sun make eyes closed

2134

Sleepiness

2hr-3hr

Want to sleep

Stop and have a coffee,wash face and walking out side a bit

03

M 20+ No 2y

I will get sleep driving more that 2 hours, loss focus.

32

Yawning, staring somewhere

2hr+

Empty mind

Stop the car if exceed 2hrs, if stiff joints---I will move my body a bit on the seat.

04

F 20+ No 5y

Being anxiade and focused,get headache. cannot have a break from focusing

3 headache 2

Headache,misty feeling

2hr+

No place for thing any thing

Stop at the gas station, if possible switch the driver

05 DEER

M 20+ no 4y

I feel I loss the strength and tried,eyes feel something wrong, brain is misty.

2431

"feel fagtiue" cannot describe

1.5hr

Empty mind

Open the window, eat guns, move the butt,wasit and move the leg.

06

M 60+ no 40+y

I feel boring

2

Sleepiness

8-10hrs

How long it will take to the destination

Drink coffee and listen to music

07

M 40+ no 30+y

It depends on weather, I feel good in the car anyway, I really like driving.

Loss concentrate 4

Loss concentrate

3hs

Empty mind

Gas stop, I will drink something

08 di

M 60+ no 30+y

Feel uncomfortable with necks, need to keep adjust the posture (specially back part of chair)

3421

Stiff Joint

3hs

Think about stop to rest

Adjust the seat, move the butt, drink the water.or stop use cold water to wash the face, or stop the car sleep for a while

09 me

M 20+ no 1+y

Feel tired and sleepiness, sometimes I will be angry with the traffic jam.

2341

stiff joint

2hs

When time intense,I will feel unhappy, if it is not urgent, I will try to find somethere to stop.' I do not want to die.'

I will play the music and listen to the novel, sometimes I will sing, and make the hurt feeling to refresh.

10xuedi

M 20+ no 2+y

It makes me feel impatient ar I cannot focus on the road fo long time.I am not experience driver, means I keep a straigh posture, which makes waist sour easily.

2341

Cannot focus

2hrs

I want to stop immediately and have a rest.

snesation stimulus. I eat mint candy to stay conscious or listen to rock music.

11 zj

1 30+ no 8+y

iet tired and bored. specially when driving on highway for ommuting purposes, it's asy to get bored

2

rowsy/sleepiness

leepy mainly, I feel unexcited, luggish, and unable to concentrate. t his kind of moment, I just want to top the car or at least talk with omeone because I know it could be xtremely dangerous if I continue riving

-1.5hr

usually realized that I should stop riving. I don't feel emotional about his because it's normal

est, talking, singing to some iusic. These measures have iminishing effectiveness in ghting fatigue

12 fengjing

M 20+ no 6ys

Distracted. Mind-wandering,not easy to focus on the road.

41

mind got distracted by other than the raid informaytion

2-3hrs

not unhappy, but feel that I need some rest at the service area.

Listen to some exciting music with strong drumbeats, try to some overtakes, rest at the service area.

13 Maria

F 20+ NO 2+ys

Stiff and fatigue

3

Tell myself to keep concentrate

1hr

I will tell myself to keep concetrate

I will stop when traffic light is red, and I will eat the gun.

14 lychee

15HTTP

M 20+ cervical spondylosis 2y+

I feel my feet and leg are really uncomfortable

4321

sleepiness/cannot concentrate

1hr

Think I need to focus on driving or stop

I will try to stop the car, if the body is not comfortable, I will try to switch people to drive or just stop at side.

16 ciaoge

M 65+ no 15+y

I feel tired

2431

I think the sleepiness

4hrs

did not think about it

i want to stop to have a rest

17XIao

M 40+ no 15+

I feel so happy when I am driving,

4312

sleepiness

2hrs

I want to sing a song or have a rest.

I will drink tea and coffee, or stop and have a sleep

18 jiejie

M 30+ no 6+

I feel tired and want to bend the body on the chair, concentration loss

waist uncomfortable, sleepiness, dizzie, butt uncomfortable.

Sleepiness

2hrs

I will listen to the music and sing a song, i want to sit straight when my waist is uncomfortable, I try to sit closed to the steer wheel, I will move my body anyway.

19 zuowen

M 20+ no 6+

I feel tired, eyes strain, and sleepiness. Sometimes the butt and leg will feel paralysis

2, butt/leg uncomfortable

eye strain, yawning, sleepiness

2hrs

I go to the service stop and I will stop and have a rest.

20 lm

Wait to fill

21 lm

Wait to fill

APPENDIX VI VAS SELF REPORT & BEHAVIOR RECORD FORM

Record form

Test person 1

	0 mins	15 mins	30 mins	45mins	60mins
iness					
limbs					
ache					
ache					
bness					
nuscles					

Test person 2

	0 mins	15 mins	30 mins	45mins	60mins
ness					
mbs					
he					
che					
ness					
uscles					

APPENDIX VII DESCRIPTION FLOW OF PRE PILOT TEST

Preparation

Open the suitcase of EMG. make the cables in a right place and open the software of EMG pretest. The set up should be prepare

1. Introduce the project tell the testers about what we are going to measure. HRV , your mood, and your muscle activities.

2. asking a person sitting on the chair in Multisensory Lab

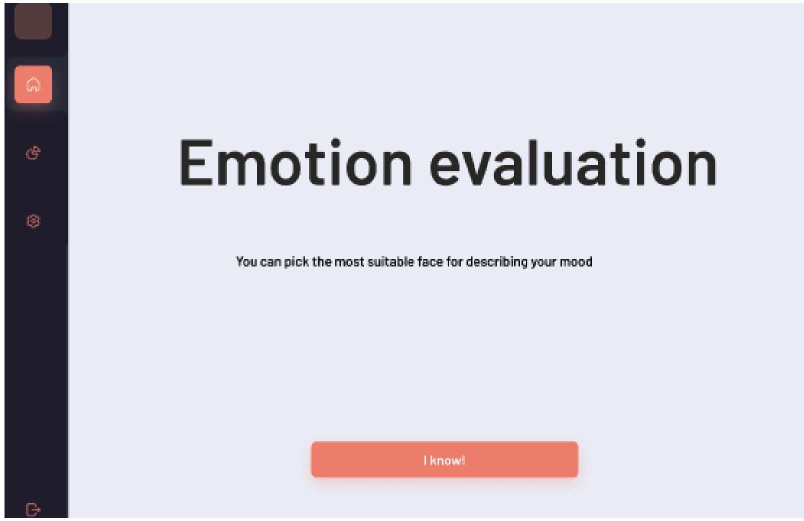
3.Open the switch of **rhythm 24+,** Give the tester the band and a them to wear it at root of low arms.

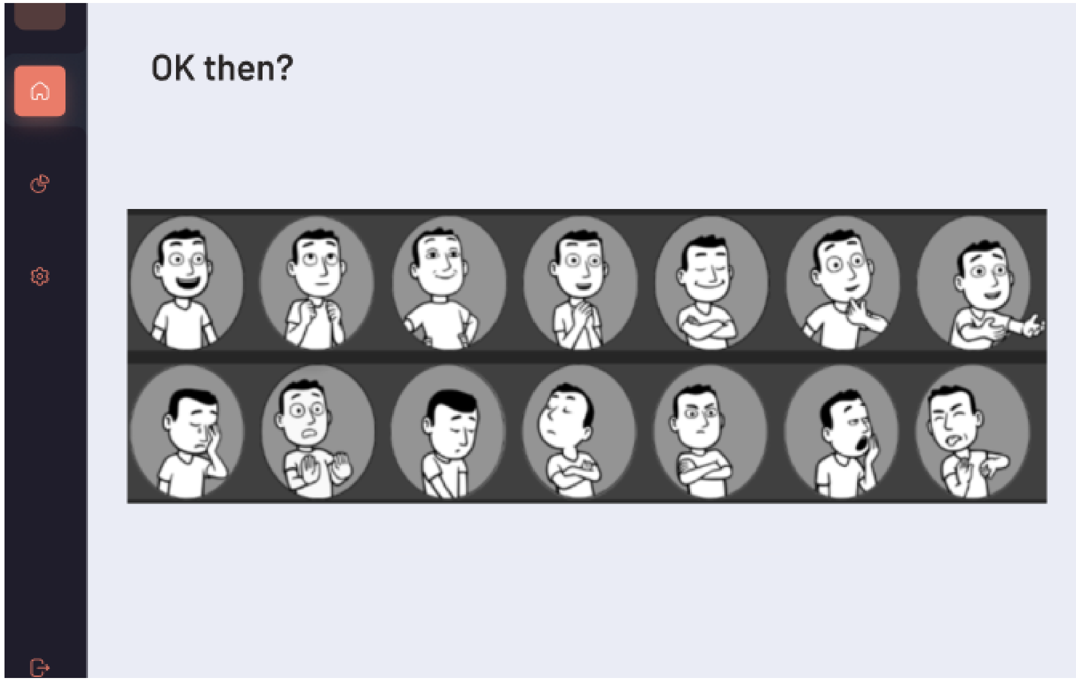
4.put the **stickers at the waist muscle** and if it is possible at lo leg muscle. Open the EMG software laptop.

5.**Ipad.**Put the interface of emotion selection in front of testers, l them choose their mood.

Everything is ready, open the timer. to count 15mins without ma Then next 15mins with mat (mat pls move evenly per 3 minutes) and 15mins mat again, and 15mins without mat.

APPENDIX VIII EMOTION EVALUATION FLOW ON IPAD





APPENDIX VIIII TESTER 1 DATA

Tester 1

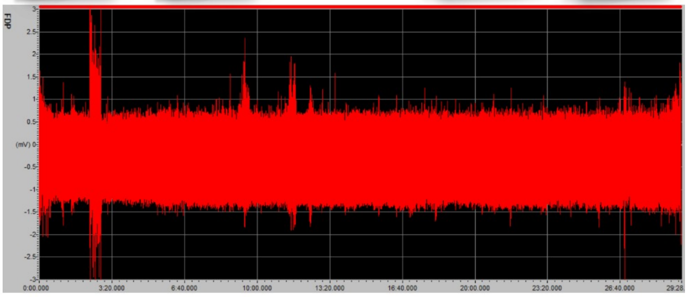
First 30mins EMG loss

3rd 15mins

with pressure distriubtion

4th 15mins

without pressure distrubtion

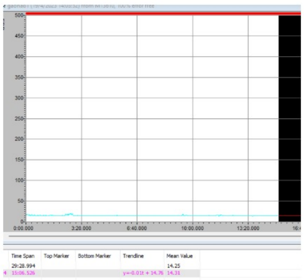


Frequcny domain

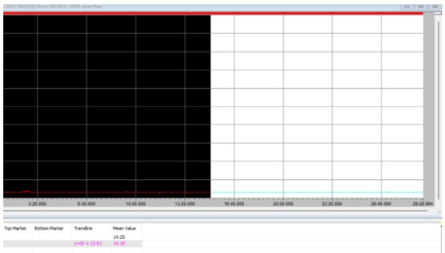
5mins say it is happy emotion

RMSSD

chair shaking

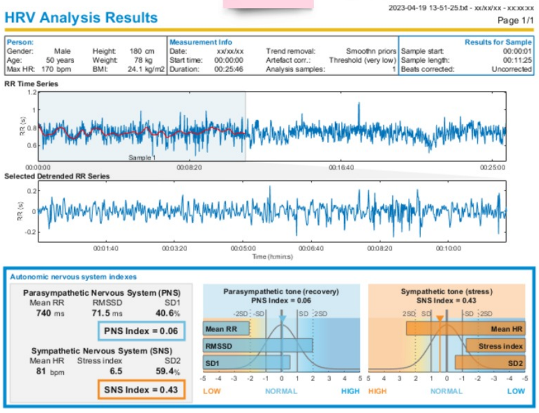


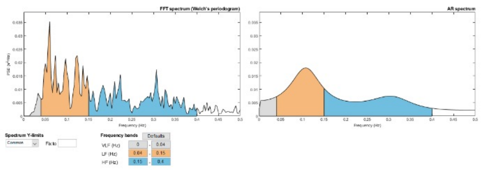
3rd 15 mins with pressure distribution



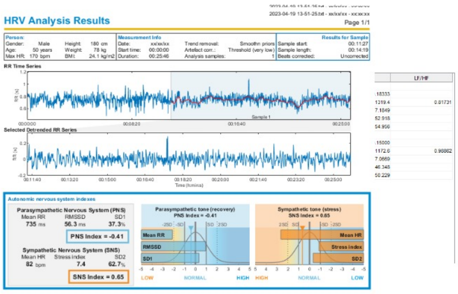
4th 15 mins with pressure distribution

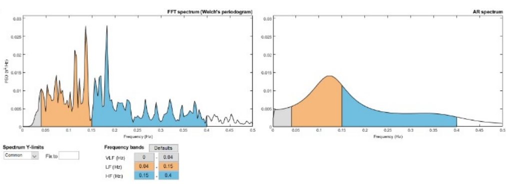
with pressure distriubtion





without pressure distrubtion





RMSSD, a Measure of Heart Rate Variability, Is Associated With Risk Factors For SUDEP: The SUDEP-7 Inventory

The results indicate that a measure of vagus-mediated control of the heart, RMSSD, is highly associated with the SUDEP-7 risk inventory score. Subjects with low RMSSD values (poor vagus-mediated HRV) tended to have higher SUDEP-7 scores (higher risk for SUDEP). Although these findings will require validation in a larger cohort, the results provide preliminary evidence that a measure of HRV is associated with risk factors of SUDEP.

	0 mins	15 mins	30 mins	45mins	60mins
Sleepiness	8	6		5	4
Sore limbs	6	5		4	4
Backache	2	1		1	1
Headache	6	5		4	3
Numbness	2	2		1	1
Stiff muscles	3	3		2	2
	17	16			

APPENDIX VIIII TESTER 2 DAT

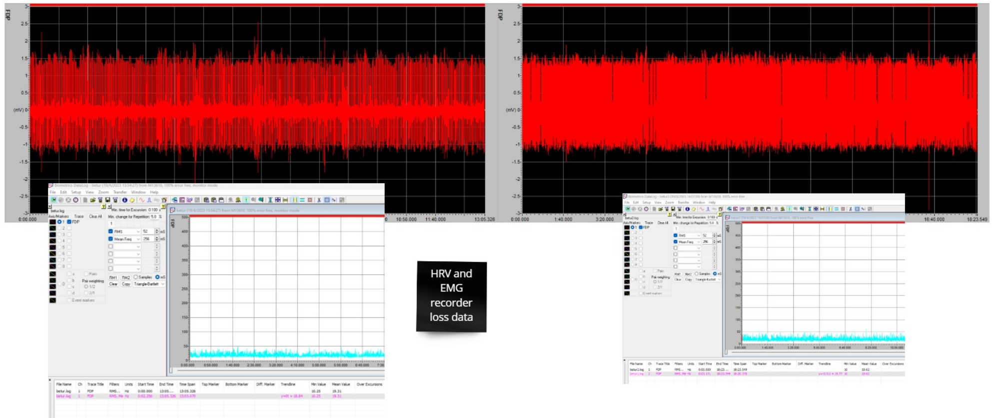
No.2

First 15mins

with pressure distriubtion

second 15mins

without pressure distrubtion

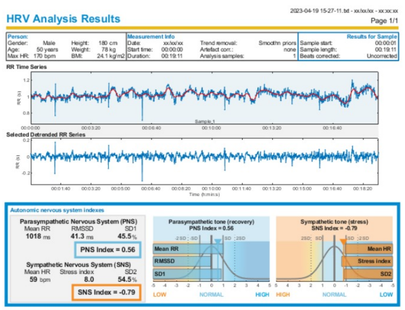


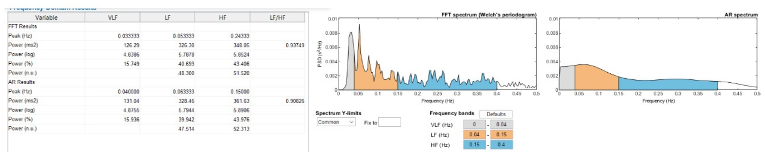
HRV and EMG recorder loss data

without pressure distrubtion

NO EMG

15-27-11





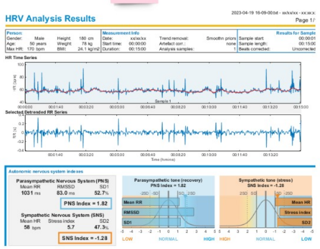
5mins say it is happy emotion

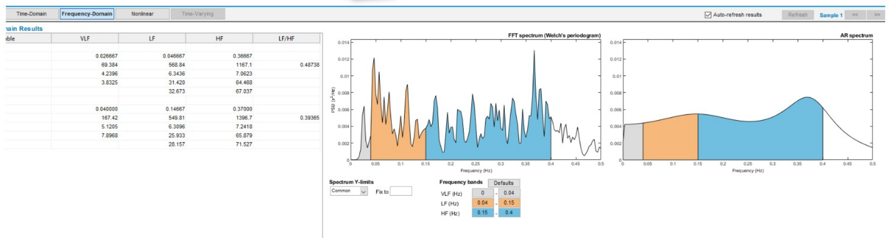
RMSSD

chair shaking

Frequcny domain

with pressure distriubtion





APPENDIX VIIII TESTER 3 DATA

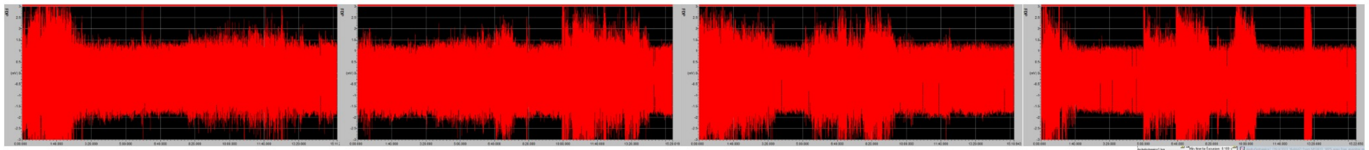
No.3

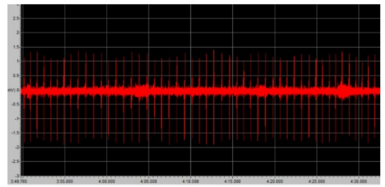
Testers are

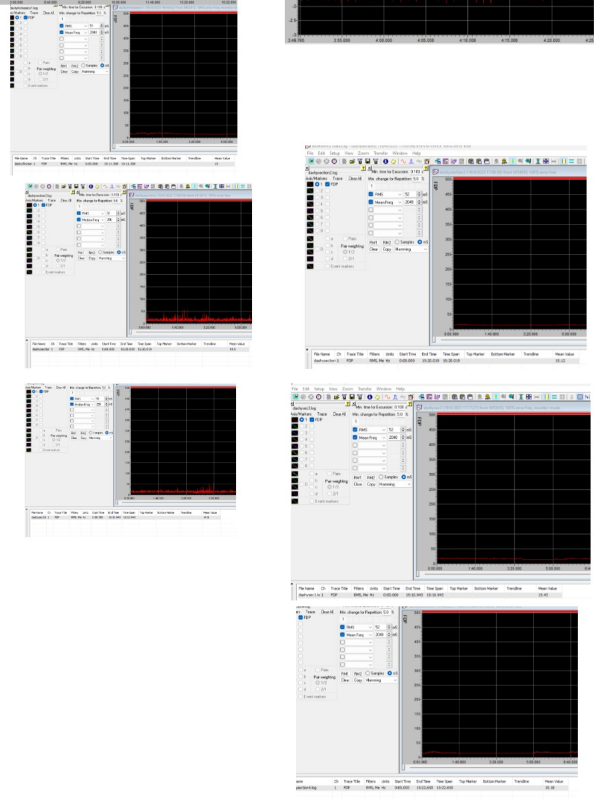
First 15mins

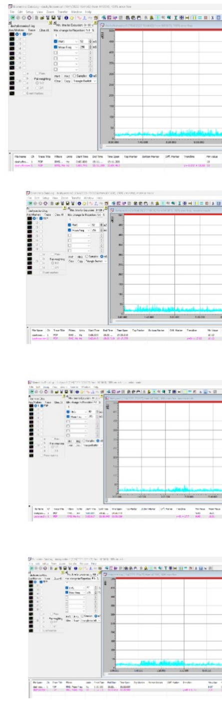
second 15mins

second 15mins









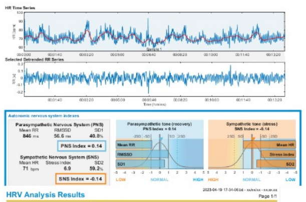
RMSSD

chair shaking

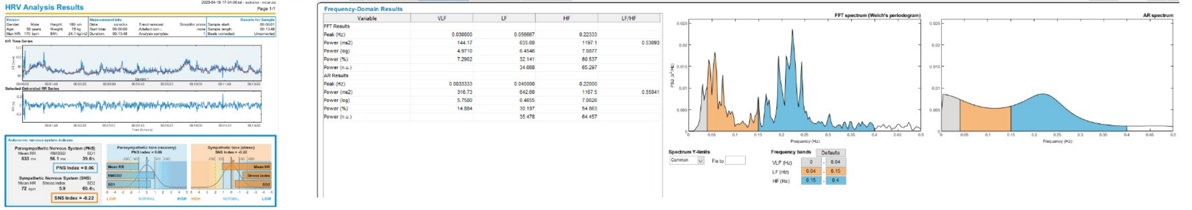
Frequcny domain

First two have no reference due to the tester was running to the office

with pressure stiruibution



without pressure strubution



0 mins 15 mins 30 mins 45mins 60mins

Sleepiness	5	1	5	7
Sore limbs	0	0	0	0
Backache	0	3	3	5
Headache	5	0	3	2
Numbness	0	0	0	0
Stiff muscles	0	0	0	0
	5	3	6	7

APPENDIX X CHECKLIST

IPADD | Research Form for testing QSt car seat

CHECK LIST

BEFORE PARTICIPANT COMING

- [ ] Check the height of the table
- [ ] Check the screen & other setting
- [ ] Check the EMG device & Battery
- [ ] Check the EMG software
- [ ] Check the app Elite HRV
- [ ] Check the HRV band

WHEN PARTICIPANTS COMING

- [ ] Introduce the research to participants
- [ ] Ask participants sign the consent form

SETTING PREPARATION

- [ ] Help participant wear the HRV device band on the arm
- [ ] Help participants wear EMG at
- [ ] the right and left trapezius
- [ ] the lumbar portion of the Erector Spinae muscle
- [ ] the Vastus lateralis muscle
- [ ] Fill Leg circumference form

1ST PART START

- [ ] Ask participant filling (Dis)comfort form
- [ ] Start the HRV (on App)record at the middle of 1st part for 5mins
- [ ] Start the EMG(on PC) record at the middle of 1st part for 5mins
- [ ] Fill Leg circumference form

2ND PART START

- [ ] Ask participant filling (Dis)comfort form
- [ ] Start the HRV (on App)record at the middle of 1st part for 5mins
- [ ] Start the EMG(on PC) record at the middle of 1st part for 5mins
- [ ] Fill Leg circumference form

3RD PART START

- [ ] Ask participant filling (Dis)comfort form
- [ ] Start the HRV (on App)record at the middle of 1st part for 5mins
- [ ] Start the EMG(on PC) record at the middle of 1st part for 5mins
- [ ] Fill Leg circumference form

4TH PART START

- [ ] Ask participant filling (Dis)comfort form
- [ ] Start the HRV (on App)record at the middle of 1st part for 5mins
- [ ] Start the EMG(on PC) record at the middle of 1st part for 5mins
- [ ] Fill Leg circumference form

AFTER SITTING SECTION

- [ ] give 5o euro to participants with crash or bank transform

APPENDIX XI THE FORMS

RESEARCH DATA SHEET FOR LEG CIRCUMFERENCE

NO:___________ AGE: 20+ 30+ 40+ 50+ 60+ OTHER WEIGHT: HEIGHT:  UPPER LEG LENGTH:

BEFORE SITTING	ATFER 1ST PD	ATFER 2ND PD	ATFER 3RD PD	FNISH PD

NO:___________ AGE: 20+ 30+ 40+ 50+ 60+ OTHER WEIGHT:

BEFORE SITTING	ATFER 1ST PD	ATFER 2ND PD	ATFER 3RD PD	FNISH PD

APPENDIX XI THE FORMS

IPADD | Research Form for testing QSt car seat

DISCOMFORT AND FATIGUE SYMTOPS 1STPART PD ~~PD~~

NO:____________

1.How do you feel your ***Neck****?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

2.How do you feel your ***Upper Back****?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

3.How do you feel your ***Mid Back****?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

4.How do you feel your ***Lower Back****?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

5.How do you feel your ***Buttock****?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

6.How do you feel your ***Thighs****?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

Feel Sleepiness?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Sore limbs?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Backache?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Headache?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Numbness?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Stiffness muscles?

Totally not agree — Totally agree

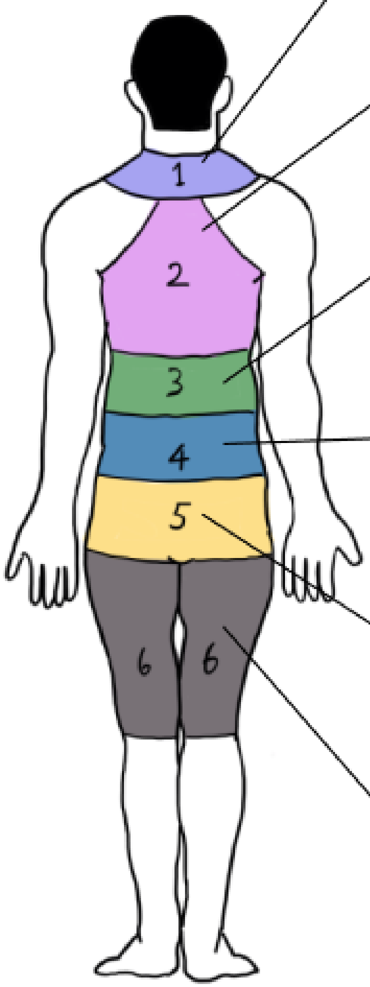
0 1 2 3 4 5 6 7 8 9 10

APPENDIX XI THE FORMS

IPADD | Research Form for testing QSt car seat

DISCOMFORT AND FATIGUE SYMTOPS 2NDPART PD PD

NO:____________



*1.How do you feel your **Neck**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*2.How do you feel your **Upper Back**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*3.How do you feel your **Mid Back**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*4.How do you feel your **Lower Back**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*5.How do you feel your **Buttock**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*6.How do you feel your **Thighs**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

Feel Sleepiness?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Sore limbs?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Backache?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Headache?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Numbness?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Stiffness muscles?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

APPENDIX XI THE FORMS

IPADD | Research Form for testing QSt car seat

DISCOMFORT AND FATIGUE SYMTOPS 3RDPART PD PD

NO:____________

*1.How do you feel your **Neck**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*2.How do you feel your **Upper Back**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*3.How do you feel your **Mid Back**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*4.How do you feel your **Lower Back**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*5.How do you feel your **Buttock**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*6.How do you feel your **Thighs**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

Feel Sleepiness?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Sore limbs?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Backache?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Headache?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Numbness?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Stiffness muscles?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

APPENDIX XI THE FORMS

IPADD | Research Form for testing QSt car seat

DISCOMFORT AND FATIGUE SYMTOPS 4THPART PD PD

NO:___________

*1.How do you feel your **Neck**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*2.How do you feel your **Upper Back**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*3.How do you feel your **Mid Back**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*4.How do you feel your **Lower Back**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*5.How do you feel your **Buttock**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

*6.How do you feel your **Thighs**?*

No discomfort at all — Extreme Discomfort

0 1 2 3 4 5 6 7 8 9 10

Feel Sleepiness?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Sore limbs?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Backache?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Headache?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Numbness?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

Feel Stiffness muscles?

Totally not agree — Totally agree

0 1 2 3 4 5 6 7 8 9 10

APPENDIX XI COMFORT FORM

IPADD | Research Form for testing QSt car seat

COMFORT FORM

NO:____________

Part 1

What is the comfort rating of the seat experience, circle the correct value (0-10, 0= lowest rating. 10 = highest)?

No comfort　　　　No comfort

0 1 2 3 4 5 6 7 8 9 10

Part 2

What is the comfort rating of the seat experience, circle the correct value (0-10, 0= lowest rating. 10 = highest)?

No comfort　　　　No comfort

0 1 2 3 4 5 6 7 8 9 10

Part 3

What is the comfort rating of the seat experience, circle the correct value (0-10, 0= lowest rating. 10 = highest)?

No comfort　　　　No comfort

0 1 2 3 4 5 6 7 8 9 10

Part 4

What is the comfort rating of the seat experience, circle the correct value (0-10, 0= lowest rating. 10 = highest)?

No comfort　　　　No comfort

0 1 2 3 4 5 6 7 8 9 10

APPENDIX XII CONSENT FORM

Informed Consent

(08/06/2023)

Dear Participants,

Thank you for collaborating with this research on the topic: **Fatigue and discomfort of a luxury car seat.**

Purpose of the Research

The study of the new chair's aspects influencing fatigue and (dis)comfort is crucial, as it can help improve the chair as a product. The research lasts 2 hours and 30 minutes in total, sitting on two different chairs (one chair is a regular car seat, and another is a chair with a CE massage function). You are required to wear two devices to record your heart rate variability (measured by Scosche Rhythm 24+) and muscle signals(recorded by Biometrics DataLog). Additionally, you need to fill out a form during the sitting to gather information about fatigue symptoms, such as sleepiness and discomfort, and some anthropometric measures are needed such as lower leg Circumference, leg length, and back length. This information will be used for comparison with a regular chair to assess whether the new chair shows any progress.

Benefits and risks of participating

The (dis)comfort and fatigue symptoms will be asked during sitting.

There are no risks in this study.

There will be a 50 euros financial compensation for participating entirely in this sitting session, and you will help us to get information about the chair's function and performance on people, which can increase the experience of people sitting on the chair in the future.

Withdrawal from the study

You can withdraw from the study at any moment during the study. The (partially) collected data regarding you will be destroyed with your requirement. Your compensation will be adapted for this condition, and you will receive the travel costs.

Withdrawal Anonymize & Store & Access the data

The collected data will be anonymized in such a way that the name & addresses of the participants will not be traceable in the publications. In the publication only the following results will be published:

- The statistical results of average age and standard deviation of the group, weight, and basic anthropometry measures, e.g., lower leg Circumference;
- The statistical results of any subjective questions regarding the experience of fatigue symptoms and (dis)comfort;
- The statistical results of heart variability rate and electromyography.

The data will NOT be shared and re-used by default. But the participants can voluntarily donate the data to the research team to be anonymously used in future research.

APPENDIX XII CONSENT FORM

Consent form for
Study of fatigue symptoms and (dis)comfort of a new chair

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated [__/__/*2023*], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason. I also understand that I will not get financial compensation due to the incompletes of participating.	☐	☐
3. I understand that taking part in the study involves providing my anthropometric information, including heart rate variability, muscle fatigue signals, age, lower leg circumference, and my subjective scores of past experiences related to fatigue and (dis)comfort.	☐	☐
4. I understand that I will be compensated for my participation, with 50 euros and a travel fee.	☐	☐
5. I understand that the study will around 2 hours and 30 mins.		
B: POTENTIAL RISKS OF PARTICIPATING		
6. I understand that participating in the study involves the following risks: physical discomfort and fatigue symptoms due to prolonged sitting during driving.	☐	☐
7. I understand that these risks can be mitigated by allowing withdrawal from the study at any time.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
8. I understand that after the research study, the de-identified information I provide will be used for reports and publications.	☐	☐
9. I agree that my responses, views or other input can be quoted anonymously in research outputs	☐	☐
D: LONG-TERM RESEARCH ASSISTANT		
10. I voluntarily donate the collected anonymous data for future research.	☐	☐

APPENDIX XII CONSENT FORM

Signatures

Name of participant	Signature	Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Xiranai Dai	Xiranai Dai	16th July 2023
Researcher name	Signature	Date

APPENDIX XIII SPSS REPORT

M SPSS Statistics Viewer

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Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	withQST1+2	72.0694	16	13.01838	3.25460
	WithoutQST1+2	72.3356	16	15.19866	3.79967
Pair 2	WithQST3+4	76.7200	16	16.01107	4.00277
	Without QST3+4	70.0506	16	12.65570	3.16393

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	withQST1+2 & WithoutQST1+2	16	.288	.280
Pair 2	WithQST3+4 & Without QST3+4	16	.899	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	withQST1+2 - WithoutQST1+2	-.26625	16.92831	4.23208	-9.28671	8.75421	-.063	15	.951
Pair 2	WithQST3+4 - Without QST3+4	6.66937	7.23624	1.80906	2.81345	10.52530	3.687	15	.002

APPENDIX XIII SPSS REPORT

BM SPSS Statistics Viewer

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T-Test

[DataSet1]

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	With QST1+2	7.00	16	1.932	.483
	Without1+ 2	6.94	16	1.948	.487
Pair 2	WithOST 3+4	7.25	16	2.049	.512
	Without OST3+4	6.81	16	2.007	.502

Comfort form

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	With QST1+2 & Without1+ 2	16	.248	.355
Pair 2	WithOST 3+4 & Without OST3+4	16	-.117	.665

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	With QST1+2 - Without1+ 2	.063	2.380	.595	-1.205	1.330	.105	15	.918
Pair 2	WithOST 3+4 - Without OST3+4	.438	3.032	.758	-1.178	2.053	.577	15	.572

IBM SPSS Statistics Processor is ready

APPENDIX XIII SPSS REPORT

*Output1 [Document1] - IBM SPSS Statistics Viewer

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T-Test

[DataSet1]

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	withQST1+2	93.9381	16	10.88854	2.72214
	WithoutQST1+2	63.9213	16	13.26249	3.31562
Pair 2	WithQST3+4	91.4631	16	15.21138	3.80284
	Without QST3+4	60.4887	16	9.28293	2.32073

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Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	withQST1+2 & WithoutQST1+2	16	-.018	.948
Pair 2	WithQST3+4 & Without QST3+4	16	-.040	.884

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	withQST1+2 - WithoutQST1+2	30.01688	17.30700	4.32675	20.79463	39.23912	6.938	15	.000
Pair 2	WithQST3+4 - Without QST3+4	30.97438	18.13189	4.53297	21.31258	40.63617	6.833	15	.000

IBM SPSS Statistics Process

APPENDIX XIII SPSS REPORT

Output1 [Document1] - IBM SPSS Statistics Viewer

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T-Test

[DataSet1]

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	withQST1+2	86.5581	16	21.40605	5.35151
	WithoutQST1+2	65.3275	16	12.93908	3.23477
Pair 2	WithQST3+4	83.6719	16	17.64109	4.41027
	Without QST3+4	62.6231	16	15.10483	3.77621

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Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	withQST1+2 & WithoutQST1+2	16	.126	.643
Pair 2	WithQST3+4 & Without QST3+4	16	.234	.382

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	withQST1+2 - WithoutQST1+2	21.23063	23.57945	5.89486	8.66602	33.79523	3.602	15	.003
Pair 2	WithQST3+4 - Without QST3+4	21.04875	20.35915	5.08979	10.20013	31.89737	4.135	15	.001

- IBM SPSS Statistics Viewer

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T-Test

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Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	withQST1+2	74.1094	16	17.28381	4.32095
	WithoutQST1+2	69.2544	16	13.71657	3.42914
Pair 2	WithQST3+4	74.1031	16	13.05459	3.26365
	Without QST3+4	68.5313	16	13.00526	3.25131

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	withQST1+2 & WithoutQST1+2	16	.482	.059
Pair 2	WithQST3+4 & Without QST3+4	16	.770	.000

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	withQST1+2 - WithoutQST1+2	4.85500	16.07026	4.01757	-3.70824	13.41824	1.208	15	.246
Pair 2	WithQST3+4 - Without QST3+4	5.57188	8.83003	2.20751	.86668	10.27707	2.524	15	.023

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APPENDIX XIII SPSS REPORT

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Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	2[a]	10.25	20.50
	Positive Ranks	11[b]	6.41	70.50
	Ties	3[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	5[d]	8.80	44.00
	Positive Ranks	9[e]	6.78	61.00
	Ties	2[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2

b. WithoutQST1+2 > withQST1+2

c. WithoutQST1+2 = withQST1+2

d. Without QST3+4 < WithQST3+4

e. Without QST3+4 > WithQST3+4

f. Without QST3+4 = WithQST3+4

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-1.761[b]	-.539[b]
Asymp. Sig. (2-tailed)	.078	.590

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Backache

APPENDIX XIII SPSS REPORT

*Output1 [Document1] - IBM SPSS Statistics Viewer

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	6[a]	7.33	44.00
	Positive Ranks	7[b]	6.71	47.00
	Ties	3[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	4[d]	5.38	21.50
	Positive Ranks	5[e]	4.70	23.50
	Ties	7[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2

b. WithoutQST1+2 > withQST1+2

c. WithoutQST1+2 = withQST1+2

d. Without QST3+4 < WithQST3+4

e. Without QST3+4 > WithQST3+4

f. Without QST3+4 = WithQST3+4

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-.107[b]	-.120[b]
Asymp. Sig. (2-tailed)	.915	.905

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Stiffness muscle

APPENDIX XIII SPSS REPORT

ut1 [Document1] - IBM SPSS Statistics Viewer

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Test Statistics

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	5[a]	7.70	38.50
	Positive Ranks	7[b]	5.64	39.50
	Ties	4[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	3[d]	6.83	20.50
	Positive Ranks	8[e]	5.69	45.50
	Ties	5[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2

b. WithoutQST1+2 > withQST1+2

c. WithoutQST1+2 = withQST1+2

d. Without QST3+4 < WithQST3+4

e. Without QST3+4 > WithQST3+4

f. Without QST3+4 = WithQST3+4

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-.039[b]	-1.116[b]
Asymp. Sig. (2-tailed)	.969	.264

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

sleepiness

APPENDIX XIII SPSS REPORT

NPar Tests

[DataSet1]

Wilcoxon Signed Ranks Test

Headache

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	2[a]	5.50	11.00
	Positive Ranks	6[b]	4.17	25.00
	Ties	8[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	4[d]	5.88	23.50
	Positive Ranks	7[e]	6.07	42.50
	Ties	5[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2

b. WithoutQST1+2 > withQST1+2

c. WithoutQST1+2 = withQST1+2

d. Without QST3+4 < WithQST3+4

e. Without QST3+4 > WithQST3+4

f. Without QST3+4 = WithQST3+4

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-1.027[b]	-.884[b]
Asymp. Sig. (2-tailed)	.305	.377

APPENDIX XIII SPSS REPORT

ut1 [Document1] - IBM SPSS Statistics Viewer
put1 [Document1] - IBM SPSS Statistics Viewer

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  - Active Dataset
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    - Title
    - Ranks
    - Test Statistics

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	4[a]	6.63	26.50
	Positive Ranks	5[b]	3.70	18.50
	Ties	7[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	5[d]	3.80	19.00
	Positive Ranks	3[e]	5.67	17.00
	Ties	8[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2

b. WithoutQST1+2 > withQST1+2

c. WithoutQST1+2 = withQST1+2

d. Without QST3+4 < WithQST3+4

e. Without QST3+4 > WithQST3+4

f. Without QST3+4 = WithQST3+4

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-.476[b]	-.141[b]
Asymp. Sig. (2-tailed)	.634	.888

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Sorelimbs

IBM SPSS Statistics Processor is ready | Unic

APPENDIX XIII SPSS REPORT

[Document1] - IBM SPSS Statistics Viewer

View Data Transform Insert Format Analyze Graphs Utilities Extensions Window Help

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Test Statistics

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	4[a]	9.50	38.00
	Positive Ranks	8[b]	5.00	40.00
	Ties	4[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	5[d]	6.50	32.50
	Positive Ranks	5[e]	4.50	22.50
	Ties	6[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2
b. WithoutQST1+2 > withQST1+2
c. WithoutQST1+2 = withQST1+2
d. Without QST3+4 < WithQST3+4
e. Without QST3+4 > WithQST3+4
f. Without QST3+4 = WithQST3+4

Test Statistics[a]

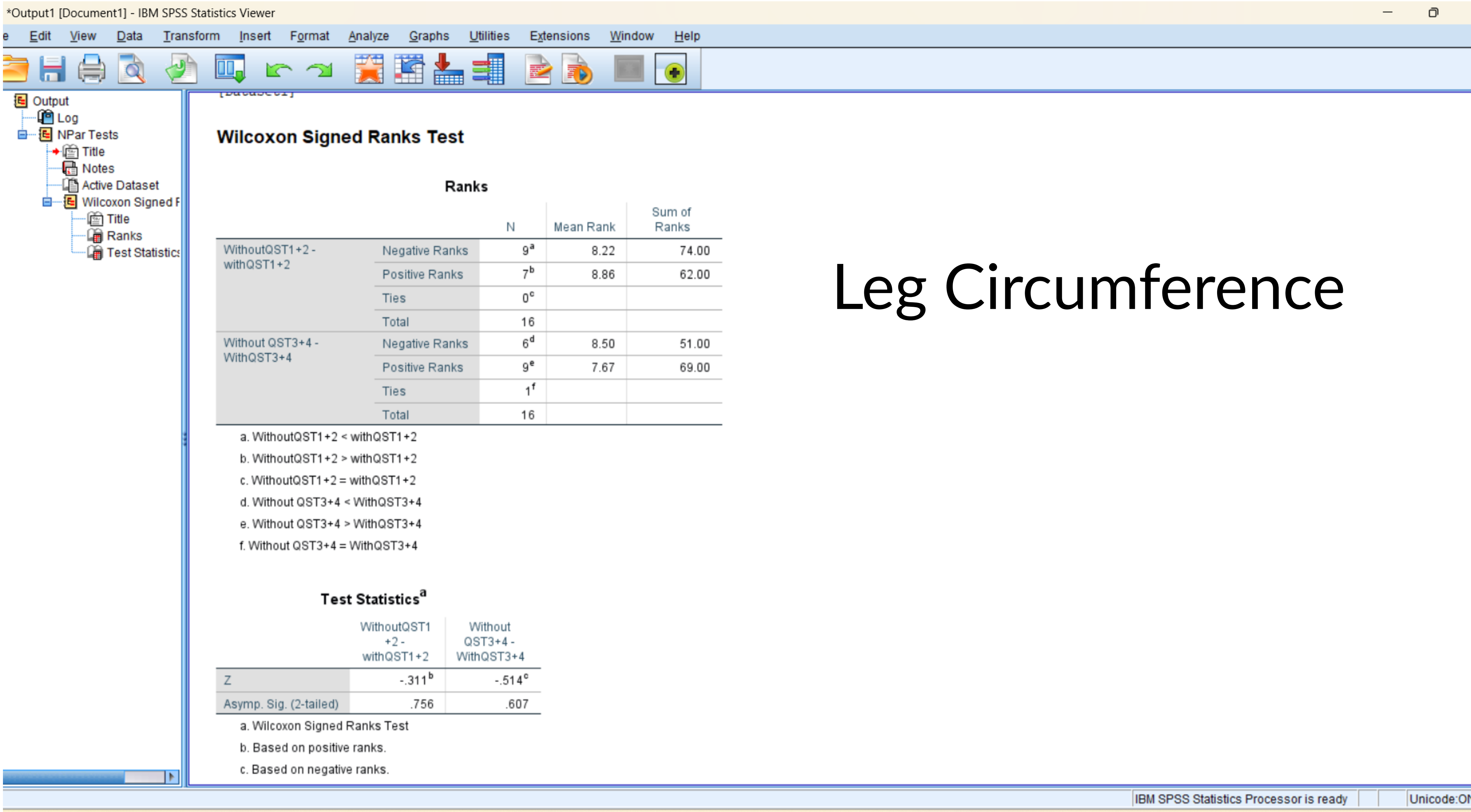
	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-.080[b]	-.514[c]
Asymp. Sig. (2-tailed)	.937	.607

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.
c. Based on positive ranks.

Numbness

IBM SPSS Statistics Processor is ready

APPENDIX XIII SPSS REPORT



Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	9[a]	8.22	74.00
	Positive Ranks	7[b]	8.86	62.00
	Ties	0[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	6[d]	8.50	51.00
	Positive Ranks	9[e]	7.67	69.00
	Ties	1[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2
b. WithoutQST1+2 > withQST1+2
c. WithoutQST1+2 = withQST1+2
d. Without QST3+4 < WithQST3+4
e. Without QST3+4 > WithQST3+4
f. Without QST3+4 = WithQST3+4

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-.311[b]	-.514[c]
Asymp. Sig. (2-tailed)	.756	.607

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks.
c. Based on negative ranks.

Leg Circumference

APPENDIX XIII SPSS REPORT

[Document1] - IBM SPSS Statistics Viewer

View Data Transform Insert Format Analyze Graphs Utilities Extensions Window Help

Output
Log
NPar Tests
Title
Notes
Active Dataset
Wilcoxon Signed R
Title
Ranks
Test Statistics

NPar Tests

[DataSet1]

Wilcoxon Signed Ranks Test

lowerback

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	4[a]	7.63	30.50
	Positive Ranks	11[b]	8.14	89.50
	Ties	1[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	3[d]	3.17	9.50
	Positive Ranks	8[e]	7.06	56.50
	Ties	5[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2

b. WithoutQST1+2 > withQST1+2

c. WithoutQST1+2 = withQST1+2

d. Without QST3+4 < WithQST3+4

e. Without QST3+4 > WithQST3+4

f. Without QST3+4 = WithQST3+4

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-1.700[b]	-2.105[b]
Asymp. Sig. (2-tailed)	.089	.035

IBM SPSS Statistics Processor is ready | Unicode:ON

APPENDIX XIII SPSS REPORT

[Document1] - IBM SPSS Statistics Viewer

View Data Transform Insert Format Analyze Graphs Utilities Extensions Window Help

out
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NPar Tests
Title
Notes
Active Dataset
Wilcoxon Signed F
Title
Ranks
Test Statistics

NPar Tests

[DataSet1]

Wilcoxon Signed Ranks Test

Buttock

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	6[a]	7.25	43.50
	Positive Ranks	6[b]	5.75	34.50
	Ties	4[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	5[d]	6.00	30.00
	Positive Ranks	7[e]	6.86	48.00
	Ties	4[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2

b. WithoutQST1+2 > withQST1+2

c. WithoutQST1+2 = withQST1+2

d. Without QST3+4 < WithQST3+4

e. Without QST3+4 > WithQST3+4

f. Without QST3+4 = WithQST3+4

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-.355[b]	-.717[c]
Asymp. Sig. (2-tailed)	.722	.473

IBM SPSS Statistics Processor is ready | Unic

APPENDIX XIII SPSS REPORT

ocument1] - IBM SPSS Statistics Viewer

View Data Transform Insert Format Analyze Graphs Utilities Extensions Window Help

ar Tests
Title
Notes
Active Dataset
Wilcoxon Signed R
Title
Ranks
Test Statistics

NPar Tests

[DataSet1]

Wilcoxon Signed Ranks Test

Mid Back

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	2[a]	7.25	14.50
	Positive Ranks	10[b]	6.35	63.50
	Ties	4[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	0[d]	.00	.00
	Positive Ranks	9[e]	5.00	45.00
	Ties	7[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2

b. WithoutQST1+2 > withQST1+2

c. WithoutQST1+2 = withQST1+2

d. Without QST3+4 < WithQST3+4

e. Without QST3+4 > WithQST3+4

f. Without QST3+4 = WithQST3+4

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-1.956[b]	-2.716[b]
Asymp. Sig. (2-tailed)	.050	.007

IBM SPSS Statistics Processor is ready

APPENDIX XIII SPSS REPORT

[Document1] - IBM SPSS Statistics Viewer

View Data Transform Insert Format Analyze Graphs Utilities Extensions Window Help

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NPar Tests
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Notes
Active Dataset
Wilcoxon Signed F
Title
Ranks
Test Statistics

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	4[a]	4.63	18.50
	Positive Ranks	7[b]	6.79	47.50
	Ties	5[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	4[d]	7.50	30.00
	Positive Ranks	8[e]	6.00	48.00
	Ties	4[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2
b. WithoutQST1+2 > withQST1+2
c. WithoutQST1+2 = withQST1+2
d. Without QST3+4 < WithQST3+4
e. Without QST3+4 > WithQST3+4
f. Without QST3+4 = WithQST3+4

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-1.299[b]	-.719[b]
Asymp. Sig. (2-tailed)	.194	.472

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

neck

IBM SPSS Statistics Processor is ready

APPENDIX XIII SPSS REPORT

- Output
  - Log
  - NPar Tests
    - Title
    - Notes
    - Active Dataset
    - Wilcoxon Signed F
      - Title
      - Ranks
      - Test Statistics

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	6[a]	5.50	33.00
	Positive Ranks	5[b]	6.60	33.00
	Ties	5[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	4[d]	4.50	18.00
	Positive Ranks	4[e]	4.50	18.00
	Ties	8[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2

b. WithoutQST1+2 > withQST1+2

c. WithoutQST1+2 = withQST1+2

d. Without QST3+4 < WithQST3+4

e. Without QST3+4 > WithQST3+4

f. Without QST3+4 = WithQST3+4

Thight

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	.000[b]	.000[b]
Asymp. Sig. (2-tailed)	1.000	1.000

a. Wilcoxon Signed Ranks Test

b. The sum of negative ranks equals the sum of positive ranks.

IBM SPSS Statistics Processor is ready | Unicode

APPENDIX XIII SPSS REPORT

Document1] - IBM SPSS Statistics Viewer

View Data Transform Insert Format Analyze Graphs Utilities Extensions Window Help

t
Log
NPar Tests
Title
Notes
Active Dataset
Wilcoxon Signed R
Title
Ranks
Test Statistics

Upper back

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
WithoutQST1+2 - withQST1+2	Negative Ranks	1[a]	5.00	5.00
	Positive Ranks	6[b]	3.83	23.00
	Ties	9[c]		
	Total	16		
Without QST3+4 - WithQST3+4	Negative Ranks	2[d]	4.25	8.50
	Positive Ranks	5[e]	3.90	19.50
	Ties	9[f]		
	Total	16		

a. WithoutQST1+2 < withQST1+2

b. WithoutQST1+2 > withQST1+2

c. WithoutQST1+2 = withQST1+2

d. Without QST3+4 < WithQST3+4

e. Without QST3+4 > WithQST3+4

f. Without QST3+4 = WithQST3+4

Test Statistics[a]

	WithoutQST1+2 - withQST1+2	Without QST3+4 - WithQST3+4
Z	-1.535[b]	-.933[b]
Asymp. Sig. (2-tailed)	.125	.351

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

IBM SPSS Statistics Processor is ready

APPENDIX XIV INTERVIEW

articipant 2

---

how would you call / give a name to this seating experience, for instance if you would have to tell ‹ iend about your experience today ?

hink it is "comfort". I would recommend my friend about this device.

. please tell us how you experienced the QSt in comparison with the non-QSt seat

ieed to sit straight on the black chair. I feel soreness around my waist part and side part. I need these uscle to help me sit straight. However, the brown chair has the support to help me keep straight. Thi elps me to pay attention on the road.

. What were the main differences between the two seats?

ie brown chair can provide physical support. Also it has massage functions.

In case you have a car, would you like to have the QSt installed in your carseat?

epend on the price. In case, I want to lay down on the chair, if it cannot I would not.

. would you recommend somebody else to install the QSt in their carseat? (Forget to ask in the vide id the answer was gotten afterwards.)

lso depend on the price

. did you notice whether or not you wanted to move your body yourself as well during all the tests, r were the movements of the QST enough when you sat in the QSt seat?

an notice, it is noticeable around my waist. It is slightly below enough. The movement of motor can e increased. I think this will not disturb driving.

. In case you have a car, how much would you be willing to pay for the installation of the QSt in you irseat?

lo not want to pay more than 2.5 times more than regular chair.

Participant 3

---

a.how would you call / give a name to this seating experience, for instance if you would have to tell a friend about your experience today ?

Promising. However, there are noise and heating too much on the back due to the enginie at the back side.

b. please tell us how you experienced the QSt in comparison with the non-QSt seat

I need to sit straight on the black chair. I feel soreness around my waist part and side part. I need these muscle to help me sit straight. However, the brown chair has the support to help me keep straight. This helps me to pay attention on the road.

c. What were the main differences between the two seats?

Movement.

d. In case you have a car, would you like to have the QSt installed in your carseat?

Depend If there are some improvement on the noise. It also depends on the price.

e. would you recommend somebody else to install the QSt in their carseat?

f. did you notice whether or not you wanted to move your body yourself as well during all the tests, or were the movements of the QST enough when you sat in the QSt seat?

I move a lot in the normal seat but not in the QSt seat.

g. In case you have a car, how much would you be willing to pay for the installation of the QSt in your carseat?

€1500 - €2000

APPENDIX XIV INTERVIEW

'articipant 4

ı.how would you call / give a name to this seating experience, for instance if you would have to tell ɛ riend about your experience today ?

:ero. The massage is too comfortable and it makes me really sleepy during the test.

ı. please tell us how you experienced the QSt in comparison with the non-QSt seat

/ly lower back feels much more comfortable when using QSt. At beginning it is hard but after a while it ; getting warmer. Maybe not good for summer weather.

:. What were the main differences between the two seats?

/lassage and the angle for the lower back.

l. In case you have a car, would you like to have the QSt installed in your carseat?

will install it except the driver because it is too comfortable.

ɛ. would you recommend somebody else to install the QSt in their carseat?

/laybe not this version but feture version.

f. did you notice whether or not you wanted to move your body yourself as well during all the tests, ır were the movements of the QST enough when you sat in the QSt seat?

t is enough.

ʒ. In case you have a car, how much would you be willing to pay for the installation of the QSt in you arseat?

:2000 but depend on what kind of car I have.

Participant 5

---

a.how would you call / give a name to this seating experience, for instance if you would have to tell a friend about your experience today ?

It makes me feel sleepy, it is very relaxing but not helping me to keep focus during driving.

b. please tell us how you experienced the QSt in comparison with the non-QSt seat

For QSt the button part is a bit flat.

c. What were the main differences between the two seats?

The form is different

d. In case you have a car, would you like to have the QSt installed in your carseat?

e. would you recommend somebody else to install the QSt in their carseat?

No, I think they will get an acciedent.

f. did you notice whether or not you wanted to move your body yourself as well during all the tests, or were the movements of the QST enough when you sat in the QSt seat?

I don't need to move it is pretty good but not all the movement I like it.

g. In case you have a car, how much would you be willing to pay for the installation of the QSt in your carseat?

€3000

APPENDIX XIV INTERVIEW

articipant 6

.how would you call / give a name to this seating experience, for instance if you would have to tell a 'iend about your experience today ?

1assaging chair

. please tell us how you experienced the QSt in comparison with the non-QSt seat

'. What were the main differences between the two seats?

'ne is with massage one is not.

. In case you have a car, would you like to have the QSt installed in your carseat?

'. would you recommend somebody else to install the QSt in their carseat?

he QSt chair is more comfortable so yes.

. did you notice whether or not you wanted to move your body yourself as well during all the tests, r were the movements of the QST enough when you sat in the QSt seat?

fter a long time I would like to adjust the sitting angle, for example to sit straight. The massage can be :ronger.

;. In case you have a car, how much would you be willing to pay for the installation of the QSt in youı arseat?

500

Participant 7

a.how would you call / give a name to this seating experience, for instance if you would have to tell a friend about your experience today ?

Active seat.

b. please tell us how you experienced the QSt in comparison with the non-QSt seat

It is better to have massage because it keeps you focus.

c. What were the main differences between the two seats?

The QSt seat is active on the back and botton.

d. In case you have a car, would you like to have the QSt installed in your carseat?

Yes because it keeps you active and your mussels keeps moving, I will adjust it a bit slowly, now is too strong.

e. would you recommend somebody else to install the QSt in their carseat?

Yes

f. did you notice whether or not you wanted to move your body yourself as well during all the tests, or were the movements of the QST enough when you sat in the QSt seat?

It is enough I don't need to move extra, it is a pretty good chair.

g. In case you have a car, how much would you be willing to pay for the installation of the QSt in your carseat?

€300

APPENDIX XIV INTERVIEW

ticipant 8

---

ow would you call / give a name to this seating experience, for instance if you would have to te nd about your experience today ?

'ing massage

lease tell us how you experienced the QSt in comparison with the non-QSt seat

vibration is different and massage.

Vhat were the main differences between the two seats?

color and vibration.

n case you have a car, would you like to have the QSt installed in your carseat?

vould you recommend somebody else to install the QSt in their carseat?

really. I can't adjust too much and it is too hot, I don't think in the summer I will use it.

lid you notice whether or not you wanted to move your body yourself as well during all the test vere the movements of the QST enough when you sat in the QSt seat?

n't need to move too much just some time put my back forward and adjust my moving position.

n case you have a car, how much would you be willing to pay for the installation of the QSt in y seat?

Participant 9

---

a.how would you call / give a name to this seating experience, for instance if you would have to tell a friend about your experience today ?

Massage seat.

b. please tell us how you experienced the QSt in comparison with the non-QSt seat

if the movement is there I don't care, if I need to sit there for more than 8 hours maybe it is good.

c. What were the main differences between the two seats?

The length of the button. When I sit on the back of the non QSt chair, I feel not comfortable.

d. In case you have a car, would you like to have the QSt installed in your carseat?

No, I don't want to pay for it, I think it doesn't bring any comfort.

e. would you recommend somebody else to install the QSt in their carseat?

Yes, if you higher 180cm maybe it is something nice.

f. did you notice whether or not you wanted to move your body yourself as well during all the tests, or were the movements of the QST enough when you sat in the QSt seat?

At the beginning yes, after a few minutes I feel it's fine. For non QSt seat I feel it is difficult to find my position. I think it can be more.

g. In case you have a car, how much would you be willing to pay for the installation of the QSt in your carseat?

€1000

APPENDIX XIV INTERVIEW

articipant 10

.how would you call / give a name to this seating experience, for instance if you would have to tell ɩ
ɩiend about your experience today ?

get distracted by the movement, I would really love to sit in this seat for long drive

. please tell us how you experienced the QSt in comparison with the non-QSt seat

,St is much more comfortable and especially for the lower back.

. What were the main differences between the two seats?

he distraction from the movement so I can sit more time on the seat.

. In case you have a car, would you like to have the QSt installed in your carseat?

epend on the price, if I need to travel longer I want it.

. would you recommend somebody else to install the QSt in their carseat?

es, I would like to recommend to truck drivers.

. did you notice whether or not you wanted to move your body yourself as well during all the tests,
r were the movements of the QST enough when you sat in the QSt seat?

move less when I sit on the QSt seat and when I sit on the non QSt seat I need to stretch my back. I
ıink the movement is strong but I miss something in the neck. Lower back and butt is nice.

;. In case you have a car, how much would you be willing to pay for the installation of the QSt in yoı
ırseat?

4000

Participant 11(most in Dutch)

---

a.how would you call / give a name to this seating experience, for instance if you would have to tell a friend about your experience today ?

Massage seat, I need more support on my neck.

b. please tell us how you experienced the QSt in comparison with the non-QSt seat

c. What were the main differences between the two seats?

d. In case you have a car, would you like to have the QSt installed in your carseat?

e. would you recommend somebody else to install the QSt in their carseat?

f. did you notice whether or not you wanted to move your body yourself as well during all the tests, or were the movements of the QST enough when you sat in the QSt seat?

g. In case you have a car, how much would you be willing to pay for the installation of the QSt in your carseat?

€

APPENDIX XIV INTERVIEW

Participant 12

---

a.how would you call / give a name to this seating experience, for instance if you would have to tell a friend about your experience today ?

calm experience.

b. please tell us how you experienced the QSt in comparison with the non-QSt seat

I feel I bit more sleepy on QSt seat and I think QSt seat is more comfortable.

c. What were the main differences between the two seats?

The QSt seat at beginning it feels nice and I think it is nice but on non QSt seat your body is getting only worse and worse. But if the massage goes to long maybe it goes more and more relex.

d. In case you have a car, would you like to have the QSt installed in your carseat?

Yes I would like to have the function I like to have it to turn on and off, or it can detact when it need to turn on.

e. would you recommend somebody else to install the QSt in their carseat?

I don't know it is good for everyone but definity for people have back pain or other problems.

f. did you notice whether or not you wanted to move your body yourself as well during all the tests, or were the movements of the QST enough when you sat in the QSt seat?

With non QSt I need to move a lot, leg and back is move a lot but on QSt I feel I don't need to move to much, but legs still maybe because there is no massage for legs.

g. In case you have a car, how much would you be willing to pay for the installation of the QSt in your carseat?

Half more than the normal seat

Participant 13

---

a.how would you call / give a name to this seating experience, for instance if you would have to tell a friend about your experience today ?

Special seat.

b. please tell us how you experienced the QSt in comparison with the non-QSt seat

The non QSt seat is comfortable and QSt seat is uncomfortable.

c. What were the main differences between the two seats?

The non QSt seat is softer and QSt seat is harder.

d. In case you have a car, would you like to have the QSt installed in your carseat?

No

e. would you recommend somebody else to install the QSt in their carseat?

No

f. did you notice whether or not you wanted to move your body yourself as well during all the tests, or were the movements of the QST enough when you sat in the QSt seat?

I need to move a lot when I sit on QSt seat because I feel too much movement. The massahe is enough but not comfortable.

g. In case you have a car, how much would you be willing to pay for the installation of the QSt in your carseat?

€50 if non QSt seat is €100

APPENDIX XIV INTERVIEW

Participant 14

---

a.how would you call / give a name to this seating experience, for instance if you would have to tell a friend about your experience today ?

it is comfortable. Massage seat.

b. please tell us how you experienced the QSt in comparison with the non-QSt seat

the QSt seat is much better, the non QSt seat I don't feel comfortable about the leg, and without massage.

c. What were the main differences between the two seats?

The massage function, the hight of the seat and hardness.

d. In case you have a car, would you like to have the QSt installed in your carseat?

Depend on the price. If I can afford I will buy it.

e. would you recommend somebody else to install the QSt in their carseat?

If people can afford yes.

f. did you notice whether or not you wanted to move your body yourself as well during all the tests, or were the movements of the QST enough when you sat in the QSt seat?

I don't need to move my body on QSt seat but I need to move a lot in non QSt seat. I think the the massage is enough.

g. In case you have a car, how much would you be willing to pay for the installation of the QSt in your carseat?

5% of the entire car or €150 if non QSt seat is €100

Participant 13

---

a.how would you call / give a name to this seating experience, for instance if you would have to tell a friend about your experience today ?

Special seat.

b. please tell us how you experienced the QSt in comparison with the non-QSt seat

The non QSt seat is comfortable and QSt seat is uncomfortable.

c. What were the main differences between the two seats?

The non QSt seat is softer and QSt seat is harder.

d. In case you have a car, would you like to have the QSt installed in your carseat?

No

e. would you recommend somebody else to install the QSt in their carseat?

No

f. did you notice whether or not you wanted to move your body yourself as well during all the tests, or were the movements of the QST enough when you sat in the QSt seat?

I need to move a lot when I sit on QSt seat because I feel too much movement. The massahe is enough but not comfortable.

g. In case you have a car, how much would you be willing to pay for the installation of the QSt in your carseat?

€50 if non QSt seat is €100

APPENDIX XIV INTERVIEW

Participant 16

---

a.how would you call / give a name to this seating experience, for instance if you would have to tell a friend about your experience today ?

Unique.

b. please tell us how you experienced the QSt in comparison with the non-QSt seat

at the beginning I feel pretty wried with QSt seat but once you get use to it it feel s okay, and maybe it keeps you focus during the driver.

c. What were the main differences between the two seats?

The massage, QSt seat is a bit hard and I will prefer the seat with neck support and the non QSt seat is softer.

d. In case you have a car, would you like to have the QSt installed in your carseat?

I would like to try if the back massage is stronger.

e. would you recommend somebody else to install the QSt in their carseat?

I will ask them to try first I believe different people have different experience. I will recommend some one to try not directy buy it.

f. did you notice whether or not you wanted to move your body yourself as well during all the tests, or were the movements of the QST enough when you sat in the QSt seat?

I am not moving my body at all. For the back it is not enough can be stronger but for the butt I think it is not necessary.

g. In case you have a car, how much would you be willing to pay for the installation of the QSt in your carseat?

€150 if non QST is €100

APPENDIX XIIV3 GRADUATION PROJECT

TU Delft

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Peter Vink   date 10-5-2023   signature

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: ______ EC

Of which, taking the conditional requirements into account, can be part of the exam programme ______ EC

List of electives obtained before the third semester without approval of the BoE

YES all 1st year master courses passed

NO missing 1st year master courses are:

name ______   date - -   signature ______

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: V APPROVED   NOT APPROVED

Procedure: V APPROVED   NOT APPROVED

- this new version has been approved

comments

name Monique von Morgen   date KE 17/4 AJ 30/5/2023   signature MvM

Initials & Name Dai   Student number 4450582

Title of Project Design an experiment to research the IPADD seat in the luxury car

APPENDIX XIIV3 GRADUATION PROJECT

TU Delft

Personal Project Brief - IDE Master Graduation

Design an experiment to research the IPADD seat in the luxury car — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 24 - 04 - 2023 — 04 - 09 - 2023 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Project Context

The project is initiated by IPADD, a company that develops parts of innovative chairs in the Netherlands. In this case, they develop an adaptable seat pan. The chair's seat pan has an innovative technology to record pressure between the buttock and seat pan, which is input for adjusting the seat pan to a better pressure distribution. This could influence fatigue and discomfort experienced by long-sitting drivers. They are planning to implement the system in a luxury car. In this context, IPADD requires research on whether their chair performance affects discomfort and fatigue in luxury cars for long-sitting drivers. To do this research an experiment has to be developed to test the seat performance.
Three stakeholders are involved directly in the project, the inventor of the chair(IPADD), the designer of the chair in the luxury car(Spark Innovation Design), and the buyers, who are the potential consumers of luxury cars. By synergizing with these stakeholders' requirements, a user-research-based concept experiment is needed in this project.

Opportunities

The IPADD system aims to use pressure redistribution to decrease fatigue and discomfort by implementing their technology at the buttock part and a small area on the back part of the chair. The innovative chair from IPADD might bring the opportunity of influencing discomfort and fatigue caused by prolonged driving due to the pressure redistributed technique. However, there is no evidence that a better pressure redistribution reduces discomfort and fatigue in driving conditions in other research.
Since fatigue has different definitions in different fields, the literature research and drivers' perspectives can provide clues to define fatigue specifically in this project. The fatigue framework can give a clue of different ways of measurement, which can be found in the literature. In the experiment, we intend to design an environment by the framework based on the literature, including possible methods mentioned in the literature review, such as recording participants' behavior, blood pressure, muscle activities, etc. This is used as evidence to show whether the chair can reduce fatigue and discomfort.

Limitations

The direction of the research, which IPADD proposes is complex. It is the question of whether their chair is safe enough to embed in the luxury car, besides, whether the chair affects fatigue and discomfort is unknown and the definition of fatigue is unknown.In this project, an experimentis designed to make this study possible. To fulfill the demand from IPADD, research is needed to measure fatigue and discomfort/comfort. Some devices for these applications might be needed as well, such as blood pressure, heart rate or hart rate variability, muscle activity, etc. It is only possible to do some of the research and design needed for this seat. My role would be to study literature on the relationship between the system and fatigue and discomfort, and to design the research experiment.

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Initials & Name Dai Student number 4450582

Title of Project Design an experiment to research the IPADD seat in the luxury car

APPENDIX XIIV3 GRADUATION PROJECT

TU Delft

Personal Project Brief - IDE Master Graduation

introduction (continued): space for images

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Title of Project Design an experiment to research the IPADD seat in the luxury car

APPENDIX XIIV3 GRADUATION PROJECT

Personal Project Brief - IDE Master Graduation

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

A research experiment is needed to study the effect of the new device. Therefore, background information is needed on what has to be studied, in this project, the framework of fatigue recording is essential before designing the experiment. The task should be translated to a research environment around the seat and how to measure fatigue.. The interaction between the occupant, the seat with the new system, and the experiment has to be designed. Based on the interaction a simulator (experiment) of a car interior should be made, which has the facilities to test the effect of the system on fatigue and (dis)comfort.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

My project is described in the following sentence: I want to design an interaction environment with the essential elements of a car interior that can assist in validating the relationship between the seat pan system and fatigue and discomfort.

The expected solution is a description of the important types of interaction between the occupant and the new system (the seat pan that adapts based on pressure distribution and controls) that influence fatigue and (dis)comfort while driving. These interactions are translated into an experiment. This experiment is not a complete car interior, but consists only of the elements needed to test the effects on fatigue and (dis)comfort. The research strategy is defined and translated into requirements for an experiment.A preliminary research on the effects of the seat will be done as well. In the end report the process defing the interaction, the model of the experiment, and what should be improved of the seat are described.

Initials & Name Dai Student number 4450582

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APPENDIX XIIV3 GRADUATION PROJECT

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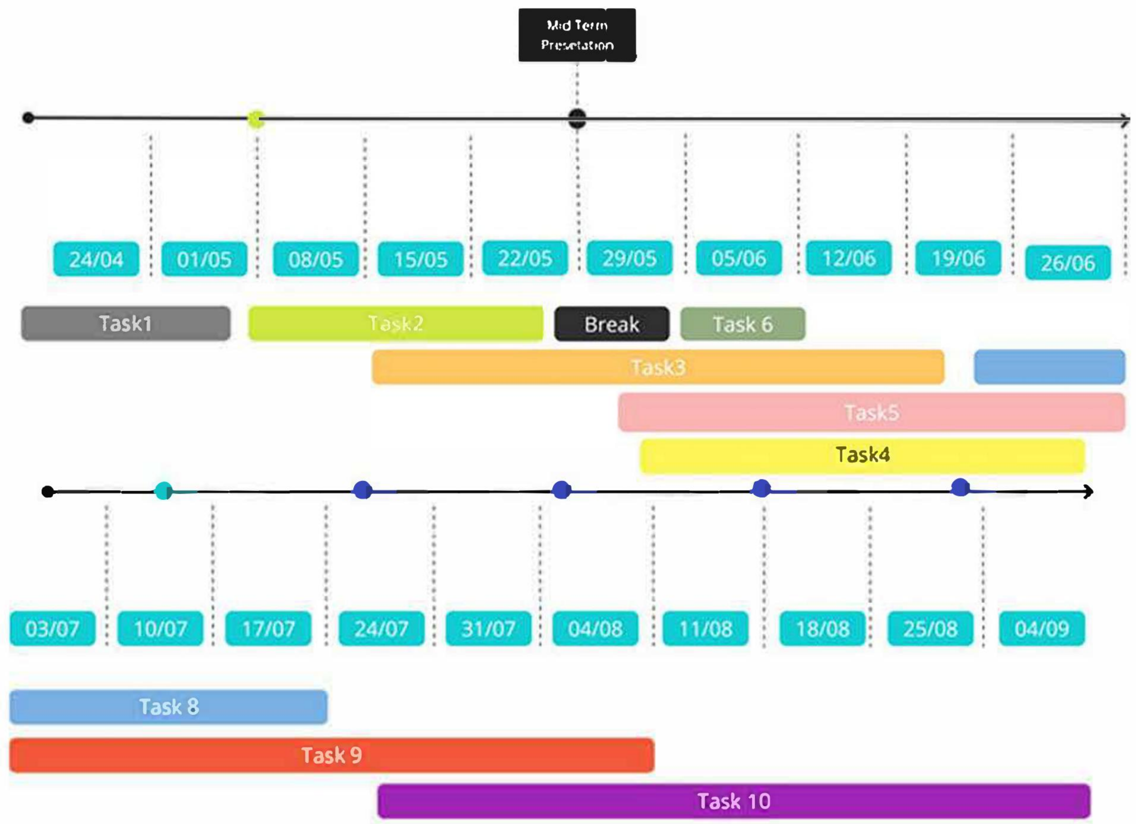
PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 24 - 4 - 2023 | 4 - 9 - 2023 end date



	Activities For TUD	Activities For IPADD
April 24th-May 1st Task 1	Finish the draft design proposal and goal as a formal document to hand in to the university.	-
May 1st-May 22nd Task 2	I need to have a basic understanding of fatigue, comfort, and discomfort, etc., and make documentation based on literature.	
May 15th – June 6th Task 3	I discussed with Peter Vink and Xinhe Yao the whole process, including how to implement the research about the comfort and fatigue of the seats and the back part related research. We will provide a detailed plan to present to the Company and University.	
May 25th – June 26th Task 4	The current chair's requirements and first drafts should be made, and I want to try different ways of implementing the experiment of testing fatigue, comfort, discomfort, etc., and make documentation. While I want to start building parts of the structure of the car	
May 22nd – June 5th	I will build the environment and configuration of objects.	I will implement the pilot test in the car structure, which is a test

Task 5		before the formal test. This pi test will not transform information fully.
June 5th Task 6	Pilot test.	
May 23 No.7	I want to determine this date as mid-term presentation day, which means th project officially needs to be done in half.	
May No.5	I need to (re)build the environment based on the test and configuration of objects and start to recruit participants for testing.	I need to deal with these data the research or continue to re if necessary.
June 19th — June 24th No.8	The test will be done during this period.	
July 3rd – Aug 4th No.9	Data analysis and documentation	
Aug 20 — Sep 11 No.10	The test is done, poster and report are made	The IPADD and Spark Innovation Design will receiv the report

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APPENDIX XIIV3 GRADUATION PROJECT

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MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

I have some personal ambitions, but the most attractive one is doing research. Initially, I tried some research in projects and I discovered the charm of research. I can explore new facts by performing experiments and analyzing data to check whether my hypothesis is right or wrong. The outcomes always make me feel excited, and the whole process is interesting. So, before starting the graduation project, I also tried two electives with different topics, one is ergonomics related, and the other is robotics related, they are both 9 ects. The robotic one focused on human behaviors, in which a running robot was made to be placed on the road to see how people react to that and record the way of interaction. This is also used for vehicle design. After that I did research in a different field, I found out I am more interested in the ergonomics aspects, precisely speaking, I like more researching the relationship between products people' s body. The second research project on the form of smart phones based on the human contour did lead to a scientific paper. According to the description of the graduation project provided by IPADD, I can get experience in chair design and manufacturing. Besides, I can research the new technology of an automatic pressure distribution chair, whether can contribute to reducing fatigue in a driving context or by utilizing the method that I develop. As user research is another type of research, I am also interested in doing that and the results from this user research can assist the design, I want to see how research assists the designers as well. So in short:

1. Developing a methodology of comparing/measuring the fatigue and discomfort between chairs with innovative technology and normal chair under driving conditions.
2. Learn to analyze the data from the experiments conducted by utilizing the methodology that I mentioned above
3. Developing a user interface including a mockup to do user research.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.