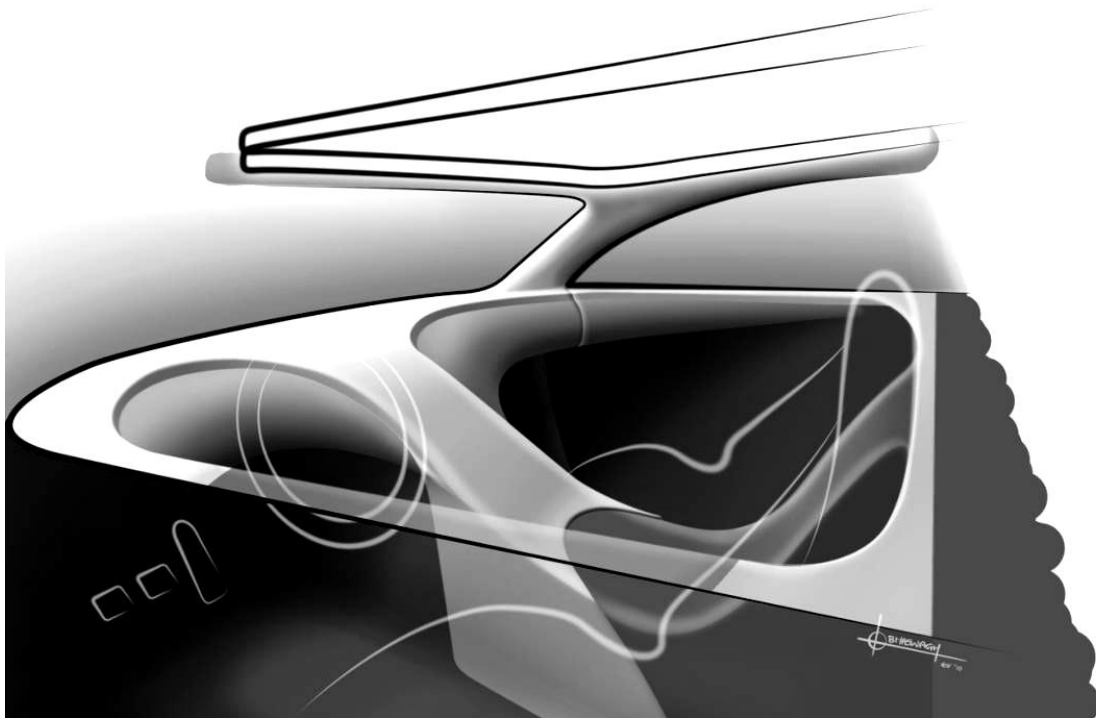# CHALMERS

Affective design to reduce aggressive driving
Is it possible to relax a driver through intentional design of the vehicle interior?

Master of Science Thesis in Automotive Industrial Design Engineering

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Göteborg, Sweden, 2014

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Cover:
Concept sketch, Lobhas Wagh

Abstract

Aggressive driving has been recognized as a substantial problem in Europe and USA. This project aims to investigate whether it is possible to design a vehicle interior environment that communicates with the driver on a subconscious level to relax him/her. A calmer driver should react less aggressively towards other road users.

The work is divided in 3 phases: data collection & analysis, concept development and evaluation. The report also includes phase 4 where I reflect about the results and experience from the first 3 phases. In phase 1, I build a knowledge base by studying aggressive driving, aggression in humans, relaxation techniques and the effects of colour on emotion. This is supported by benchmarking studies of local spa facilities and targeted user exercises to collect people's relaxation preferences. The results of phase 1 are used to drive the concept development. A number of concept vehicle interiors are developed through sketch-ideation and one of them is selected. The selected concept is then developed in detail including lighting concepts, main driver controls, basic user interface, colour scheme and materials. For the evaluation phase, a full scale physical mock-up of the driver area of the concept environment is created. A mock-up of a "standard car" environment is also created to use as a reference. The concept is evaluated by methodically-chosen test persons in terms of how it affects the driver emotionally as compared to the standard reference. Two aspects of the concept are evaluated: user first impression (perception) and effect on the driver (experience).

The concept has been perceived by the participants as conveying most of its design intentions well. It is also seen to positively affect the driver, significantly more than the reference environment, on the chosen emotional scales.

In conclusion, it is definitely possible to design a vehicle interior to relax the driver subconsciously to a certain extent. This design needs to be based on a solid analysis supported by user studies.

One also needs to note that people from different cultures react differently to the same design cues. The methods and results from this study can be used as a guideline for affective design in this area, but they need to be applied to the targeted users.

Keywords: aggressive driving, affective design, relaxing design, vehicle interior design, user centered design.

Acknowledgements

Contents

1 Introduction

1.1 Background

Aggressive driving has been recognized as a substantial problem[1] in Europe and USA. It comprises aggressive acts by drivers towards other road users. A number of these incidents have also been known to escalate into acts of violence[2] like destruction of property or even assault with a weapon. Efforts are therefore being made by traffic authorities to curb aggressive driving through better driver training and more severe legislations and penalties.

For his transport design final project at Coventry University in 2006, Lee Atwell designed a vehicle interior that tried to reduce aggressive driving by communicating on an emotional level with its occupants[3].

This thesis is an attempt to tackle the problem at its root and try to minimize aggression while driving.

1.2 Aim

The aim of this project is to investigate whether it is possible to relax a driver through focussed design of the vehicle interior environment. A calmer driver should react less aggressively towards other road users.

This type of product design, which communicates with its users through its physical attributes with the aim of eliciting specific emotional responses from them can be termed as affective design[4]. It is necessary to ensure that this "affect" should not interfere with the primary functions and usability of the product.

1.3 Delimitations

The outcome of the project can be used as a guideline to design a vehicle interior intended to relax the driver. However it is based on a limited target base - European drivers.

The resulting design considers aspects like shape, colours and materials. A basic concept of the user interface is also explored. The main focus is the dashboard and center console area. including basic shape and colour concepts for the steering wheel and the gearshift. However, the rest of the vehicle interior environment - seats, detailed design of the HMI and lighting - is not covered by the study.

Other aspects of vehicle interior design such as brand identity and functional design are not included.

The evaluation study is performed in a physical mock-up of the driver area of the vehicle. It was not possible to build a complete vehicle interior environment due to time and resource constraints.

1.4 Procedure

The work is divided in 3 phases: data collection & analysis, concept development and evaluation.

In phase 1, I build a knowledge base by studying aggressive driving, aggression in humans, relaxation techniques and the effects of colour on emotion. This is supported by benchmarking studies of local spa facilities as well as targeted user exercises to collect people's relaxation preferences. The results of phase 1 are used to drive the concept development.

A number of concept vehicle interiors are developed through sketch-ideation and one of them is selected. The selected concept is then developed in detail including lighting ideas, main driver controls, basic user interface, colour scheme and materials.

For the evaluation phase, a full scale physical mock-up of the driver area of the concept environment is created. A mock-up of a "standard car" environment is also created to use as a reference.

The concept is evaluated by methodically-chosen test persons in terms of how it affects the driver emotionally as compared to the standard reference. Two aspects of the concept are evaluated: user first impression (perception) and effect on the driver (experience).

Phase I: Data collection & analysis

The main aim of Phase I was to understand the phenomenon of aggressive driving, it's possible causes, the roots of these causes, and their consequences. Moreover the aim was to delve deeper into the sciences underlying aggression and relaxation in humans and to research some of the relaxation design principles used today.

To form a base for the concept development in phase II, I felt it very necessary to support my literature studies with input from potential users of the concept. The goal was to create a basis for the concept design to follow.

2 Literature study

2.1 Overview

I began with a wide search of the Internet to collect as much information and relevant research papers as possible. The search was filtered keeping the following targets in mind: compile a complete definition of aggressive driving, identify its causes, and study the science behind aggression and relaxation in humans.

A second internet study was focussed on understanding the various theories about how colours can be used in the design of an environment to affect emotions and mood.

2.2 Aggressive driving

After looking through various definitions of aggressive driving, I realized that the best way to define it for my purposes was by simply listing all the activities that are classified as aggressive driving by various traffic authorities over the world.

Aggressive driving includes activities like traffic weaving, repeated honking, headlight flashing, red-signal running, tailgating, speeding, excessive braking, verbal abuse, obscene gestures, chasing other drivers and violence. These activities cover a wide range of offences with some only capable of causing inconvenience or annoyance to other road users and others being downright dangerous.

It is common to come across the term "road rage" while searching for information on aggressive driving. It is important to note that aggressive driving and road rage are not interchangeable concepts.

Road rage is a term used for extreme acts arising from aggressive driving. Road rage is uncontrolled anger that results in violence or threatened violence on the road[5]. It is more intense than aggressive driving, for example, drivers physically assaulting other drivers, threatening to shoot other drivers or pedestrians, or threatening to destroy property etc.

There have been numerous studies to identify the major causes of aggressive driving. Most commonly, they are classified as:
1. Situational: like driver mood, stress level, or other drivers' behaviour which can elicit a response;
2. Dispositional: a person's attitude or personality which decides the extent or type of reaction

Some common situational causes are reactions to traffic congestion, road repairs etc, "punishing" other drivers for not following rules or driving slow, competing with other drivers to display superior driving skills, bad mood and stress. Stress can be further

classified as general stress and driving stress as research shows that automobile driving is a source of everyday stress[6].

The dispositional causes affect the intensity of aggression as they determine how the driver reacts to situational factors. The nine dispositional factors identified by Donovan et al[7] are:
1. emotional liability, irritability and oversensitivity to criticism;
2. feelings of depression, sadness and discontent:
3. feelings of helplessness and personal inadequacy (low level of self-efficacy);
4. impulsivity and thrill/sensation-seeking motive;
5. low frustration tolerance;
6. harbouring grudges and resentment;
7. expression of overt hostility and aggression;
8. easily influenced/intimidated by others (low level of self assertion);
9. perceived inability to control one's own destiny.

Another important term one comes across while researching dispositional factors is 'trait-anger'. It is defined as the disposition to perceive a wide range of situations as annoying or frustrating, and the tendency to respond to such situations with higher levels of anger[8]. It seems to cover Donovan's dispositional factors 1, 5, 6 and 7.

However, some researchers suggest that the vehicle itself also encourages aggressive behaviour. Drivers consider their car not only as a means of transport, but also a reflection and manifestation of their personality. Moreover, a car is of high personal value for some and they will instinctively try to protect it from potential threats at all costs. For some owners, the car is a fortress as it gives them a feeling of safety which encourages them to use it as a "weapon" - it seems very easy to cause harm or damage and get away quickly. Therefore, they might use their vehicle as an instrument of expressing dominance, anger or frustration.

Anonymity is a substantial factor in the tendency to exhibit aggressive driving[9]. If a driver thinks that he/she is not easily identifiable in his vehicle, he/she tends to be more aggressive than otherwise. In the same paper, Patricia Ellison-Potter proved through studies that a driver is less aggressive while driving a convertible with the top down than with the top up.

Moreover, the intensity of aggression, which has already been provoked by the aforementioned factors, can be aggravated by environmental factors such as high noise, temperature and congestion[10]. One study[11] found that the type of vehicle and its features that enable the commuter to control his/her environment (space, seating comfort, air conditioning, music etc.) may also influence the degree of stress that is experienced. Other hypotheses relate poor ergonomic design, obstructions to free movement or blinding sunlight to an increase in driver stress and hence aggression.

It is these environmental factors affecting the intensity of aggression which are most interesting for this study. The focus will be on visual and haptic cues in the driver environment to reduce aggression.

I created image 1 which provides an overview of the various causes.
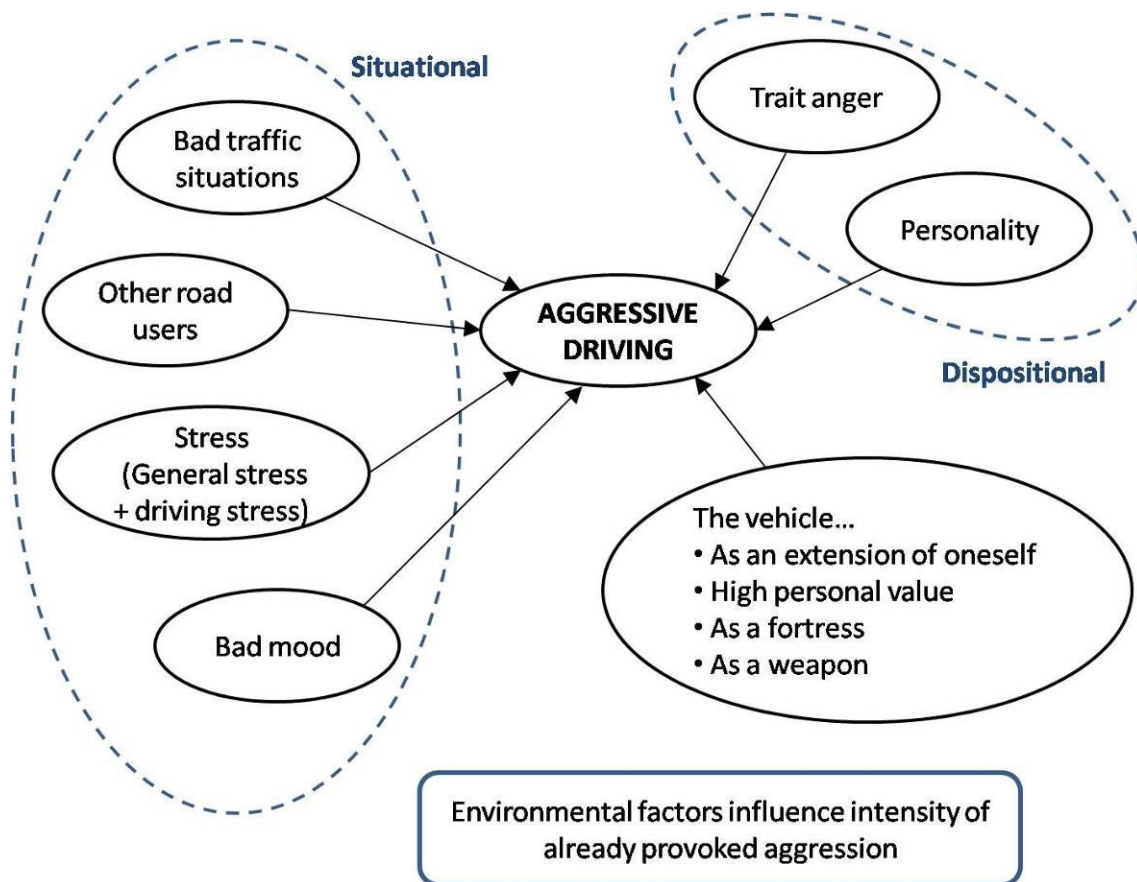
Image 1. *Causes of aggressive driving*

2.3 Instruments to measure driver aggression

In order to study the influence that a driver's surroundings can have on his/her daily behaviour, I wanted to identify some aggressive and non-aggressive drivers who could later be invited for the evaluation study in phase III. I decided to conduct an online survey but in order to identify the different types of drivers relevant instruments were required. My literature studies resulted in the following options:

1. Trait anger scale (TAS)[1]

2. Driving anger scale (DAS)[2]

3. Driver angry thoughts questionnaire (DATQ)[3]

4. Manchester driver behaviour questionnaire (Extended DBQ)[4]

5. Driver anger expression inventory (DAX)[5]

Each of these methods estimates driver aggression by measuring one or more dispositional factors. One study[12] exposed both low-anger and high-anger drivers to the same traffic conditions but high-anger drivers still resorted to more aggressive driving.

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[1] Spielberger 1988, 1999

[2] Deffenbacher, Oettin and Lynch 1994

[3] Deffenbacher et al, 2003

[4] Lawton et al, 1997

[5] Deffenbacher et al, 2001

This means that aggressive driving is more dependent on trait anger than on bad situations. TAS attempts to measure trait-anger but does not take into account other factors.

DAS (see appendix A1) can be used to classify drivers as high-anger drivers and low-anger drivers. It measures the intensity of anger felt by a driver when encountering 33 commonly occurring traffic situations. DATQ (see appendix A2) asks respondents how often they feel each of 65 specific angry thoughts when they are angry while driving. Both measure the anger felt by a driver when reacting to other traffic events, but do not assess fundamental driver behaviour.

DAX (see appendix A3) and Manchester DBQ (see appendix A4) focus more on daily driving habits. They try to estimate driver aggressiveness by looking at the frequency with which a driver performs certain aggressive actions or violations.

I think they are better at estimating a driver's "in-built" aggressiveness and are therefore more suitable for my purpose. Among the two, I chose the Manchester DBQ for two reasons:

1. The behaviours covered by DAX are focused on interaction with other road users whereas those included in the Manchester DBQ are situation-independent everyday driving habits which are a better judge of driving character. They also seem easier for everyday drivers to relate to.

2. The Manchester DBQ is much shorter (27 questions) than DAX (49 questions) and therefore more easy for respondents to answer. This should help collect more reliable responses.

The driver behaviours in Manchester DBQ cover a wide range including minor lapses, errors, small violations as well as aggressive violations. Of these, only the violations are deliberate actions which provide insight into the driver's aggression. So I filtered out the lapses and errors and decided to use only the 13 violations for my online survey. This modified Manchester DBQ can be found in section 4.3.2.

2.4 Aggression and relaxation

In order to investigate if it could be possible to induce relaxation in drivers by triggering certain physical responses through the cabin design, it was necessary to understand the physical causes of aggression in humans.

Aggression occurs in all humans with varying intensities, controlled by biological phenomena in the body. Summarizing numerous hypotheses found online, this aggression may be based on one or more of the following bodily sciences:

1. Chemical;
2. Hormonal;
3. Genetic

The chemical serotonin is a neurotransmitter whose levels in the human body have shown the highest correlation with the intensity of aggressive behaviour. Neurotransmitters are chemicals that transmit signals from a nerve cell to a target cell. The only direct effect of a neurotransmitter is to activate one or more types of receptors in the target cell. These receptors can be excitatory (encouraging an action) or inhibitory (discouraging an action). The effect of the neurotransmitter on eventual human behaviour therefore depends directly on the type of receptors it activates.

The seven receptors activated by Serotonin are called 5-hydroxytryptamine receptors ($5\text{-}HT_1$ to $5\text{-}HT_7$). Among these, only $5\text{-}HT_{1A}$ or $5\text{-}HT_{1B}$ receptors directly affect

aggression, but others may indirectly affect it through functions such as anxiety, blood pressure, mood etc. Activation of 5-HT_{1A} receptors inhibits or reduces aggression in humans. Therefore, high levels of brain serotonin means increased activation of the 5-HT_1 receptors, thus reducing aggression.

One should not confuse "blood serotonin" level with "brain serotonin" level. Only 20% of the human body's total serotonin is present in the central nervous system where it has various functions including the regulation of mood, appetite and sleep. This is measured as brain serotonin. The remaining 80% is synthesized in the abdomen, where it is used to regulate intestinal movements[13]. This eventually finds its way into the blood and is stored in blood platelets. This serotonin is measured as "blood serotonin". Thus, higher brain serotonin implies lower blood serotonin and vice versa.

GABA is also a neurotransmitter that mainly activates inhibitory receptors. Therefore, increased levels of GABA also mean reduced aggression, better mood and increased relaxation.

Dopamine is a neurotransmitter normally associated with the reward system of the brain and released to provide feelings of enjoyment and reinforcement to motivate a person to actively perform certain activities. Common examples of stimuli are food, sex and drugs. Recent studies[14] show that aggression may also stimulate dopamine release, which might encourage the person to behave aggressively again.

Some of the ways to increase brain serotonin levels are:

- Specific diet changes;
- Exercise;
- Absorption of vitamin D through exposure to sunlight;
- Anti-depressant drugs;
- Air ionizers.

An air ionizer creates negative charges particles in air. In nature, good quality negatively ionized air is found in abundance in outdoor environments, especially around evergreen trees, beach surf, or waterfalls. Negative ionized air therefore feels "fresh". These negative ions in air have been shown to increase brain serotonin level.

GABA levels can also be increased through diet changes or by using specific drugs.

Hormones like testosterone and estrogen could have a significant effect on aggressive behaviour in males and females respectively. Testosterone is not the sole cause of increased aggression but is one of the factors that helps to sustain it[15]. Increased testosterone in males increases sustained aggression. Reduction of estrogen production has shown a decrease in aggressive behaviour in mice, suggesting that estrogen also acts to increase aggression[16]. Estrogen is also known to reduce depression in females[17]. Specific diet, moderate exercise and reduced stress levels can reduce estrogen levels in females.

Studies have also been performed to investigate how the genetic constitution of persons might affect their aggression but so far they have not been able to prove any convincing correlations[18]. Some genes have been shown to affect neurotransmitters such as serotonin in mice[19] but this has not been proved in humans. Nevertheless, this does not concern my study as it does not attempt to affect the genes in any way imaginable.

Relaxation is not the opposite of aggression but one of the ways to reduce its intensity and duration.

Relaxation response (RR) is a quieting of the sympathetic nervous system[20], the opposite of the "fight-or-flight" response. It results in a decrease in blood pressure, heart rate and oxygen consumption.

Chemically, GABA can induce relaxation, pain relief and sleep in the body. Physical exercise has been shown to produce chemicals known as endorphins, which help reduce depression and anxiety and help sleep.

To balance relaxation, the body produces the hormone norepinephrine which increases heart rate. This is to combat too low blood pressure.

I came across a variety of a variety of relaxation techniques online, that one can actively perform to trigger the relaxation response (ref). To simplify, I choose to classify them as follows based on the triggers they use for relaxation:

1. Physical comfort / muscle relaxation: increasing blood flow to major muscles, reducing muscle tension and chronic pain, or by releasing specific hormones;
2. Focussed breathing: lowering heart rate, lowering blood pressure, slowing your breathing rate etc.;
3. Concentration: concentrating on something specific so that you don't think about everyday stressful happenings;
4. Alternative imagination: imagining a relaxing environment through multiple senses using the following different tools:
    a. Relaxation imagery
    b. Music / silence
    c. Aromas

Categories 1 and 2 focus on physically inducing relaxation whereas 3 and 4 try to induce it mentally. Various techniques use one or more of the above triggers to induce relaxation, as listed in Table 1.

Table 1. Various relaxation techniques

Relaxation technique	Description	Triggers
Massage therapy	Progressive muscle relaxation by tensioning and relaxing your muscles one by one	Physical comfort
Exercise	Physical activity to increase the production of endorphins	Physical comfort
Deep breathing	Inhaling slowly through your nose and the exhaling slowly through the mouth	Focussed breathing
Meditation	Variety of techniques to reduce stress through a combination of controlled breathing and concentration e.g. yoga - a series of postures and controlled breathing exercises	Focussed breathing, concentration
Combined meditation and exercise	E.g. Tai chi is a gentle Chinese martial art where one performs a self-paced series of movements while practicing deep breathing.	Physical comfort, focussed breathing, concentration
Art therapy	Draw or paint something to reduce stress and relax. It is the process as well as the end result which help.	Concentration, alternative imagination

Guided imagery	Imagining a scene in which one feels at peace - everything one would see, hear, smell, touch and taste. Pictures, music, and/or smells can be used as guides	Alternative imagination
Hydrotherapy	e.g. taking a 20 minute bath in warm water mixed with alkaline salts and scents	Physical comfort, alternative imagination
Music	Listening to soothing music or sounds from nature	Alternative imagination
Aromatherapy	Being surrounded by scented oils diffused in the air by heating	Alternative imagination

To complement these theories, I researched online forums for ways people actually use and recommend for relaxing and de-stressing. I compiled a list by reading topics like "What do you do to relax?" and "Favourite places to find peace and relaxation" on the following forums:

- www.yelp.com
- www.collegenet.com
- www.sandiegoreader.com
- answers.yahoo.com
- Carers UK forum

The list comprises of 78 distinct activities people perform for everyday relaxation. The complete list is found in appendix B and a summary is shown in image 2.

The activities are very varied, ranging from "floating on a raft with music" to "face booking". However, the key characteristic observed in these activities is that they are easy to perform in and around your home and do not need special equipment or assistance which is not readily accessible. My main conclusion from this quick study is that different people relax in very different ways. Something that might be relaxing for one person might in fact be stressful for another (e.g. exercising).
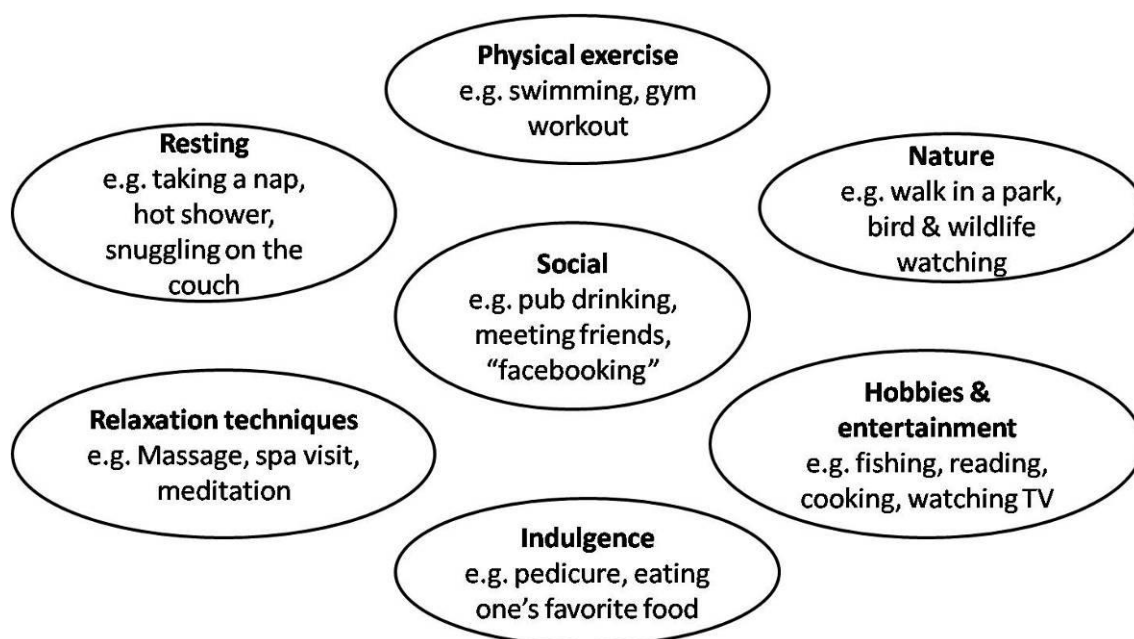
Image 2. *Simplified classification of everyday relaxation activities*

2.5 Emotion and colour

In a vehicle interior, the design elements which provide the biggest opportunities to influence the occupants are shapes, colours and materials and their combinations since they define the physical environment that surrounds the them. Among these, there are a lot of existing theories about how colours can affect mood and emotions. This section summarizes some of these theories and their applications.

In terms of how colours affect emotions, they can be broadly classified as warm and cool colours. Warm colours are the hues from red through yellow, including browns and tans while cool colours are the hues from blue-green through blue-violet, including most greys.

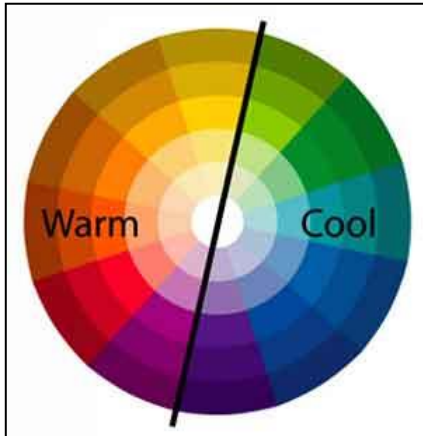

Image 3. *Colour wheel showing warm and cool colours*

A number of theories are based on design of homes or other interior spaces. According to one[21], the most relaxing colours are generally believed to be cool shades, such as green and blue. That is why specific shades of sage green are used in hospital waiting rooms where it is important to de-stress the occupants. One hypothesis is that this relaxing effect of green is due to associations to where the colour is found most abundantly in nature such as leaves or meadows. However, some researchers have found preliminary evidence that these effects could be explained by scientific phenomena in the fields of neurology, psychology and ophthalmology. Our eye perceives colour using tiny sensors called cones. Certain cones are sensitive to red or green or blue light. However, overall they are most sensitive to wavelengths corresponding to green light. Researchers hypothesize that this sensitivity to green objects might affect hormonal production or the circulation of neurotransmitters that in turn influence mood[22].

Certain techniques of colouring a room can also be used to enhance the environment in specific ways. Lighter colours will open up a room, giving it an illusion of expansion while darker shades will bring the walls together and may create a sense of being tucked away and warm. This controlled appearance of the room, in turn, influences the occupants based on their preferences.

Usually a combination of multiple colours, called a colour scheme, is used in the design of an interior space. In any colour scheme, it is imperative to make sure that there exists colour harmony. It is defined as a blending of colours which produces a pleasing effect[23]. The two most basic formulae for achieving colour harmony are:

1. Analogous colour scheme which is a combination of colours which are placed adjacent to each other on the colour wheel;
2. Complimentary colour scheme which is a combination of colours which are placed opposite to each other on the colour wheel.
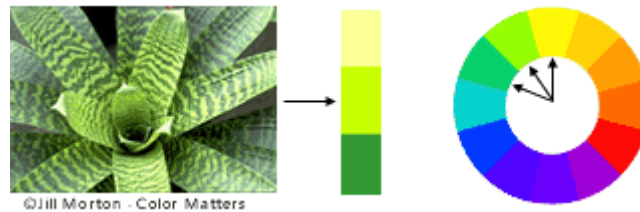
Image 4. *Analogous colour scheme example[24]*
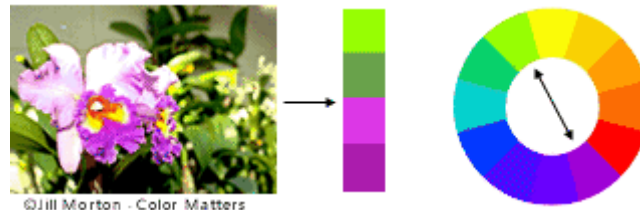
Image 5. *Complimentary colour scheme example*

One theory suggests that analogous colour schemes are good for relaxation whereas complimentary colour schemes are useful for stimulation.

According to Wijkmans[25], the following things must be considered while developing a colour scheme to help people relax:

1. One must keep the scheme simple by not using too many colours in one room;
2. It is necessary to consider individual preferences for relaxing. For example, clearer shades may work well for someone who finds it easier to relax when surrounded by light, air and space whereas richer hues may be better for someone who relaxes by cuddling up somewhere cosy.

For those who prefer lighter colour schemes for relaxing, Wijkmans recommends either a combination of "neutral" colours like off-whites and creams or very light slate greys or whites with just a hint of very light blue or green. For others who want to create a cosy, welcoming space in which to relax, he suggests 'earthy tones' like soft clay shades, warm earthy browns, oaty shades and mossy greens. Even with the dark colour scheme, it is necessary to keep the ceiling light, as this will prevent the room from feeling too closed-in, thus, still retaining a sense of restful retreat.

The neutral and earthy-tone colour schemes for relaxation are reiterated by another theory[26] derived from trends in paint colours most preferred for bedrooms.

3 Spa benchmarking

3.1 Background and overview

I did not find strong scientific research to back the colour theories sufficiently. To investigate further the colour design for relaxation and to complete it with other aspects of spatial design such as shapes, materials, lighting and their combinations, I performed a benchmarking study of the interior design of spas, i.e. spaces which are designed to provide a relaxing environment.

The benchmarking study of spa interior design was conducted in two stages:
1. Collection and classification of spa interior images available on the internet;
2. Visits to local spas in Göteborg.

Stage 1 allowed access to a huge variety of designs quickly and efficiently and to identify the common underlying themes, whereas stage 2 provided an opportunity to actually feel a few environments and get more insight by talking to the staff at the spa.

3.2 Online images research

All in all, 155 pictures were collected through online searches. I tried to identify certain themes, based on my colour and emotion research, into which these images could be classified. Many spa designs were focussed on a specific theme, but some also seemed to be a based on more than one theme.

The five spa design themes identified in stage 1 were:
1. Rich luxury
2. Natural
3. Cool, soothing
4. "Home" feel
5. Minimalistic

Image 6. *Spa design images sorted into the 5 themes*

3.3 Visits to local spas

In stage 2, I visited four spas in Göteborg, namely, Art Garden Spa at the Best Western Arken hotel, Den Lilla Kurorten, Göteborg Spa and Hagabadet. Among these, Den Lilla Kurorten and Göteborg Spa seemed to be small establishments which spend more of their resources on their services and focus less on theme based design of their spaces. The latter of these was a day spa.

Hagabadet is a spa and swimming facility housed in a grand old-fashioned building and the interior design also reflects this. The main pool was housed in a big hall with an overlooking balcony and a high domed ceiling. Apart from this, I recognized the application of several of the aforementioned colour principles and spa design themes (Table 2). I used the bath facilities and my feeling was that while this focussed interior design did not cause an overwhelming feeling of relaxation, if you spend time there doing something that relaxes you, the environment certainly aids the relaxation process.

Table 2. Design principles used at Hagabadet, Göteborg

	- Earth tones - Light coloured ceiling and skylight to "expand" a room - Natural theme
	- Shades of pale green - Support from natural light

	- Light colours to enhance the feeling of space - Light coloured ceiling and skylight - Use of natural light
	- Earth tones - Natural + cool soothing themes

The Art Garden Spa at the Best Western Arken hotel is significantly different from Hagabadet. It is a dedicated modern spa facility and the overall interior design reflects this. There is an extensive use of light earth tones and natural materials overall. However, each section of the spa also follows its own sub-theme. A number of places have vast open views of nature to let in natural light and create an enhanced sense of space whereas some areas have been specifically been designed to feel dark and cosy. The reason for these multiple themes is to cater to the varied relaxation preferences of their guests. My feeling was that some of the environments would definitely help my relaxation process whereas others would, in fact, hinder it. Table 3 shows some examples of the different principles observed.

Table 3. *Design principles used Art Garden Spa at the Best Western Arken hotel, Göteborg*

	• Light "neutral" earth tones • Large windows and natural light to enhance the space • Natural + minimalistic theme
	• Neutral earth tones, moss green • Rich luxury theme
	• Warm cosy feeling • Rich luxury theme
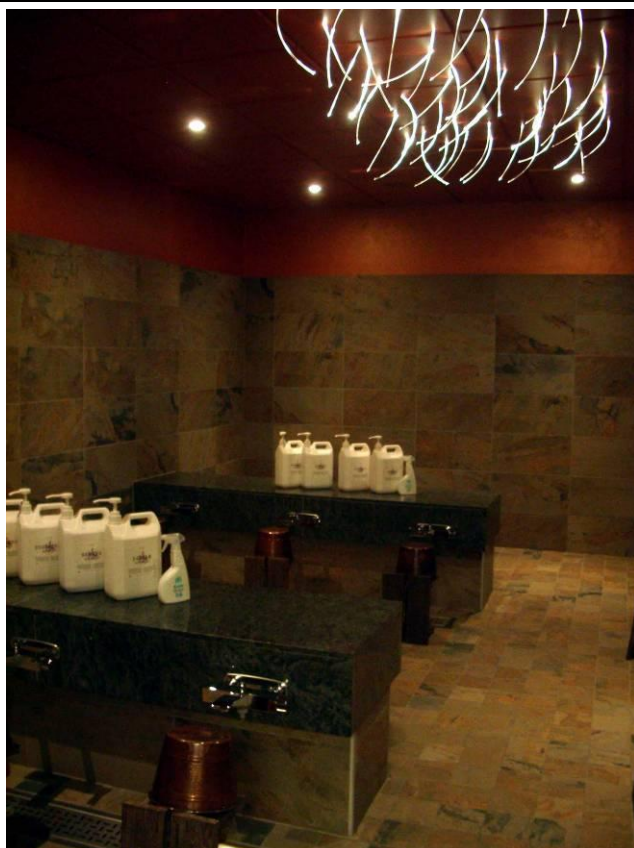
	- Dark earth tones - Darkness and controlled lighting to create cosy feeling - Light coloured ceiling and minimal natural light to prevent closed feeling - Minimalistic theme
	- Different themes to fit various preferences / moods - Analogous colour scheme

4 User studies

4.1 Overview

To form a base for the concept development in phase II, I felt it very necessary to support my literature studies with input from potential users of the concept. The user group for these exercises was very broadly defined as European drivers. I decided to restrict the user group to European drivers living in Göteborg mainly for practical reasons as it would be easier to contact them for personal interviews and evaluations clinics.

I studied a number of methods and tools for user-centered design and developed 3 tools to help me collect specific information:

1. Property extraction: To identify properties of objects which make the users be relaxed
2. Emotional scales: To identify how different environments make the users feel.
3. Driver behaviour questionnaire: To identify aggressive and less-aggressive drivers for the evaluation phase

10 master students from the industrial design engineering program at Chalmers were interviewed for property extraction. The properties collected from the interviews were then ranked according to the highest number of occurrences. 20 responses to the emotional scales were used to identify desirable colour schemes and form language. This data would then be used to create mood boards to inspire the concept design in phase II.

An online survey was conducted using a modified version of the Manchester DBQ to identify 10 aggressive and 10 less aggressive European drivers living in Göteborg who could later be invited for the evaluation studies in phase III.

4.2 Property extraction

4.2.1 Aim
The aims of this study were to:

1. identify and rate the properties or design elements of everyday objects which make their users feel relaxed;
2. identify and rate the existing or desired properties of a driving environment which make the driver feel relaxed.

The properties that arose most frequently (highest count) and got the highest ratings (score) were grouped together to form the base for concept development, together with the results from the emotional scales.

4.2.2 Method
Ten master students from the industrial design engineering program at Chalmers were interviewed for property extraction. The main reason for this choice of participants was that being design students, they are familiar with the methods used and would be able to express design properties into words with relative ease. Moreover, they are still a part of the intended user group (drivers).

Each student was asked to bring a personal object that makes him/her feel relaxed. They were then requested to describe what properties of that object helped them relax. I listed all properties and the participant was then asked to rate how important each property was towards making him/her feel relaxed, on a scale from 1 to 10 where 1=Not important and 10=Most important.

The personal object acted as an ice-breaker and made it easier for the participants to describe their feelings. The same process was then repeated by asking the participants to describe and rate the properties of a driving environment that would make them feel relaxed. Here the participants were given the freedom to list existing features as well as out-of-the-box features they would wish to have for relaxation.

Each interview's audio was recorded to enable me to make notes later and also to understand the context of the participants' comments.

4.2.3 Results
The participants brought a variety of objects ranging from a mobile phone to a ceramic tile.

Image 7. *Participants' relaxing possessions*
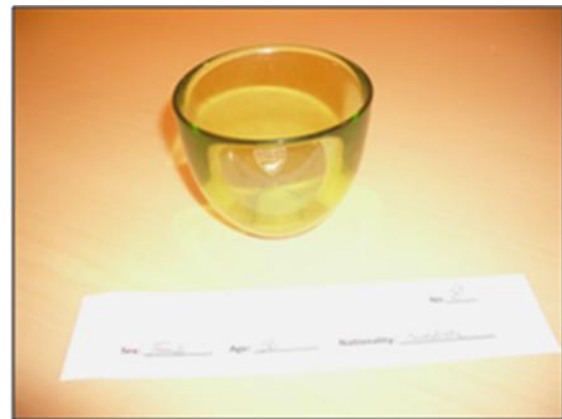
Image 7. Participants' relaxing possessions (continued)

An example of a property list and ratings (from participant 1) is shown below.

No. 1

Sex: Male   Age: 24   Nationality: Swedish.

Driving Environment

Clear Visibility	10		
Minimal Controls	5		
Minimal Clutter	7		
Bright Colours	3		
Small steering wheel	1		
Interactive HUD	6		
Easy to drive	7		
Easy to understand	9		
Minimal warnings	7		
Unobtrusive Info.	8		
Good music	7		

Unobtrusive

No. 1

Sex: Male   Age: 24   Nationality: Swedish.

Personal Object

Connected	6	Physical Activity	7
Trusty	8	Occupied Mind	6
Fits me	6		
Portable	2		
Easy to understand	9		
Rounded shapes	5		

I found that the personal objects and the driving environment generated a lot of similar properties. Moreover, most of the personal object properties were generic and also applicable to a vehicle interior. Therefore I decided to analyse all properties together. All similar ones were grouped together, considering the correct context intended by each participant. The resultant 23 sets of properties included physical properties as well as functional features. There were six properties which were mentioned only once

or twice, not rated very high and did not belong well to any of the 23 sets. These were discarded .The resultant 23 sets are listed in Table 4.

Table 4. Relaxing properties identified in property extraction

No.	Property	Description	Count	Personal object score	Driving environment score	Total score
1	Soft	soft to touch	6	37	7	44
2	Smooth	smooth texture, not rough, e.g. like a soft smooth blanket	7	34	12	46
3	Rounded shape, curves	rounded soft shapes, curves, flowing lines	10	72	9	81
4	Comfortable, reachable	physical comfort, free movement, keeps warm, reachable controls	25	35	137	172
5	Simple, no clutter	visually simple, minimal clutter	14	34	75	109
6	Natural feel, water	natural feel, water, e.g. rough textures reminding of cliffs	11	57	16	73
7	Easy to understand, use, feel in-control	easy to understand, use, feel in-control, driving assistance	19	34	110	144
8	Quiet, unobtrusive	soundproof, unobtrusive warnings, e.g. no engine sound, voice warnings etc	9	8	64	72
9	Interactive, responsive, trusty	interactive, precise and responsive tactile feedback, trusty	7	15	37	52
10	Personal feeling	personal feeling, fits me, ownership, sentimental value, memories	13	64	38	102
11	Feel safe, protected, privacy	feeling of safety, protected, privacy	8	16	52	68
12	Clear visibility	clear visibility, e.g. no A-pillars	6	0	54	54
13	Interesting, looks fun	interesting, looks fun, not boring	8	38	8	46
14	Beautiful, balanced, colour harmony	beautiful, balanced design, colours mix well with each other and surroundings	10	66	8	74
15	Portable, light	portable, light, easy to carry wherever you go	4	19	0	19
16	Versatile	versatile, multifunctional	2	8	0	8
17	Reminds of leisure, sleep	reminds of leisure activities, sleep	7	32	14	46
18	Weak colours, unsaturated	weak colours, unsaturated, no strong colours	5	16	17	33
19	Good brand	brand I like	2	14	0	14
20	Professional look, adult	professional look, adult	4	23	0	23

		good music, soft music, classical music				
21	Good music	good music, soft music, classical music	4	0	29	29
22	Good smell	good smell, non-toxic	2	0	16	16
23	Place for everything	place for everything, organized, cup holders etc.	2	0	12	12

The property sets with 5 or fewer counts were discarded. The remaining were sorted according to the highest total score followed by the highest count (see Table 5).

Table 5. Highest rated relaxing properties

Rank	No.	Property	Count	Total Score
	4	~~Comfortable, reachable~~	~~25~~	~~172~~
	7	~~Easy to understand, use, feel in-control~~	~~19~~	~~144~~
1	5	Simple, no clutter	14	109
2	10	Personal feeling	13	102
3	3	Rounded shape, curves	10	81
4	14	Beautiful, balanced, colour harmony	10	74
5	6	Natural feel, water	11	73
6	8	Quiet, unobtrusive	9	72
7	11	Feel safe, protected, privacy	8	68
	12	~~Clear visibility~~	~~6~~	~~54~~
8	9	Interactive, responsive, trusty	7	52
9	13	Interesting, looks fun	8	46
10	17	Reminds of leisure, sleep	7	46
11	2	Smooth	7	46
12	1	Soft	6	44

Property #4 "comfortable, reachable" concerns the physical, ergonomic design of the vehicle interior. For the scope of this study, I think it is safe to assume that all vehicles today already offer good driver ergonomics so this set was excluded from my study. Property 12 "clear visibility" is also defined by the actual vehicle design which cannot be controlled in my study, so this was also excluded. Property 7 "easy to understand, use, feel in-control" needs a lot of focus on user interface design which I did not consider in detail for this study. However, I accepted this as a basic requirement for relaxation while driving and I needed to ensure that my concept(s) would not require a difficult user interface.

Among the remaining 12 properties, it can be noted that some properties complement all the other properties whereas some of them are contradictory to each other. I call these basic and extreme properties respectively. Five of the 6 top-ranked properties

complement all the rest. These highest-rated properties must therefore be included in any concept that aims at relaxing the driver:

1. Simple, no clutter
2. Personal feeling
3. Rounded shape, curves
4. Beautiful, balanced, colour harmony
5. Quiet, unobtrusive

A closer look at the remaining extreme properties helped me to define two distinct design directions, both of which can possibly relax the driver. This variation can be because different people relax in different ways. Based on this, I defined the following 2 concepts:

Concept A	Concept B
Natural feel, water	Feel safe, protected, privacy
Interactive, responsive, trusty	Reminds of leisure, sleep
Interesting, looks fun	Smooth
	Soft

Both of these concepts must also satisfy the five basic properties.

4.3 Emotional scales

4.3.1 Aim
This user study was performed to understand the combination of colour, shape and lighting design that would help to relax drivers. The results were to be used to support the concepts with colour and form input.

4.3.2 Method
Here I selected 10 pictures of home interiors representing a variety of colour, shape and lighting themes and asked participants to rate them on four specifically developed scales. The participants comprised of the 10 design students interviewed also for property extraction as well as 10 additional persons from different fields of work. Pictures of home interiors were used because most people are familiar with them and have experienced a variety of them already.

The 10 pictures with the various themes chosen are listed below:

1 Mainly black & white colours, high contrast, soft shapes, natural white lighting

2 Mainly warm greyscale with one bright accent colour (orange), no clutter, mixed shapes, soft rug, soft white lighting

3 Cool colour scheme, strong colours and graphics, soft shapes, moderate visual complexity, natural white lighting

4 Natural materials with artificial lighting, rectangular shapes, strong lighting, mixed (warm and cool) lighting

5 Pale earthen colours, rectangles, visually simple, plants, sunlight

6 Very bright colours, strong contrast, low visual complexity, strong lighting

7 Warm colour scheme, wood, rectangular shapes, varying contrast, soft natural lighting

8 Completely cool colour scheme, soft curved shapes, white bathed in strong blue light, supported by dim spotlights

9 Strong primary colours, very strong contrast, rectangular and soft shapes, moderate visual complexity, natural lighting

10 Mix of many strong colours, wood, mixed shapes, high visual complexity, lot of spotlights

The participants were asked to place all the images on the following four scales to answer the question below:

How does this image make you feel?

				Neutral			
SCALE 1	**Calm**	2	1	0	-1	-2	**Excited**
SCALE 2	**Positive**	2	1	0	-1	-2	**Negative**
SCALE 3	**Happy**	2	1	0	-1	-2	**Sad**
SCALE 4	**Interested**	2	1	0	-1	-2	**Bored**

The scales were presented to the participants in two groups, without the numbers, as shown below:

How does this image make you feel?

Calm

Negative · ——————————— · Positive

Excited

How does this image make you feel?

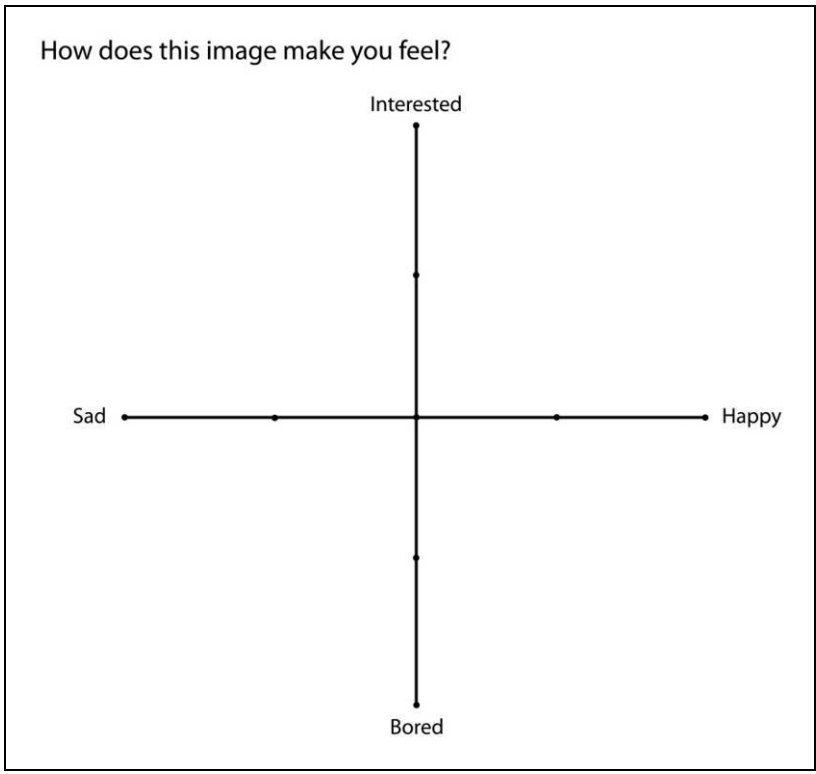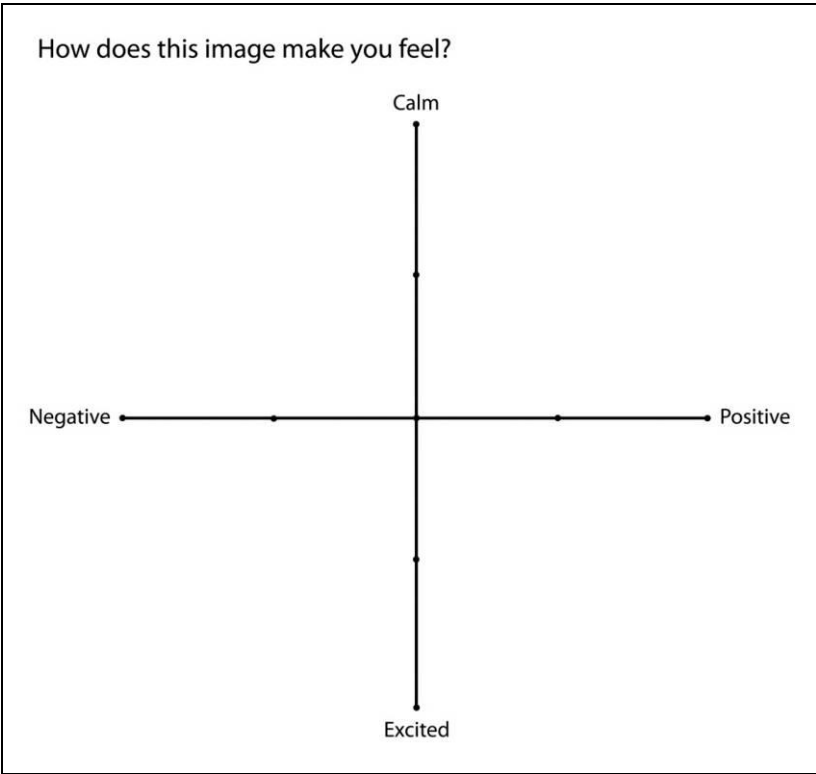Interested

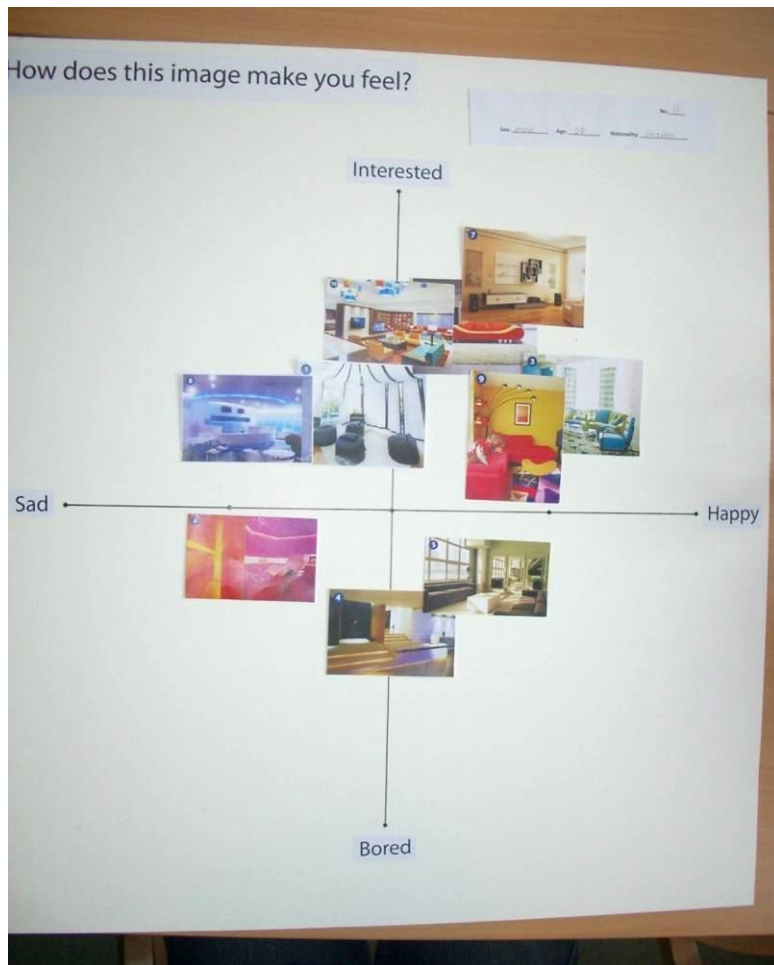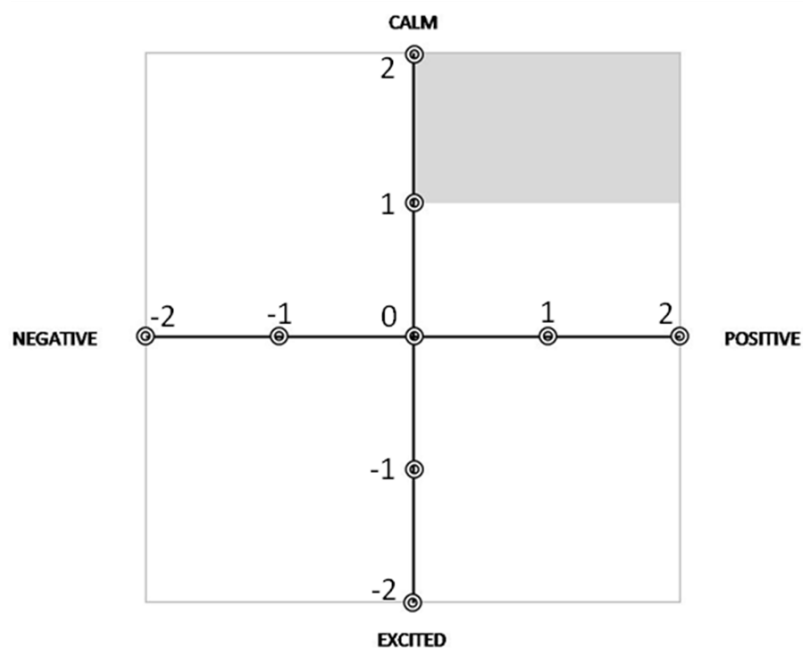Sad · ——————————— · Happy

Bored

Image 9 below shows the images placed by participant 11 on one of the scale-groups.
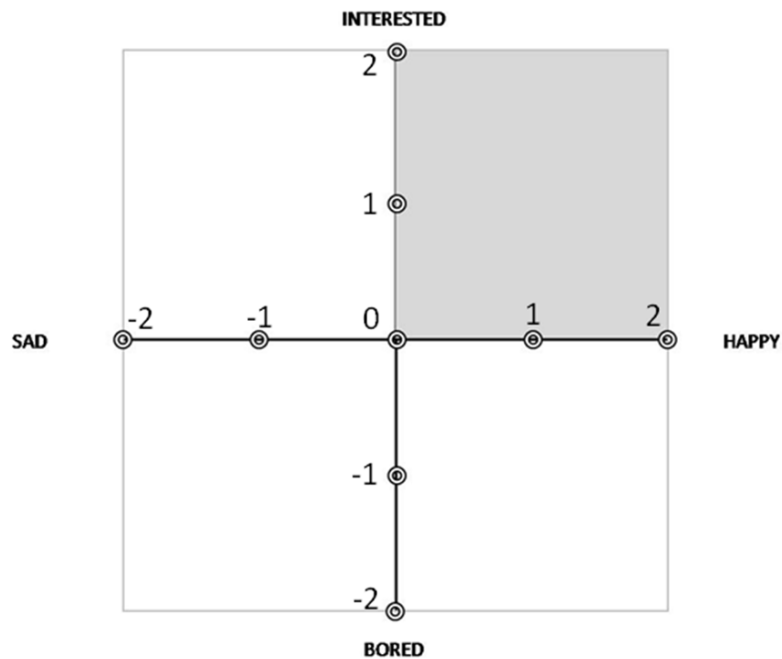
***Image 9.** Example placement on emotional scales*

4.3.3 Results

I was looking for images which reliably make most of the participants feel calm, but at the same time not make them feel negative, bored or sad. Ideally, this can be represented by the grey areas marked below.

I first looked at how all the images were placed on scale 1: calm-excited. By examining these scores, I could directly eliminate images which do not make participants feel calm and are therefore not useful for my purpose. The scores are shown in table 6.

Table 6. Scores for images 1-10 on the 'calm Vs excited' scale

Participant	Img1	Img2	Img3	Img4	Img5	Img6	Img7	Img8	Img9	Img10
1	0.5	1.5	-1.5	-1.5	2	-2	2	-1	0	-1
2	1.5	1	0.5	0.5	1.5	-1	1.5	-0.5	-1	0
3	0.5	-0.5	-0.5	-0.5	1.5	-1	1	-1	-1	0
4	0.5	-1	-1.5	-1.5	0.5	-2	1.5	-1	-1	-1
5	-0.5	1	1	0.5	1	-1.5	1.5	1	-1	-0.5
6	0	-1	0.5	-0.5	0.5	-2	1.5	-0.5	-1	-1
7	0.5	-1	1	0.5	1.5	-0.5	0.5	-0.5	-1	-1
8	0.5	-1	-0.5	1.5	2	-1.5	1	1	0	0
9	1	1	0	0	2	1.5	1	-1	-1	0
10	1	1.5	1.5	0	-0.5	-0.5	0	-1	-1.5	-1
11	1	0	1	-0.5	0.5	-0.5	-0.5	-1	1	-0.5
12	0	0	-1	0	-0.5	-1.5	1	-1	0	1
13	1.5	1.5	0	0.5	1.5	-1.5	0	-0.5	-0.5	-0.5
14	0.5	-0.5	1.5	0	0.5	-1.5	2	0	-1.5	-1
15	0.5	2	2	1.5	0.5	-0.5	-0.5	-2	-0.5	-1
16	1	-0.5	1	-1	1	-0.5	0.5	1.5	0.5	0
17	1.5	-0.5	-0.5	0	0	-1.5	1	-1	0.5	0
18	2	-1	1	1	1	-1	-0.5	1	0	0
19	0	0	0	2	1.5	-1.5	1.5	-2	0	0
20	2	2	1	1	-1	-0.5	2	-1.5	1	-0.5

The above results are summarised in table 7.

Table 7. Summary of scores on 'calm Vs excited' scale

Image	Percentage of participants & summary
1	Calm 80%, excited 5%, neutral 15% - **Highly calm** (mostly moderate and a few strong "calm" scores), only one "excited" (-0.5) score

2	Calm 40%, excited 45%, neutral 15% - **Can be either exciting or calm.** Moderate "excited" scores and strong "calm" scores, three "neutral" scores
3	Calm 55%, excited 30%, neutral 15% - **Mostly calm** (mainly moderate and a few strong scores), a few "excited" and three "neutral" scores
4	Calm 45%, excited 30%, neutral 25% - **Difficult to conclude.** Needs further analysis on the other scales.
5	Calm 85%, excited 10%, neutral 5% - **Highly calm**, two "excited" (-0.5) scores, only 1 neutral score
6	Calm 5%, excited 95% - **Absolute exciting**
7	Calm 75%, excited 15%, neutral 10% - **Highly calm** (mostly strong "calm" scores), three (-0.5) "excited" scores, two "neutral" scores
8	Calm 20%, excited 75%, neutral 5% - **Highly exciting** (mostly moderate "excited" scores, few strong)
9	Calm 20%, excited 55%, neutral 20% - **Mostly exciting**
10	Calm 5%, excited 55%, neutral 40% - **Mostly exciting**, only one "calm" score

Based on the above observations, images 6 and 8 could be eliminated from further analysis as they made a majority of the participants feel excited. In addition, image 10 and image 9 (to a lesser extent) did not make many participants feel calm, so they could also be discarded.

The remaining images (images 1, 2, 3, 4, 5,7) were analyzed on scales 2,3 and 4 in a similar way. Based on this analysis, I assigned a summary rating (between -2 and 2) for each image on each of the four scales. The ratings on the calm-excited and positive-negative scales were given double the weight of the other two scales as it was imperative that the resulting concept made the drivers feel calm but not negative. A total score was calculated by adding all the weighted ratings. The images with the highest score was selected to provide design input for the concepts.

Table 8. *Weighted summary rating for the non-eliminated images*

Image	Calm/Excited (Weight=2)	Positive/Negative (Weight=2)	Interested/Bored (Weight=1)	Happy/Sad (Weight=1)	Total score
Img 1	2	1	-1	0	**5**
Img 2	0	2	2	2	**8**
Img 3	1	0	0	1	**3**
Img 4	0	1	0	0	**2**
Img 5	2	2	-1	1	**8**
Img 7	2	2	0	2	**10**

From a maximum total score of 12 points (4+4+2+2), image 7 scored 10 whereas image 2 and image 5 scored 8 points each. The remaining images did not even score half of the total points and therefore were considered not to support the concept intention well.

Thus images 2, 5 and 7 were chosen to be used to strengthen the concepts A and B defined through property extraction.

Among these, image 5 (pale earthen colours, rectangles, visually simple, plants, sunlight) seemed to directly support concept A (natural, interesting, responsive) whereas image 2 (mainly warm grey scale with one bright accent colour, no clutter, mixed shapes, soft rug, soft white lighting) supported concept B (safe feeling, leisure, smooth, soft). Image 7 (warm colour scheme, wood, rectangular shapes, varying contrast, soft natural lighting) did not seem to favour one concept more than the other, but was considered to support either concept if applied in a good way. Moreover, it received the highest total score, so its design cues are essential for either concept to fulfil the primary purpose of relaxing the driver.

In summary, I decided to use design cues from images 5 and 7 to develop concept A and those from images 2 and 7 to strengthen concept B.

4.3 Driver behaviour questionnaire

4.3.1 Aim
The purpose of this study was to identify non-aggressive and relatively more aggressive drivers so that an equal number of both driver types could be invited to the planned evaluation study.

4.3.2 Method
Based on the literature study in section 2.3, I chose to use the Manchester DBQ shortened to fit my needs. I created an online survey using this questionnaire.

The only conditions for choosing the participants were that they must have driven in Europe for more than a year (so they have developed their own driving habits) and that they live in Göteborg (so that they have the possibility to attend the evaluation planned at Chalmers).

I excluded the errors and lapses from the Manchester DBQ in order to:
1. Focus only on voluntary driver behaviour, and
2. To shorten the survey so that more people are encouraged to answer it.

This shortened Manchester DBQ (only violations) reads as follows:

Table 9. Modified Manchester DBQ questions

No.	"How often do you... "
1	Sound your horn to indicate your annoyance to another road user?
2	Pull out of a junction so far that the driver with right of way has to stop and let you out?
3	Disregard the speed limit on a residential road?
4	Become angered by another driver and give chase with the intention of giving him/her a piece of your mind?
5	Stay in a motorway lane that you know will be closed ahead until the last minute before forcing your way into the other lane?
6	Overtake a slow driver on the inside?
7	Become angered by a certain type of driver and shout and/or gesture at them?
8	Race away from traffic lights with the intention of beating the driver next to you?

9	Drive so close to the car in front that it would be difficult to stop in an emergency?
10	Cross a junction knowing that the traffic lights have already turned against you?
11	Become angered by a certain type of driver and stop your car with the intention of arguing about it?
12	Disregard the speed limit on a motorway?
13	Flash your headlights to indicate your annoyance to another road user?

The participants were asked to answer the each question on the following 6-point scale:

Table 10. Modified Manchester DBQ scale

0	1	2	3	4	5
Never	Hardly ever	Occasionally	Quite often	Frequently	Nearly all the time

The questionnaire was created using Google Drive and shared online with 40 drivers in order to collect the planned 20 participants for the evaluation study. I received 30 responses. The respondents were European drivers with ages ranging from less than 20 years to more than 60 years. 37% of all respondents were female while 63% were Swedish.

4.3.3 Results

The average rating for the 13 questions was calculated for each driver. Table 11 lists the results sorted from the most aggressive drivers (highest frequency of performing the violations) to the least. It mentions only the initials of the participants to protect their identity.

Table 11. Results of online survey using the modified Manchester DBQ

No.	Participant	Age	Sex	Nationality	Average rating
1	AL	25-30 years	Male	Swedish	2.46
2	C	18-24 years	Female	Italian	1.77
3	AH	31-40 years	Male	Swedish	1.69
4	IB	25-30 years	Male	Portuguese	1.69
5	PK	31-40 years	Male	Polish	1.46
6	MV	41-50 years	Male	Italian	1.38
7	MD	31-40 years	Male	Italian	1.38
8	GT	31-40 years	Male	Italian	1.31
9	SM	25-30 years	Female	Swedish	1.31
10	LN	25-30 years	Male	Swedish	1.23
11	ER	31-40 years	Female	Swedish	1.23
12	FB	25-30 years	Male	Italian	1.15
13	OH	25-30 years	Male	Swedish	1.15
14	M	51-60 years	Male	Swedish	1.08
15	LH	31-40 years	Female	Swedish	1.00
16	AF	61 and above	Female	Swedish	1.00

17	PM	31-40 years	Female	Finnish	1.00
18	BF	25-30 years	Male	Swedish	0.92
19	RR	61 and above	Male	Swedish	0.92
20	CB	31-40 years	Female	Swedish	0.69
21	YR	25-30 years	Female	Swedish	0.69
22	SK	31-40 years	Female	Dutch	0.69
23	AN	25-30 years	Female	Swedish	0.69
24	MF	51-60 years	Male	Italian	0.62
25	TS	31-40 years	Male	Swedish	0.62
26	MH	51-60 years	Male	British	0.54
27	S	25-30 years	Female	Swedish	0.38
28	P	41-50 years	Male	Swedish	0.38
29	AB	41-50 years	Male	Swedish	0.31
30	GG	51-60 years	Male	Swedish	0.23

As seen here, only one of the 30 drivers performs (or admits to performing) these violations "more than occasionally". This survey gives me 30 drivers to choose from, who drive with different levels of aggression. The aim for the evaluation study is to include as many drivers as possible from the two ends of this list while attempting to have the same number of drivers from the first 15 as from the last 15. The final list is of course subject to the participants' availability.

5 Summary and basis for concepts

5.1 User studies summary

The results of the property extraction study gave me two separate concepts of design elements aimed at relaxing the driver. The two different concepts probably signify that people have different personal preferences for relaxation, as concluded from the quick study of online user forums in section 2.4. The two concepts are shown below in image 10.
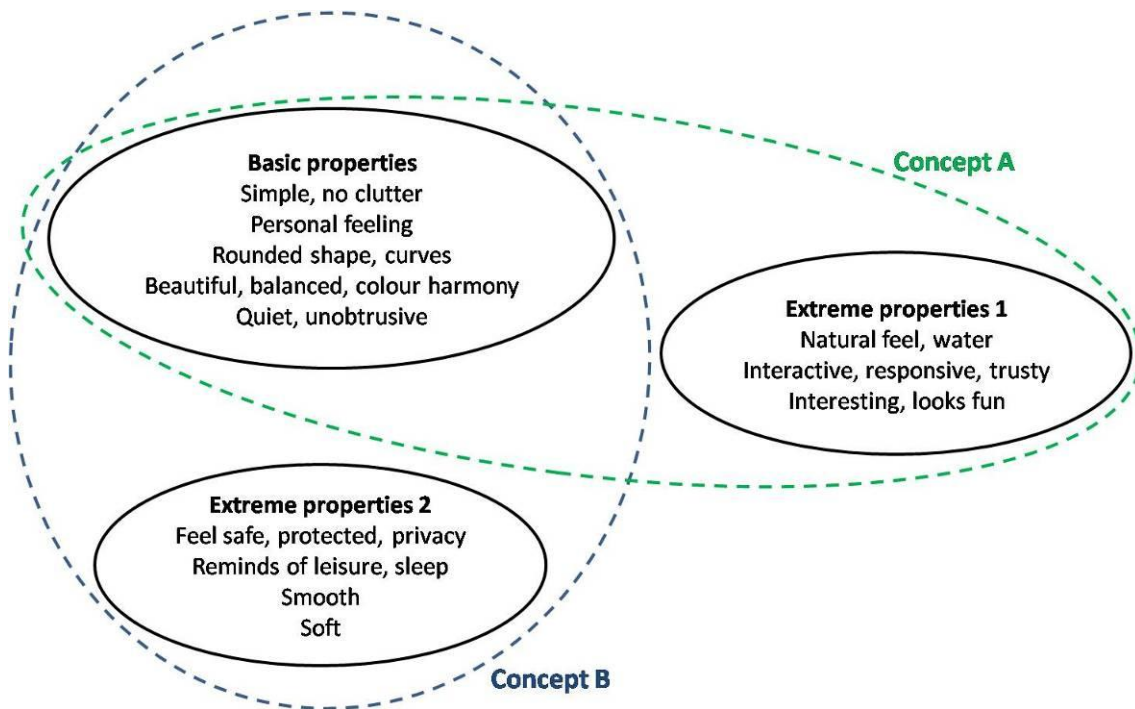
Image 10. Concepts A and B for driver relaxation

Moreover, the images chosen in the emotional scales user study will be used to support concepts A and B with colour and form input. The following three images were identified as the ones most likely to make the participants feel calm and positive but not sad or bored at the same time (out of a maximum score of 12).

#7 warm colour scheme, wood, rectangular shapes, varying contrast, soft natural lighting. **SCORE 10**

#2 mainly warm greyscale with one bright accent colour (orange), no clutter, mixed shapes, soft rug, soft white lighting. **SCORE 8**

#5 pale earthen colours, rectangles,
visually simple, plants, sunlight. **SCORE 8**

Image #7, which received the highest total score, did not seem to favour one concept more than the other, but could support either concept to fulfil the primary purpose of relaxing the driver. Image #5 seemed to directly support concept A (natural, interesting, responsive) whereas image #2 supported concept B (safe feeling, leisure, smooth, soft). Therefore, I decided that the design cues from images #5 and #7 to were to be used to develop concept A and those from images #2 and #7 to develop concept B.

5.2 Mood boards

In order to design vehicle interior concepts using the above results, it was necessary to express them visually in a simplified way. I decided to create mood boards to achieve this. The mood board for each concept combined the five basic properties, the concept-specific properties and the colour cues from the relevant images.

Image 11. *Mood board for Concept A - Natural*

The extreme properties of Concept A were simplified by choosing fewer words among them which most completely represent them all. The three words for concept A were natural, interesting and responsive. Here, natural was the key word which defined the main characteristic of concept A. Moreover, this mood board also used colour cues from images #5 and #7.

Similarly, four words were chosen to represent concept B. They are safe-feeling, leisure, smooth and soft. Here, safe-feeling was the key word which defined the main characteristic of concept B. This mood board used colour cues from images #2 and #7.

Image 12. Mood board for Concept B - Safe-feeling

5.3 Inspiration boards
The mood boards helped to express each concept visually and to set the mood for sketching. However, I found it difficult to use these directly as an inspiration for ideas. Therefore, I decided to collect a substantial group of images which, according to me, showed physical samples which represent the concept. I call this collection an "inspiration" board.

The inspiration boards created for concepts A and B are shown below.
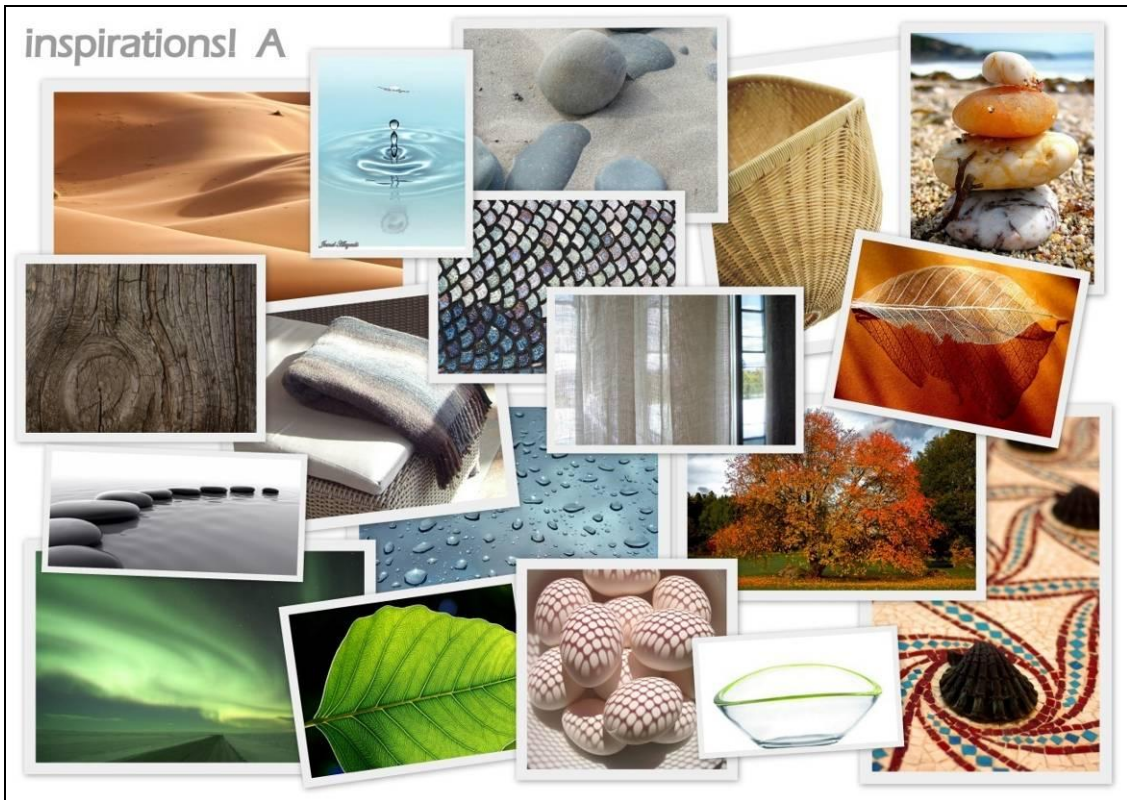
Image 13. *Inspiration board for Concept A*

Image 14. *Inspiration board for Concept B*

Each inspiration board was used for driving the initial sketch ideas for the respective concept in phase II.

Phase II: Concept development

The aim of phase II was to develop and choose one concept vehicle interior which can help to relax the driver and reduce the occurrences and/or intensity of aggressive driving. The effectiveness of this concept would be evaluated in phase III.

6 Concept development

6.1 Overview

I used sketching extensively throughout the concept phase. Initially, quick sketches were used to generate many ideas which would fit concepts A and B as defined by the respective mood boards. The inspiration boards were used to drive these sketches. After filtering out and selecting one concept, more focussed sketches were used to develop each aspect of this concept in detail. Towards the end, outline sketches were also used as a base for renderings of the final concept.

To explore the colour schemes, various colour plates were developed for each theme in Adobe Photoshop. The plate which fit best with the requirements defined by the emotional scales and the colour & emotion literature studies was chosen to adorn the final concept. Various physical paint samples were created to match the software colours in this plate. The paint shades which matched the software colours closely enough were chosen to be used for the prototype.

I visited a number of local textile shops to find a material which offered the right feel, texture and visual appearance. It was vital that the chosen material was available in the desired colour.

The final concept and user interface renderings were created using Photoshop.

6.2 Sketch ideation

The main purpose of sketching was to generate ideas inspired by the inspiration board for each concept while making sure that these ideas followed the 5-basic properties. These sketches focussed on shape, basic colour ideas, as well as lighting concepts.

Since the two concepts have a common base, it is possible that sketches for concept A inspire an idea which is valid for concept B or vice versa. Therefore, I did not restrict myself to one concept at a time while sketching and each sketch sheet has a mix of both the concepts. Below is a sequence of sketches with some notes in orange (concept A) and black (concept B) indicating how they fit in the 2 concepts.

Many of the early sketches for concept A (see images 15 and 16) were inspired by natural phenomena such as soil formations and layers, sand dunes, flowing water, waves, water drops and ripples, sunset, pebbles, tree growth rings and leaves.
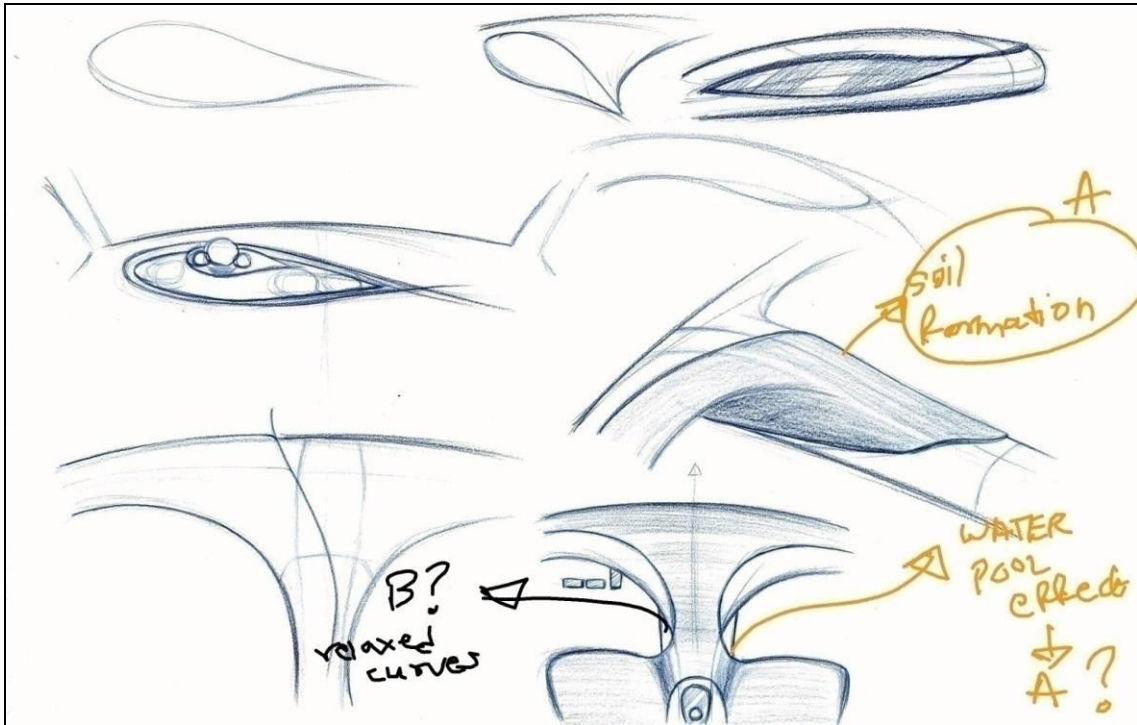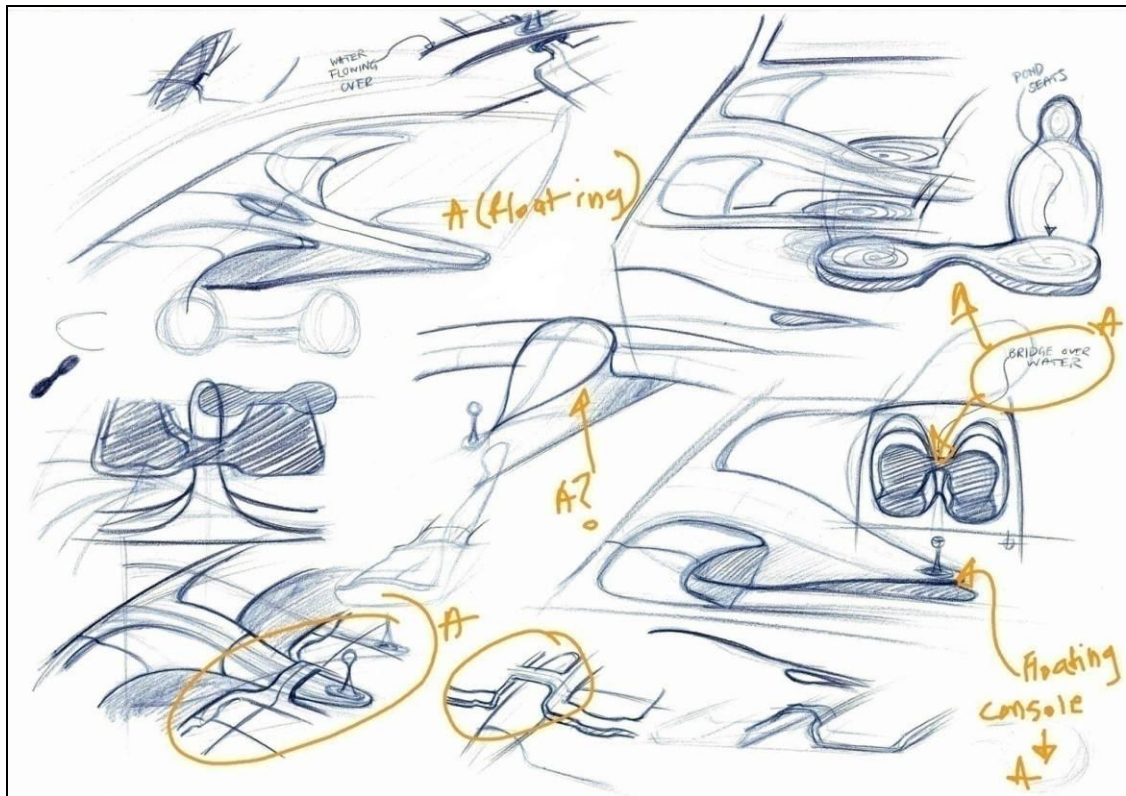
***Image 15.*** *Concept A form sketches based on soil formations and water pools*
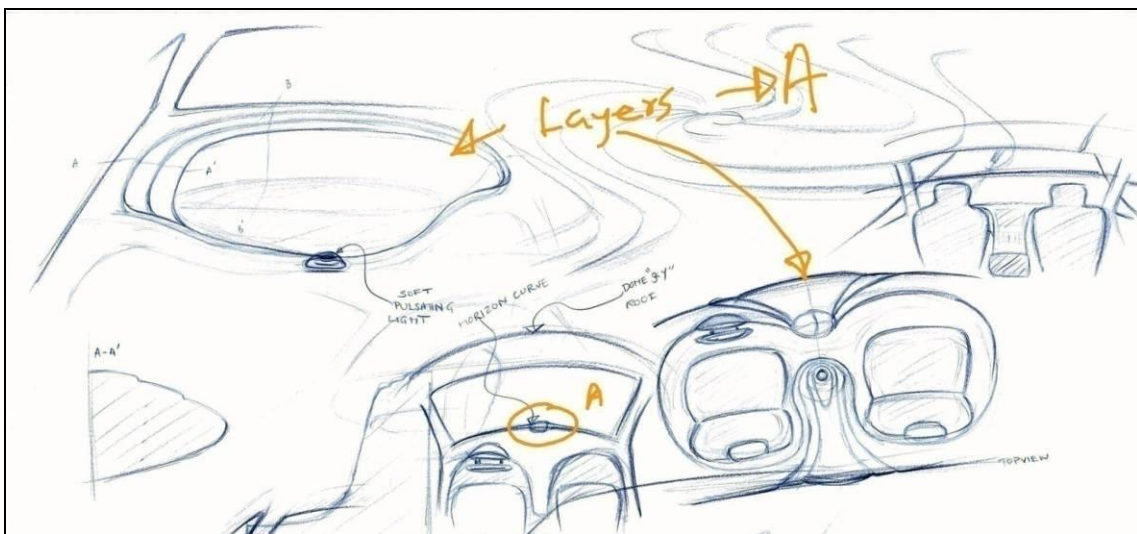
Image 16. *Concept A form sketches based on layers of sand*

More ideas for concept A were explored based on other natural phenomena.

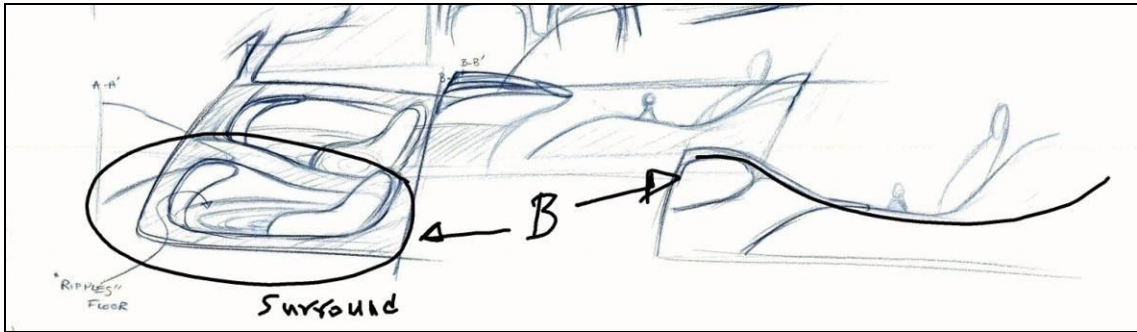***Image 17.** Concept A form sketches based on age-rings in trees and floating objects*

Some ideas were discarded for not following the 5 basic properties. For example, image 18 below shows a dashboard inspired by sand dunes which was thought to be visually complicated. It did not satisfy the "simple, no clutter" property and was therefore discarded.
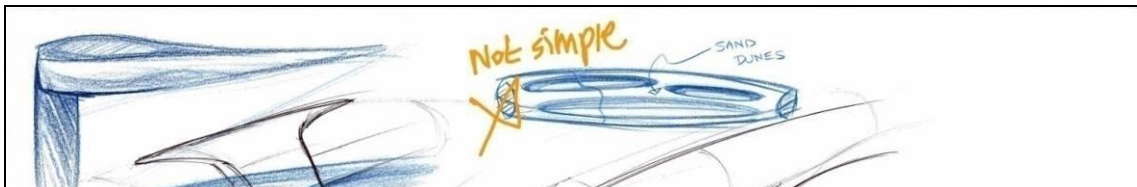
***Image 18.** Rejected idea for Concept A judged not to be visually simple*

The early sketches for concept B were inspired by soft cloth and its flow patterns, beds and relax-chairs, gentle slopes, surrounded protection and soft lighting.

Image 19 shows one of the prominent inspirations for concept B. This sketch is based on an idea that being cocooned in an embrace could create a feeling of being safe. That is why the shape of the dashboard flows around the driver and surrounds him/her to make him/her feel safe.

Image 19. Concept B form sketches based on a safe cocoon

Image 20 shows further development of this "surround flow" idea for concept B. The flowing shapes were made softer and with gentle angles to further support the feeling of safety and leisure. One idea to enhance this feeling of a safe embrace even in the dark was to use surround lighting instead of spot lighting.

Image 20. Evolution of concept B's "surround flow" idea supported by surround lighting

While concept B was evolving nicely, I was still searching for a promising idea for concept A. Image 21 explores an asymmetrical dashboard layout inspired from flowing water.
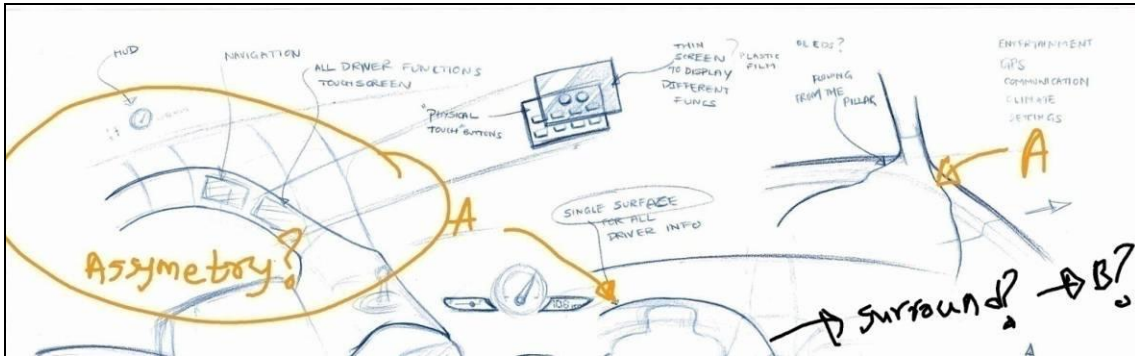
Image 21. *Asymmetrical concept A ideas based on flowing water*

To support the incomplete ideas for concept A, I decided to explore a number of natural patterns and textures which could emphasize the interesting and responsive characteristics of concept A (see image 22).
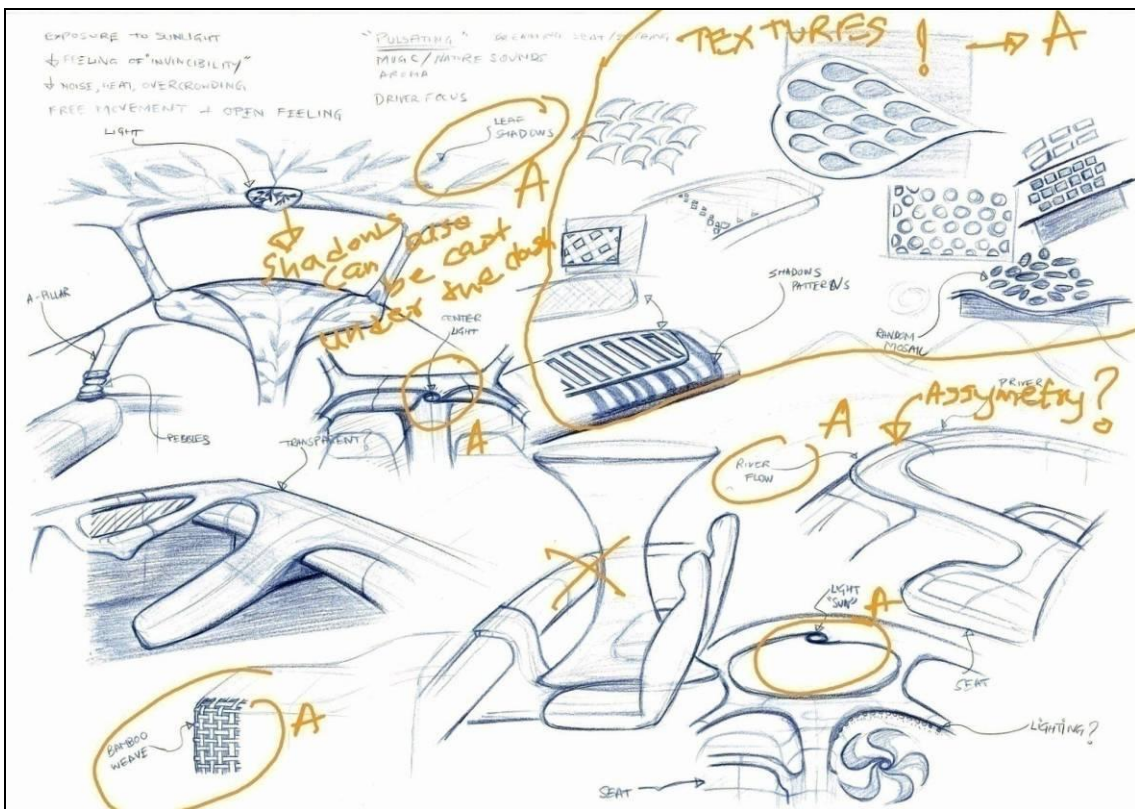
Image 22. *Natural patterns and textures to support form sketches of concept A*

It was necessary to further develop some ideas in full colour to understand their eventual appearance. Images 23 and 24 below show an exploration of the water-flow, water-ripples and pebble texture concepts. Image 24 also shows the idea of "sunrise" lighting over the dashboard which was explored to support the natural theme of concept A.

Image 23. *Colour exploration of water flow, ripples and a pebble texture*
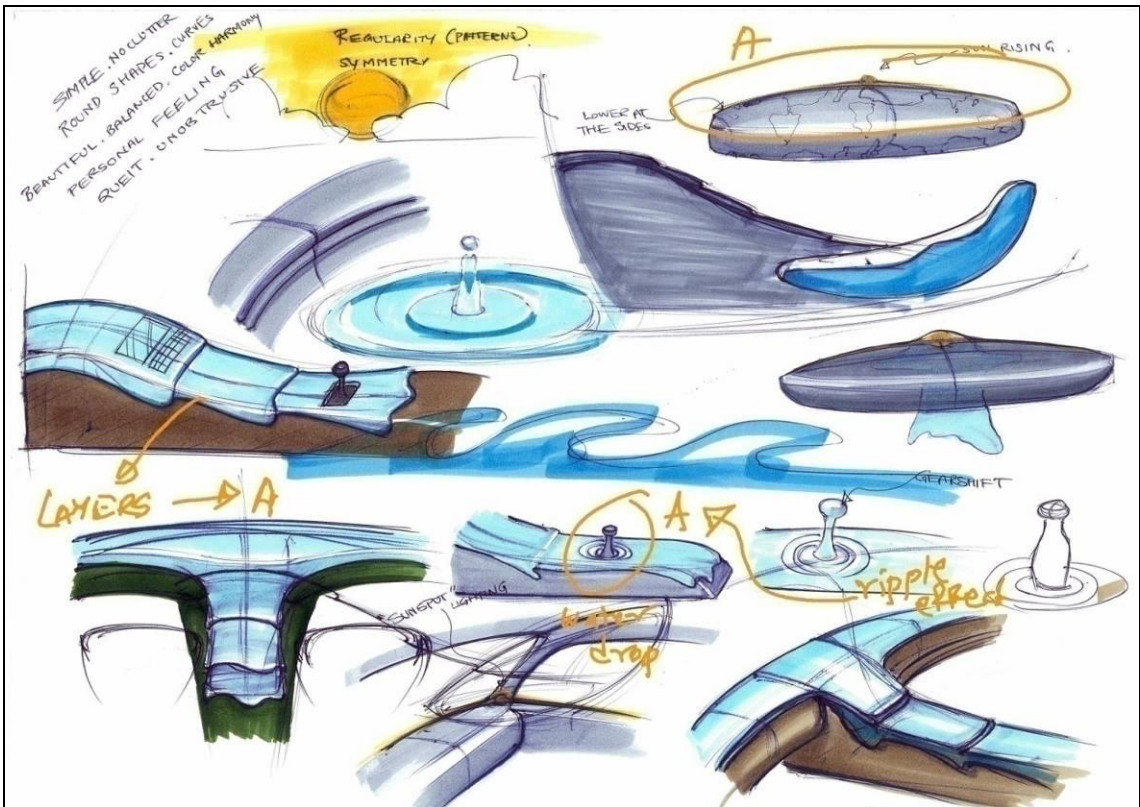
Image 24. *Colour exploration of water flow and sunrise lighting to support concept A*

6.3 Concept selection

The "surround flow" concept was identified as a key-sketch for concept B because I thought it represented the concept very well. Here, the softly curved dashboard surface flows around the occupants to surround them and give them the feeling of being wrapped safely. The unbroken large continuous surfaces could be made soft and smooth and could give a feeling of luxury by using appropriate materials and colours to cover them. An evolution of this concept after several iterations of sketches is shown in image 25 below.
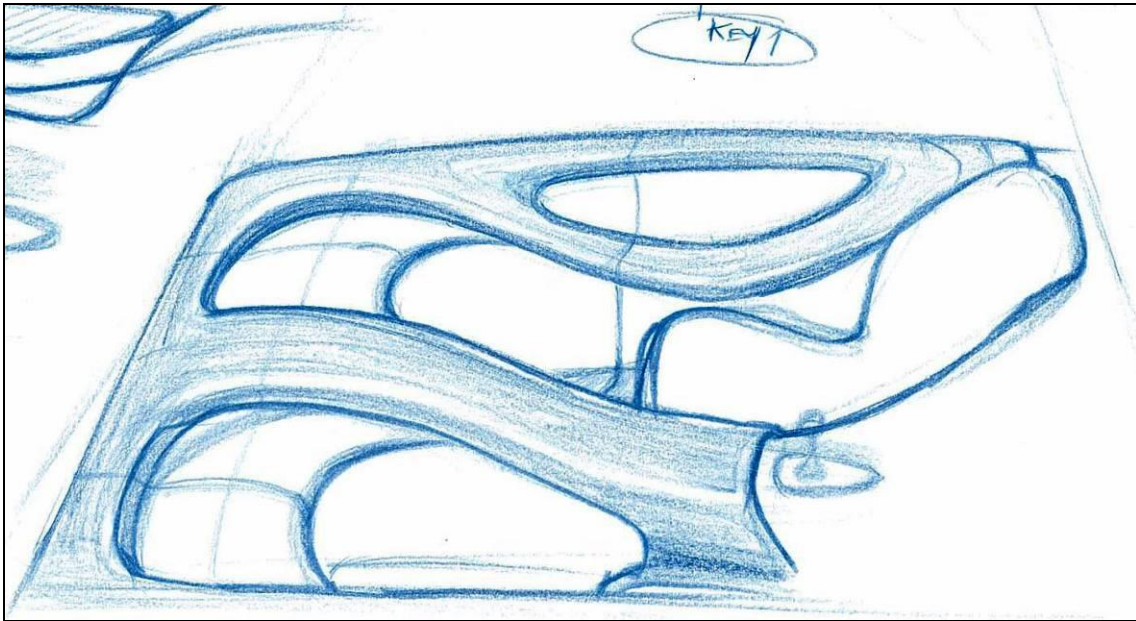
Image 25. *Surround flow concept for concept B*

However, even after several loops of sketching, I had not been able to identify an idea that represented concept A very well while, at the same time, following the basic properties. I realised that it was very difficult to develop a concept that felt interesting and responsive but also simple, quiet and unobtrusive at the same time. Time was running out and I only had one promising concept after the sketch ideation phase - the surround flow concept for concept B.

Moreover, the surround flow concept also had the potential to follow the basic properties quite well. It had rounded shapes, curves and good balance. With focussed development of its details, it could be made simple, quiet, unobtrusive, beautiful and could provide a personal feeling and colour harmony.

Detailed development requires considerable time and effort and it was necessary to narrow down to one concept before developing the details. Based on the status after sketch ideation, only the surround flow concept for concept B looked promising to convey most of the properties summarized from phase I.

The surround flow concept for concept B was therefore chosen for further development and it was decided to not pursue concept A any further.

6.4 Detailed development

In order to reach a level of detail which would be good enough for user evaluation studies, it was necessary to further develop the concepts regarding the following aspects:

- Lighting concepts
- Design of main driving controls: steering wheel and gearshift
- Basic user interface
- Colours and materials

6.4.1 Lighting concepts

Image 26 shows lighting ideas supporting the surround flow concept. They include a softly-lit roof, or surround lights in the headlining or around the occupants. The main intent is to have a soft ambient light and avoid focussed spotlights. The lighting concepts were not explored further as they would not be implemented in the physical prototype.
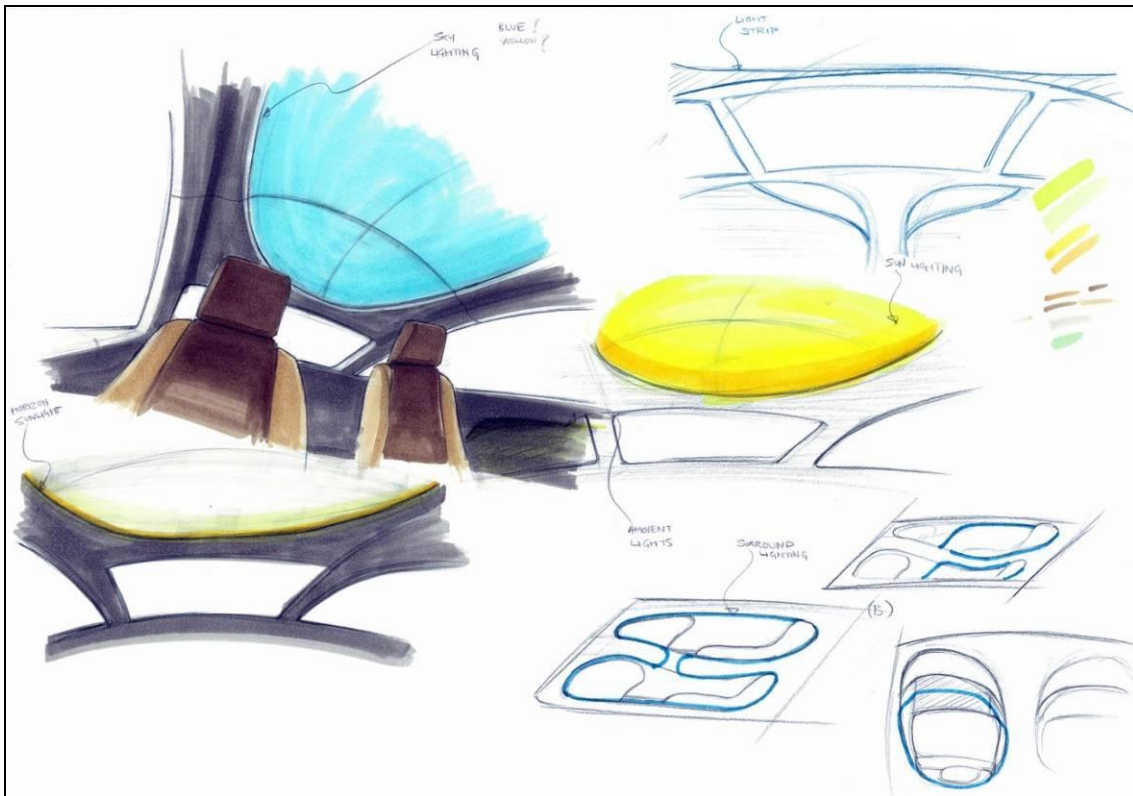
Image 26. Ideas for soft ambient lighting

6.4.2 Steering wheel and gearshift design

The exploration of steering wheel designs is seen in image 27. The common theme behind these sketches is to have a flowing steering wheel shape to fit well with the surround flow dashboard concept .
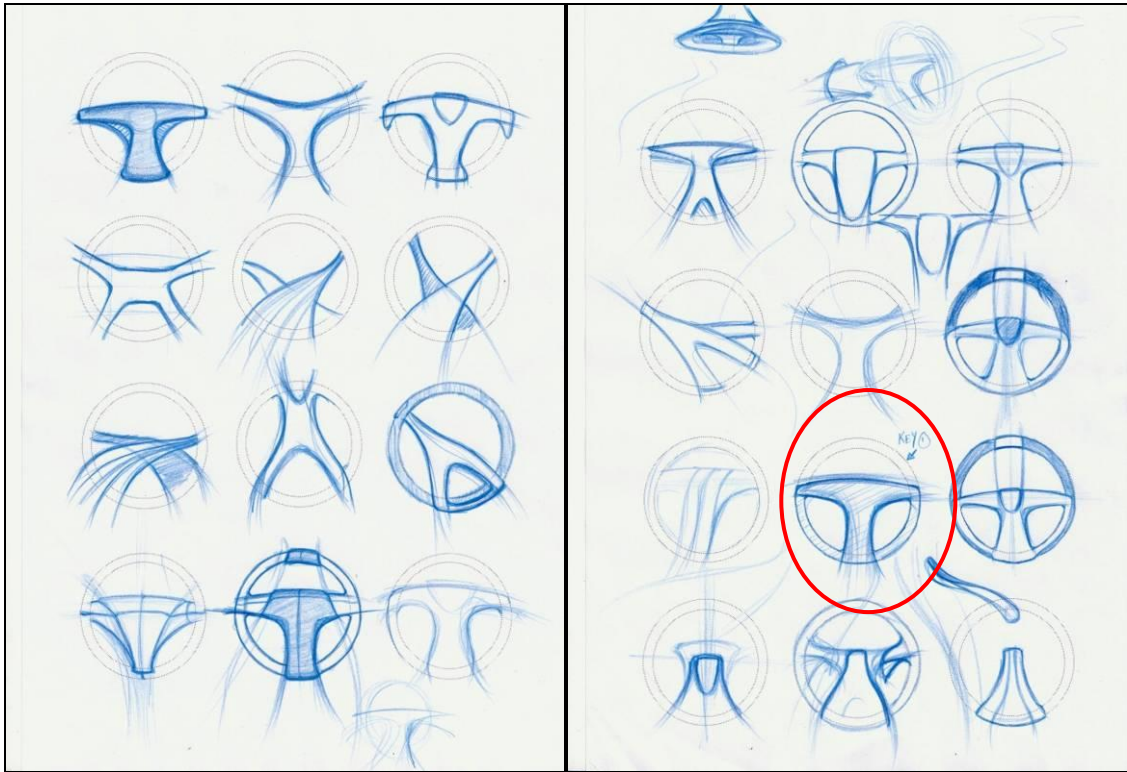
Image 27. Exploration of steering wheel shapes to fit the chosen dashboard concept

Some of these steering wheels were overlaid on a sketch of the concept interior. The steering wheel circled in red in image 27 was chosen as it's form lines when viewed from the driving position matched the overall shape of the interior quite well.
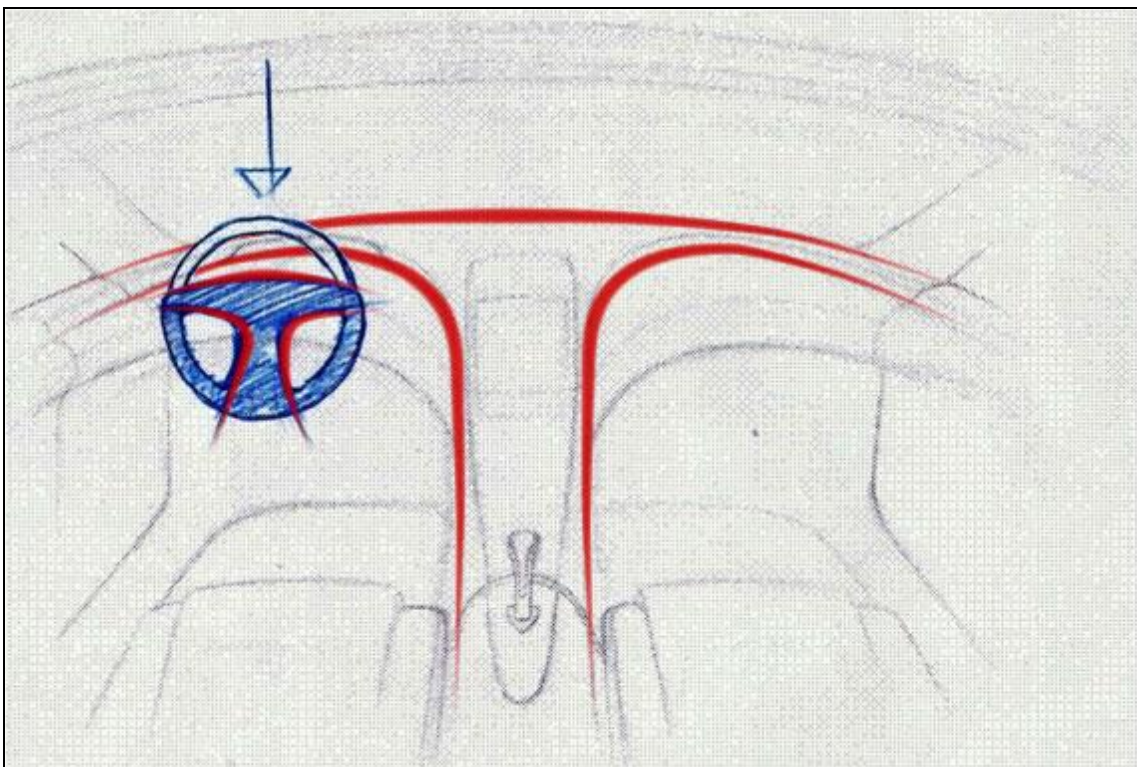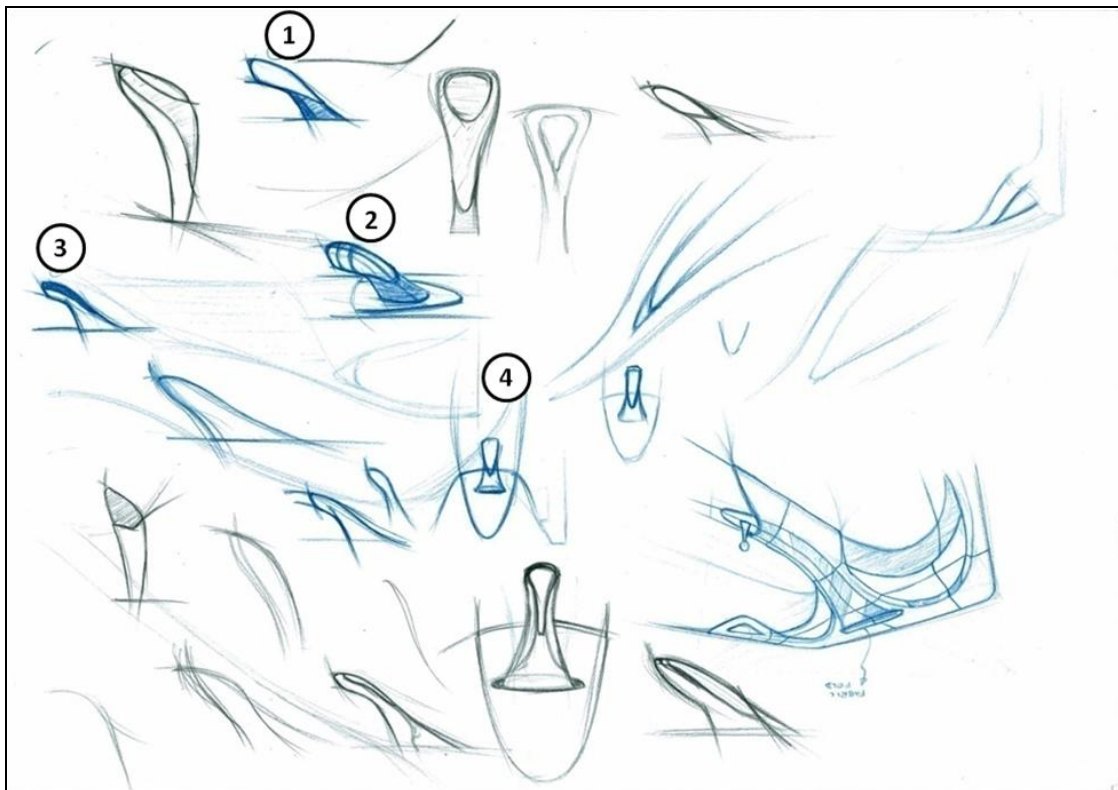

Image 28. Harmony between steering wheel and dashboard shapes

To understand how this steering wheel would look in 3D, some sketches from various angles were made (see image 29).
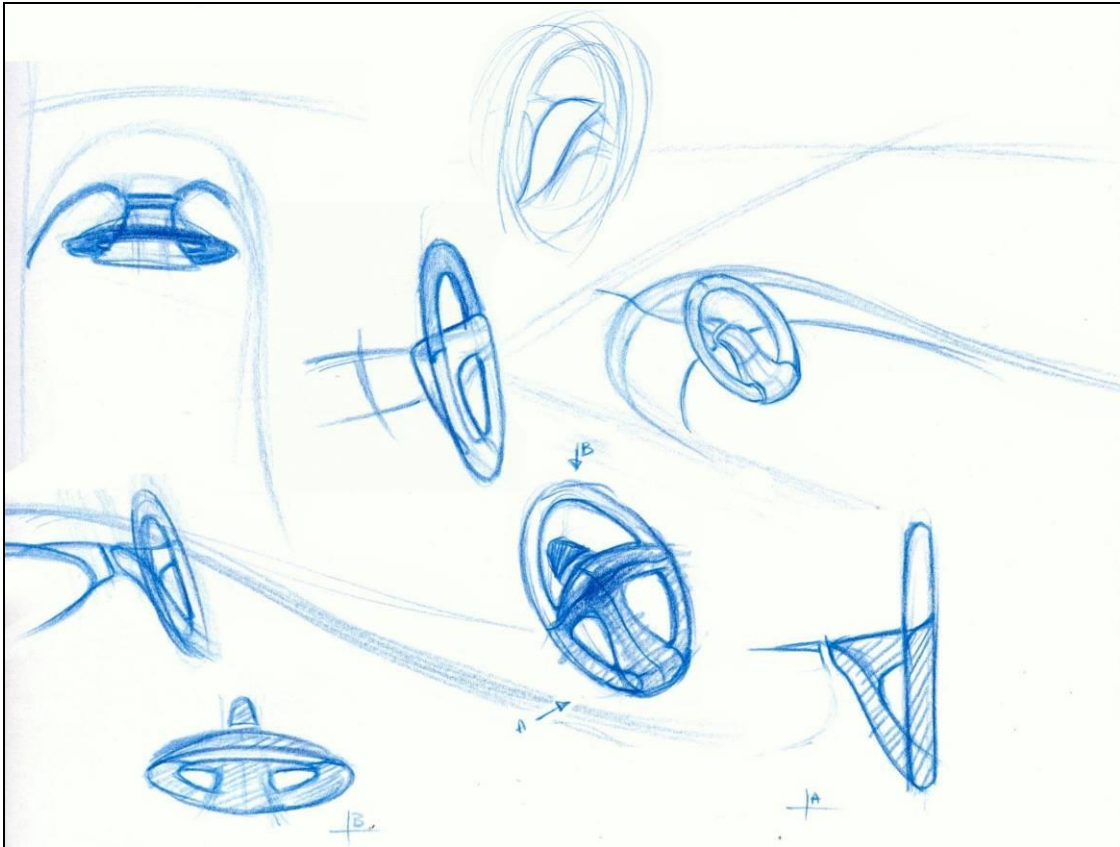
Image 29. *Exploration of chosen steering wheel shape*

A similar process was followed for the gearshift design.

Image 30. *Gearshift sketch ideation - with key sketches 1,2,3 & 4*

The sketches 1,2, 3 and 4 in image 30 were identified as key sketches because the shape of the gearshift lever in these sketches follows the form of the dashboard concept. Sketches 1,2 and 3 showed the gearshift design that follows the gentle slope of the center console when viewed from the side by the driver while sketch 4 showed a gearshift shape that follows the shape of the dashboard when viewed from behind. Therefore the final gearshift shape was developed by combining the cues from these four sketches.

The fully developed forms of the surround flow concept including the steering wheel, gearshift lever and center console are shown in the quick sketch below.
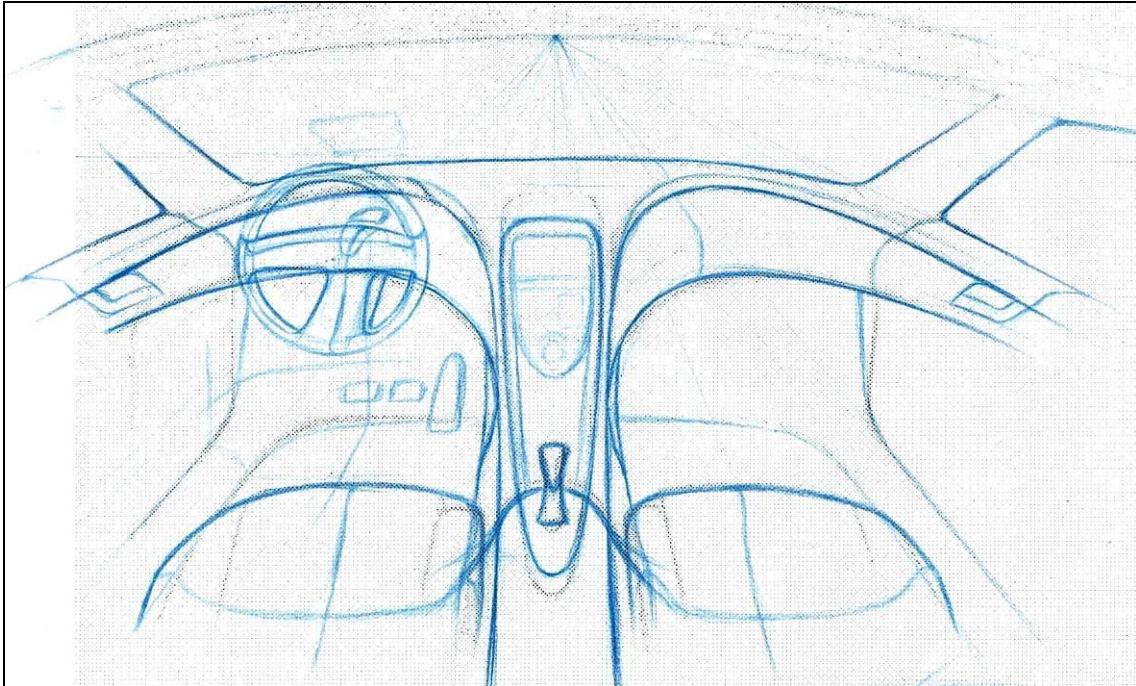
Image 31. Fully developed forms of the chosen concept

6.4.3 Basic user interface
The main intent of this driver interface is to offer the full range of controls expected in today's vehicles with as little visual clutter as possible. This interface is not fully developed but shows one possible way to support the surround flow concept without excessive loss of functionality.

The overall concept is shown in image 32 below. The instrument cluster information is divided into 2 zones: driver warnings are shown on the dashboard whereas other information such as speed, fuel level etc. is shown on a Head Up Display (HUD) on the windscreen. The centre console includes the navigation screen and controls for all secondary functions such as climate, radio etc.
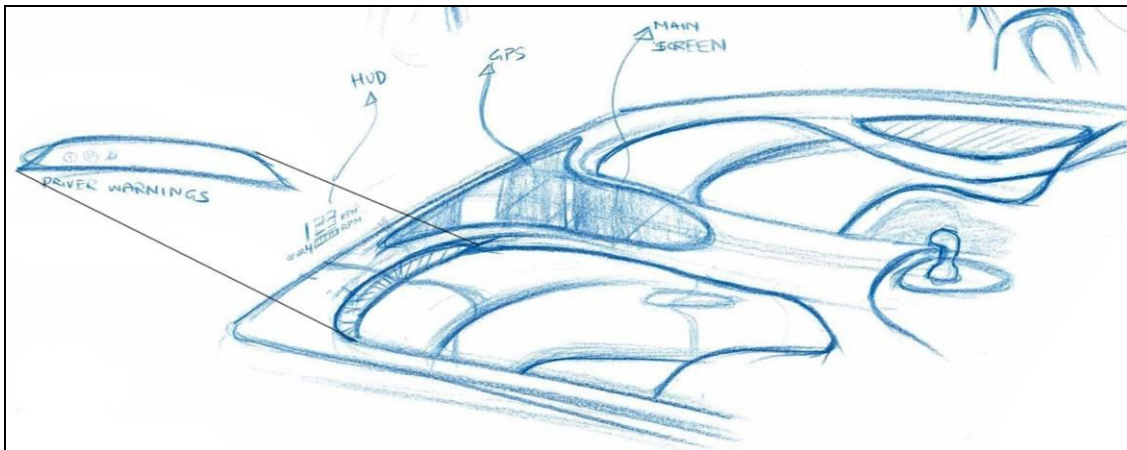
Image 32. *Placement of different types of information in the user interface concept*

The controls on the centre console will use a combination of physical buttons and dials overlaid with a touch-screen (image 33). Depending on the menu selected by the driver, the screen displays a specific function for each physical control. This allows each control to have multiple functions and thus reduces the number of buttons and, therefore, the visual clutter around the driver. At the same time, the controls offer a tactile feeling which allows the driver to locate the controls without looking away from the road.
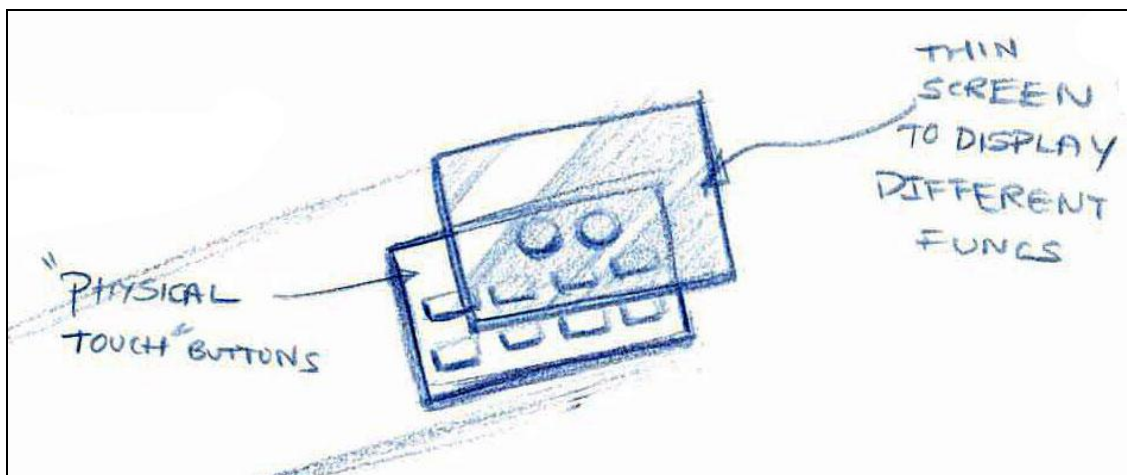
Image 33. *Basic concept for secondary controls*

One way to group the functions is by using the following 4 menus:
- Driver - driving functions such as suspension settings, cruise control etc
- Climate - climate functions such as air conditioning, seat heating etc.
- Media - entertainment functions such as radio, music etc.
- Phone - communication functions such as a phone

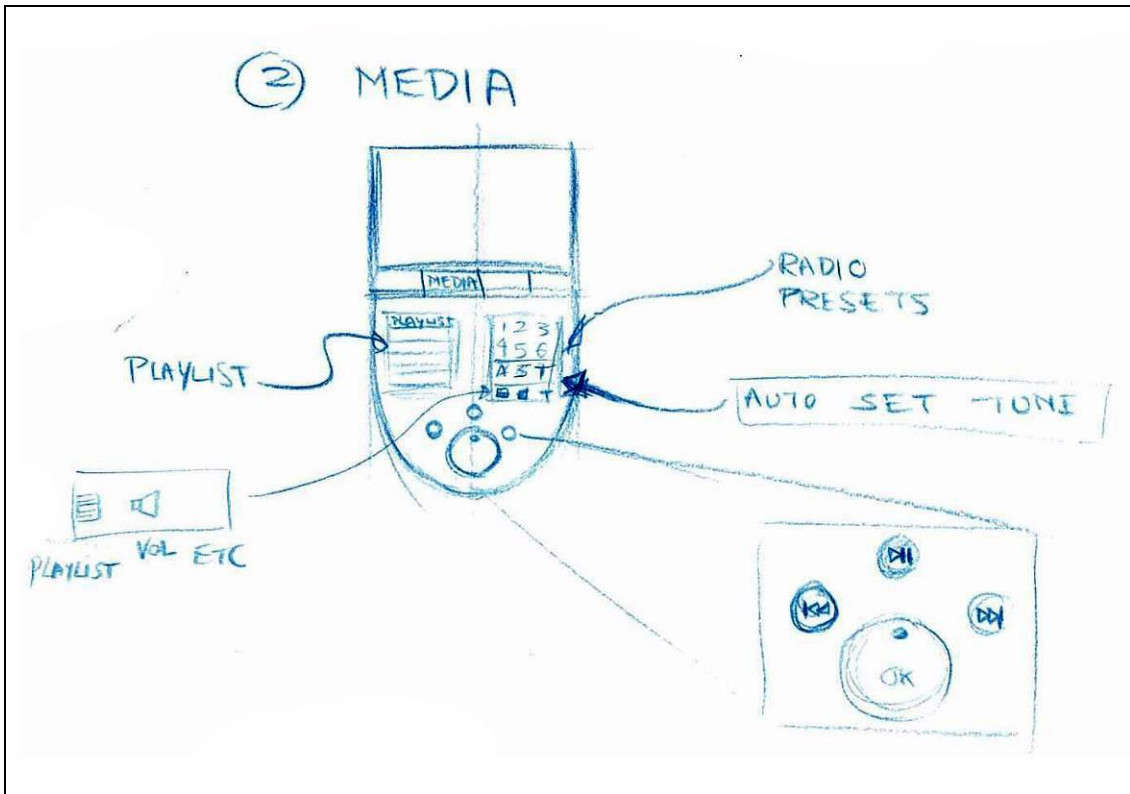Image 34 shows the basic interface which can facilitate these functions.
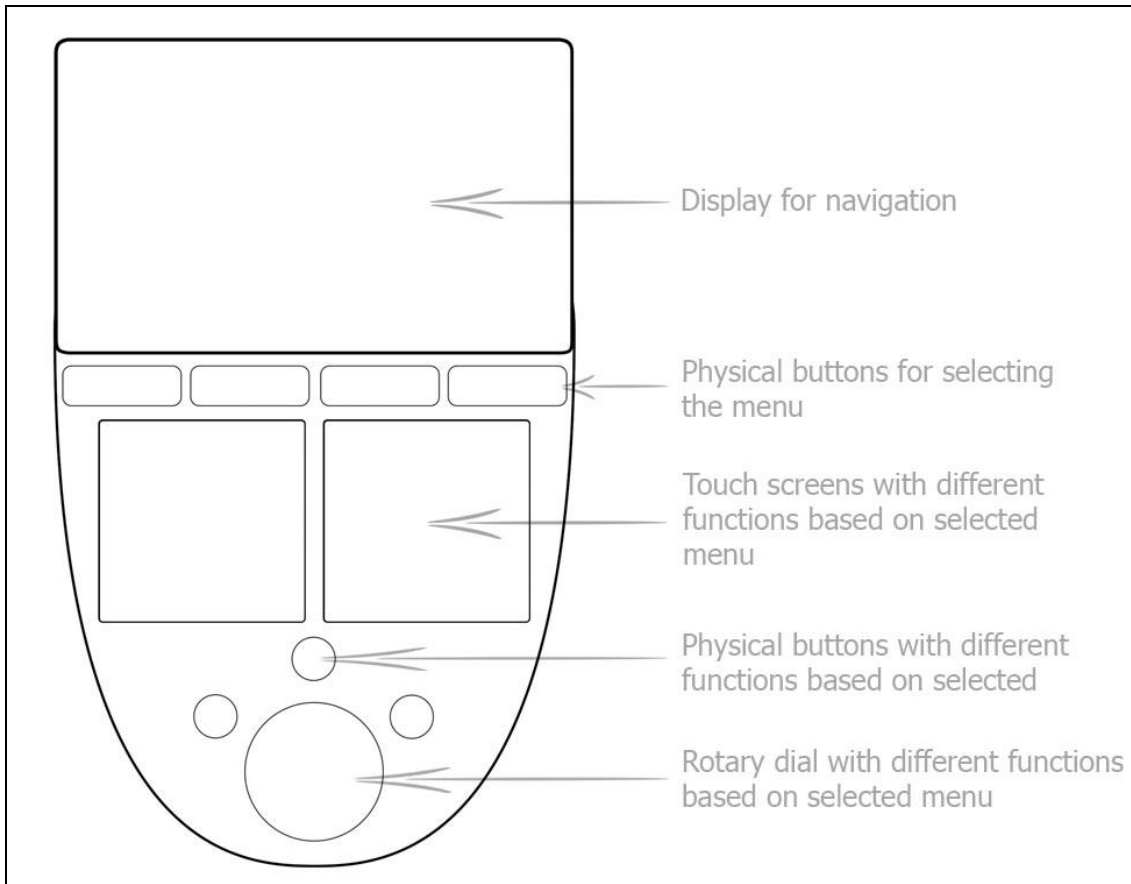
***Image 34.** Driver interface outline sketch*

The sketches in images 35 and 36 demonstrate how this interface offers the relevant functions for the Phone and Media menus respectively.
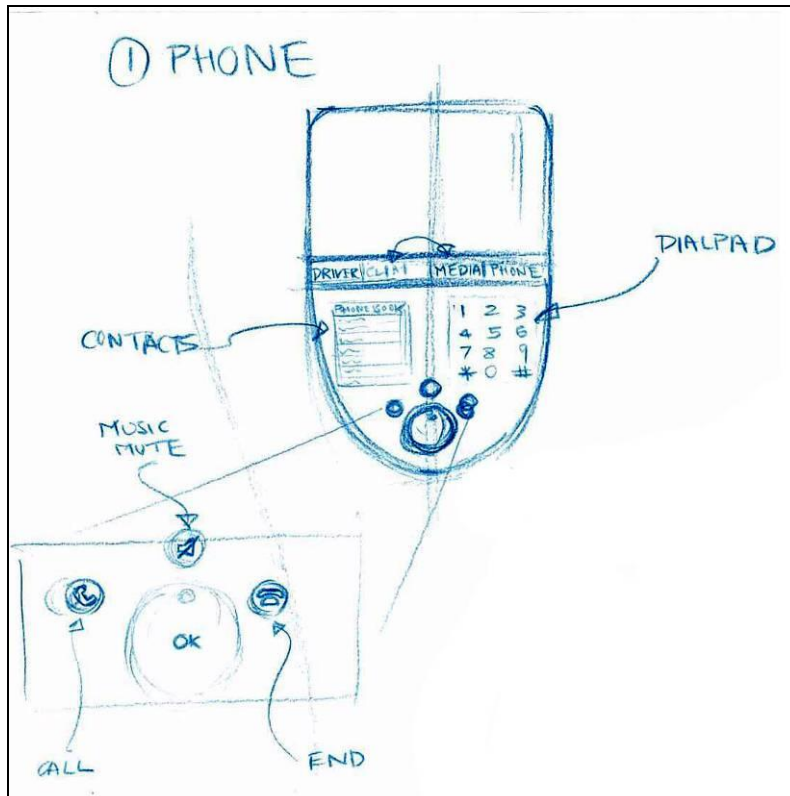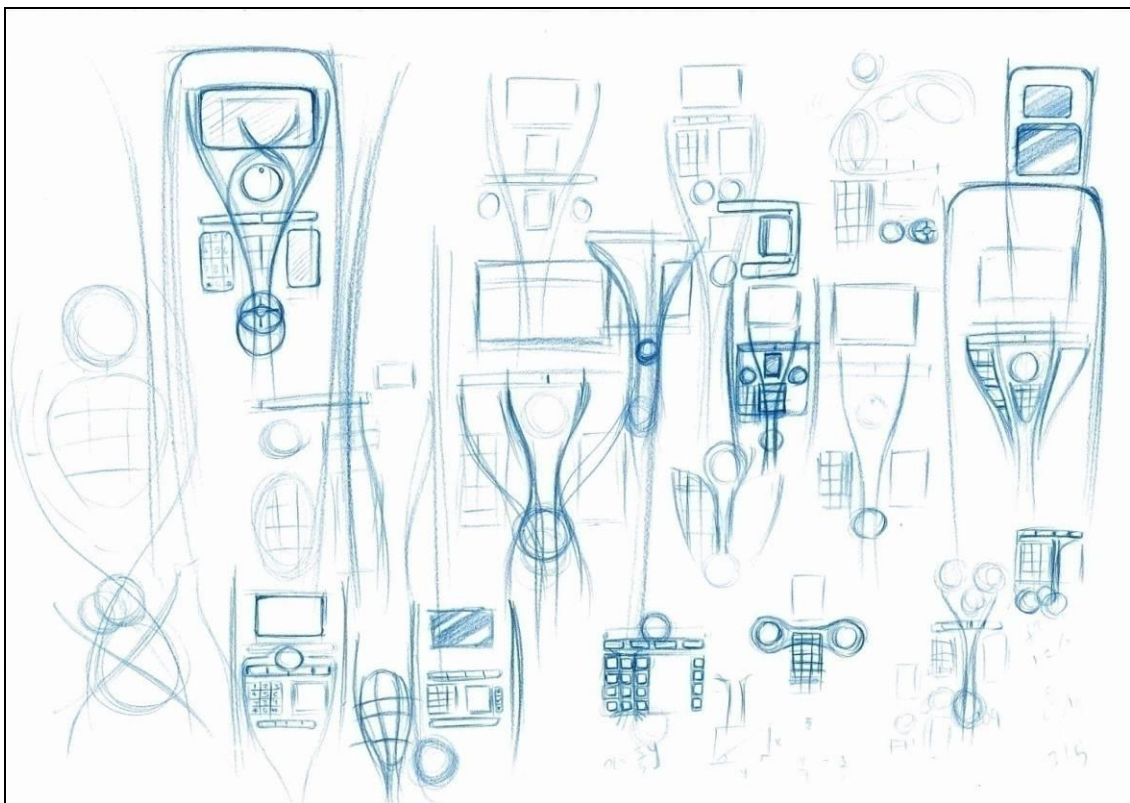

***Image 35.** Phone menu functions in the user interface*

Image 36. Media menu functions in the user interface

Once these requirements for the interface were established, several sketches were made to explore the different forms which would work well with the surround flow concept.


Image 37. A sample of shape explorations for the center console user interface

These were then tried out in the concept to see which fit best with the overall shape and form lines (see image 38).
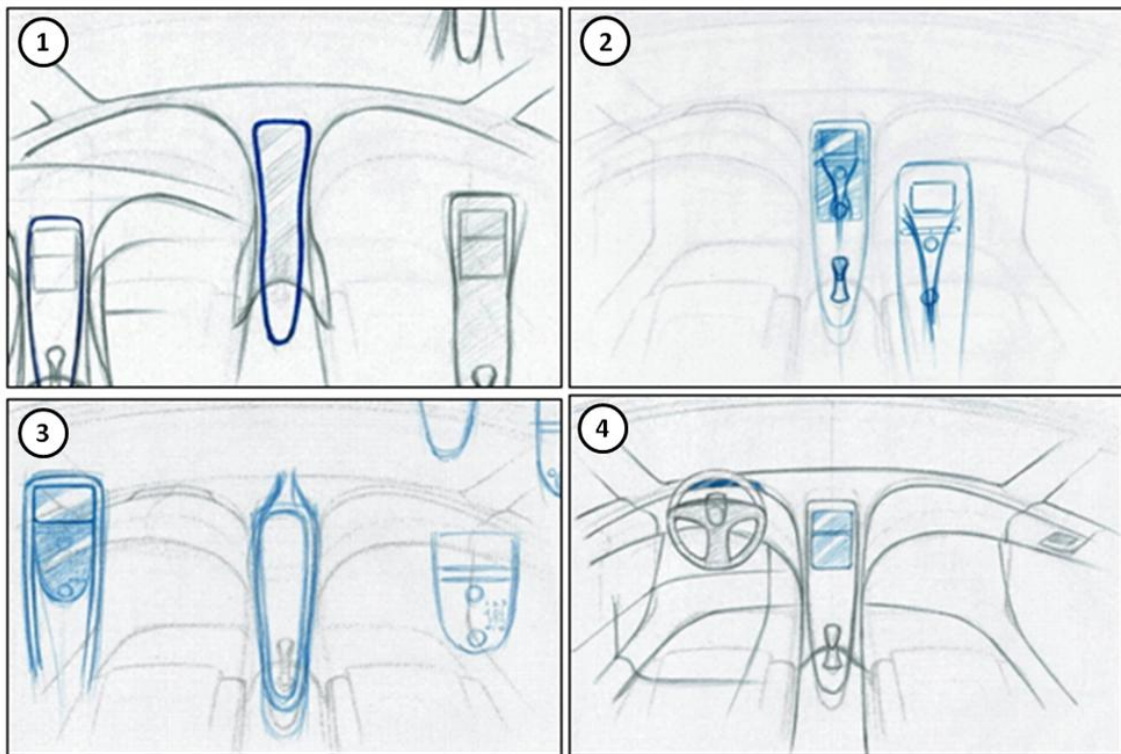
Image 38. Different center console concepts overlaid on the chosen dashboard concept

The shape in sketch 4 of image 38 was chosen and was then refined to an acceptable level. The final centre console is shown below in image 39.
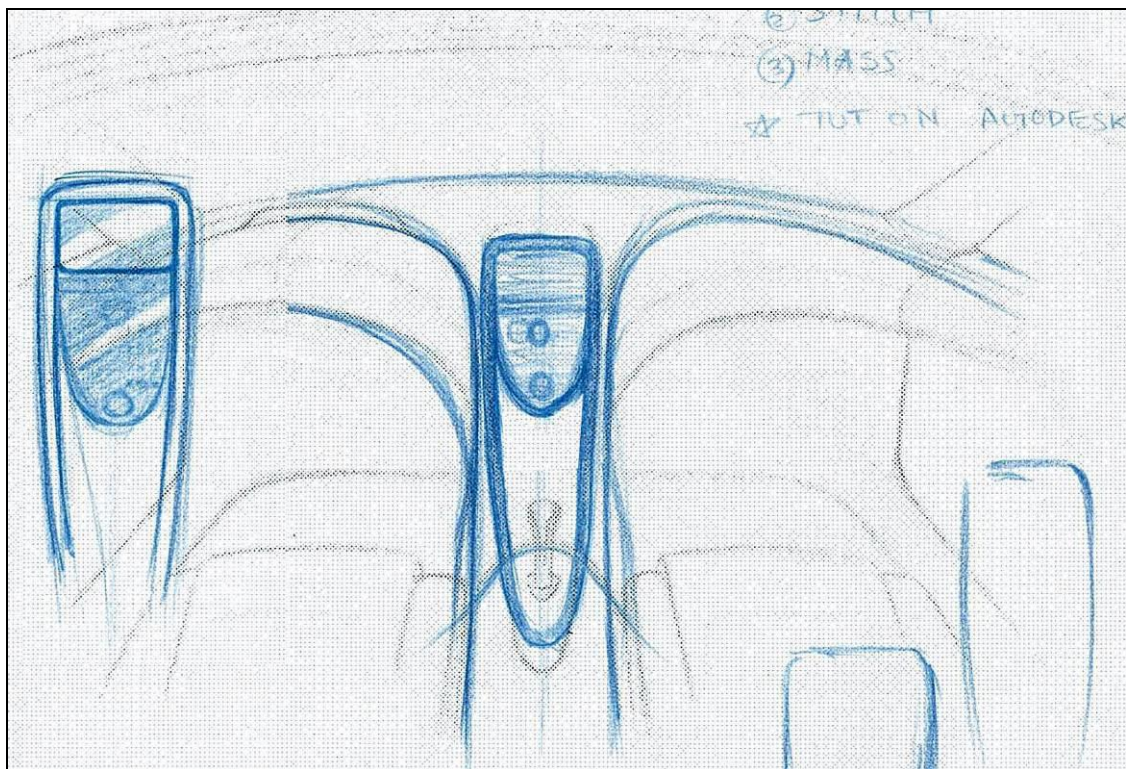
Image 39. Final form concept of the center console user interface

6.4.4 Colours and materials

The colour design is based on images #2 and #7 from the emotional scales user study which also inspire the concept B mood board. It is supported by following guidelines from the colour & emotion literature studies.

Images #2 and #7 are described as:

- **#2** mainly warm greyscale with one bright accent colour (e.g. orange), no clutter, mixed shapes, soft rug, soft white lighting.
- **#7** warm colour scheme, wood, rectangular shapes, varying contrast, soft natural lighting.

To explore the combination of neutral or warm shades with one accent colour, I tried out a number of colour plates.

A. Neutral greys: The neutral tones were combined with both warm and cool accent colours. The accent colours include lemon-yellow, light orange and bright blue. Pale blue and green shades were also tried as suggested by the literature study.

B. Cool greys: Combinations of cool greys were tried mainly with cool accent colours as well as light-orange.
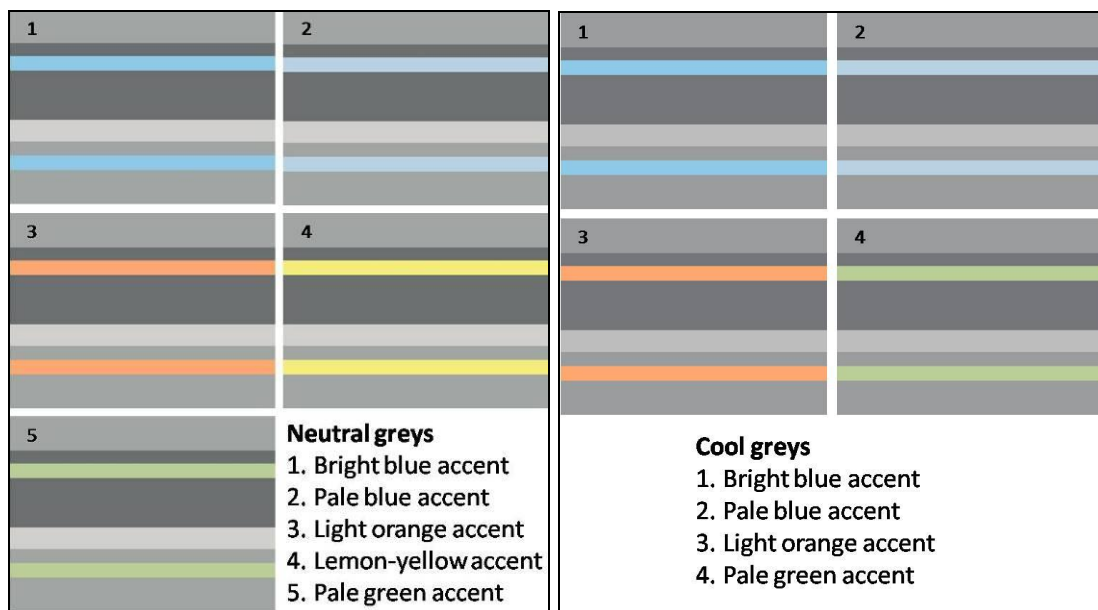
Image 40. Neutral and cool greys with various accent colours

C. Warm greys: To move closer to the colour suggestions from images #2 and #7, a warm tone of greys was tried with various shades of yellow, orange, blue and green as accents.

D. Earthy browns: To try the suggestion of earthen colours from the literature studies, shades of browns were combined with various shades of yellow, orange, blue and green as accents.
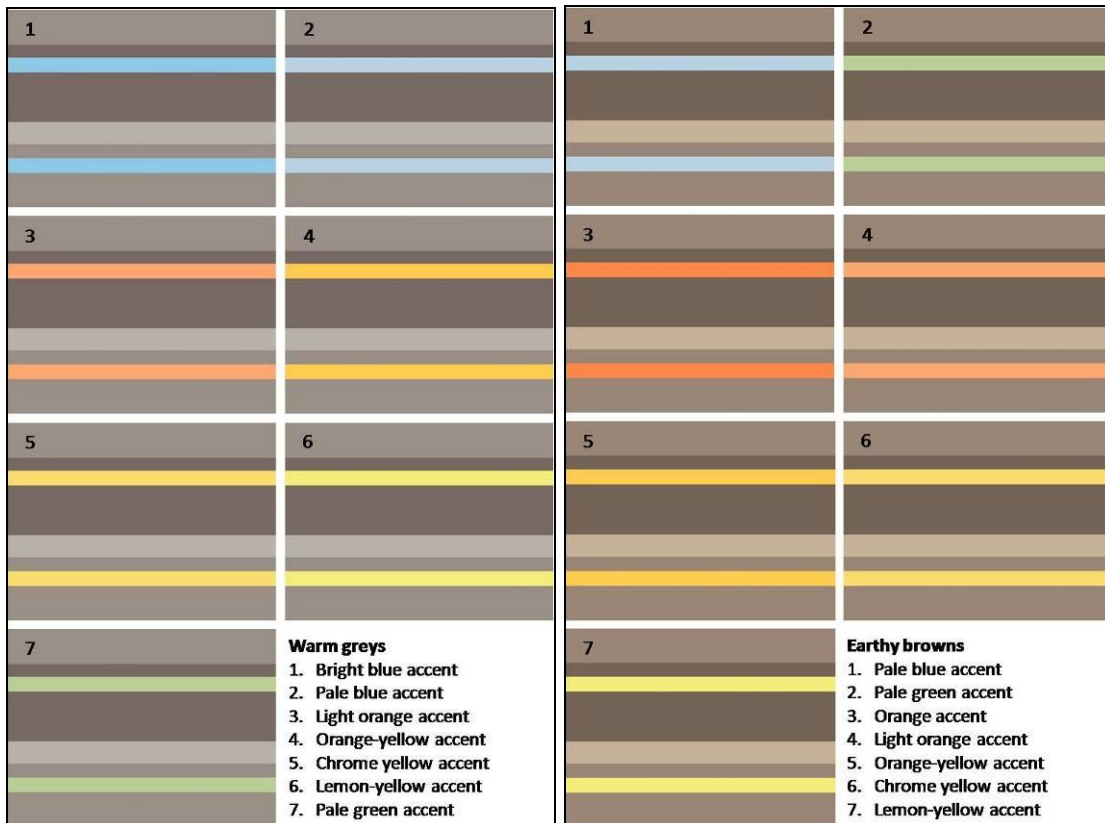
Image 41. Warm greys and earthy browns with various accent colours

Colour plate 4 from the earthy brown scheme (D) was chosen because:
- It follows a warm colour scheme as per the emotional scales user study
- It uses earthen tones as per the emotion and colour literature studies
- The colours seem to be in harmony as all the colours are warm tones
- The accent colour is not too bright and fits best with the main colours
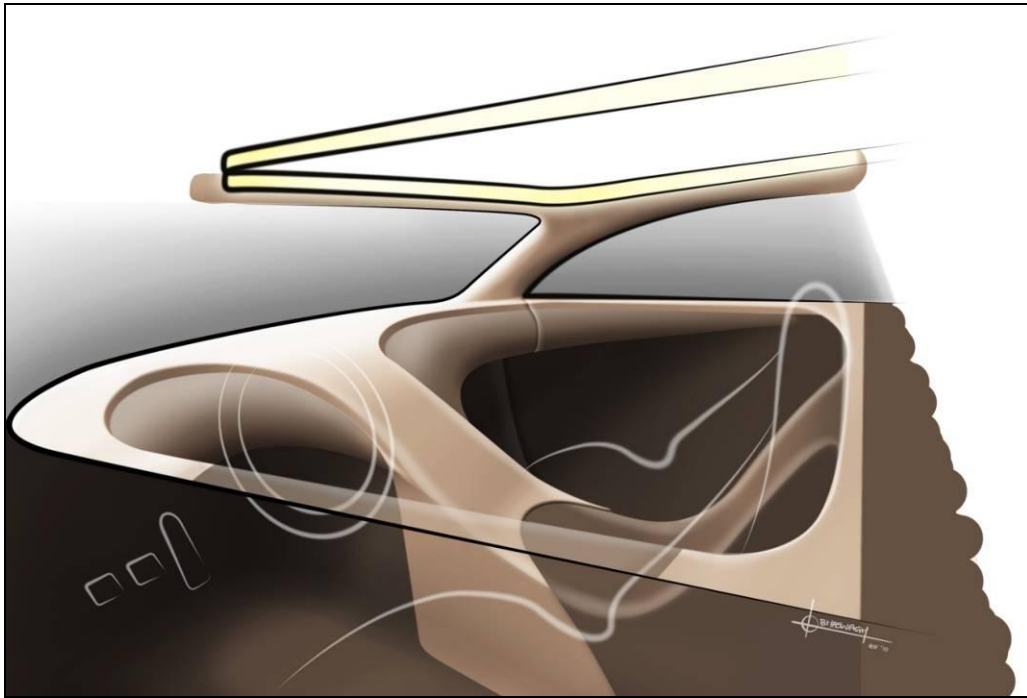

Image 42. Chosen colour scheme

While applying this scheme to the surround flow concept, it was decided to keep it simple by limiting the scheme to 3 colours (two shades of brown and the accent). These two shades of brown needed to offer good contrast.

In order to find the right shades, I compared physical paint samples from various paint manufacturers with this colour plate. The dark shade was matched perfectly by RAL 8025 "pale brown" (R=114.81, G=86.18, B=68.42). The accent colour was matched well by NCS "orange" S1050-Y50R. I found an approximate shade to match the light browns at local paint shop. I combined it with varying levels of white to find a shade that worked best with the other colours (see examples below).

The shades in picture 2 were chosen as they offered a good balance of contrast and colour harmony.

The flow concept draped in this scheme is shown in image 43. The orange accent colour will be used for the trim around the centre console and on the steering wheel.

Image 43. Surround flow concept with the chosen colour scheme

The material choices can be used to directly emphasize the smooth and soft characteristics of concept B. At the same time, the chosen materials should not feel cheap or uncomfortable in order to promote the leisure feeling.

All the visible surfaces will have a smooth texture. In order to promote safe-feeling, softness and leisure, it was decided to upholster areas close to the driver's reach in a smooth cloth. This cloth would be under-laid by foam to provide a soft touch. The light brown section was chosen as it encompasses the centre console and is accessed by the driver often. I tried a number of smooth cloths and chose a satin material with a matte visual appearance.

The dark brown surface would be finished to resemble smooth but matte plastic. It was necessary to avoid a glossy finish on all surfaces for promoting relaxation.

Image 44. Light brown smooth satin fabric with matte finish with an underlay of soft foam

6.5 Final concept

The completed final concept is shown in image 45.

Image 45. *Final concept*

The basic user interface can be visualized as in image 46 (Phone menu example).

Image 46. *Phone menu of the user interface including the colour scheme*

Phase III: Evaluation

The overall purpose of phase III was to verify whether the concept developed in phase II helps to relax the driver by carrying out a study in a mock-up.

7 Creating a physical mock-up

7.1 Overview
In order to evaluate how an environment affects its occupants, it is vital to carry out the test physically.

I built a 1:1 scale prototype of the driver area of a car cabin. This was achieved by using a wooden skeleton and fitting it with interchangeable vehicle interior components (dashboard and floor mats) to achieve two different interior environments:

- Prototype I - Standard car: This used a dashboard from a 2007 Opel Vectra, which was bought at a spare parts shop and modified to fit the skeleton.
- Prototype II - Concept: This used a full-scale mock-up of the concept created by using modelling foam and finished in the correct colours, materials and textures.

7.2 Construction
I found a wooden structure of the driver area from a previous project at the Department of Production and Production Development (PPU). This structure was built to follow the driver position of a Volvo S80 and included the original seat and appropriately placed mounting supports for gaming pedals and steering wheel. I decided to modify this and use it as a common base for both the prototypes.
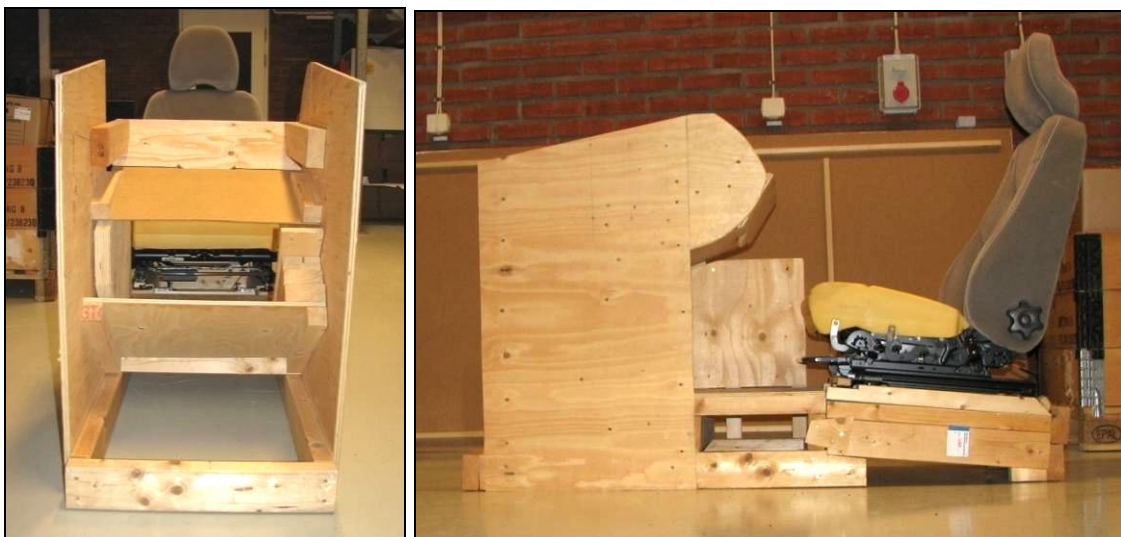
Image 47. *Original wooden structure representing a Volvo S80 driver position*

It was necessary to extend the structure towards the passenger side to create space and support for the centre consoles of the prototypes. I removed the sideboard that limited the passenger side. The steering wheel support was also removed to make room for the new dashboards.

Image 48. *The structure after removing the passenger-side limiter and steering wheel support*

The structure was extended towards the passenger-side and a beam was added for supporting the dashboard. The driver-side sideboard was extended in height to facilitate this. A base for supporting the centre console was constructed while retaining the original mounting for the pedals.
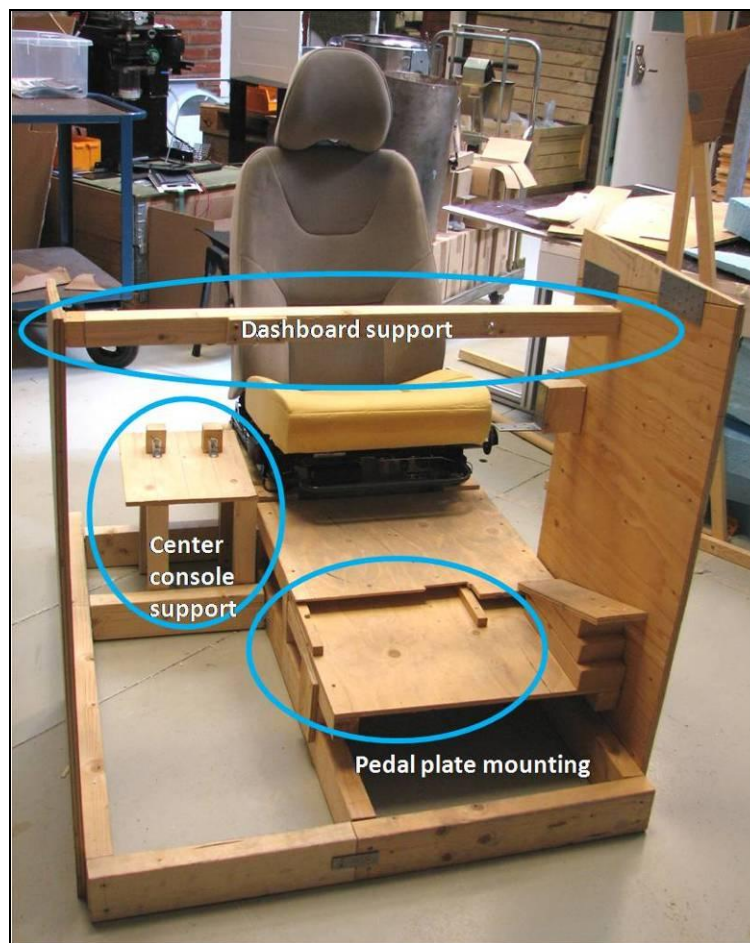
Image 49. *Modified wooden base structure*

For prototype I, I bought a used car dashboard from a 2007 Opel Vectra - the basic trim part without any inserts (instrument cluster, steering column, centre console control box, display and gear-shifter).

Image 50. Opel Vectra 2007 dashboard panel without inserts

The passenger-side of the dashboard was cut away to fit the wooden base skeleton. I created mock-ups of the missing inserts in cardboard using printed pictures from a Vectra and fit them to the dashboard. The holes left by the missing gearbox, transmission and steering column were covered with matte black lids.
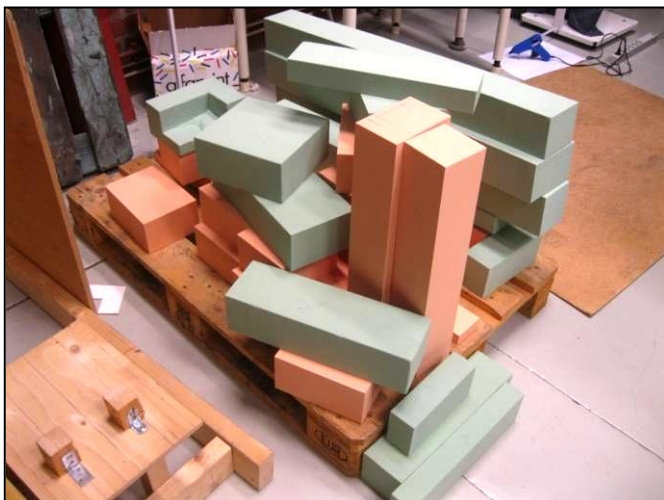

Image 51. Opel Vectra 2007 dashboard panel fitted with mock-up inserts

Certain modifications were also made on the underside to make it easy to mount and dismount on the wooden base skeleton.

Image 52. Prototype I mounted on the new skeleton

For prototype II, I needed to create the complete dashboard shape and finish it in the chosen colours and materials. Modelling foam (polyurethane) was used to create the main shape. Two densities of foam were purchased - $0.08g/cm^3$ (green) and $500g/cm^3$ (apricot). The low density foam gives a low quality surface finish but it is light and cheap. This was used for the core structure of the dashboard as well as for visible surfaces which would later be covered in foam and cloth. This was very useful to reduce the overall weight of the dashboard and facilitate easy handling later. Being cheap, it also helped to maintain a low cost. The higher density foam is heavier and more expensive but gave the desired level of surface finish.


The two slabs of foam were divided into smaller blocks with the aim of using minimum material. This meant a large number of smaller blocks which increased the effort needed to build the prototype.

These blocks were glued together to form an oversized dashboard shape. The actual shape would be scuplted out from this oversized form.

Image 53. Cut blocks of foam

Image 54. Gluing the blocks to form the base of the dashboard

I started on the center console area by marking the shape and then cutting it away with a saw. The rough cuts were smoothened using sandpaper.
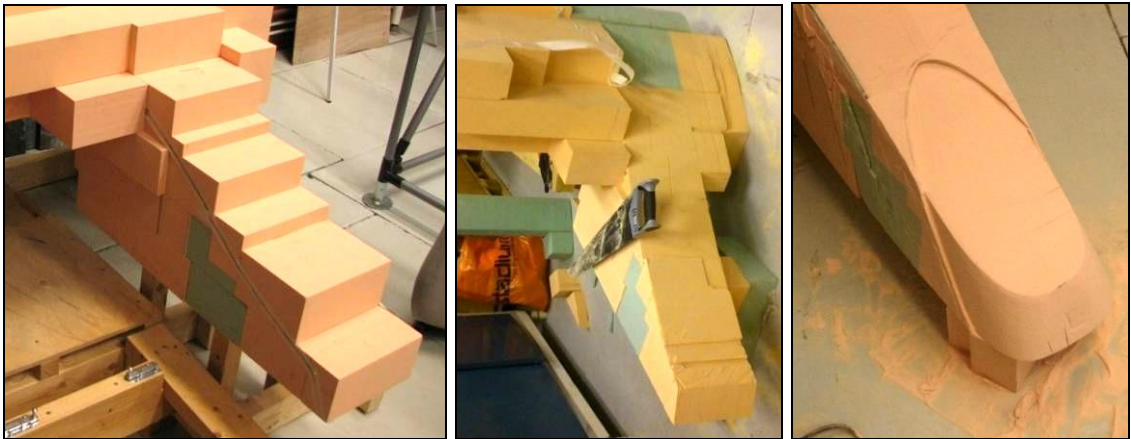
Image 55. Basic shaping of the dashboard for prototype II

The same process was followed for the gearshift area. In order to shape the double curved surface of the driver-side dashboard, I needed to use much smaller cuts. These were achieved by using a small electric saw and a japanese precision saw. The electric saw also had attachments for sanding which helped to achieve smooth curves.

Image 56. Shaping the dashboard for prototype II

After the shaping, I used spackel to fill in the holes and irregularites in the surface. This was then smoothened by sanding with a flat block of cork covered in smooth sandpaper. After this, more irregularities were identified and this process was repeated till I was satisfied with the surface finish.

Image 57. *Refining the shape and finishing the surface for prototype II*

The finished dashboard shape was masked for painting. I began with the dark brown paint (RAL 8025) so all other areas were covered carefully using newspaper and masking tape.

Image 58. *Masking before painting*

I applied 3-4 layers of the paint and each painted surface was sanded to achieve a smooth tactile finish. It was then polished with car-wax to cover up visible patches and to make the paint finish look even. The masking was removed and the painted surfaces were now masked. The centre console trim was spray-painted with the chosen orange accent colour in multiple layers.

Image 58. *Painting of the prototype II dashboard*

Once the painting was completed, foam and cloth was glued on to the remaining surfaces. Pictures representing the driver warnings and the centre console controls were pasted in the chosen areas. The centre console was covered with a thin transparent plastic sheet. The finished prototype was then mounted on the base structure (see image 59).

Image 59. Painted dashboard trimmed with the chosen materials

The base structure also needed some finishing before the prototypes could be used for evaluation. The areas of the structure visible from the driver seat were painted black. The driver floor areas would be covered with black and dark-brown carpets for prototypes I and II respectively. The pedal plate was mounted. Surfaces of the base structure visible from outside were covered with white hardboards. A handle was also mounted as a handhold to support the participants while adjusting their seating position. The seat base cushion was re-upholstered and the plastic trims were installed. The finished prototype environments are shown in images 60 and 61 below.

Image 60. Finished prototype I environment

Image 61. Finished prototype II environment

7.3 Practical issues

The most important issue I came across while building prototype II was the realization that I did not have all the skills needed to build it. The build needs a wide range

including carpentry, sawing, hot-gluing, shape-cutting, puttying (spackeling), rough and smooth sanding, spray and brush painting, wax polishing, foam and fabric finishing and seat re-upholstering. It also needed able handling of specific tools like drills, precision saws, electric sanding machine. However, I developed the skill-set over the course of the build with very useful practical tips from Hans and Ralf.

Another issue was cost. The modelling foam was not cheap so we bought just enough to fit in our budget. This meant that I needed to maximize its use and minimize the waste. As a result, I cut smaller and more number of blocks from the foam slabs than preferred to achieve the desired shape. This increased the effort in cutting as well as gluing and lengthened the build time.

During the build, I suffered a number of small to big breakages, some of which were quite discouraging. One such breakage is shown in image 62. This was fixed by gluing the parts together, adding supporting metal plates in non-visible areas and then filling in the visible cracks with putty.

Image 62. Breakage during construction and after fixing

8 Evaluation study

8.1 Aim

The aim of the evaluation study was to determine how the interior environment was perceived by drivers (perception) and how it made them feel (effect/experience).

8.2 Method

8.2.1 Participants

Each environment was evaluated by drivers chosen from the list of the DBQ respondents in section 4.3.3.

The evaluation study was carried out with 17 participants from the list of 30 drivers who answered the online DBQ survey. They included five of the eight most aggressive drivers and 12 drivers from the least 16. The population included drivers with ages ranging from 18 years to more than 61 years. It included drivers from Sweden, Holland, Portugal, Poland, Finland, Italy and UK. 53% were male and 47% were female.

To encourage participants to join, each one was offered some 'fika', tea/coffee and two TRISS Lotto coupons.

8.2.2 Materials

Various supporting tools were used for the evaluation including pictures, animation and video aids and specially developed rating scales.

To support the perception evaluation, two A3 images of each concept were printed: one showing the driver's point of view and the second depicting the complete environment.


***Image 63.*** *A3 boards of the standard car environment*
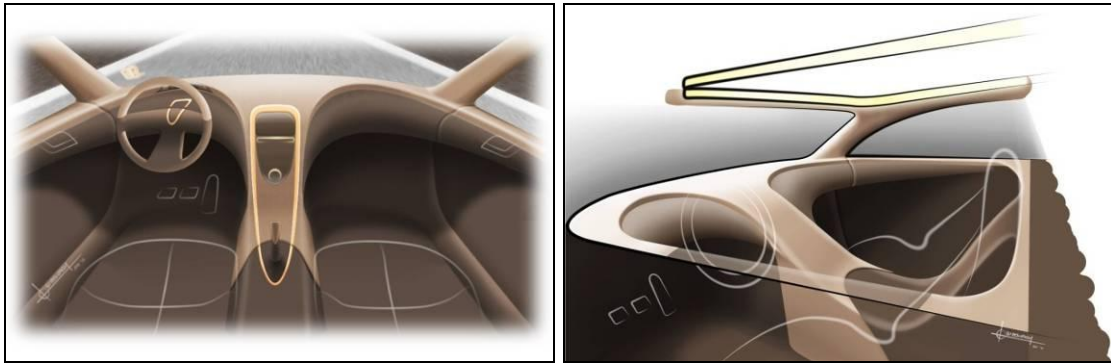
Image 64. A3 boards of the concept environment

These images were then followed by a 2 minute animation of each environment which first zooms in on the environment from afar, shows the occupant area and then acts out the point of view of a driver approaching the vehicle, sitting in it and turning it on. These were created in Alias AutoStudio. A short storyline depicting the concept animation is shown belowin image 65.
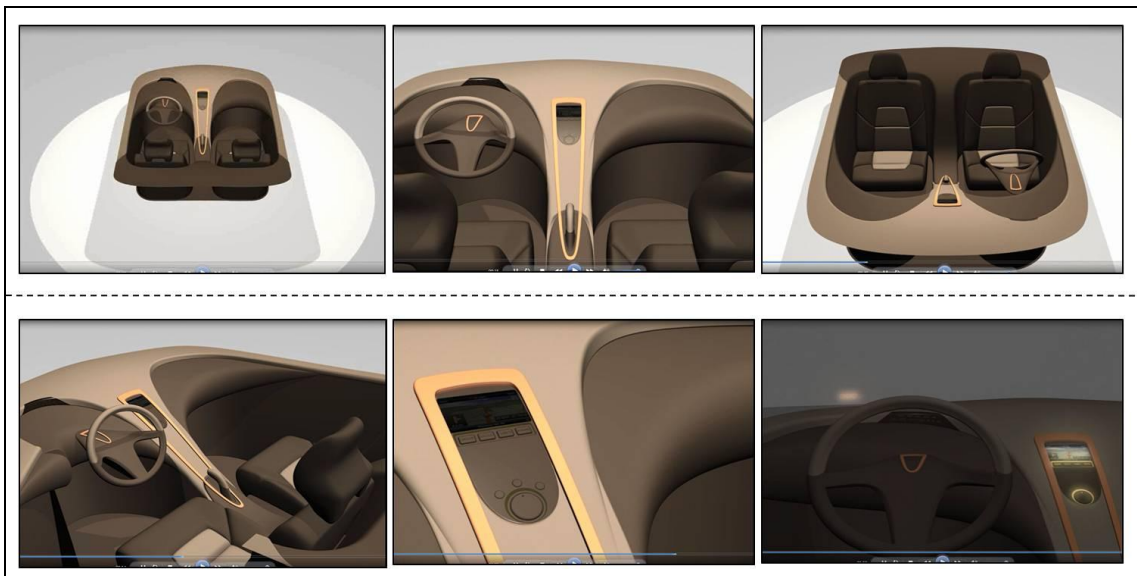

Image 65. A sequence of stills form the concept environment animation film

To support the driving scenario enactment, a 2 minute video of highway driving was shown on a big screen in front of the driver when seated in the prototypes. A part of a video filmed while driving from Göteborg to Jönköping using a dashboard-mounted GoPro camera was used for this. A screenshot is shown in image 66.
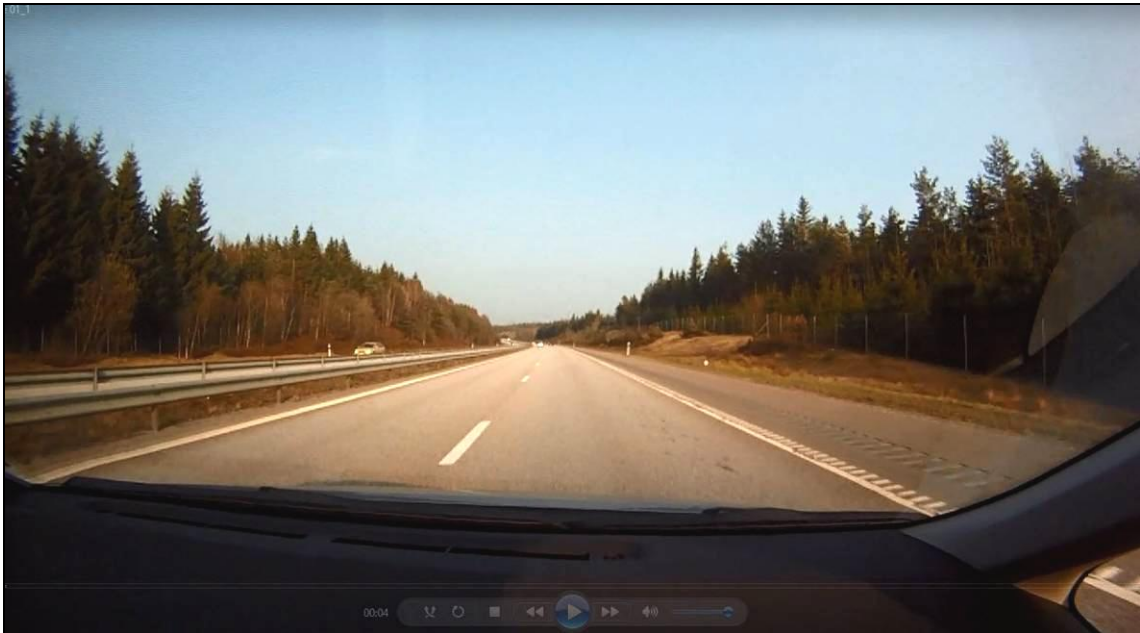
Image 66. Still from the driving video played during the effect evaluation

Arrangements were also made to facilitate other activities involved, like sitting, talking, filling questionnaires, looking at images and animations, having coffee etc. The complete evaluation area looked like this (see image 67).
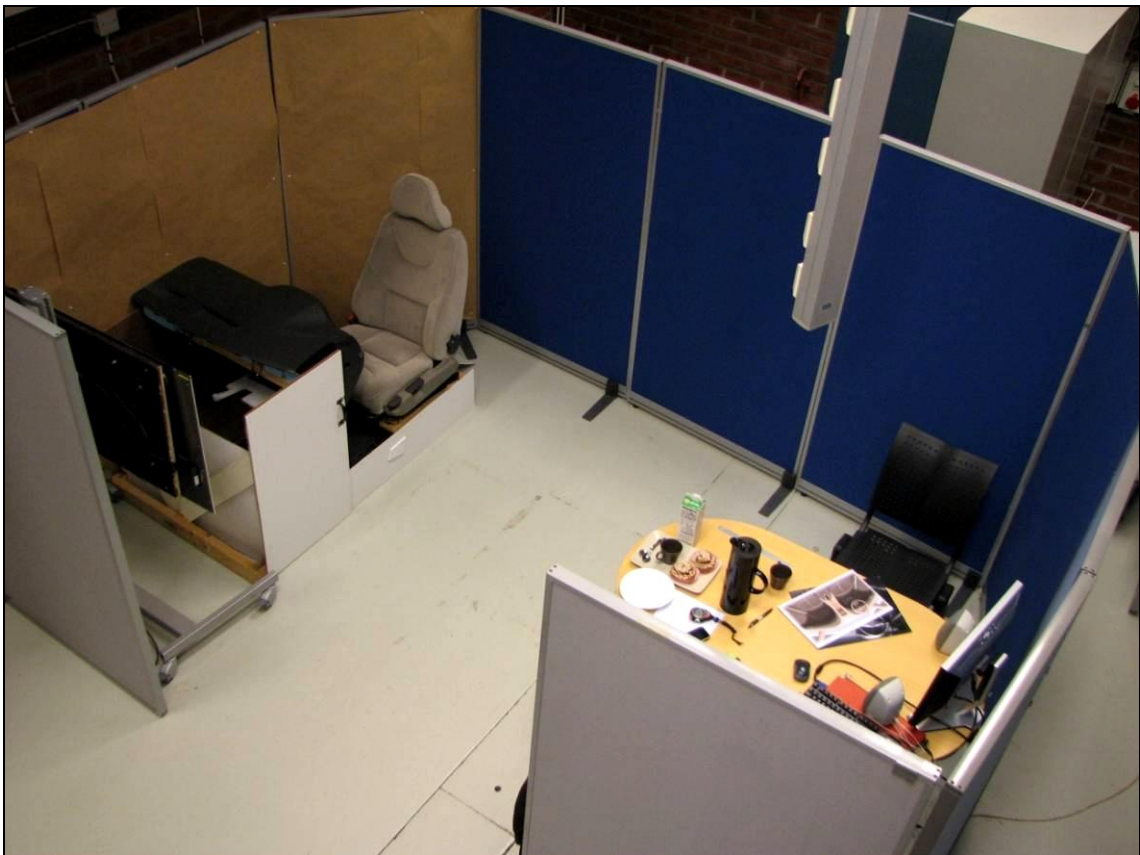
Image 67. Evaluation area with the standard car environment installed

8.2.3 Procedure
The evaluation process was designed to evaluate two aspects of each vehicle interior:
1. how the user perceived the environment (perception) and;

2. how using the environment affected the user (effect/experience).

The perception stage of the process evaluated the impression that the user formed about the environment before he/she experienced it. The user was slowly introduced to the environment by first showing him/her pictures of it, followed by a two minutes animation video depicting how the complete interior would look like. After this overview, he/she was shown the physical prototype but was not allowed to touch it. The user was now asked to rate the environment based on what he/she had seen so far.

A semantic scale including eight items was used to rate the user perception (see image 68 below). These scales were based on the basic and extreme properties that defined concept B. The aim was to check if the concept managed to depict the characteristics which it was designed to portray. Another purpose was to evaluate if the user perceived these properties more in the concept environment as compared to the standard environment.

After the perception stage, the user was asked to sit in the prototype and experience the environment. First, he/she was given time to get accustomed to it by observing it, touching and feeling it. Once the user was satisfied with this, he/she was asked to imagine a pre-defined scenario where he/she was driving in this vehicle environment for 1.5 minutes. This enactment was supported by video aid, pedal operation and instructions to perform a specific driving task.

After this, the user was asked to rate his/her experience of the environment by answering the question "How does this environment make you feel?" using the same effect rating scales from the emotional scales user study (see section 4.3.2). This again served two purposes: to see if the concept made the user feel relaxed and positive but not bored or sad, and which of the two environments did this better.

Please rate the driving environment on the following scale:

Tick the appropriate box.

	3	2	1	0	1	2	3	
Simple	□	□	□	□	□	□	□	Complicated
Beautiful	□	□	□	□	□	□	□	Ugly/Clumsy
Personal	□	□	□	□	□	□	□	Impersonal
Quiet	□	□	□	□	□	□	□	Flashy
Safe	□	□	□	□	□	□	□	Unsafe
Relaxing	□	□	□	□	□	□	□	Stressful
Soft	□	□	□	□	□	□	□	Hard
Smooth	□	□	□	□	□	□	□	Rough

Image 68. Perception rating scales based on basic and extreme properties of concept B

The participant's heart-rate (pulse) was measured twice during this process, once before they are introduced to the environment and once just after they have experienced it. This is done to see if a measurable amount of physical relaxation could be observed after using each environment and to support the subjective assessments.

The steps described above were then repeated for the second environment.

The sequence of evaluating the two environments was reversed for half the participants to neutralize the effect of judging the second environment by using the first-seen environment as reference.

In order to ensure that the evaluation test was conducted in the same way for all participants, an evaluation protocol was put together. A list of materials needed for each test was also created and used as a preparation checklist to ensure that everything was available to perform each test. The evaluation test protocol and checklist are found in appendix C1 and C2 respectively.

In addition, a pilot test was conducted to find the shortcomings of the process and to refine it.

8.3 Results
A sample of the ratings (participant 1) received for the concept environment is attached in appendix D.

8.3.1 Perception
The perception ratings received for both environments are shown below in images 69 and 70. Each dot represents one participant's rating. 0 is neutral. The positive side of the scales - where one wants the ratings to be - is to the left of the zero and to its right is the negative side.
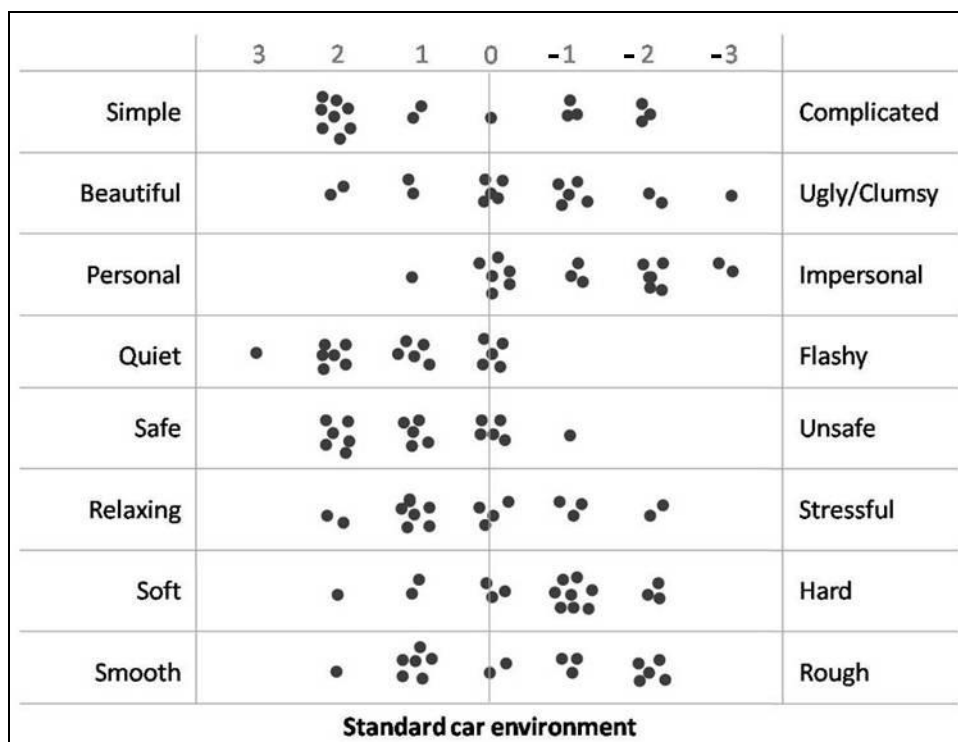
Image 69. *Summary of perception ratings for the standard car environment*
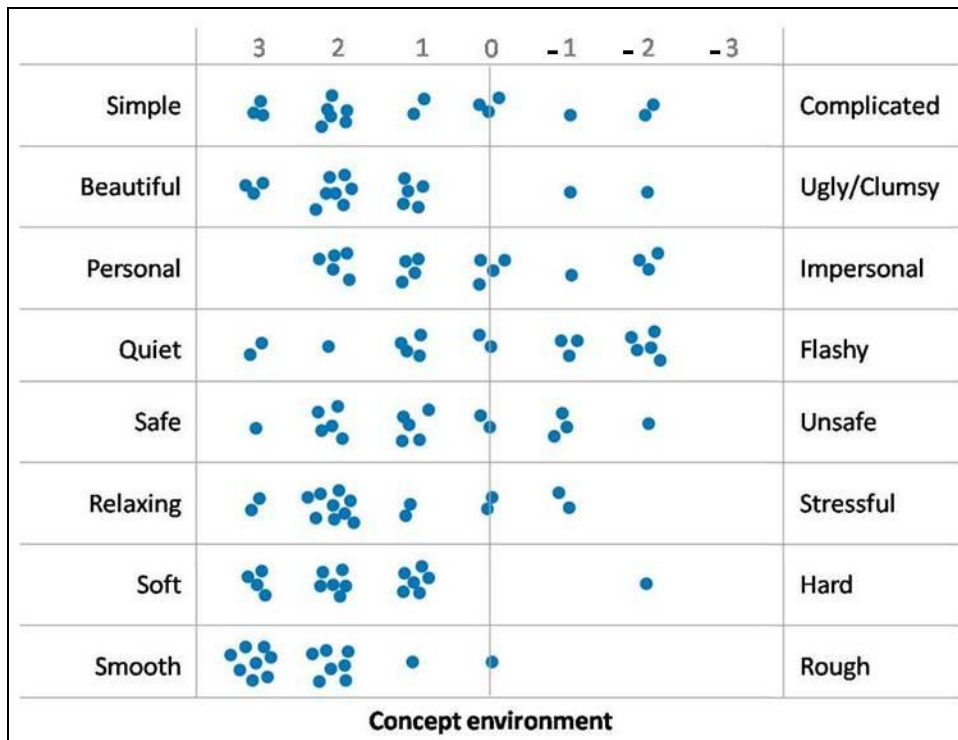
Image 70. *Summary of perception ratings for the concept environment*

At first glance, it can be seen that the ratings for the concept environment are more concentrated on the positive side whereas those for the standard environment are evenly spread out across the scales. Two exceptions to this is that the standard car environment was perceived by almost all participants as very quiet and safe.

Another observation is that the participants felt quite strongly about the concept environment as it received very few neutral ratings (14 out of a possible 136) as compared to the standard car environment (31). This is also supported by the fact that the concept received 23 high ratings (a positive or a negative 3) as compared to 4 for the standard car.

Statistics from the perception evaluation are summarized in table 12 below, which should help in making more specific conclusions on each of the 8 scales.

Table 12. *Summary of statistics of the perception ratings for both environments*

Scales	Standard car environment			Concept environment		
	Mean	**Median**	**Std Dev**	**Mean**	**Median**	**Std Dev**
Simple-Complicated	0.5	1.0	1.7	1.1	2.0	1.6
Beautiful-Ugly/Clumsy	-0.4	0.0	1.4	1.5	2.0	1.3
Personal-Impersonal	-1.1	-1.0	1.2	0.4	1.0	1.5
Quiet-Flashy	1.2	1.0	1.0	-0.1	0.0	1.7
Safe-Unsafe	0.9	1.0	1.0	0.8	1.0	1.4
Relaxing-Stressful	0.2	0.0	1.2	1.4	2.0	1.2
Soft-Hard	-0.6	-1.0	1.1	1.6	2.0	1.2
Smooth-Rough	-0.3	0.0	1.4	2.2	2.0	1.1

The mean values do not give a very reliable picture because the standard deviation is quite high (≥1) for each of them. However, the median value can be used as a good measure of the typical rating[27] each concept received on each of the eight scales.

1. Simple Vs complicated: The median values for the standard and the concept environments were 1 and 2 respectively. Thus, the concept was perceived as slightly more simple by the participants.

2. Beautiful Vs ugly/clumsy: The median values for the standard and the concept environments were 0 and 2 respectively. Thus, the concept was perceived as significantly more beautiful by the participants.

3. Personal Vs impersonal: The median values for the standard and the concept environments were -1 and 1 respectively. Thus, the concept was perceived as significantly more personal by the participants.

4. Quiet Vs flashy: The median values for the standard and the concept environments were 1 and 0 respectively. Thus, the standard car was perceived as more quiet by the participants.

5. Safe Vs unsafe: The median value for both the standard and concept environments was 1. Thus, the two environments were perceived as equally safe by the participants.

6. Relaxing Vs stressful: The median values for the standard and the concept environments were 0 and 2 respectively. Thus, the concept was perceived as significantly more relaxing by the participants.

7. Soft Vs hard: The median values for the standard and the concept environments were -1 and 2 respectively. Thus, the concept was perceived as significantly more soft by the participants.

8. Smooth Vs rough: The median values for the standard and the concept environments were -1 and 2 respectively. Thus, the concept was perceived as significantly more smooth by the participants.

In summary, based on their first impression, participants strongly perceived the standard car environment as quiet and safe, in that order. It was also perceived as simple and somewhat relaxing. On the other hand, it was strongly perceived as hard and impersonal. It was also perceived as ugly/clumsy and somewhat rough.

Based on their first impression, almost all participants perceived the concept environment as smooth and soft. It was strongly perceived as beautiful, relaxing and simple in that order. It was also perceived as safe and somewhat personal. On the other hand, it was perceived as slightly more flashy than quiet.

In comparison to the standard car environment, the concept was perceived as significantly more beautiful, personal, relaxing, soft and smooth. It was also perceived as slightly more simple. At the same time, the standard car was considered more quiet. Both the environments were perceived as equally safe.

8.3.2 Effect/experience
After experiencing the environment in a simulated driving scenario, the participants were asked to answer the question "How does this environment make you feel?". As described in section 4.3.3, the environment should reliably make participants feel calm, but at the same time not make them feel negative, bored or sad. Ideally, this can be represented by the grey areas marked on the two scale-groups in image 71.
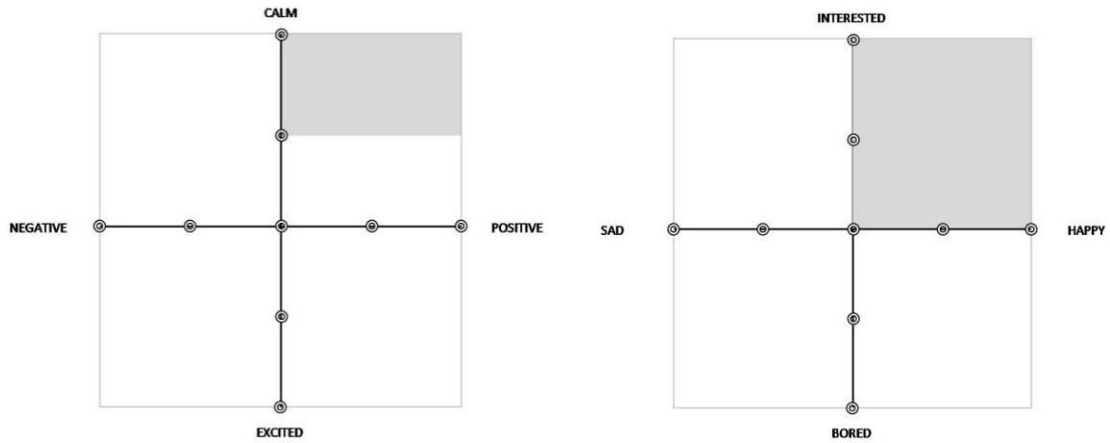
Image 71. *Desired ratings marked in grey on the two scale-groups*

The results of the effect ratings for the standard car environment are shown below in images 72 and 73. Each dot represents one participant's rating.
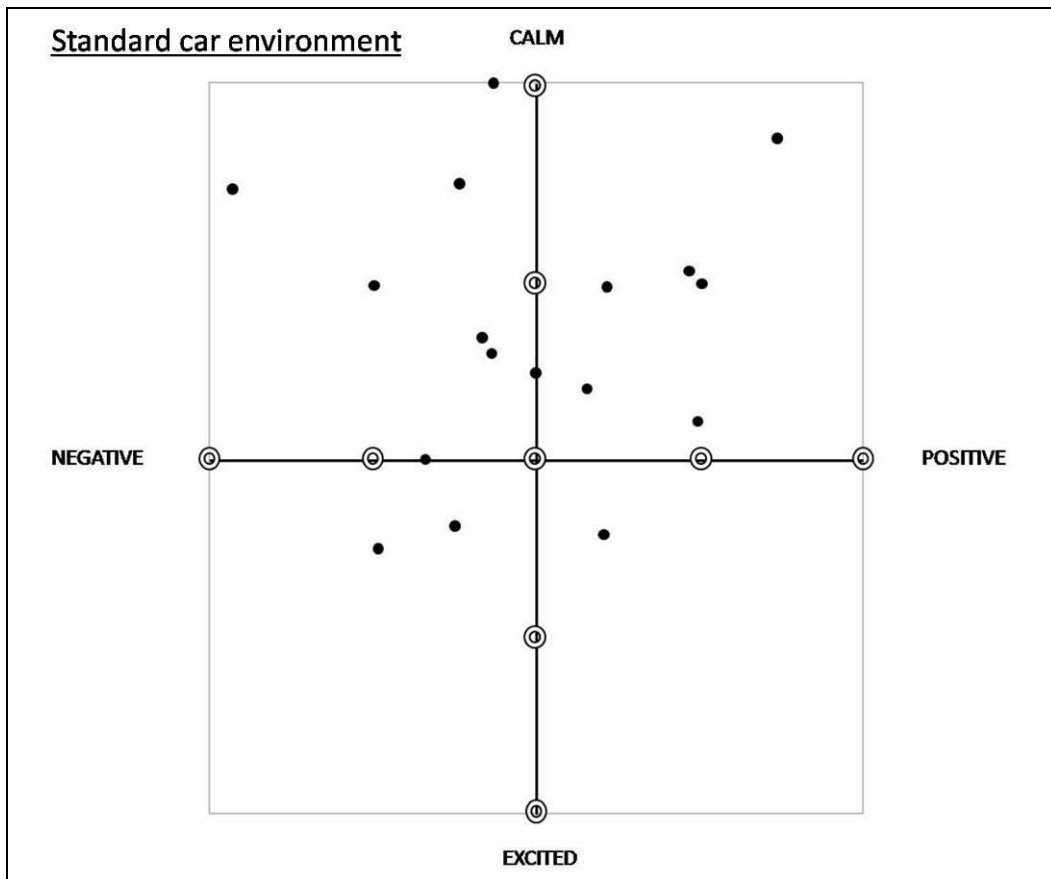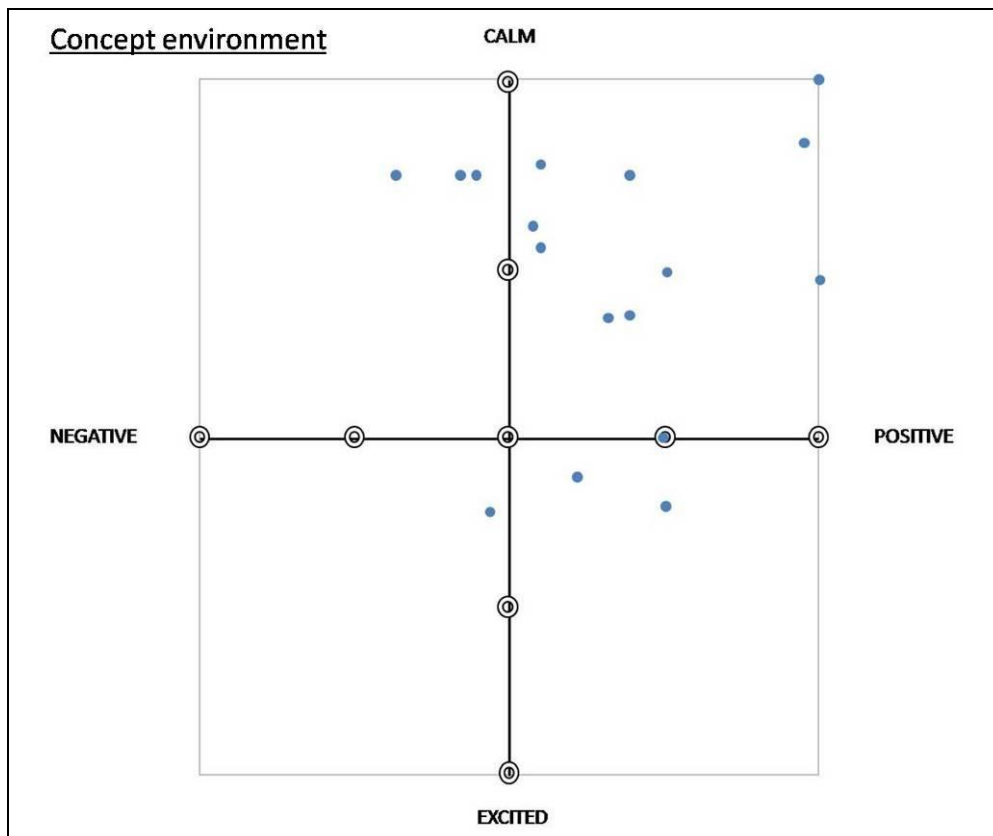

Image 72. *Effect ratings calm-excited and positive-negative for the standard car environment*

The standard car made most of the participants feel calm but not very strongly (image 72). The opinions were evenly divided on whether they felt positive or negative. It also made most participants feel bored, but neither happy nor sad (image 73).
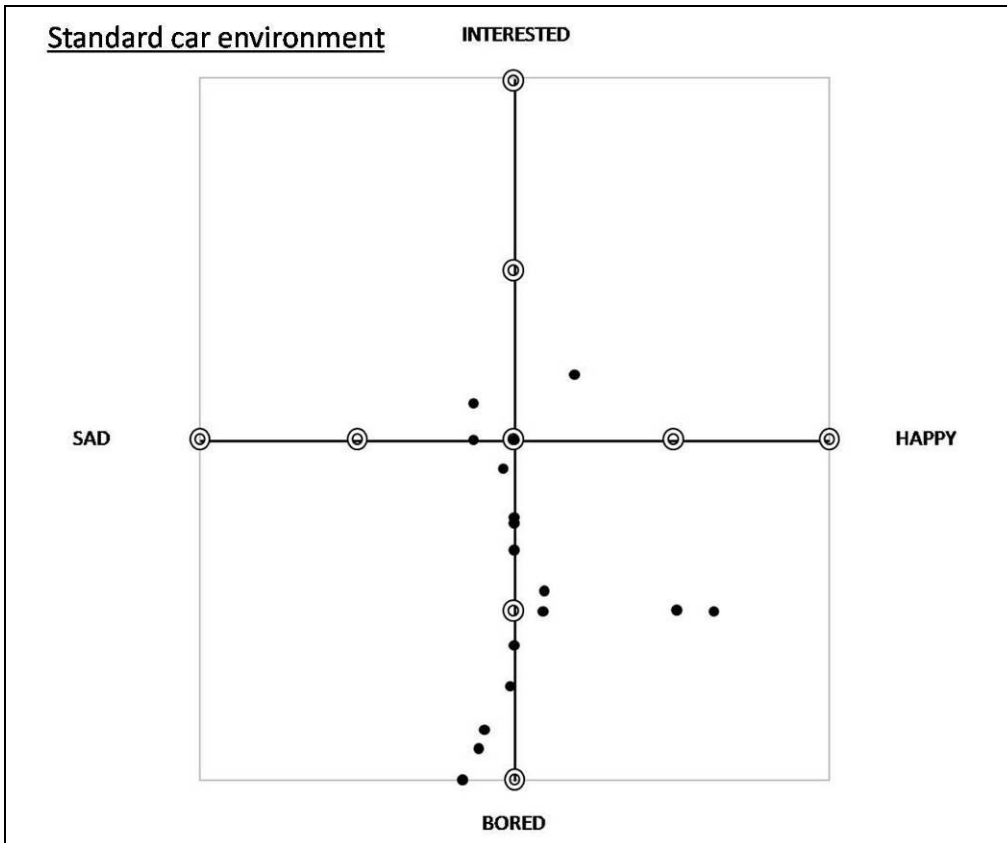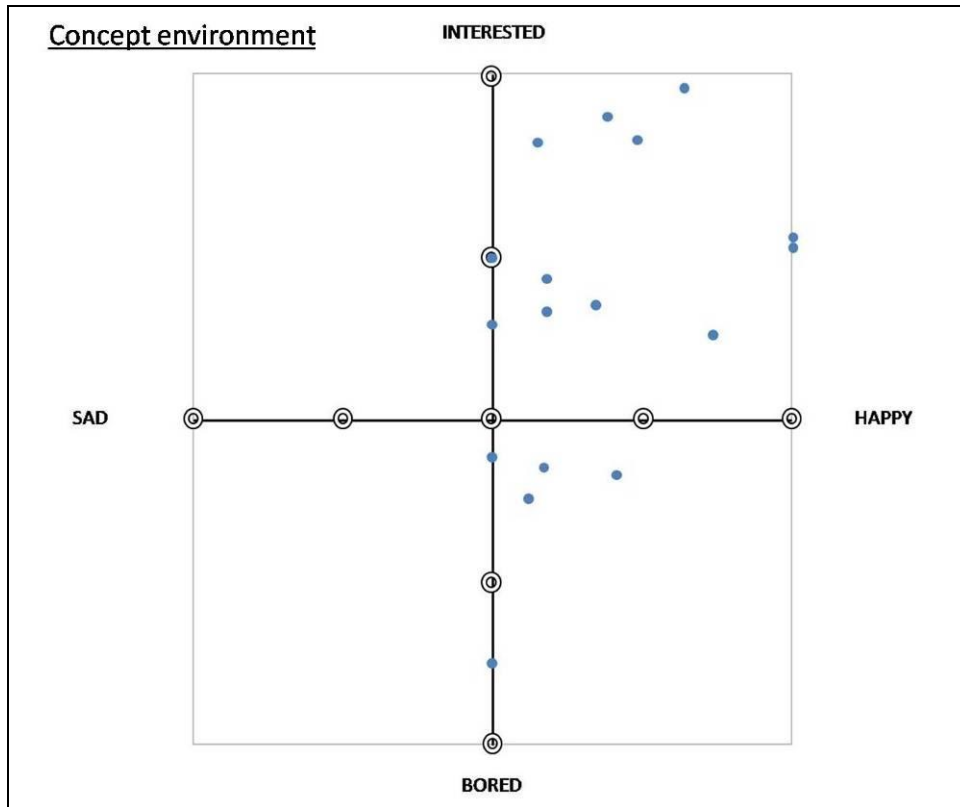
Image 73. *Effect ratings interested-bored and sad-happy for the standard car environment*

Images 74 and 75 show the results of the effect ratings for the concept environment.

Image 74. *Effect ratings calm-excited and positive-negative for the concept environment*

Image 75. *Effect ratings interested-bored and sad-happy for the concept environment*

The concept environment received close to ideal ratings. It made most participants strongly feel calm and also positive (image 74). There were exceptions as a few participants felt slightly negative as well as slightly excited. The environment also made most of the participants feel happy and interested (image 75).

As compared to the standard car environment, the concept was significantly better at making the drivers feel calm, and at the same time positive, interested and happy.

The heart-rate measurements from the participants are shown below in table 13.

Table 13. *Heart-rate measurements for all participants in beats per minute (bpm)*

	Participants																	Mean value
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Ref. pulse (bpm)	72	58	47	80	60	64	67	49	67	69	66	57	88	83	61	76	61	66.2
Standard car (bpm)	66	64	57	77	61	63	64	60	69	60	61	61	65	86	62	73	62	65.4
Concept (bpm)	68	60	55	71	63	71	71	52	72	61	61	61	86	78	68	70	62	66.5
Sequence number (standard car)	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	

The values do not seem to follow a specific pattern related to any environment. They also show different behaviours over time for different participants. Overall, the pulse measurements were inconclusive as I think they were highly affected by physical movements like standing up, walking, sitting etc. as well as mental states like nervousness, calm, thinking etc.

8.4 Conclusions

The main findings from the evaluation study are listed below. I also discuss my understanding as to why the concept received the ratings which it did.

1. The concept environment conveyed almost all its design intentions reasonably well. The exception to this was that the drivers perceived the environment as flashy and not quiet.

Based on the participants' open interviews at the end of each evaluation test, I think that this perception of being flashy was mainly due to the brighter colours and an unfamiliar visual appearance of "something new". Colour and material design is very personal and needs to be handled with care.

2. In comparison to the standard car environment, the concept was perceived as significantly more beautiful, personal, relaxing, soft and smooth. It was also perceived as slightly more simple. At the same time, the standard car was considered more quiet and slightly more safe.

The participants perceived the standard car as safer because they were used to its familiar appearance and felt assured that they knew how the controls worked and how to use them. This shows that drivers might not feel relaxed in an unfamiliar environment. Care needs to be taken that the resultant affective design is not very different from the industry standard.

3. Their experience in the concept environment made most participants strongly feel calm and also positive. The environment also made most of the participants feel happy and interested. There were exceptions as a few participants felt slightly negative as well as slightly excited.

This result is almost ideal. I would like to perform the same evaluation tests with more drivers to confirm whether the exceptions still remain few.

4. As compared to the standard car environment, the concept was significantly better at making the drivers feel calm, but at the same time positive, interested and happy.

The difference seen in the experience of the two environments was very significant. I am very confident about the reliability of this particular result. I can conclude that this concept design has succeeded, to a good extent, in making this target group of drivers feel relaxed.

Phase IV: Reflection

In phase IV, I think about the results of my thesis and discuss what I learned while performing this project. Based on this, I recommend how they can be applied in vehicle interior design.

9 Discussion

I noticed that there was a detectable difference in the quality of finishing between the standard car mock-up and the concept mock-up. I think that the evaluation participants could understand that one of the mock-ups was taken from a real car whereas the other was made by me. This could have biased the responses they gave on the perception and effect scales for the concept car (even if they were not aware of the purpose of my study).

In order to make the test less unbiased, I recommend that both the mock-ups have a similar level of fit and finish quality. This could make the final results more comparable to each other.

The chosen concept was developed based on the properties that defined concept B (safe-feeling, leisure, smooth and soft) while at the same time following the five basic properties that were identified as most likely to make the user feel relaxed (simple/no clutter, personal feeling, rounded shape/curves, beautiful/balanced/colour harmony, quiet/unobtrusive) in the property extraction study.

In comparison to the standard car environment, the concept was perceived as significantly more beautiful, personal, relaxing, soft and smooth. It was also perceived as slightly more simple. Both the environments were perceived as equally safe. However, the standard car was considered more quiet.

The fact that the participants of the evaluation study perceived many of these properties more strongly in the concept leads me to conclude that the concept development process worked quite well. I was able to convey the chosen properties through the final concept.

The colour scheme of the concept was chosen based on not only the result of the emotional scales user study, but also some of the colour themes which I came across in my literature studies and the benchmarking of spas. The concept followed a warm colour scheme with shades of an earthen colour and a warm accent colour. The accent colour was not so bright so as to elicit excitation. The concept used few colours (three). It followed an analogous colour scheme.

Based on the positive results of both the perception and the effect/experience evaluation studies, I agree with some of the colour theories from my literature studies.

Considering the evaluation results as well as my observations of spa environments, I think that an analogous colour scheme feels more relaxing than a complementary colour scheme.

In my opinion, it is very important not to use too many colours while designing a relaxing environment. However, an accent colour is important to keep the environment from being dull and boring.

I do not completely agree that a warm colour scheme cannot be used for relaxation, as it succeeded quite well in my concepts. It is, however, very important that the scheme follows colour harmony.

A warm colour scheme and earthen colours seem to work well for European drivers but at the same time, the combination of shapes and colours is very important. For example, applying relaxing colours on sharp and jagged shapes might not be perceived as relaxing even if the colour scheme is well thought out.

The concept had smooth surfaces a and a part of it was finished in smooth satin cloth which was soft to touch. These materials and finish were chosen to satisfy the "soft" and "smooth" properties of concept B. It was not difficult to select these materials as the properties clearly defined the tactile feeling that the user wanted to have for a relaxed feeling.

However, if the properties don't clearly define the wanted tactile feeling like in concept A (natural, responsive, interesting), it can be quite difficult to chose the materials and surface finish.

One needs to be careful and consider take different factors while choosing the materials for a vehicle environment. The same material can elicit different emotions through visual and tactile feedback. For example, a metal trim might signify premium quality to a certain user and make him/her feel relaxed on seeing it (rich-luxury spa design theme) but metal is cold to touch which might not make the same person feel relaxed.

Another important factor that could be used to enhance the feeling of relaxation in an environment is the lighting. I suggest soft ambient lighting (instead of spotlights) and utilizing natural light from outside. This suggestion is based on my benchmarking of the local spas and my personal experience of these lighting concepts there. Lighting concepts were not evaluated in this project.

Most importantly, the combination of the shapes, colours, materials and lighting needs to work well together to create a relaxing vehicle interior environment.

9 Recommendations

Based on the results from the evaluation phase, I can say that it is definitely possible to design a vehicle interior to relax the driver subconsciously to a certain extent. This design needs to be based on a solid analysis supported by user studies.

However, in actual vehicle interior design, a lot of factors need to be taken into account which this study did not cover. Considering these factors, I can make the following recommendations:

1. It is a must to verify the affective design in a physical evaluation test with a full-scale mock-up.
2. The evaluation study defined here works well. However, as it is dependent on subjective ratings alone, it needs to be performed with a much larger group of drivers (close to 40) to receive very reliable results.
3. If possible, the complete vehicle interior environment needs to be simulated for the evaluation to further improve the reliability of the results and to include factors such as lighting design.
4. The appropriate reference car environment needs to be selected which is a good representative of car interior design of that time. The reference used here is from 2007 and will not be valid for newer studies as car interior design has developed quickly and new colours, trims and shapes are already being used today. The concept design of course will also evolve over time and needs to be updated accordingly.
5. The eventual complexity of the real user interface also needs to be taken into account. For example, this will affect perceptions like simple or complicated. This can be simulated by having a working prototype of specific driver interface functions installed in the evaluation mock-up.
6. It is difficult to trust only the right colour theories. A number of theories on colour therapy exist which might not be reliable. As a rule of thumb, trust only those which are backed by scientific research, or which have been extensively applied and shown good results. It is highly recommended to perform a user study to determine colour preferences for eliciting specific emotions.
7. This project result can be used as a guideline but it is based on a very narrow user base. People from different cultures react differently to the same design cues and have different preferences for relaxation. The basic and extreme properties developed here work for this target group, but these properties will need to be re-established for specific markets.
8. In everyday vehicles, affective design must be combined with functional design and brand identity design. The extent of the overall emotional effect when the affective design is overlaid with brand identity design needs to be evaluated.

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Appendix

A1: Driving Anger Scale (DAS)

Directions: Below are several situations you may encounter when you are driving. Try to imagine that the incident described is actually happening to you, then indicate the extent to which it would anger or provoke you. Mark your response by filling in the bubble to the right.

		Not At All	A Little	Some	Much	Very Much
1.	Someone in front of you does not start up when the light turns green.	O	O	O	O	O
2.	Someone is driving too fast for the road conditions.	O	O	O	O	O
3.	A pedestrian walks slowly across the middle of the street, slowing you.	O	O	O	O	O
4.	Someone is driving too slowly in the passing lane holding up traffic.	O	O	O	O	O
5.	Someone is driving right up on your back bumper.	O	O	O	O	O
6.	Someone is weaving in and out of traffic.	O	O	O	O	O
7.	Someone cuts in front of you on the freeway.	O	O	O	O	O
8.	Someone cuts in and takes the parking spot you have been waiting for.	O	O	O	O	O
9.	Someone is driving slower than reasonable for the traffic flow.	O	O	O	O	O
10.	A slow vehicle on a mountain road will not pull over and let people by.	O	O	O	O	O
11.	You see a police car watching traffic from a hidden position.	O	O	O	O	O
12.	Someone backs right out in front of you without looking.	O	O	O	O	O
13.	Someone runs a red light or stop sign.	O	O	O	O	O
14.	Someone coming toward you at night does not dim their headlights.	O	O	O	O	O
15.	At night someone is driving right behind you with bright lights on.	O	O	O	O	O
16.	You pass a radar speed trap.	O	O	O	O	O
17.	Someone speeds up when you try to pass them.	O	O	O	O	O
18.	Someone is slow in parking and holding up traffic.	O	O	O	O	O
19.	You are stuck in a traffic jam.	O	O	O	O	O
20.	Someone pulls right in front of you when there is no one behind you.	O	O	O	O	O
21.	Someone makes an obscene gesture toward you about your driving.	O	O	O	O	O
22.	You hit a deep pothole that was not marked.	O	O	O	O	O
23.	Someone honks at you about your driving.	O	O	O	O	O
24.	Someone is driving way over the speed limit.	O	O	O	O	O
25.	You are driving behind a truck which as material flapping around in the back.	O	O	O	O	O
26.	Someone yells at you about your driving.	O	O	O	O	O
27.	A police officer pulls you over.	O	O	O	O	O
28.	You are behind a vehicle that is smoking badly or giving off diesel fumes.	O	O	O	O	O
29.	A truck kicks up sand or gravel on the car you are driving.	O	O	O	O	O
30.	You are behind a large truck and cannot see around it.	O	O	O	O	O
31.	You encounter road construction and detours.	O	O	O	O	O
32.	A bicyclist is riding in the middle of the lane and slowing traffic.	O	O	O	O	O
33.	A police car is driving in traffic close to you.	O	O	O	O	O

Six Scales Involved in Long-form (33-item) Driving Anger Scale (DAS):

(1) 3-item *Hostile Gestures* (α = .87) Items generally involve physical, verbal, or vehicular expression of displeasure toward the driver—Items 21, 23, and 26.

(2) 4-item *Illegal Driving* (α = .80) Items involve illegal driving behaviors of other drivers—Items 2, 6, 13, and 24.

(3) 4-item *Police Presence* (α = .79) Items involve presence of police involvement in one form or another—Items 11, 16, 27, and 33.

(4) 6-item *Slow Driving* (α = .81) Items involve behavior of other drivers or pedestrians which slow down or impede the driver—Items 1, 3, 4, 9, 10, and 18.

(5) 9-item *Discourtesy* (α =.81) Items involve behaviors of others that are primarily seen as discourteous, without thought or rude, rather than illegal or impeding—Items 5, 7, 8, 12, 14, 15, 17, 20, and 32.

(6) 7-item *Traffic Obstructions* (α = .78) Items involve traffic conditions, other than impeding behaviors of other drivers, that slow the individual down or cause frustration—Items 19, 22, 25, 28, 29, 30, and 31.

A2: Driver's Angry Thoughts Questionnaire (DATQ)

<u>Directions:</u> Below are a number of thoughts people have when they are angry or hostile when driving. Take a few seconds to think about whether that thought (or one similar to it) occurs to you <u>when you are angry at another driver or about something when you are driving.</u> Read each statement and then fill in the bubble indicating how much you think this thought (or one similar to it) <u>when you are angry while driving.</u> Please answer all questions:

		Not At All	Sometimes	Moderately Often	Often	All the Time
1.	What an idiot!	O	O	O	O	O
2.	They don't seem to think they can hurt others doing that.	O	O	O	O	O
3.	I'm going to get back at them.	O	O	O	O	O
4.	I'm not going to let them do that to me.	O	O	O	O	O
5.	Just what we need, someone who thinks they are more important than others.	O	O	O	O	O
6.	I want to yell at them.	O	O	O	O	O
7.	I want to kick their ass.	O	O	O	O	O
8.	I'm going to get revenge.	O	O	O	O	O
9.	I'm going to give them the finger.	O	O	O	O	O
10.	I want to curse at them.	O	O	O	O	O
11.	I hate drivers like that.	O	O	O	O	O
12.	Get off my ass!	O	O	O	O	O
13.	I'm going to box them in and show them.	O	O	O	O	O
14.	I'm going to slow them up on purpose.	O	O	O	O	O
15.	I feel like telling them off.	O	O	O	O	O
16.	I'm going to get even with them.	O	O	O	O	O
17.	They are going to get someone killed.	O	O	O	O	O
18.	People like you ought to have to take a driver's test.	O	O	O	O	O
19.	You didn't even look!	O	O	O	O	O
20.	I'm going to slam on my brakes and back them off.	O	O	O	O	O
21.	They shouldn't be allowed to drive.	O	O	O	O	O
22.	They ought to be shot.	O	O	O	O	O
23.	I'm going to slow down to spite them.	O	O	O	O	O
24.	How rude!	O	O	O	O	O
25.	Cope with it, sometimes you just have to live with bad drivers.	O	O	O	O	O
26.	What a stupid driver!	O	O	O	O	O
27.	Where do they get off doing this?	O	O	O	O	O
28.	I would like to hurt them.	O	O	O	O	O
29.	Why don't they have to drive like the rest of us?	O	O	O	O	O
30.	They are not going to get away with that.	O	O	O	O	O
31.	Where are the cops when you need them?	O	O	O	O	O
32.	Damn it!	O	O	O	O	O
33.	I'm going to tailgate them.	O	O	O	O	O
34.	I can't believe they're so inconsiderate.	O	O	O	O	O
35.	What an ass!	O	O	O	O	O
36.	They are going to kill someone doing that.	O	O	O	O	O
37.	Who do they think they are?	O	O	O	O	O
38.	What a dumb ass!	O	O	O	O	O

		Not At All	Sometimes	Moderately Often	Often	All the Time
39.	I want to beat them up.	O	O	O	O	O
40.	I want to run them off the road.	O	O	O	O	O
41.	I want to kill them.	O	O	O	O	O
42.	What a jerk!	O	O	O	O	O
43.	That's unsafe.	O	O	O	O	O
44.	How did that person get a license?	O	O	O	O	O
45.	They think they are the only people on the road.	O	O	O	O	O
46.	Who in their right mind would drive like that?	O	O	O	O	O
47.	They think they are above the rules.	O	O	O	O	O
48.	Just back off and relax.	O	O	O	O	O
49.	This is crazy.	O	O	O	O	O
50.	Nothing I can do about it so take it easy.	O	O	O	O	O
51.	I'll just have to call and tell them I'll be late.	O	O	O	O	O
52.	Get people like them off the road.	O	O	O	O	O
53.	Don't even make eye contact with people like that.	O	O	O	O	O
54.	I'm so angry.	O	O	O	O	O
55.	Just calm down.	O	O	O	O	O
56.	Just turn up the radio and tune them out.	O	O	O	O	O
57.	I want to punch them out.	O	O	O	O	O
58.	I'll cut them off and see how they like it.	O	O	O	O	O
59.	I would like to beat the hell out of them.	O	O	O	O	O
60.	They are clueless.	O	O	O	O	O
61.	I'm going to return the favor.	O	O	O	O	O
62.	I am so pissed.	O	O	O	O	O
63.	I'm going to teach them a lesson.	O	O	O	O	O
64.	Chill out.	O	O	O	O	O
65.	Just pay attention to my driving, others can be crazy if they want.	O	O	O	O	O

Five scales involved in Driver's Angry Thoughts Questionnaire (DATQ):

(1) 21-item *Judgmental and Disbelieving Thinking* (α = .94)—Items 2, 5, 17, 18, 19, 21, 24, 27, 29, 31, 34, 36, 37, 43, 44, 45, 46, 47, 49, 52, and 60.

(2) 13-item *Pejorative Labeling and Verbally Aggressive Thinking* (α = .92)—Items 1, 6, 10, 11, 12, 15, 26, 32, 35, 38, 42, 54, and 62.

(3) 14-item *Revenge and Retaliatory Thinking* (α = .93)—Items 3, 4, 8, 9, 13, 14, 16, 20, 23, 30, 33, 58, 61, and 63.

(4) 8-item *Physically Aggressive Thinking* (α = .93)—Items 7, 22, 28, 39, 40, 41, 57, and 59.

(5) 9-item *Coping Self-Instruction* (α = .83)—Items 25, 48, 50, 51, 53, 55, 56, 64, and 65.

Citation:

Deffenbacher, J. L., Petrilli, R. T., Lynch, R. S., Oetting, E. R., & Swaim, R. C. (2003). The Driver's Angry Thoughts Questionnaire: A measure of angry cognitions when driving. *Cognitive Therapy and Research, 27*, 383-402.

A3: Driver Anger Expression Inventory (DAX)

Directions: Everyone feels angry or furious from time to time <u>when driving</u>, but people differ in the ways that they react when they are angry <u>while driving.</u> A number of statements are listed below which people have used to describe their reactions when they feel <u>angry</u> or <u>furious</u>. Read each statement and then fill in the bubble to the right of the statement indicating how often you <u>generally</u> react or behave in the manner described <u>when you are angry or furious while driving</u>. There are no right or wrong answers. Do not spend too much time on any one statement.

	Almost Never	Some-times	Often	Almost Always
1. I give the other driver the finger.	O	O	O	O
2. I drive right up on the other driver's bumper.	O	O	O	O
3. I drive a little faster than I was.	O	O	O	O
4. I try to cut in front of the other driver.	O	O	O	O
5. I call the other driver names aloud.	O	O	O	O
6. I make negative comments about the other driver	O	O	O	O
7. I follow right behind the other driver for a long time.	O	O	O	O
8. I try to get out of the car and tell the other driver off.	O	O	O	O
9. I yell questions like "Where did you get your license?"	O	O	O	O
10. I roll down the window to help communicate my anger.	O	O	O	O
11. I glare at the other driver.	O	O	O	O
12. I shake my fist at the other driver.	O	O	O	O
13. I stick my tongue out at the other driver.	O	O	O	O
14. I call the other driver names under my breath.	O	O	O	O
15. I speed up to frustrate the other driver.	O	O	O	O
16. I purposely block the other driver from doing what he/she wants to do.	O	O	O	O
17. I bump the other driver's bumper with mine.	O	O	O	O
18. I go crazy behind the wheel.	O	O	O	O
19. I leave my brights on in the other driver's rear view mirror.	O	O	O	O
20. I try to force the other driver to the side of the road.	O	O	O	O
21. I try to scare the other driver.	O	O	O	O
22. I do to other drivers what they did to me.	O	O	O	O
23. I pay even closer attention to being a safe driver.	O	O	O	O
24. I think about things that distract me from thinking about the other driver.	O	O	O	O
25. I think things through before I respond.	O	O	O	O
26. I try to think of positive solutions to deal with the situation.	O	O	O	O
27. I drive a lot faster than I was.	O	O	O	O
28. I swear at the other driver aloud.	O	O	O	O
29. I tell myself its not worth getting all mad about.	O	O	O	O
30. I decide not to stoop to their level.	O	O	O	O

		Almost Never	Some-times	Often	Almost Always
31.	I swear at the other driver under my breath.	O	O	O	O
32.	I turn on the radio or music to calm down.	O	O	O	O
33.	I flash my lights at the other driver.	O	O	O	O
34.	I make hostile gestures other than giving the finger.	O	O	O	O
35.	I try to think of positive things to do.	O	O	O	O
36.	I tell myself it's not worth getting involved in.	O	O	O	O
37.	I shake my head at the other driver.	O	O	O	O
38.	I yell at the other driver.	O	O	O	O
39.	I make negative comments about the other driver under my breath.	O	O	O	O
40.	I give the other driver a dirty look.	O	O	O	O
41.	I try to get out of the car and have a physical fight with the other driver.	O	O	O	O
42.	I just try to accept that there are bad drivers on the road.	O	O	O	O
43.	I think things like "Where did you get your license?"	O	O	O	O
44.	I do things like take deep breaths to calm down.	O	O	O	O
45.	I just try and accept that there are frustrating situations while driving.	O	O	O	O
46.	I slow down to frustrate the other driver.	O	O	O	O
47.	I think about things that distract me from the frustration on the road.	O	O	O	O
48.	I tell myself to ignore it.	O	O	O	O
49.	I pay even closer attention to other's driving to avoid accidents.	O	O	O	O

Scales involved in the Driving Anger Expression Inventory (DAX):

(1) 12-item *Verbally Aggressive Expression* (α = .88) Items generally involve overt and covert verbal aggression with some nonverbal behaviors such as glares—Items 5, 6, 9, 11, 14, 28, 31, 37, 38, 39, 40, and 43

(2) 11-item *Physically Aggressive Expression* (α = .84) Items generally involve physically aggressive displays or behavior, but not where the person is using the car as an instrument of intimidation, aggression, and frustration—Items 1, 8, 10, 12, 13, 17, 18, 20, 21, 34, and 41

(3) 11-item *Using the Vehicle for Aggressive Expression* (α = .86) Items generally involve using the vehicle or one's driving behavior to frustrate, intimidate, or express displeasure with the another driver—Items 2, 3, 4, 7, 15, 16, 19, 22, 27, 33, and 46

(4) 15-item *Adaptive/Constructive Expression* (α = .90) Items generally involve cognitive and behavioral strategies for safe driving, problem-solving, distraction and cognitively reframing the situation—Items 23, 24, 25, 26, 29, 30, 32, 35, 36, 42, 44, 45, 47, 48, and 49

Citations:

Deffenbacher, J. L., Lynch, R. S., Deffenbacher, D. M., & Oetting, E. R. (2001). Further evidence of reliability and validity for the Driving Anger Expression Inventory. *Psychological Reports, 89,* 535-540.

Deffenbacher, J. L., Lynch, R. S., Oetting, E. R., & Swaim, R. C. (2002). The Driving Anger Expression Inventory: A measure of how people express their anger on the road. *Behaviour Research and Therapy, 40,* 717-737.

A4: Manchester Driver Behaviour Questionnaire (Extended DBQ)

Respondents are asked to indicate how often they themselves do each of the violations and errors when driving. Responses were on a six-point scale from "Never" to "Nearly all the time".

0=Never   1=Hardly Ever   2=Occasionally   3=Quite Often   4=Frequently   5=Nearly All The Time

Begin each question with "How often do you..."

Aggressive Violations
7. Sound your horn to indicate your annoyance to another road user
17. Become angered by another driver and give chase with the intention of giving him/her a piece of your mind
25. Become angered by a certain type of a driver and indicate your hostility by whatever means you can

"Ordinary" Violations
10. Pull out of a junction so far that the driver with right of way has to stop and let you out
11. Disregard the speed limit on a residential road
18. Stay in a motorway lane that you know will be closed ahead until the last minute before forcing your way into the other lane
20. Overtake a slow driver on the inside
21. Race away from traffic lights with the intention of beating the driver next to you
23. Drive so close to the car in front that it would be difficult to stop in an emergency
24. Cross a junction knowing that the traffic lights have already turned against you
28. Disregard the speed limit on a motorway

Errors
5. Queuing to turn left* onto a main road, you pay such close attention to the main stream of traffic that you nearly hit the car in front of you
6. Fail to notice that pedestrians are crossing when turning into a side street from a main road
8. Fail to check your rear-view mirror before pulling out, changing lanes, etc.
9. Brake too quickly on a slippery road or steer the wrong way in a skid
13. On turning left* nearly hit a cyclist who has come up on your inside
14. Miss "Give Way" signs and narrowly avoid colliding with traffic having right of way
16. Attempt to overtake someone that you had not noticed to be signaling a right* turn
27. Underestimate the speed of an oncoming vehicle when overtaking

Lapses
1. Hit something when reversing that you had not previously seen
2. Intending to drive to destination A, you "wake up" to find yourself on the road to destination B
4. Get into the wrong lane approaching a roundabout or a junction
12. Switch one thing, such as the headlights, when you meant to switch on something else, such as the wipers
15. Attempt to drive away from the traffic lights in third gear
19. Forget where you left your car in a car park
22. Misread the signs and exit from a roundabout on the wrong road
26. Realize that you have no clear recollection of the road along which you have just been traveling

This questionnaire was developed for the UK. Left and right should be interchanged while using the questionnaire in countries which drive on the right side of the road.

Lajunen, T., Parker, D., & Summala, H. (2004). The Manchester Driver Behavior Questionnaire: A cross-cultural study. Accident Analysis, and Prevention, 36, 231-238.

B: Everyday relaxation activities compilation

This is a list of 78 distinct activities prepared by reading topics like "*What do you do to relax?*" and "*Favorite places to find peace and relaxation*" on the following online forums: www.yelp.com, Carers UK forum, www.collegenet.com, www.sandiegoreader.com, www.answers.yahoo.com.

This is not a comprehensive list but a small compilation aimed at getting a basic idea of everyday activities people perform to de-stress. Several of these activities were repeated a number of times, but the frequency of occurrence is not noted here.

1. Walk on the beach
2. Walk along a lake
3. Walk in a cemetery
4. Going around town
5. Walk in a meadow
6. Bird and wildlife watching
7. Reading by the water
8. Visit a park/garden
9. Hike to a high point for a view
10. Visit a place with minimal "people and city noise"
11. Relax at a church/chapel
12. A slow walk
13. Looking at plants
14. Looking at architecture
15. Soaking in the sun
16. A drive
17. Sit in a quiet place
18. Motorbike ride
19. Watching dogs play
20. Barbeque at the beach
21. Running
22. Float on a raft with music
23. Look at nature's scenes
24. Get fresh air
25. Boating/sailing
26. Fishing
27. Scuba diving
28. Walk the dog
29. Walk/sit in the rain
30. Swimming
31. "Tickle-fights"
32. Crying
33. Pedicure
34. Eat chocolate/favorite food
35. Massage
36. Hot-tub bath
37. Spa visit
38. Get a drink (at a pub)
39. "People watching" in a crowded place
40. Gym workout
41. Soft music
42. Yoga
43. Watch movies
44. Read a book
45. Meet a friend
46. Reading in bed
47. Taking a shower
48. Meditation
49. Peaceful a quiet home
50. Sleep/nap
51. Play video games,
52. Wash car
53. Eating in bed
54. Dancing
55. Acupuncture
56. Reading in the bathroom
57. Sit in silence
58. Snuggling on the couch watching TV
59. Knitting
60. Live music
61. Clean stuff
62. Play music
63. Design shirts and bags
64. Write new music
65. Cooking
66. Skateboarding
67. Laughing
68. Solving puzzles
69. Gardening
70. Writing down thoughts
71. Play with cats
72. Do "something" on the computer
73. "Facebooking"
74. Play chess
75. Floral art
76. Deep breathing
77. Sitting in candlelight
78. Painting

C1: Evaluation test protocol

Preparation:
1. Decide the sequence of showing the 2 environments beforehand (the sequence must be reversed for half the number of participants)
2. Mount 'environment 1' in the mock-up. Cover it with a sheet of cloth, making sure that the complete dashboard is covered.
3. Ensure that all items from the checklist (Appendix C2) are ready.

Key:
- The conversations mentioned below should be used as guidelines and need not be exact. However, it is necessary to use the underlined keywords to ensure that the various participants have a similar experience.
- It is also necessary to control the level of information revealed during different stages of the evaluation procedure as per the protocol.
- It is also necessary to minimize small-talk before step 15.

Procedure:
1. Greet the participant and make introductions. The participant introduces himself/herself.
2. Help the participant get settled in. "This is your seat. You can place you belongings here."
3. Before sitting down, it is necessary to request the participant to adjust the driver seat in the mockup so that they can sit in it with a comfortable driving posture later in the process. "Before we sit down, I need you to do one thing. Could you please sit in this car seat and adjust it so that you can sit comfortably in a driving position? Use the pedals as a reference. I hope you don't mind because it is necessary to do this now to get good evaluation results." Explain the various seat adjustments to the participant and help them get into a satisfactory position. "You can use this handhold for support."
4. Now direct the participant to their seat at the desk: "Please have a seat."
5. After the participant settles down, offer some tea/coffee and fika.
6. Explain the overall procedure **without revealing the purpose** behind the evaluation.
   - "I will begin by explaining what we will do today. I would like to get your opinion on two different vehicle interior environments.
   - For each environment, the process is divided into 2 stages.
   - In the first stage, you will be shown pictures and a video of the first vehicle interior to give you an overview of what the complete environment looks like. Then I will reveal the model that you see beside us so you can take a look at the physical dashboard. At this stage you will not be allowed to touch the model. Now you will be asked to rate the environment based on what you have seen so far. For this you will use an "opposite-scale" like this one. (*Show and explain the perception rating scale using an example "Scale between opposites... 0 is neutral and 3 is maximum on each side....").*
   - In the second stage, you will be requested to sit in the mock-up so you can get a closer look, touch and feel the dashboard . This will be followed by enacting a driving scenario so you get an idea of how it

would feel to drive in this environment. I will again take another pulse reading and then ask you to rate your experience on tow scales like this one. (*Show and explain the effect rating scale using an example).*

- I will also need to take your pulse reading twice during this procedure. I hope that is OK for you? I will use this pulse meter here. Do not worry as the measurement is very quick and simple.
- After this, I will switch the model to the second vehicle environment and we will repeat the same procedure for it.
- We will then conclude with a small open discussion about this evaluation. The complete process should take approximately 45 minutes."

7. Make sure that the participant understands the process. Explain specific things again if needed.
8. Measure the participant's pulse and note it down as the reference reading. "Let us take your pulse first before we start with the evaluation. Please place your finger here lightly and wait for a few seconds till the meter beeps."
9. Begin the first stage of evaluation with environment 1:
   - Show pictures. "This is how the vehicle environment looks like. Please take a look and after this, I will show you the video."
   - Play the animation when the participant is ready.
   - Uncover the dashboard and show it to the participant. "To get a better idea of the environment, I will now show you how the physical dashboard looks. Please remain seated while you look at it. Take your time to look at it and then we can proceed to the questionnaire when you are ready."
   - After the participant is satisfied, request him/her to fill in the perception rating sheet. "I would now like you to rate your first impression of this driving environment on the following scale."
10. Stage 2 of evaluation with environment 1:
    - Request the participant to sit in the already adjusted driver seat and make himself/herself comfortable.
    - After the participant is seated, give him/her time to get acquainted with the finer details of the environment. "Try to get a good feel for the environment. You can look closely at the details and touch the various surfaces of the dashboard to get acquainted with it. I will be back after 1 minute."
    - Then ask the participant to imagine himself/herself driving in this vehicle in the following scenario – "Driving on a highway at constant speed, looking at the navigation to check the next exit, changing the radio station, and then continuing to drive." To support this imagination, the video of highway driving is played on the big screen facing the participant. "You can use the pedals, navigation screen and radio dial to support this scenario. I will be back after 1.5 minutes."
    - Measure the participant's pulse and note it down as the reading for environment 1. "Now, I need to measure your pulse again. Please place your finger here lightly and wait for a few seconds till the meter beeps."
    - Request the participant to fill in the effect rating sheets. "Now I would like you to fill in this rating sheet. The question asked is 'How does this environment make you feel?' and you have 2 scales on the 2 axes. For example, negative-positive, calm-excited …. Mark with a cross or a dot on

this scale if it made you feel calm or excited or negative or positive…. Do the same on a different scale on the next page"

11. The evaluation of environment 1 is now complete. Request the participant to sit in the next room while you switch the model in the mockup to environment 2. Cover this model with the covering sheet before you invite the participant back into the room.

12. Repeat steps 9 and 10 for environment 2.

13. Request the participant to be seated back at the desk. Ask him/her the following open questions and request him/her for permission to record the conversation for recalling their answers later. Provide one overview picture of each environment to support the participant in answering:
    a. <u>Did you feel any difference between the two driving environments? If so, what was it (describe in your own words)?</u>
    b. <u>Which one do you like/prefer and why?</u>

14. Only after the participant has answered both these questions, reveal the purpose of the study. "I would now like to tell you what this study is about. <u>I am trying to see whether it is possible to reduce aggressive driving through the design of the driving environment, whether the environment can be designed to influence a driver so he/she reacts less aggressively to annoying traffic situations or other road users</u>." Explain more if needed, before asking one final question. "<u>What is your opinion about this?</u>"

15. Inform the participant that the evaluation is complete. Thank them for their time and present them with their Lotto tickets.

C2: Evaluation study checklist

☐	Perception scale x 2
☐	Effect scales x 2
☐	Summary questions sheet
☐	Concept images
☐	Pens
☐	Pulse meter
☐	Loaded concept animation video
☐	Loaded driving video (with looping)
☐	Fika and coffee
☐	Lotto tickets
☐	Voice recorder app on phone
☐	Covering sheet cloth
☐	Conversation prompt cards

D: Sample perception and effect ratings - concept environment

Participant Name: [redacted]

Sex: M   Age: 55   Nationality: ITALIAN

Participant No: 1   Ref Pulse: 72   Pulse: 68

Environment: Bg   Seq No: 1

Please rate the driving environment on the following scale:
Tick the appropriate box.

	3	2	1	0	1	2	3	
Simple	□	□	□	□	X	□	□	Complicated
Beautiful	□	X	□	□	□	□	□	Ugly/Clumsy
Personal	□	X	□	□	□	□	□	Impersonal
Quiet	□	X	□	□	X	□	□	Flashy
Safe	□	□	X	□	□	□	□	Unsafe
Relaxing	X	□	□	□	□	□	□	Stressful
Soft	X	□	□	□	□	□	□	Hard
Smooth	X	□	□	□	□	□	□	Rough

How does this environment make you feel?

CALM

X

NEGATIVE ——————————— POSITIVE

EXCITED

How does this environment make you feel?

INTERESTED

SAD ——————————— HAPPY

BORED