SUaaVE

SUpporting acceptance of automated VEhicle

Deliverable 6.2. Evaluation framework guidelines

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Legal disclaimer

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Terminology and Acronyms

EU	European Commission
ALFRED	Automation Level Four+ Reliable Empathic Driver
UC	Use Case
V-HCD	Virtual Human Centred Design
ACE	Adaptive, Cognitive and Emotional
ODD	Operation Design Domain
VRU	Vulnerable Road User
CAV	Connected Autonomous Vehicle
AV	Autonomous Vehicle
HMD	Head Mounted Display
HVAC	Heating Ventilation Air Conditioning
VR	Virtual Reality
VD	Vehicle Dynamics
MPC	Model Predictive Control
WoZ	Wizard of Oz

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EXECUTIVE SUMMARY

This deliverable is related to task 6.1 of the SUaaVE project. It is a "living document", which means that it will continue to be updated throughout the first phase of the project. The principle aim of this deliverable is to define the framework for the validation of project hypotheses and the first iteration test (T6.2) which will begin in M12. This document gives an introduction related to what was included in D6.1. It then describes the methodology that will be used for the evaluations of all the aspects involved in the project, including the expected results. Processes for the ethical approval and necessary documentation are also presented in this deliverable. This deliverable will only inform on the methodology of the first loop of evaluation and will not detail the second loop. This decision has been made by all the partners as the second loop method will strongly depend on the results of the first loop and on the further discussions that the development of the models will open. The second loop of evaluation will be included in the deliverable D6.3, due at M20.

1 INTRODUCTION

This deliverable refers to task 6.1. This task started at month 1 of the project and will end at month 36. This means that it will be a "living task" and will be included in all the deliverables of WP6, including this one.

The aim of this deliverable is to develop the framework for the evaluation and validation of the hypotheses formulated in the first six months of the project. The evaluations activities have been divided into two phases: the first and second loop of evaluation. The first loop will be carried out starting at M12. This stage of evaluation is aimed at investigating the first versions of the models (i.e. emotional, cognitive and comfort) included in ALFRED. In this phase, the models will be assessed separately, and the results of the evaluations will guide their modification and improvement. This will allow a correct and informed integration of the models into ALFRED which will be evaluated in the second phase of evaluations starting M24. Other than giving the first data on the models composing ALFRED, another aim of the first loop of evaluation is to obtain the perceived comparison between a CAV with an interface comparable to the ones currently available in the market and a vehicle with an adaptive system. The second loop of evaluation aims at evaluating the ALFRED concept inclusive of all the models developed after the results of the first loop. This round of evaluation will give a comprehensive picture of ALFRED. In this deliverable the first loop of evaluation will be detailed. The description of the second loop will not be included in this document, but it will be reported in the next deliverable (D6.3). This decision was made as the second loop of evaluation will be strongly dependent on the results of the first loop. Furthermore, the second loop will start at M24 (T6.3) and it is possible that several fundamental aspects of the evaluation will change by this time. It is the decision of the consortium that to avoid misinterpretation on the method of the second loop, this will be explained in D6.3.

During the first loop, each partner responsible for the models will be in charge of organising and managing the evaluation and each evaluation will be specific to the aspects under investigation. Therefore, in this phase, the scenarios, methodologies and variables may be different for each partner. Agreements between partners have been made to include more than one aspect in an evaluation (e.g. emotions will be included in the evaluation of ride comfort).

This document gives details on the methodology used by each partner, the variables studied and the expected results.

For clarity, this deliverable will give an overview of deliverable 6.1 which described the use cases for the evaluation of ALFRED. Furthermore, it will include, for each model, the methodology that will be used in the first loop of evaluations.

1.1 Deliverable 6.1

Deliverable 6.2 is strongly related to what was included and discussed in D6.1. in order to have a framework for the validation of the hypothesis, it is useful to summarise here what was described in D6.1, especially regarding the creation of the use cases and the decision on the events to be included in the evaluations.

In deliverable 6.1 two categories of events were defined: general events and specific events. The general events were inputted by the partners and encompass what could happen in a normal drive through various types of roads (e.g. urban, countryside and motorway). The general events will be implemented both in short and long scenarios. There are sixteen general events. A more specific description of the events and the attribute(s) they aim at investigating is detailed in D6.1. The general events are:

1. Approaching traffic lights, they turn orange. The vehicle stops

2. Approaching a zebra crossing, a disabled person is approaching. The vehicle stops

3. Approaching a zebra crossing, a group of children is approaching. The vehicle proceeds

4. Another driver cuts in front of the vehicle. The vehicle breaks suddenly

5. The user can select between sport (aggressive) and comfort (smooth) driving during a motorway trip (Changes in car settings, includes lane change and overtaking).

6. The vehicle chooses a different route from motorway to normal way to pick up an extra passenger

7. The vehicle overtakes a cyclist cutting in front of the vehicle on a double lane road

8. The vehicle overtakes a cyclist cutting in front of the vehicle on a single lane road

9. Speedbump

10. 90 degree turn

11. Roundabout

12. Red traffic light

13. Green traffic light

14. Toll gate

15. Sunlight inside the vehicle (the vehicle asks to raise the sunvisors)

16. The vehicle asks for preferred sitting position based on activity

Other than general events, a series of specific events were also created. The specific events are designed to be included singularly in a short scenario. However, specific events that do not require a complete stop (e.g. major breakdown) can be included in longer scenarios with more events. The specific events, like the general ones, were inputted by the partners and aim at investigating a precise attribute of the SUaaVE project (e.g. acceptance, ethics). Contrary to the general events, the specific events are exceptional situations that do not usually happen during a normal drive. All the events included aim at investigating one or more of the attributes of the SUaaVE project (i.e. acceptance, trust, ethical issues, emotions, dynamic and ambient comfort). The two categories of events will be implemented in different phases of the project.

There are twelve specific events.

1. The vehicle sends a warning that the window wipers are not working

2. The vehicle sends a warning that there has been a major breakdown in the sensory

3. The vehicle suffers an accident (minor damage)

4. The vehicle suffers an accident (major damage)

5. Road works

6. Loud passenger

7. The vehicle encounters a standstill queue at a toll gate for 3 minutes

8. A pedestrian the street without a zebra crossing

9. Another vehicle does not respect a yield/stop signs

10. An ambulance/police car in emergency situation asks the way

11. The vehicle is approaching a motorway junction and increases the speed slightly above the speed limit in order to integrate safely in the ongoing traffic.

12. A motorbike is approaching the AV on the same lane from behind. The AV drives slightly beyond the lane line in order to give safe space to the motorbike

1.1.1 Use cases - Situational scenarios (specific events)

The creation of the events allowed the development of use cases that are going to be the base of the evaluations' methodology described in this deliverable.

As stated in the previous section, for the first loop of evaluations, short scenarios will be created in order to investigate specific attributes. The short scenarios can include general and specific events and are designed to be limited in time but will depend on the specific requirements of the partner. If a continuous scenario is thought to be more relevant to the attributes studied, the situational scenario can also be longer. These use cases have been called situational use cases, as they are able to investigate and evaluate a specific response to a specific situation

The first loop of evaluation and the situational scenarios are meant to validate the first components developed in the first six months of the project (Deliverable 1.2).

Figure 1 depicts the structure of a situational use case.

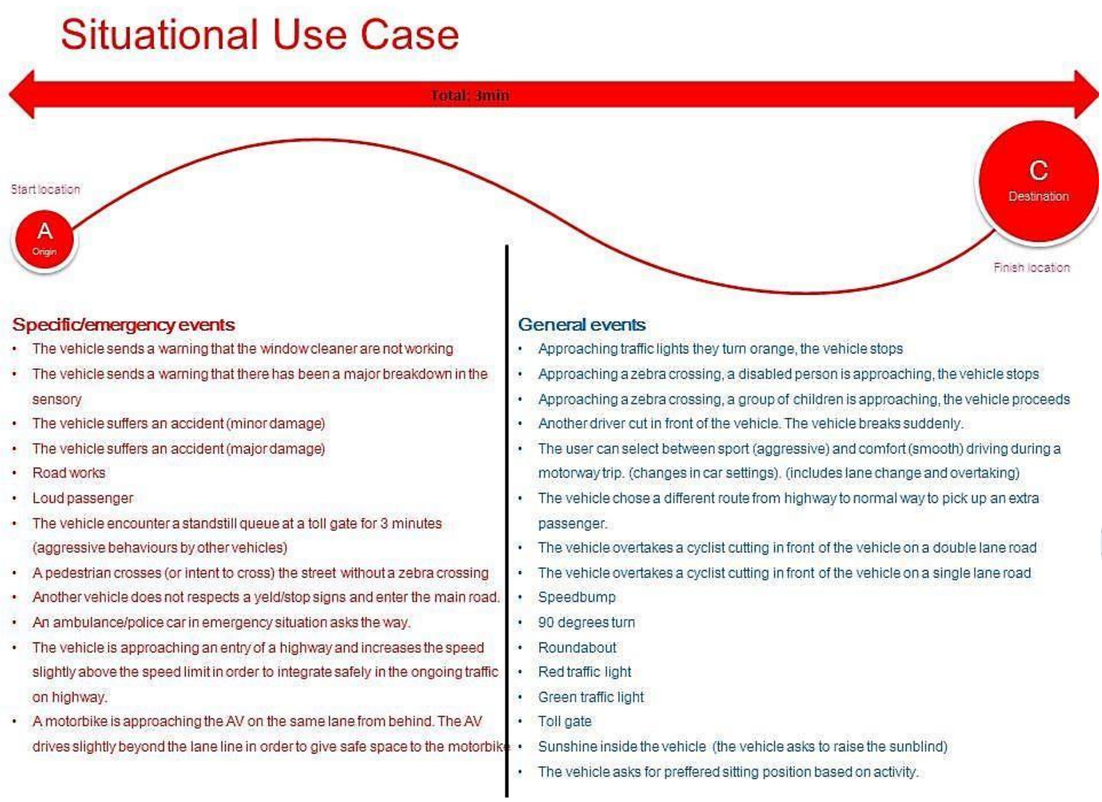

Figure 1 Situational Use Case

The use case described in this section serves as a guideline and a reference for the partners to run their evaluations. Aspects of the use cases, including events, context and users can be modified and adapted to each methodology.

The next section will describe the methodology underlying the first loop of evaluations.

2 FIRST LOOP

2.1 Introduction

As previously stated, one of the aims of this deliverable is to describe the methodology that will be used for the first loop of evaluations starting M12. The methodology will be different for each partner as it adapts to partner capability, the system availability and the attributes investigated. In order to have a clear understanding of the different methodologies, this section will be divided by attribute investigated. The partners involved, the systems used and the experimental designs will be described.

2.2 Ambient comfort (IDIADA)

2.2.1 Objective

The study of ambient comfort is responsibility of the Human Factors department at IDIADA. The objective of the study is to investigate the perception of ambient comfort. The study will evaluate four different attributes: visual comfort, acoustic comfort, posture comfort and thermal comfort. Moreover, in order to investigate the difference between an adaptive and non-adaptive interface and gather initial data on the perception of users about features that may be implemented into ALFRED, there will be two type of in-vehicle systems that will respond differently to the events taking place. The non-adaptive interface aims at representing a common interface and will not react autonomously to the changes in the environment. The adaptive interface will detect the change in the environment and change the car settings autonomously.

2.2.2 Methodology

The study for the evaluation of ambient comfort derives from the creation of an ambient comfort model, which is part of T4.3. This evaluation will investigate the characteristics of this model and its adaptation to the future ALFRED concept. In order to investigate the cabin comfort, a mixed set up will be used.

<u>Visual comfort</u>

For visual comfort, participants will be immersed in a VR environment through an HMD. This allows to modify the lighting conditions of the cabin and introduce discomfort glares into the cabin.

<u>Auditory comfort</u>

For auditory comfort, participants will use an HMD representing the interior of the car and will have high definition headphones replicating road noises. The sounds will be completely manageable by the researchers.

<u>Posture comfort</u>

For posture comfort, participants will sit in a real car. Before starting the interaction, participant will be prompted on what activity they should perform in the car. The sitting position can be changed accordingly. There will be two pre-set positions: attentive (driving position) and relaxed (lay-down position).

<u>Thermal comfort</u>

Concerning thermal comfort, the participants will be placed in a real car. The participants will be immersed in a VR environment through an HMD. During the simulated drive, the researchers will be able to modify the temperature of the car by managing the HVAC system.

As stated in the objective section, part of the aim of this evaluation is to investigate the difference between a vehicle with a common interface and a vehicle fitted with an adaptive system. In order to achieve this objective, two types of vehicle systems will be simulated. One type will be a Connected Automated Vehicle (CAV) which will not adapt to the events happening in the interaction. The second type will be a CAV equipped with an adaptive system similar to what will be implemented in ALFRED.

Scenarios and Events

Even though the initial plan was to use a different short scenario for each event, two longer scenarios will be used for this evaluation. The reason for this choice is motivated by logistic reasons, since a shorter exposure time will be required for each participant. Furthermore, fewer scenarios will avoid the continuous interruption of the experience, which could affect the immersion of the participants and will avoid continuous readjustments to the virtual environment, which could produce cybersickness symptoms. Therefore, there will be a scenario including all four aspects of ambient comfort with a normal interface and a scenario with an adaptive interface.

During the interaction with the systems, the participants will experience various events aimed at changing the cabin comfort status. Four main events will be introduced:

- A discomfort glare coming inside the vehicle (represented in the VR environment).
- Very loud road noises coming from outside the vehicle
- A change of temperature (cold and/or hot)
- A prompt by the researcher to relax.

The vehicle responses will be (for the adaptive interface):

- The vehicle raises the sun visors to avoid discomfort glares.
- The vehicle uses a noise cancellation program to avoid loud noises to come inside the vehicle
- The vehicle automatically manages the air conditioning/heating system to counterbalance the external change in temperature
- The vehicle changes the sitting position to allow a laydown posture.

The non-adaptive interface will not respond to the event, the participants will have to activate the corresponding feature (e.g. turn on the air conditioning for thermal comfort).

The graph below depicts the proposed test methodology.

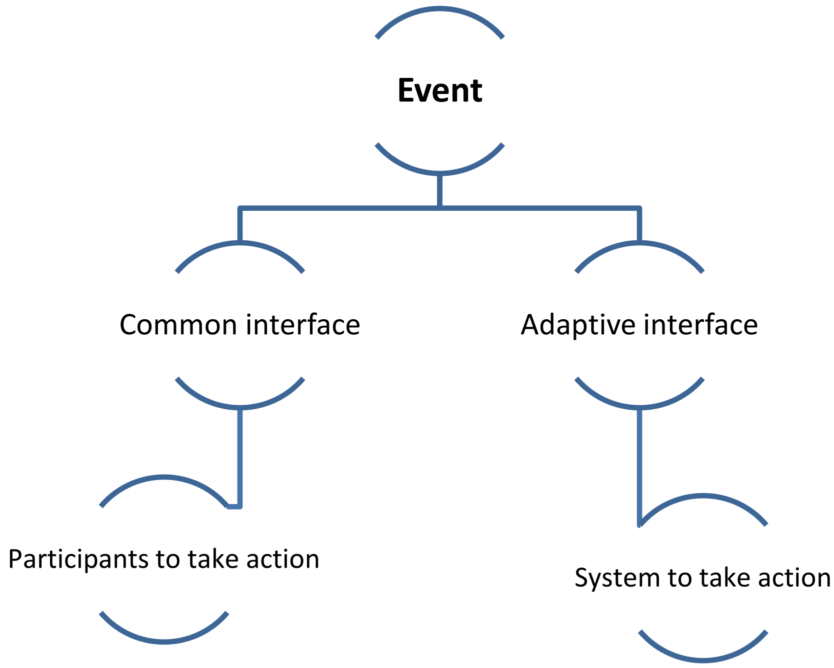

Figure 2 Outline of the ambient comfort procedure

All the vehicle actions will be preceded by a message stating the intention of the system (e.g. "I have detected some loud noise coming from outside. Do you want to activate the noise cancelling system?")

Simulator

For the evaluation of ambient comfort, an HMD will be used. The system will represent the interior of a vehicle and a driving scenario.

The HMD will be a HP® Reverb. The googles have a Dual LCD 2.89'' diagonal with Pulse Backlight technology, with a resolution of 2160 x 2160 pixels per eye (4320 x 2160 pixels combined). The frequency reaches 90Hz with a field of view of approximately 114 degrees.

The scenario will be developed using the SCANeR Studio™ software.

Participants

A total of sixteen participants will take part in the study. All the participants will evaluate the four aspect of comfort and the two interfaces. The order of attribute and interface interaction will be randomised to avoid biases. The participants' order is detailed in the table below (Table 1Table 1 Participants order for the ambient comfort study).

Table 1 Participants order for the ambient comfort study

	Interface	Common interface				Adaptive interface			
	Aspect	Visual	Acoustic	Postural	Thermal	Visual	Acoustic	Postural	Thermal
Participants	**1**	1	2	3	4	5	6	7	8
	2	2	3	4	1	6	7	8	5
	3	3	4	1	2	7	8	5	6
	4	4	1	2	3	8	5	6	7
	5	1	2	3	4	5	6	7	8
	6	2	3	4	1	6	7	8	5
	7	3	4	1	2	7	8	5	6
	8	4	1	2	3	8	5	6	7
	9	5	6	7	8	1	2	3	4
	10	6	7	8	5	2	3	4	1
	11	7	8	5	6	3	4	1	2
	12	8	5	6	7	4	1	2	3
	13	5	6	7	8	1	2	3	4
	14	6	7	8	5	2	3	4	1
	15	7	8	5	6	3	4	1	2
	16	8	5	6	7	4	1	2	3

The participants will be recruited through the IDIADA employees pool and will be mixed in terms of gender and age. In the recruitment process, people who may be susceptible to motion sickness will be discouraged from participating.

Inclusion criteria:

- To have a valid driving licence
- Age: 18-65

Exclusion criteria:

- People who suffer or have ever suffered from:
- Migraine
- Recurring headache
- Back pain or back problems
- Neck or shoulder strain
- Heart condition
- Asthmatic or respiratory disorder
- Epilepsy (photosensitive or other)
- Problems with depth perception

- Other serious injury or illness
- Pregnant women

The inclusion and exclusion criteria will be clearly stated in the recruitment poster and in the information sheet.

Procedure

Participants will be briefed before starting the study on the SUaaVE project, the objective of the study and the procedure of the experiment. Participant will also receive an information sheet and consent form that they will have to read and sign before starting the study.

The whole study should last approximately one hour. The interaction with the systems will last approximately 30min.

The scheme below describes the timeline of the study.

The interaction will be continuous through each interface with an expected time of ten minutes per session. However, due to the different characteristics and procedure for each attribute, the time allocated will not be equally distributed. Some attributes will be allocated more time compared to others. This difference will be described in the explanation of each attribute methodology below. A break between interfaces will be needed to brief the participants on the characteristics of the second interfaces and to allow the time to fill questionnaires.

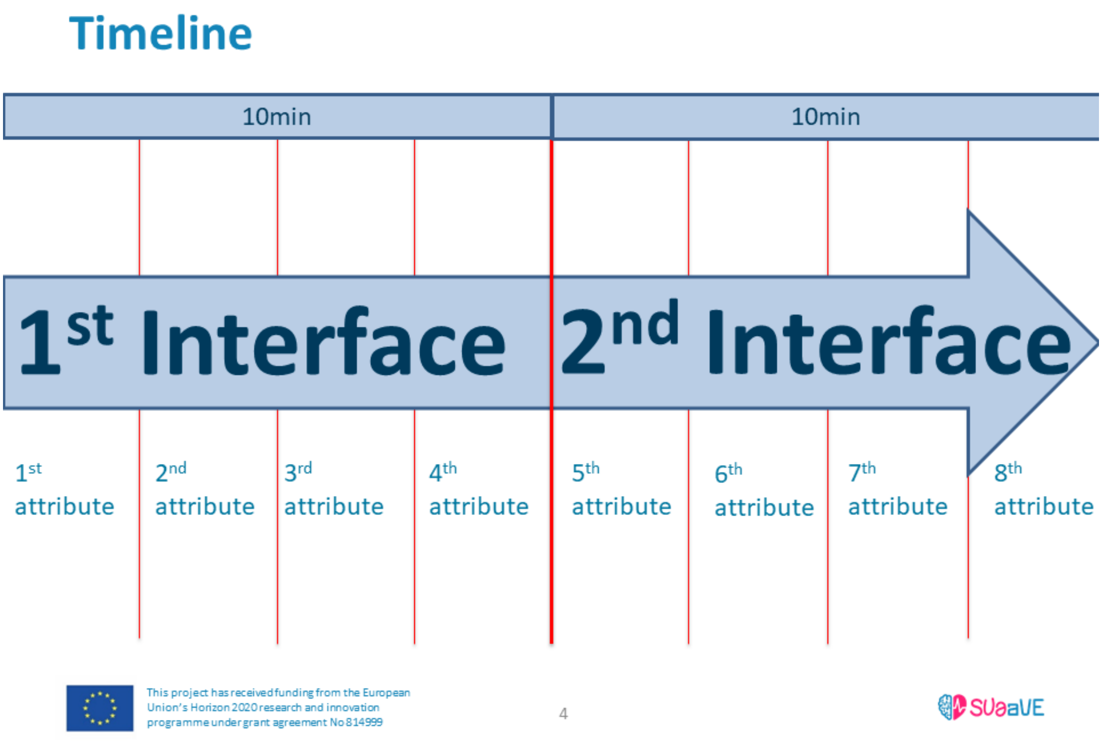

Figure 3 Timeline of the ambient comfort study.

Questionnaires

The questionnaires that will be used in the study have been created with the intention of investigating the comfort perception of the participants, and to be tailored to the experimental design.

There will be three different questionnaire that will be given to the participants during the interaction:

- A single-question survey that will be given three times during the first attribute evaluation attribute evaluation and two times thereafter. The graph below depicts the moment the first questionnaire will be given to participants.

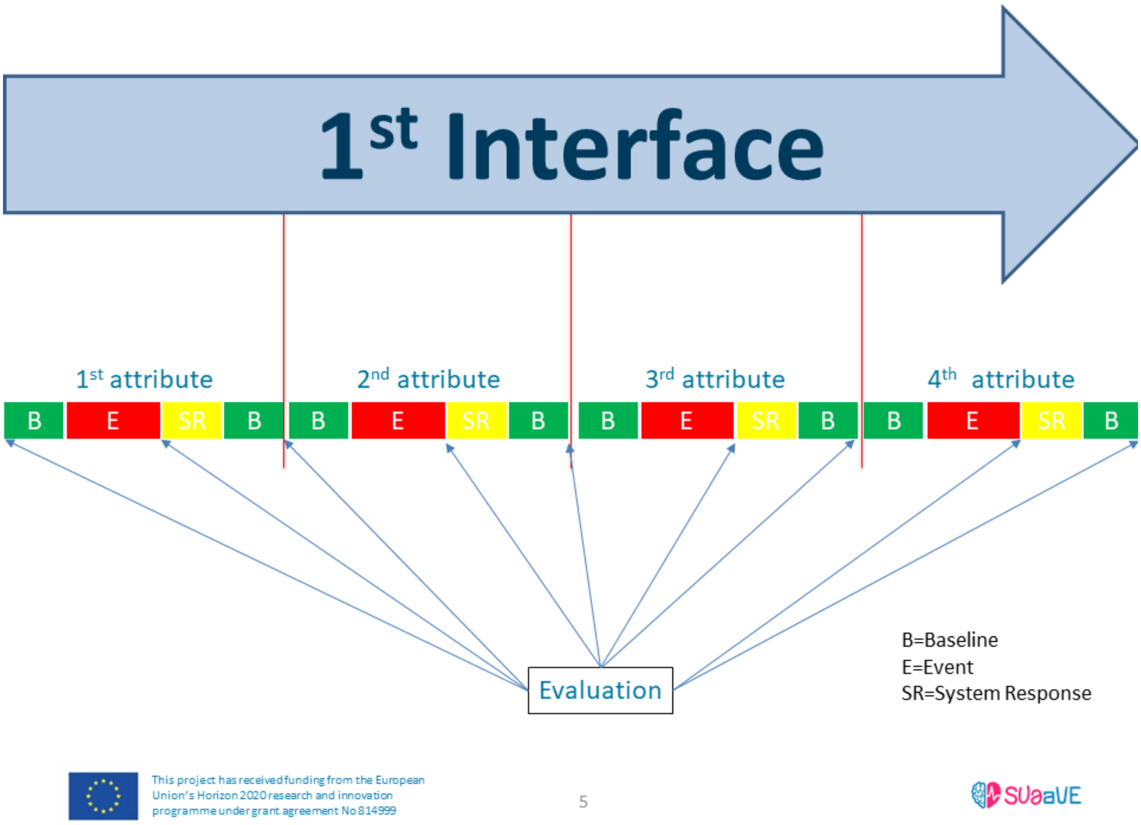

Figure 4 Timeline of each aspect evaluation.

The single question is:

Table 2 After event question

QUESTION	How comfortable did you find the situation?				
ANSWERES	1	2	3	4	5
	Not comfortable at all	Less comfortable than expected	Acceptable, not unpleasant	Comfortable, pleasant	Very comfortable, surprisingly pleasant

- The second questionnaire will be given to the participants at the end of the interaction with each interface. The questionnaire is composed by a multi-choice question and two open questions.

Table 3 After scenario questions

QUESTION	ANSWERS				
Overall, how comfortable did you find the drive?	1	2	3	4	5
	Not comfortable at all	Less comfortable than expected	Acceptable, not unpleasant	Comfortable, pleasant	Very comfortable, surprisingly pleasant
What aspect did you like the most?	Open Question				
What aspect did you dislike the most?	Open Question				

- The third questionnaire will be given to participants at the end of the entire study and aims at comparing the perception of comfort between the two interfaces.

Table 4 After study questions

Which system appeared the most comfortable for you?	☐ Common	☐ Adaptive
What difference, if any, did you experience between the two systems?	**Open question**	
What were the aspects which made the most difference between the two systems?	**Open question**	

A preliminary screening will be performed using the Motion Sickness Susceptibility Questionnaire Short-form (MSSQ-Short) (Goldin, 1998) (Appendix 8.1).

Task

The participants will be asked to perform a task during the first period of baseline. This is particularly useful for two of the aspects to investigate: postural and visual, but it could give advantages to all the methodology of all the attributes under investigation. The task will be designed to prompt the users to look outside the virtual cabin. In the postural comfort investigation, this will be important to have a justification for the upright position of the seat. In the visual comfort it will allow the participants to see the discomfort glare coming inside the cabin. In the other two aspects, this will allow more immersion, as each event is accompanied by a scenario change (e.g. traffic/road works when loud noise is played through the headphones for acoustic comfort).

The task will be decided after piloting, but it will be in the line of counting certain events in the scenario (e.g. the number of yellow cars).

2.2.3 Expected results

As stated in the introduction, the results of the evaluations will help the development and tuning of the ALFRED model and will increase the understanding on the factors influencing users' comfort in CAVs.

The evaluation is also important to have a first comparison between a normal CAV and a CAV implemented with an adaptive system.

2.3 Ride comfort (IDIADA)

2.3.1 Objective

The study of the ride comfort is responsibility of the Vehicle Dynamics (VD) department at IDIADA and will focus on the effect of vehicle motion on passenger's comfort.

As a simplification for this study, the vehicle motion is considered a consequence of the CAV chosen trajectory and of the capability of vehicle motion controller to follow it. Hence, the VD team will aim to validate the influence of the actual trajectory resulted from the CAV trajectory planner and trajectory tracker controller on the passenger dynamic comfort.

2.3.2 Methodology

The methodology of the experiments consists in defining three different variants of the vehicle motion that are the results of three different configurations of the trajectory planner and tracker. The three different configurations will be applied to the same scenario so that all participants will share the same route consisting on the same roads and the same sequence of events. However, each controller configuration will modify the trajectory so that different speeds and levels of accelerations are used during the route.

The actual definition of routes and scenarios is based on capabilities of IDIADA driving simulator and it requires the following materials and preparations.

The configuration of the controller is strictly related to the cost function parameters of a Model Predictive Control (MPC). The cost function will be defined with several terms that aim to consider the level of abruptness of the trajectory, this means, the motion comfort, but also the efficiency of the motion; considered as an addition of the time spent for the displacement and the deviation with respect to the centre of the road lane.

Abruptness / comfort factors:

- Maximum level of lateral acceleration and longitudinal acceleration for braking and acceleration, and difference with those maximum values.
- Maximum values of Jerk (derivative of the acceleration) in lateral and longitudinal direction and difference with those values.

Trajectory efficiency factors:

- Maximum vehicle speed allowed and difference with that value.
- Lateral deviation with respect to centre of the road lane.

Each of the previous factors will be modified to set a controller base configuration, a relax controller configuration and a dynamic controller configuration that will be tested by experts in comfort evaluation.

2.3.2.1 Materials

IDIADA driving simulator

IDIADA driving simulator allows to provide motion feedback to the driver thanks to a nine-degrees-of-freedom moving platform that moves in a 2.5-meter range for lateral and longitudinal motion. The platform is operated using a motion cueing technology that combines the motion of the 9 degrees of freedom, the visuals and some other haptic actuators to provide additional motion cues in favour of a realistic sensation.

Figure 5 IDIADA DiM 250 dynamic simulator

The driving simulator includes seat actuators and an active 5-point seatbelt actuator that provide acceleration cues to the driver. Since such systems are not installed in the passenger seat, the driver seat is used during the experiments and the steering wheel will be removed from the vehicle to provide a closer experience as the one provided by a CAV.

Simulation software

Several platforms are used in order to manage the different models used in the experiment.

VI-CarRealTime® is used to define and run a vehicle model. Because of the nonexistence of a vehicle CAV, IDIADA has selected a compact car model that can be considered representative of a common c-segment vehicle in the European market.

The autonomous driving algorithm coded as part of the planner and the tracker are defined in a Matlab Simulink® environment and compiled to run on a real time machine during the experiments. This algorithm also communicates with VI-CarRealTime® and SCANeR Studio™ to receive positioning feedback of the vehicle within the scenario and to continuously operate steering and powertrain systems. Hence, the algorithm adjusts the trajectory by changing vehicle speed and curvature within the same route and based on the interaction with moving objects.

The scenario is set using SCANeR Studio™ software, which allows the definition of various sequences of scenarios, roads of different types and environments that can include the logic to operate external road agents such as pedestrians and vehicles. The communication between all tools is done using a concurrent machine that allows the real time synchronisation.

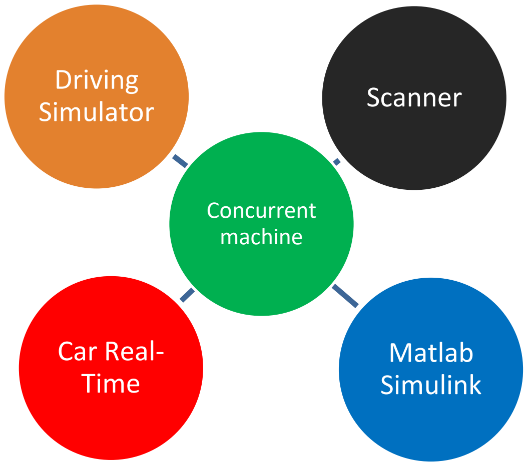

Figure 6 Ride comfort software tools

Biometrical measuring equipment

Given the methodology of the scenario developed for riding comfort, a collaboration was agreed between IDIADA and IBV to include in this study some biometrical measures to validate and train the emotional model (section 2.4). The equipment will be the same as the one used in the IBV studies:

- ECG sensor for obtaining the heart rate (HR) and the heart rate variability (HRV) (Nardelli et al. 2015).
- A skin conductance sensor to record the Electro Dermal Activiy (EDA) (Laparra-Hernández et al. 2009; Zhou et al. 2012).
- Two facial EMG sensors recording the muscle activity of zygomaticus major and corrugator supercilia (Laparra-Hernández et al. 2009).

The characteristics of each sensor will be described in section 2.4.2.1 below.

Scenario design

Even though the initial idea was to run several short scenarios, the phase of experimental design led the decision of using a single longer scenario. There are two aspects that have led to the decision or defining a unique large simulation scenario instead of several scenarios corresponding to short events.

On one side, it has been observed during previous experiences working with the simulator that transitions between simulations runs and standstill situations with disable visuals can increase the probability of motion sickness so it is recommended not to ask a person to participate in consecutive simulations that are not connected within the virtual scenario.

Also, the availability of predefined scenarios in SCANeR Studio™ has made possible the connection of different areas and to define a route that goes through different types of roads and events, which is also considered to be a more realistic scenario. A few predefined scenarios available in SCANeR Studio™ have been tested in order to select concrete sections that can be used in the experiment planned in WP6. Thus, three main areas have been connected: a country road area, a highway area and an urban area. Also, a team of experts evaluated the areas to define a route that is set as basis for the experiment.

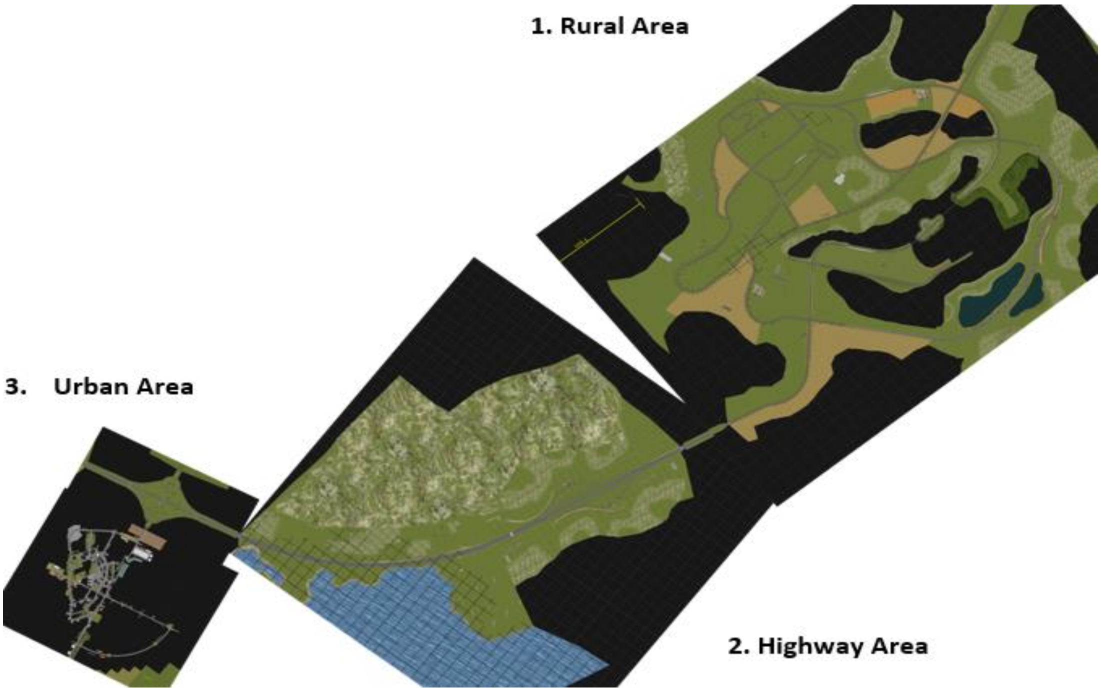

Figure 7 Scenario design

Furthermore, IDIADA VD team is aware of the potential effect of concatenating different type of roads and the difficulties for passengers to set different comfort references along the experiment because of having a bias related to the previous road or section. To reduce the effect of the bias, passengers will be tested in each of the areas independently and randomly. More details are given in the questionnaire and participants section.

In addition, specific events are to be modelled within the scenario so that a large variety of dynamic manoeuvres are encountered. The list of proposed events is provided below.

Table 5 List of events

Rural area		Highway area		Urban area	
1.1	Start	**2.1**	Acceleration	**3.1**	Car intercept
1.2	Tight corner	**2.2**	Overtake	**3.2**	Pedestrian crossing
1.3	Hill slope	**2.3**	Toll gate	**3.3**	Long bump
1.4	Bump	**2.4**	Car follow up	**3.4**	90deg corner
1.5	Roundabout	**2.5**	Weather change	**3.5**	Traffic light
1.6	Pick up (stop-start)	**2.6**	Highway exit	**3.6**	Car blocking
				3.7	Stop

The total duration of the route will be less than 40 minutes and each section should not last more than 20 minutes.

Questionnaires

The purpose of the questionnaires is to collect subjective feedback of the passengers as subjective numerical values that can be used for data correlation, however, numerical values will not be directly asked to the passengers. On the contrary, two different types of questionnaires will be used during the experiment.

Questionnaire A will consist on a list of multichoice questions that will be asked after concrete events during the route. Hence, the data collection frequency will be as per concrete event listed in Table 6. The possible answers will have to be translated into numerical values during the data analysis.

The route and simulation scenario should be defined to give enough time for the passengers to provide an answer without causing any stress.

Table 6 Ride comfort questionnaire A

SECTION	URBAN		EVENT	1.1 Start	
QUESTION	**How comfortable did you find the situation?**				
ANSWERES	1	2	3	4	5
	Not comfortable at all	Less comfortable than expected	Acceptable, not unpleasant	Comfortable, pleasant	Very comfortable, surprisingly pleasant

The participants will be asked to select one out of five possible choices that refer to both a numerical value and a short explanation of the comfort felt. The numerical ratings defined in the answers will range from 1 to 5 and they will be postprocessed to be comparable to the subjective ratings given by the experts during the preparation.

To do this, the three different controller configurations explained in the methodology section will be tuned so that an expert driver rates the relax setting as very good, and the dynamic setting as very poor, according to IDIADA standard subjective scale. Hence, numerical ratings are considered to be between 4 and 8 in the IDIADA experts scale, and to correlate directly with the non-experts' ratings collected during the experiment. The minimum numerical rating of 4 in the expert scale is chosen considering that vehicles with a performance below 4 are unlikely to be found in production. Also, 9 and 10 ratings are saved for exceptional vehicles with additional systems like active suspensions and will not be covered during this experiment.

The equivalence between the IDIADA experts scale and the SUaavE Questionnaire A is given next (Table 7).

Table 7 Equivalence between expert scale and Questionnaire A

IDIADA Experts scale			SuaavE Comfort scale	
RATING	PERCEPTION		RATING	PERCEPTION
1	Impossible to drive			
2	Rejection			
3	Terrible			
4	Very Poor	↔	1	Not comfortable at all
5	Poor	↔	2	Less comfortable than expected
6	Neutral	↔	3	Acceptable, not unpleasant
7	Good	↔	4	Comfortable, pleasant
8	Very good	↔	5	Very comfortable, surprisingly pleasant
9	Excellent			
10	Exceptional			

Questionnaire B will be asked at the end of each area or section and it will aim to collect a general overview of the level of comfort during the section, as well as some additional information that justifies the overall perception. The questionnaire will then consist on one question with a single choice answer and a multichoice answers to explain the reasoning for the previous one.

Table 8 Ride comfort questionnaire B

SECTION	HIGHWAY				
QUESTION	**How comfortable did you the find ride during the section?**				
ANSWERS	Not comfortable at all	Less comfortable than expected	Acceptable, not unpleasant	Comfortable, pleasant	Very comfortable, surprisingly pleasant
QUESTION	**Please mark the motivations for your previous answer**				
ANSWERS	One event was significantly worse than the others and drove my rating	A less comfortable event occurred several times and I got tired of it	Nothing special happened, I rated based on a general perception	I got sick	

Participants and testing plan

A total of 18 participants will take part in the study. The participants will be recruited through the IDIADA employees pool and will be mixed for gender and age. In the recruitment process, people who may be susceptible to motion sickness will be discouraged from participating. The participant will be randomly assigned to each of the sections to be tested and will be asked to evaluate the three different settings of the controller on the same section.

The allocation of each participant to the section and the sequence of controller settings is showed in Table 9.

Table 9 Experimental sequence for participants

	Section	RURAL			HIGHWAY			URBAN		
	Controller setting	**R**	**B**	**D**	**R**	**B**	**D**	**R**	**B**	**D**
Participant	**1**	1	2	3						
	2	3	1	2						
	3	2	3	1						
	4	1	3	2						
	5	2	1	3						
	6	3	2	1						
	7				1	2	3			
	8				3	1	2			
	9				2	3	1			
	10				1	3	2			
	11				2	1	3			
	12				3	2	1			
	13							1	2	3
	14							3	1	2
	15							2	3	1
	16							1	3	2
	17							2	1	3
	18							3	2	1

R	Relax
B	Base
D	Dynamic

2.3.3 Expected results

The results of the evaluations will help the development and tuning of the ALFRED model and will increase the understanding on the factors influencing users' comfort in CAVs.

Hence, the ride comfort experiment expects to provide enough information to validate the following:

- A list of vehicle state variables and objective metrics that correlate with the subjective feedback collected from experiments.
- A list of biological variables that correlate with the subjective feedback collected from the experiments.
- An understanding of the most relevant events and/or sections where the influence of the controller settings can have the major impact on comfort evaluations in the driving simulator.

2.4 Ride comfort (TUM)

2.4.1 Objective

Development and test of ride comfort algorithms is the responsibility of TUM together with the help of IDIADA. The purpose of these tests is to evaluate the comfort algorithm as well as to provide inputs to improve it.

2.4.2 Methodology

Ride comfort algorithms will be based on the observations made by the tools form T3.2. In order to create the ride comfort algorithm, techniques from control theory will be used to invert the relation between vehicle trajectory and emotional state of the passenger (T3.2).

Testing of the ride comfort algorithm will be done in three different stages by making improvements on the algorithm after every stage.

- Numerical simulation in MATLAB

  At first stage, the algorithm will be tested in numerical simulation (MATLAB). For this a standard dynamical model of vehicle (Bicycle model, R. Rajamani 2011) is modelled on MATLAB. The dynamical model of the vehicle takes driving parameters such as input acceleration, and steering angle as inputs. In our case, these inputs are suggested by the comfort algorithm to the model of the vehicle. The outputs of the vehicle model are, among others, trajectory, velocity and acceleration of the centre of gravity of the vehicle. These parameters will be used as stimuli to the emotional model. Based on these stimuli and other parameters, the observer will estimate the emotional state of the passenger and will suggest the driving parameters to the vehicle model, hence closing the loop.

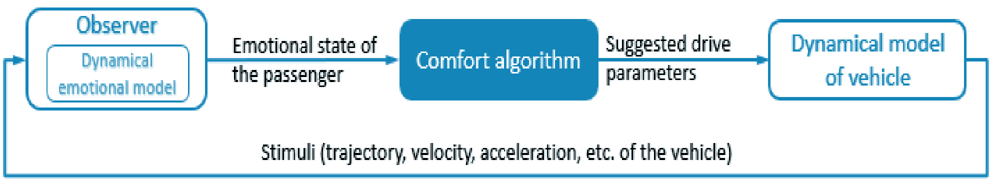

Figure 8 Testing comfort algorithm in simulation

- VHCD + Test setup at TUM

  Simulator setup will be created at TUM with Logitech G29 Steering wheel and V-HCD platform. The comfort algorithm together with the observer algorithm will be connected in loop. At this stage, the algorithm will be tested in this setup with subjects. Subjects will be put in front of the V-HCD simulator and attached with physiological sensors (ECG Sensor, EDA Sensor, Temperature sensor, Respiration sensor, Blood volume pulse sensor, etc.). The emotion observation will be coupled to the decision making of the driving of V-HCD platform.

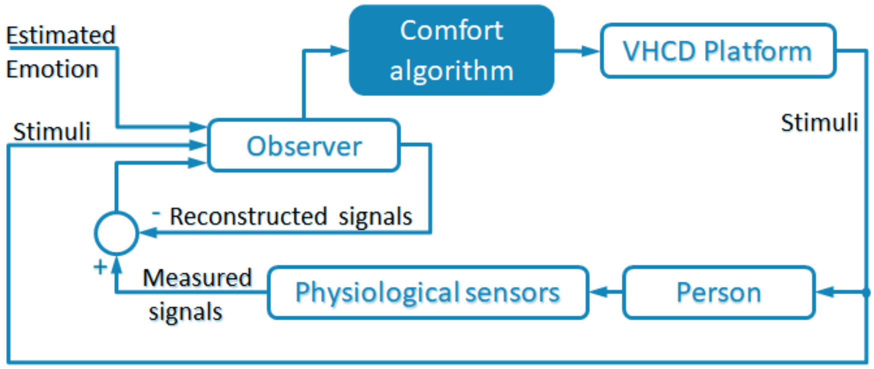

Figure 9 Testing comfort algorithm with VHC-D platform and human in loop

- Dynamic simulator

  In the final stage the algorithm will be tested in an actual testing environment, i.e. on the following simulators

  a. Siemens testbed at TUM

  b. Dynamic simulator at IDIADA

The Siemens test bed at TUM is undergoing the process of adjustment. Testing at IDIADA will be coordinated with IDIADA and IBV.

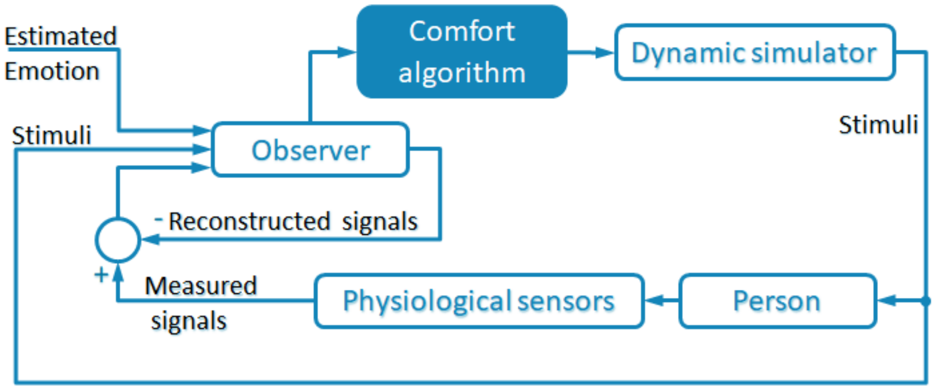

Figure 10 Testing comfort algorithm with dynamic simulator and human in loop

2.4.2.1 Materials

Software and simulators

The first stage of the evaluation will be software based. MATLAB® will be used for this phase.

In the second stage, a low-cost driving simulator running the VHC-D software will be included.

In the third stage two simulators will be used:

- IDIADA dynamic simulator (DiM 250) which is described in section 2.3.2
- Siemens testbed

2.4.2.2 Scenario Design

Driving trajectory will be designed and developed for each case to be tested in the simulation software (MATLAB) for the simulation phase. Different driving scenarios created in the V-HCD platform will be used in the later phase of testing. In addition, the driving scenarios considering the comfort algorithm developed at IDIADA (Section 2.3.2) will be used to test the algorithm in the dynamic simulator at IDIADA.

2.4.2.3 Participants

The tests will be done with 20 adult drivers.

2.4.3 Expected results

The results of evaluations will help the development and improvement of the comfort algorithm and improve the performance of the observer algorithm.

2.5 Emotions (IBV)

2.5.1 Objective

The study of emotions is the responsibility of Instituto de Biomecánica de Valencia (IBV).

The purpose of the first loop of the experimental tests is to obtain a database to train an emotional model to estimate the passenger's state, following a dimensional and a categorical approach.

For the categorical approach, the most relevant emotions and situations will be tested with the users that served as a base for OCC model structure of emotions described in D6.1 aimed to build an emotion prediction framework for the autonomous vehicle.

For the dimensional approach, the goal is to generate a dimensional model from physiological variables to estimate the passenger's state based on the parameter's arousal and valence.

2.5.2 Methodology

2.5.2.1 Materials

Simulator

VHCD + Own Simulator: VHCD simulation software to be connected to the partner's driving simulator cabin.

After the delivery of the **VHCD** scenarios, IBV will evaluate to complement the experiments using their own driving simulator software if needed.

Data gathering equipment

To gather a database to train an emotional model for a reliable estimation of emotions, a number of sensors for the recording of the physiological signals of the participants will be included in the protocols:

- ECG sensor to obtain the heart rate (HR) and heart rate variability (HRV) (Nardelli et al. 2015).
- An skin conductance sensor to record Electro Dermal Activity (EDA) (Laparra-Hernández et al. 2009; Zhou et al. 2012).
- Two facial EMG sensors recording muscle activity of zygomaticus major and corrugator supercilia (Laparra-Hernández et al. 2009).

These signals have been shown to be influenced by the emotional state of the participants. In particular:

- Corrugator supercilii increases the activity when the valence of the person is low.
- Zygomaticus major increases the activity when the valence of the person is high.
- EDA produces fast changes associated to emotional events. These changes are higher for higher arousals.
- HR increases with arousal.
- The low frequency component of HRV decreases with higher arousals.
- The high frequency component of HRV increases with higher valences.

Therefore, all these sensors make it possible to have a good representation of the emotional state of the participants.

Furthermore, FICOSA will participate in this test through camera-based monitoring equipment, together with Affectiva® software, to measure the state of driver in real time, his/her emotional state, and reactions to driving experience.

Questionnaires

As each physiological signal has its own representation, all of them requires to be set in the same proper scale. As we aim at having a continuous representation of the emotional state of the participants (in the domains of valence and arousal), physiological signals will be calibrated with a self-reported emotional status at some specific times.

To this purpose, a questionnaire based on the Self-Assessment Manikin rating scale (SAM) (Geethanjali et al. 2017) will be used (Figure 11). After each scenario the participants will indicate their self-assessment of the emotional state (i.e. valence and arousal) related to specific events happened during the simulation.

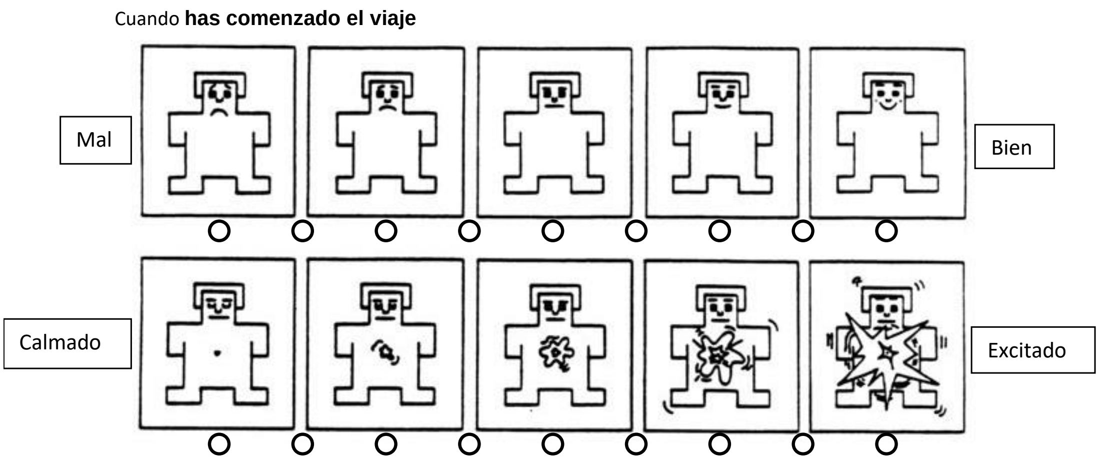

Figure 11 Self-Assessment Manikin rating scale (SAM)

Additionally, a questionnaire based on the OCC model structure of emotions will be used for the self-assessment of the emotion felt and its intensity.

2.5.2.2 Scenario Design

The scenarios for data gathering are designed in order to elicit the following emotion according to OCC model:

- Fear (Safety, high arousal).
- Fear (Stress, medium arousal).
- Distress.
- Anger.
- Relief.
- Satisfaction.

The scenarios built according to D5.1 are detailed in Table 10

Table 10 IBV scenario description

Scenario for data gathering	Description
1 A traffic jam, oh no!	The idea is to measure and assess the emotional response when the passenger experiences a traffic jam when getting late to a destination
2 The anger experience	Other drivers commit an infringement that affecting the passenger drive. For instance, they do not stop at a "stop" signal while the CAV does stop.
3 I feel jealous	Another driver (the driver in front of us) crosses the traffic light in green whereas the CAV passenger does not because the light shifts to red.

4 I don't want to die	Another driver commits an infringement that affects the passenger safety; for instance, a sudden change of lane
5 The accident	The CAV experiences an accident: it stops suddenly with a broken windshield.
6 The fellow man's accident	A car near the CAV experiences an accident, something serious, probably with victims
7 You had it coming	A driver near the CAV drives without respecting the rules, driving very fast and overtaking other cars. The police appear and stop the car.
8 I chose well	The passenger chooses the route between the two that Alfred suggested. They get to destination earlier and save time.
9 Thanks, folks	The incorporation of the CAV is facilitated by the other drivers
10 Long driving	**Long driving modalities couplet experiences**. The idea is to measure and assess differences in the emotional responses in a scenario with opposite driving mode (smooth vs. aggressive driving). We would like to incorporate, if possible, some of the previous short events to this long trip with different aggressive driving levels.
10.1 Long driving: smooth trip	**Smooth driving**: relaxed speed, wide safety envelope, extra distance with other vehicles and soft acceleration and braking, etc.
10.2 Long driving: aggressive trip	**Aggressive driving**: higher speed, tight safety envelope, short distance with other vehicles, higher acceleration and braking, etc.
11 Short driving	**Short traffic modalities experiences**. The idea is to measure and assess differences in the emotional responses in a same scenario but with changes in traffic flow. By **fluid** understand: Few cars around, traffic lights in green, etc. By **dense** understand: Lots of cars, long queues, traffic lights in red, etc
11.1 Short driving: fluid & late	**Fluid traffic** scenario – The passenger gets **late** to destination
11.2 Short driving: Dense & late	**Dense and stressful traffic** scenario – The passenger gets **late** to destination
11.3 Short driving: fluid & on time	**Fluid traffic** scenario - The passenger gets to destination **on time**
11.4 Short driving: Dense & on time	**Dense and stressful** traffic scenario: The passenger gets to destination **on time**

The participants will experience these scenarios in a simulated L4+ vehicle.

The participants' physiological signals will be continuously measured and synchronised with the simulator. The synchronisation is needed to associate the scenario events with the onset of the participants' emotional reactions.

After each scenario the participants will indicate their self-assessment of the emotional state (i.e. valence and arousal) related to specific events happened during the simulation.

The experimental session will be designed in order not to exceed the duration of two hours.

This experimental data (i.e. the physiological signals, SAM questionnaires and labelled with emotion type, arousal and valence) will be the input to train the emotional model.

2.5.2.3 Participants

Fifty volunteers will participate in the first loop.

In order to get useful and rich information from participants they must meet the following requirements:

- Driving licence.
- Age: 18-50 years old.

Also, soft quotas are based considering the following aspects:

- Gender: 50% sample women and 50% men approx.
- Age: 18-25 years old (25% sample) // 26-34 years old (25% sample) // 35-43 years old (25% sample) // 44-50 years old (25% sample).
- Not (50%) // Interested in trying new products (50%).
- Not (50%) // Driving Affinity 50%

2.5.3 Expected results

For the first loop, the expected result will be a data base of physiological signals in the different autonomous driving situations and their self-appraisal of the emotion felt, characterised according to an adapted OCC model.

This database will be used to train the dimensional emotional model. To this purpose, the most appropriate classificatory system will be used. These include: Artificial Neural Networks (ANN), Support Vector Machines (SVM), Relevance Vector Machine (RVM), Linear Discriminant Analysis (LDA) and others (Shu et al. 2018; Jang et al. 2012; Bong, Murugappan, and Yaacob 2013; Mohamad 2005).

2.6 Acceptance and HMI usability evaluation (CRF)

This section describes the CRF methodology to assess HMI usability and to gather a preliminary evaluation on acceptance.

2.6.1 Objective

The main goal of this assessment is to evaluate the usability of SUaaVE HMI in relation to main representative driving scenarios and to obtain a preliminary evaluation of the acceptance of that HMI.

2.6.2 Methodology

To assess the usability and acceptance a qualitative and quantitative method will be used. Usability will be evaluated using specific interaction metrics to obtain data on efficacy, effectiveness and satisfaction of the HMI in the prescribed scenarios: in particular, variables related to each specific scenario (e.g. situation awareness data) will be gathered. Furthermore, variables linked to each specific aspect shown on HMI will be considered (icons, overall framework, scenario-related information, contextual information) like the number of interpretation errors, comprehensibility and intuitiveness of each icon/information and pleasantness of the graphics.

Acceptance will be analysed using a collection of variables linked to that construct. In particular, following mainly the SUaaVE deliverable D1.1 the analysis will focus on several aspects such as perceived trust in CAV, perceived safety of the vehicle, perceived control, perceived pleasure and convenience, perceived usefulness, perceived ease of use, social influence, individual differences in people's perceptions and evaluations of CAV (e.g. psychological individual difference factors, such as values or personality differences, attitude to innovations).

The first loop evaluation will involve participants in L4 driving scenarios. The trials will be performed in two different conditions: without the SUaaVE HMI and with the SUaaVE HMI, to gather what is the impact of the designed HMI on the interaction with the scenarios in terms of situation awareness, comprehension of the status of the driving system and of the possible warnings; this method will also help preliminary understanding the user acceptance, comparing data between the two situations.

2.6.2.1 Materials

Simulator

For this first loop of evaluation, CRF will use the V-HCD Low Cost simulator. In this simulator, the V-HCD, software developed in WP5, runs on SUaaVE specific CRF computers, with SUaaVE specific CRF screens to display the simulated road environment. The CRF mock-up will have an ad hoc plug and play steering wheel and pedals.

Data gathering equipment

All the interaction with the controls (e.g. steering-wheel, pedals, secondary controls) will be monitored in order to study all the behaviours linked to emergency and usual driving scenarios. At the end of each trial usability and acceptance questionnaires/interviews will be used to acquire subjective data.

Questionnaires/interviews

Specific usability evaluation tools will be developed and used during the study. In a first phase, an in-depth interview on situation awareness and on the overall framework of the HMI will be used at the end of each specific scenario. At the end of all the trials a questionnaire focused on the analysis of the intuitiveness and comprehensibility of all the specific HMI aspect will be submitted to the participants.

For the acceptance analysis the questionnaire developed from the Large Scale Surveys (WP1) data will be used.

2.6.2.2 Scenario Design

The first loop will include short scenarios with emergency or sudden events that could impact the autonomous driving experience.

The order of scenarios presented to participants in each phase will be randomised to avoid biases.

The study will follow a within-subject experimental design.

The trials for each participant will last approximately 2h.

2.6.2.3 Participants

In the first loop of the study twelve participants, segmented by age, gender, technological experience and driving expertise of the L0 and L2, will be involved. The recruitment requirements written here will be harmonised with indications emerged from WP1 outcomes.

Participants to CRF first loop experiments will be recruited by an external company to avoid any bias in the involved sample.

2.6.2.4 Expected Results

The described research design will allow to gather at first a preliminary evaluation on the current development of the designed HMI, understanding also its relationship with specific scenarios. An in-depth analysis of each aspect linked to the HMI will also be provided, understanding possible usability problems linked to the overall framework (e.g. different areas, location of the visualisation, intuitiveness of the identified zones) and to the specific features of the HMI (icons, dynamic contextual info visualization, specific scenarios' info). This analysis will give hints for the definition of HMI guidelines to drive the redesign process and mitigate the identified problems.

Moreover, the first loop study will drive to a preliminary evaluation of the driver/passenger acceptance with and without HMI and will suggest changes for the final acceptance questionnaire version.

2.7 Acceptance (RUG)

This section describes the RUG methodology for the evaluation of acceptance.

2.7.1 Objective

The study's objective is to assess acceptance of connected autonomous vehicles among both potential users and other road users in simulator and on-road studies. Several aspects will be assessed: acceptability before the participant has had any experience with connected autonomous driving, acceptance after the experience, perceived characteristics of the vehicle, and emotions related to their experience.

2.7.2 Methodology

Two types of studies will be used for the evaluation of acceptance. A Simulator study and an on-road study using a Wizard of Oz (WoZ) vehicle.

2.7.2.1 Simulator study

2.7.2.1.1 Materials

A slightly different setup will be used for participants who are adult drivers (N = 40) and participants who are other road users (N = 10 pedestrians and 10 other road users). Before participants enter the simulator, they will read a short description of CAV and fill out a pre-test survey assessing acceptability, perceived safety of CAV, trust in CAV technology, and perceived convenience. Next, participants will enter the simulator (i.e. V-HCD with own simulator). After experiencing the scenarios, participants will fill out a post-test survey assessing acceptance, emotions related to their experience, perceived safety, trust in CAV technology, and perceived convenience. Participants will go through two rounds in the simulator, and the same variables will be assessed each time (leading to a total of three measurement points). To assess acceptance from other road users, these participants will be asked to imagine either being a cyclist or pedestrian who has to interact with CAV after they experienced the scenario in the simulator.

2.7.2.1.2 Questionnaires

Acceptability, perceived safety, trust in CAV technology, and perceived convenience will be assessed with the same scales as used in the Large Scale Survey (WP1). Emotions will be measured with a recently developed scale to investigate the role of emotions on innovation adoption. Acceptance will be measured with a new scale based on previous research assessing acceptance of autonomous driving. Two different scales for acceptance will be used; one for potential users (focus on adoption intention), and one for other road users (focus on willingness to interact with CAV).

2.7.2.1.3 Events and Scenarios

In total four scenarios will be used. In the first round, participants will be randomly assigned to either a scenario in a rural environment or in an urban environment. In both scenarios, the following events will take place: roundabout, green traffic light, 90 degrees turn. The goal of these scenarios is to give a neutral impression, allowing to make a distinction in acceptance of CAV in rural and urban environments. For the second round, participants will be randomly assigned to either a 'positive' scenario, in which the vehicle properly adapts to the situation, or to a 'negative' scenario, in which the vehicle fails to adapt to the situation. In the positive scenario the following events will take place: sunlight inside the vehicle, red traffic light, CAV drives slightly beyond the lane line in order to give safe space to an approaching motorbike, green traffic light. In the 'negative' scenario, the following events will take place: approaching orange traffic lights with vehicle stopping, speedbump, a pedestrian on the street without a zebra crossing, the vehicle suffers an accident (minor damage).

2.7.2.1.4 Participants

Participants must meet the following criteria in order to participate:

- Possess a valid driver's license (for the 40 adult drivers only)
- Age: 18-55 years old
- Gender: aiming for a sample of 50% men and 50% women
- Must not get motion sick in the simulator

2.7.2.2 On-road study with a Wizard of Oz vehicle

2.7.2.2.1 Materials

A Wizard of Oz (WOZ) vehicle will be used for the on-road study. WOZ is a manual vehicle used by the driving schools, that is, with vehicle controls on both sides, which gives the impression of an AV to the participant. The participant is seated on the left seat. An expert pilot, seated on the right side, has access to the vehicle controls via a joystick mounted on the door and hidden by a cover and via the pedals on the right side (Figure 12). The steering wheel and the vehicle controls have priority over the joystick. Hence, participants can take over control whenever they wish. The brake pedal on the expert pilot's side can override all other controls for ultimate safety. The vehicle is equipped with an HMI to communicate the vehicle state and transition of control.

Figure 12 The interior of the WoZ

2.7.2.2.2 Questionnaires

The questionnaires used in the simulator study will be used also in the WOZ study. They will be complemented by semi-structured interviews.

2.7.2.2.3 Events and scenarios

As the study will be carried out on public roads, the scenarios and events will be less structured than a controlled study carried in a driving simulator laboratory. The experimental drive will take place in the urban areas around VED (highlighted in red in Figure 13). The neighbourhood includes interaction points with other users, such as traffic lights, intersections, roundabouts, pedestrian crossings, and bicycle paths. This allows testing a variety of situations in real-life conditions.

Figure 13 Map of the events evaluation

2.7.2.2.4 Participants

We will test 20 drivers. Since the experiment will be on public roads, participants will be required to hold a valid driver's license for a minimum of five years and drive regularly, that is, 4-5 times a week.

2.7.3 Expected results

It is hypothesised that the scenarios will influence both the perceived characteristics of CAV, as well as the acceptance of CAV. The results of the experiment will be used to test our model of acceptance, and to make adjustments in the model where needed.

2.8 Acceptance from the CAV/pedestrian interaction point of view (IFSTTAR)

2.8.1 Objective

The objective of the experiment to be implemented by ISFTTAR is the in-depth study of interactions between Connected Autonomous Vehicles (CAVs) and pedestrians during road crossing situations.

Indeed, in the future, CAVs will coexist with conventional vehicles as well as with pedestrians. In order to contribute to a safe traffic system and to increase the public acceptance of CAVs, the one key challenge is therefore their interactions with pedestrians. The study of these interactions is an important issue for SUaaVE, with the aim to design a future empathic AV (i.e., ALFRED) by considering both drivers/passengers and pedestrians' points of view.

To achieve a safe interaction with conventional vehicles, pedestrians and car drivers need to have a shared understanding and awareness of the traffic situation (Endsley, 1995; Bellet et al., 2009). Otherwise, critical conflicts may occur. Misinterpretation of others' intentions is one of the most common causes of accidents involving pedestrians (Habibovic and Davidsson, 2012). It is particularly true in the case of road crossing decision-making. In this context, especially when there are ambiguities in terms of priority rules, pedestrians and car drivers frequently interact using non-verbal communication to clarify their intentions. For instance, Sucha, Dostal and Risser (2017) found that pedestrians' decision to cross, as well as their feeling of safety, are impacted by various signals provided by the driver, such as eye contact, postures, waving hand or flashing lights. In a similar way, Schmidt and Färber (2009) found that pedestrians who want to cross the street look at the approaching vehicle to get acknowledgment from the driver; if the driver returns the eye contact, pedestrians assume that they have been seen and that they have achieved mutual understanding. Similar conclusions were drawn by Rasouli et al. (2017) who show that the most prominent signal to transmit pedestrians' crossing intention is looking or glancing towards the oncoming traffic. In their study, Schneemann and Gohl (2016) also found that, when pedestrians interact with vehicles at low speed, they tend to rely on eye contact with the driver; whereas, at faster speed, they more frequently base their decisions on the dynamics of the vehicle.

All these studies clearly indicate that eye contact between pedestrians and conventional car drivers is a crucial element to manage situational risks, to support pedestrians' decision making, and to increase their safety while crossing roads. Therefore, a key concern regarding CAV introduction on public roads is that automated vehicles may negatively impact interactions with pedestrians because of the changing status of the drivers. With the transfer of control to vehicle automation, pedestrians will not be able to rely on cues from driver behaviours anymore. This could lead to misinterpretation of a CAV's intention and increase the risk of critical conflict. In their study, Malmsten Lundgren et al. (2017) suggested that the introduction of CAV in the urban context may lead to a notable change in how pedestrians experience CAV compared to conventional vehicles. The pedestrians rated eye contact with a driver as promoting safe interaction; whereas apparent driver distraction in CAV (e.g., phoning or reading the newspaper) increased stress for the pedestrians and was associated with an unpleasant interaction.

2.8.2 Methodology

To study how the interaction between pedestrians and CAVs might look like in the future, and how this interaction might be impacted by the CAV behaviours, IFSTTAR will implement two complementary experiments: the first one focusing on the CAV passenger/driver point of view, and the second one focusing on the pedestrian point of view.

2.8.2.1 Materials

The two IFSTTAR experiments will be implemented using the V-HCD software, jointly developed with CVT for SUaaVE, interfaced with a simulator cabin for the first experiment and with Virtual Reality glasses for the second one.

The first experiment (i.e., involving CAV driver/passenger) will be performed on the IFSTTAR dynamic simulator (i.e., Develter "*Pro Evolution"* cabin) to support controlled examination of interactions with simulated pedestrians. Even if the dynamics of this simulator is limited (i.e., based on four small cylinders), it will be possible to simulate different levels of braking (i.e., from smooth to emergency, according to pedestrian behaviours).

The second experiment will be implemented using a Head Mounted Display (i.e., Virtual Reality glasses *HTV VIVE Pro Eye*, integrating an eye tracking system able to collect participants' gaze behaviour). Virtual reality will allow participants to experience different types of interactions with CAVs approaching at various speeds and with diverse ways to stop, while being in a safe and immersive situation. This technical solution will be explored for SUaaVE, but its final use will, however, be dependent of the motion sickness experienced (or not) by the participants when using the VR systems during pre-tests.

2.8.2.2 Questionnaires

This experiment will take place in the "Acceptability (before use) versus Acceptance (after use)" paradigm, initially introduced by Schade & Schlag (2003), and more recently implemented at IFSTTAR to study Autonomous Shuttle acceptance (Distler, Lallemand and Bellet, 2018). With this aim in mind, a similar questionnaire about CAV will first be completed by the participants before starting the experiment, and then filled in a second time after having experienced CAV. From this approach, it will be possible to explore how the CAV, as virtually experienced, will increase or decrease their acceptance of vehicle automation, compared to their initial (i.e., *a priori*) acceptability judgement.

In addition, specific evaluation questionnaires about CAV interactions with pedestrians will be administered, either after each scenario or at the end of the experiment, as described in the next section.

2.8.2.3 Events and scenarios

Regarding the first experiment focused on CAV driver/passenger, participants will experience CAV reactions when facing different pedestrians' road crossing behaviours (i.e., more or less expected and/or critical). For this experiment, two types of driving scenarios will be considered: with or without zebra crossing. Traffic scenarios with zebra crossing will include the two scenarios presented in D6.1 (i.e., general events 2 and 3, as presented in section 1.1) related to CAV interaction with a disabled person in a wheelchair, and with a group of children. Traffic scenarios without zebra crossing will be related to the specific event 8 presented in section 1.1, which will, in addition, be the central focus of the second experiment dedicated to pedestrians' points of view. During each scenario, the behaviour of the CAV interacting with the pedestrian will be fully managed by vehicle automation (i.e., based on own CAV decisions). However, participants will have the possibility to use the horn to warn pedestrians if needed. This way, it will be possible to measure if, and when, they feel that the interaction is becoming dangerous. After each scenario, participants will also have to assess the situational criticality and the reaction of the CAV according to pedestrians' decisions and behaviours, by using continuous Likert scales ranging from 0 to 100. After having experienced all the scenarios, they will be asked to provide suggestions about how an "empathic AV" should react when facing pedestrians and/or should inform them about its decisions and reactions. At this level, the aim will be to collect material for future ALFRED user-centric design with a view to progress towards empathic vehicle automation from the passenger's point of view.

The second experiment will focus on pedestrians' willingness or unwillingness to cross the street in an area without zebra crossing where the yielding rules of CAV are unclear (i.e., corresponding to the specific event 8 presented in section 1.1). The focus will be put on pedestrians' perceived safety and decision to cross, or not, when interacting with a CAV, without effectively implementing the crossing behaviour. For this experiment, participants will be located on the pavement facing a continuous flow of approaching vehicles. First, a randomised number of conventional vehicles will not stop; then a CAV will be approaching. Participants will have to use a joystick to assess the safety *versus* dangerousness of crossing the road in front of the CAV. Depending on the estimated safety level; the more they will assess the crossing behaviour as safe, the further they will have to push the joystick forward. On the contrary, the more the crossing will be assessed as dangerous, the further they will have to pull the joystick backwards. Keeping the joystick in a neutral position during the whole scenario will correspond to an intention not to cross from the beginning. This way, it will be possible to collect their risk assessment in a dynamic way throughout the approaching phase of the CAV (whether or not the CAV stops). For each scenario, different CAV behaviours will be implemented (i.e., in terms of dynamics and ways to stop). Moreover, the CAV occupant, simulated by an avatar, may have different on-board activities (e.g., phoning or discussing with another CAV occupant) or attentive/distracted status, as illustrated in the figure below.

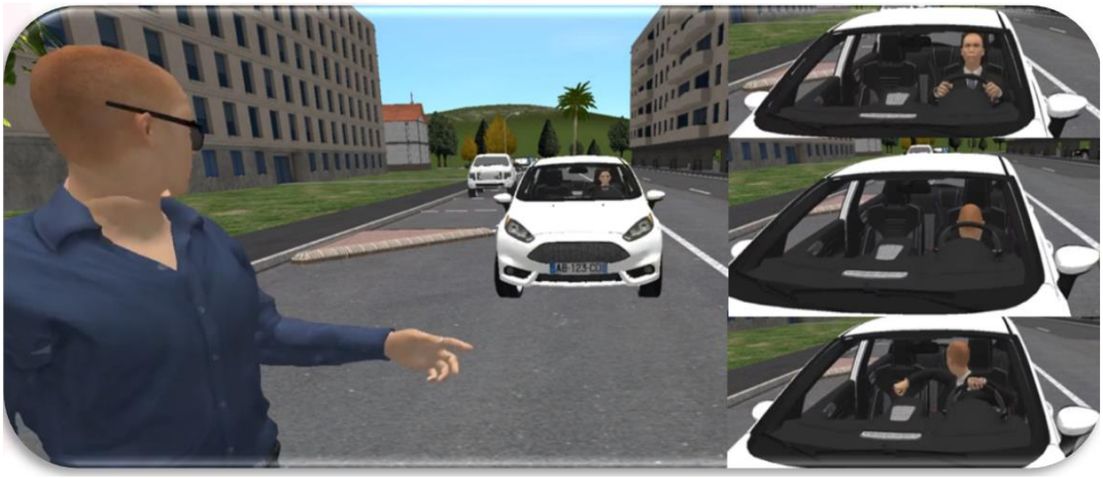

Figure 14 Example of driving scenarios implemented on the V-HCD platform to study interactions between a Pedestrian and CAV occupied by more or less attentive avatars

After each scenario, participants will complete a set of Likert scales to assess their perception regarding the possibility to safely cross the road, or not, their understanding of the CAV intention, and their acceptance of CAV behaviours. At this level, data will be collected from continuous Likert scales ranging from 0 to 100. Theoretical justification for the use of such scales can be found in Bellet, Paris, & Marin-Lamellet (2018).

2.8.2.4 Participants

Twenty-four participants will be involved in these two experiments: 12 as CAV drivers/passengers for Experiment 1 (i.e., Group 1), and 12 as Pedestrians for Experiment 2 (i.e., Group 2).

However, if the duration of each experiment were to last 1.5 hour or less, it would be feasible to involve all 24 participants in both experiments. In this case, a rotating experiment plan would be designed: Group 1 would first perform the driver/passenger experiment and then the pedestrian experiment, and Group 2 would first participate to the pedestrian experiment and then to the CAV experiment. This decision will be made later on, according to the total duration of each experiment assessed from pre-tests.

Regarding their profiles, participants (50% women and 50% men) will be aged between 20 and 55 years old and should have a valid driving license. Group 1 and Group 2 should be fairly similar regarding both mean age and gender balance.

2.8.3 Expected results

From this study, it is expected to further investigate the communication needs of pedestrians in interactions with CAVs in order to support the user-centric design of an external and pedestrian-friendly HMI to be implemented on ALFRED. The interaction principles of this empathic HMI will be to inform pedestrians (and also, accordingly, CAV occupants) about the status and intentions of vehicle automation towards pedestrians, as a replacement for the current driver–pedestrian interactions. During the second loop of the project, a new experiment will be implemented for evaluating its interest for increasing road safety and its empathic benefits regarding both CAV passengers and pedestrians' acceptance.

2.9 Ethical issues (VEDECOM)

2.9.1 Objective

The research on the identification of the ethical challenges related to the deployment of connected automated vehicles and to the acceptability of different decision-making strategies are under the responsibility of VED.

2.9.2 Methodology

This research will be carried out employing two methodologies. The first one is an experimental study that will be conducted using the V-HCD platform. The second one is an online survey.

2.9.2.1 Experimental study

The current research investigates public acceptance of CAV decisions in critical situations using ethics policies inspired by a form of moral claim mitigation. This approach is framed by the Ethical Valence Theory (EVT). The philosophical grounds and the computational aspects of the EVT have been documented in (Evans et al., under review). The ethics policies are based on a moral claim mitigation approach. More precisely, it is assumed that every road user in the AV's immediate environment holds a claim regarding the vehicle's decision, that is, each individual has certain expectations with respect to how the vehicle will take them into account in the decision-making process. The ethics policies pave way to several moral profiles, which define the deliberation process mitigating the claims and the valances of different road users. One should also take into account research showing the social dilemma of users: a preference for a utilitarian AV which sacrifices its driver for the good of a larger number of vulnerable road users is reversed when people consider directly impacted by the decisions of such vehicle as its owner (e.g. Bonnefon et al., 2016). The moral profiles can, thus, vary on a continuum from prioritising the driver to prioritising a vulnerable road user (outside the vehicle), with mitigation strategies in-between. A survey on the acceptability of the moral profiles revealed a preference for moral profiles with a mitigation approach, rather than absolute rules of protection (Dogan et al., under review). In the current study, the aim is to surpass the limitation of a survey study by using a more immersive methodology.

2.9.2.2 Materials

V-HCD platform: The scenarios will be implemented in the VHCD platform. Currently, there is no intention to couple the V-HCD with a simulator platform, that is, participants will not interact with the scenarios. Instead, they will be presented with video clips.

Semi-structured interview grid and questionnaire measures will be used to examine acceptability of the different moral profiles.

2.9.2.3 Scenario design

The primary use case of interest is a critical situation. In D6.1, an immediate accident situation has been proposed for implementation. The outcome behaviour in the main use case will change in each scenario depending on the decision-making strategy described in the moral profile.

An additional use case of secondary interest is a mundane driving situation, which does not involve an imminent danger for any road user in the vehicle's immediate environment, but still requires a higher-level ethical reflection. A use case has been proposed in D6.1. However, the decision to include this use case in the experiments will depend on the eventual number of scenarios that need to be tested for the primary use case.

2.9.2.4 Participants

A total of 45 participants will be tested in two groups, namely, drivers and pedestrians. Participants will be recruited via a specialised agency and be assigned to one of the two experimental groups randomly.

2.9.2.5 Online survey

A focus group study has been carried out as part of T2.1. The aim of the focus groups was to examine the ethical and social issues perceived and identified by potential end-users. Three groups of road users, namely, drivers, pedestrians, and mobility impaired road users, were invited to the sessions. A fourth group consisting of experts was organised. The online survey aims at extending the tendencies observed in the intense focus group sessions to a larger number of public.

2.9.2.6 Materials

The outcome of the focus group study will be used to construct a questionnaire that can be disseminated at large scale. The items will be complemented by the ethical-social issues raised in different expert documents, such as Ethics Guidelines for Trustworthy AI (AI HLEG, 2019) and the final report of the expert group on ethical issues raised by driverless mobility (RTD-Ethics-CAD[1]).

2.9.2.7 Participants

Four hundred participants from France will be recruited via specialised agency.

2.9.3 Expected results

The results of the experimental study on the acceptability of different moral profiles will be used to define the potential ethics policies that could be implemented in ALFRED by excluding the moral profiles that are considered unacceptable or unfair.

The results of the survey study are expected to give an overview of public opinion on ethical issues related not only to the critical situations, but to the deployment of the technology at a broader level. These results will be reported in D2.4.

2.10 HMI concept and Cognitive model (Bordeaux INP)

2.10.1 Objective

The study of the cognitive model and the design of ACE Interface are supported by Bordeaux INP (Cognitics group) and CATIE (Human Centred Systems team). The objectives of the first evaluation loop will be (1) to validate and refine the cognitive model and (2) to confront the interface with a realistic situation. These two objectives have been pooled in order to reinforce the results via a larger sample.

Hypotheses:

- The cognitive load will be higher in complex road traffic situations than in simple situations.
- Hypovigilance will be higher in monotonous traffic situations than in simple situations.
- Fatigue will be higher after inducing a high cognitive load for 10 minutes than in a simple situation.
- Situational awareness will be better in simple situations than in complex or monotonous driving situations.
- Users will evaluate the CAV more acceptable with ACE than without ACE.
- Cognitive load will be lower and situational awareness will be better with the use of ACE than without the use of ACE.
- Cognitive load will be lower and situational awareness will be better with the use of ACE than without, especially as the situation is complex.

2.10.2 Methodology

2.10.2.1 Participants

Thirty participants will be recruited for this study. The sample will be mixed for age and sex. The proposed sample is detailed in Table 11.

Table 11 Participants characteristics

EXPERIENCE LEVEL	MEN	WOMEN	TOTAL
Young driver (5 years > licence > 2 years)	5	5	10
Confirmed driver (licence > 5 years)	5	5	10
Senior driver (age > 60 years)	5	5	10
TOTAL	15	15	30

The criteria for inclusion are as follows:

- Possession of a driving license for at least 2 years and 2500 km travelled
- Regular driving preferably
- French as native language
- Normal eyesight, or corrected with lenses (not corrected with glasses)

The exclusion criteria are as follows:

- Participants having prior knowledge of the experiment.
- Participants with cardiac problems
- Participants with history of traffic accidents
- People with epilepsy / who are photosensitive / claustrophobic / suffer from balance disorders
- Participants with past neurological or psychological problems
- Participants under drugs or medications that affect the sleep-wake cycle

2.10.2.2 Independent variables

- **Complexity of the situation** (5 levels, intra-subject): this variable will be operated by playing on the type of road, the traffic density, the number of lane changes of other vehicles on the motorway, the proximity to other vehicles during these lane changes.
- **Monotony of the situation:** according to the curvature of the terrain, the repetition of sets, the driving task.
- **Interface type**: with VS. without ACE (e.g. daily news), inter-subject variable.

2.10.2.3 Moderating or mediating variables:

- Engagement in the task: Eye-tracking
- Anxiety: Tat-Trait Questionnaire Y-Shape (Spielberger)
- Cybersickness: Questionnaire from the UQO Cyberpsychology Laboratory

2.10.2.4 Materials

Simulator

- A neutral and silent experiment room (about 8m²)
- Low cost simulator:
- Driving seat: Playseat ATGP,
- Logitech G27 driver's station with steering wheel, pedals and gearshift lever.
- Computer with simulation software,
- Simulation software: A.V. Simulation (formerly Oktal) SCANeR Studio™, version 1.8.
- Three 32-inch screens with high resolution (2560 x 1440 pixels)
- V-HCD

Data gathering equipment

- A *Tobii Glasses 2* eye-tracking device (sampling frequency at 60Hz) will be used to investigate
- Cognitive workload: extent of visual field, frequency of fixation zones, distance between two saccades (Chan et al., 2010a; Underwood, 2007; Underwood et al., 2002).
- Hypovigilance: blink frequency, amplitude/velocity ratio, blink duration at 50%, PERCLOS (Picot, 2009).
- Tiredness: number of blinks, scanning of the environment (Silvagni et al., 2020)
- One tablet (to be specified) equipped with ACE interface (ACE condition) and neutral display (to be determined, e.g. a current application)
- Two Axis M1114 cameras and their iSpy software
- RT Maps synchronization system: synchronization of the simulator, the eye-tracker and the video streams. It also processes the data flows in real time.

Questionnaires

Acceptability : TAM3 or UTAUT2 questionnaire

Situation Awareness: Situation Awareness Global Assessment Technique (SAGAT)

Cognitive load

- Cognitive load tolerance - Vulnerability to stress: Weekly Stress Inventory (WSI), (included in Appendix 8.2).
- NASA-TLX questionnaire (included in Appendix 8.3)

Hypovigilance

- Sleep typology: Horne and Östberg's questionnaire, and Jouvet's Calendart (included in Appendix 8.4).

- Propensity to drowsiness: Cognitive Failures Questionnaire and the Epworth Sleepiness Scale (1991), (included in Appendix 8.5).
- Propensity for mind wandering: Mind-Wandering Questionnaire (MWQ)

Tiredness

- Tiredness Scale of Pichot (included in Appendix 8.6).

Cybersickness: Questionnaire sur les cybermalaises Laboratoire de Cyberpsychologie de l'UQO (Translated from Kennedy, R.S.et al., 1993), (included in Appendix 8.7).

2.10.2.5 Scenario design

1. Familiarisation Task

A training session will take place before the experimental tests are carried out. Participants will practice the driving task for at least 15 minutes and then familiarise themselves with the autonomous car system for 10 minutes. This phase will avoid learning bias by allowing the participant to become familiar with the controls and the type of environment. At the end of the training phase, the participant will be in control of the vehicle.

2. Experimental trials

Several phases will succeed one another in order to test the model and the interface in different situations for different cognitive states of the passenger. This will be repeated twice, with and without the interface.

a) Engagement Step

- The purpose of this phase is to record the visual behaviour of the driver while engaged in driving. However, situation awareness will be measured in order to see if the model can detect the presence or not of a good situation awareness.

b) Cognitive Load Step

Due to the inter-individual difference (e.g. vulnerability to stress, expertise) it will be necessary to provoke different levels of cognitive load. The simulator will allow to create five different levels depending on the traffic flow, the type of vehicles, the number of lane changes on motorways and their proximity, the type of road and the more or less demanding task. The conditions will be counterbalanced in order to control the order effect.

c) Hypovigilance Step

Monotony will be induced by:

- a repetitive environment: flat terrain; pine trees on each side of the road at a rate of two per second at a speed of 80km/h; pine trees will be visible up to the point of the horizon
- a 20-minute uneventful driving. In this condition, the driver will have to follow a lane at a constant speed (80km/h), without changing gears, changing lanes and using car features (e.g. turning signals, mirrors).
- Few road infrastructure variations: no red lights, no stopping, little traffic; no T-intersection or perpendicular bends, the road will be essentially straight with few curves.

d) Tiredness step

Cognitive tiredness will be induced by a continuous cognitive overload of 10 minutes. The overload will be induced by driving in a city, with demanding tasks (left turn intersection, hairpin bend), high flow of cars, presence of trucks.

2.10.2.6 Measurements (dependent variables)

2.10.2.7 Procedure

This participation will be individual, carried out in the simulator room of the ENSC in the East building with constant luminosity. All the experiments will be supervised by the same two experimenters. After a presentation of the objective of the study, the participant will be asked to answer the questionnaire on cybersickness. The result of the cybersickness questionnaire will discern whether the participant will be allowed to participate or not. The cockpit will be presented to the participants and they will be asked to take a seat on the chair and make adopt a comfortable position.

After that, the eye-tracking calibration phase will be carried out. The experiment will be divided into two tasks: familiarisation tasks and test tasks. After each task, the participants will evaluate their cognitive sub-status with the help of questionnaires.

2.10.2.8 Results and data

The following data will be collected

<u>Model inputs:</u>

Involvement in the task: 60Hz sampling, gaze position with x_norm and y_norm data. These data will be filtered according to the degree of confidence and analysed to obtain the necessary metrics.

Anxiety: 5 per participant, for a total of 150 scores.

Situation awareness: 4 per participant, for a total of 120 scores.

Cognitive load tolerance: 1 per participant for a total of 30 scores.

Subjective cognitive load: 1 per participant for a total of 30 scores

Sleep typology: 2 per participants for a total of 60 scores

Propensity to drowsiness: 1 per participant for a total of 30 scores

Propensity for wandering of mind: 1 per participant for a total of 30 scores

Subjective tiredness: 1 per participant for a total of 30 scores

Driving performance: 35Hz sampling of the 7 variables. The analysis of these data is a statistical study of the differences between the means as a function of the experimental conditions (with or without interface). There will also be an input to the model.

Acceptability: 2 per participant (TAM3 or UTAUT2 score). Each dimension will be analysed

Cybersickness: 5 per participant for a total of 150 scores. The data will not be analysed, they are used as exclusion criteria.

3 ETHICS AND DOCUMENTATION

As the evaluation will include studies with users, ethical approval has to be obtained. Each partner is responsible for its own ethical approval, through the means considered opportune. In this section, the process of each partners will be described.

3.1 IDIADA

In order to obtain ethical approval and given the fact that IDIADA does not have an ethic committee, the company collaborates with the University of Tarragona: "Universitat Rovira i Virgili". The university is provided with the detailed study experimentation, the information sheet and consent form that will be given to participants

3.2 IBV

Instituto de Biomecánica de Valencia (IBV) has already obtained the approval of Universidad de Politécnica de Valencia ethical committee, university where IBV is located, for the experiment in SUaaVE framework involving experimental test with users, including first and second loops of experiments.

3.3 TUM

TUM will receive ethical approval through their own ethical committee.

3.4 RUG

RUG will submit their ethical application through the Faculty of Psychology at the University of Groningen.

3.5 IFFSTAR

The agreement of the IFSTTAR ethical committee (i.e. *CRPH; Comité pour les Recherches impliquant la Personne Humaine*) has been obtained in October 2019 for implementing this experiment at IFSTTAR, in accordance with the French and the European Ethical laws.

3.6 CRF

CRF will act as an Ethical Committee, as written in the Part 4-5 of the proposal. CRF, as an FCA Group company, adopted a Code of Conduct and acts in compliance with internal policies and applicable national and European/international law.

3.7 Bordeaux INP/CATIE

Bordeaux INP and CATIE will seek ethical approval from the IMS (Laboratoire de l'Intégration du Matériau au Système) ethics committee.

3.8 VEDECOM

VEDECOM will obtain approval on data privacy, GDPR compliance and on all the study documents from the VEDECOM legal department.

4 COMMON METHODOLOGY

As described in the previous sections, each partner of the project chose the methodology that best fitted the aim of the evaluation.

However, some common methodologies have been chosen to widen scope of the applicability of the results. In this sense, a shorter questionnaire on acceptance has been developed and will be given to all the participants in all the evaluations. This will be useful to have more data on the acceptance of the models and guide their improvements in the next phase.

5 IMPACT

The impact of this deliverable and the content it explains can be divided in two categories: the impact on the project and the impact on society/work culture.

5.1 Impact on the project

The work underlying what is described in this deliverable impacts the project in several levels. First of all, it describes the method for the evaluation of the aspects composing ALFRED, which will help each partner to develop their models in an accurate way. Second, the collection of all the methods in one deliverable will help the partners understand how each entity is tackling the evaluation task, allowing the mutual learning and promoting discussion and advancements.

5.2 Impact on society

This deliverable and the work it describes can be used by entities outside the project as guidelines for evaluations of new systems and new models. In-depth research is currently being carried out on autonomous vehicles and new systems, this document could give an example to researchers and OEMs on how the process of evaluation should be carried out. Moreover, the results of the first loop of evaluations will provide new information on aspects that should be taken into consideration when developing a system for autonomous vehicles.

Once ALFRED is developed, this deliverable will serve as demonstration on the thorough process it undertook to be implemented. Enhancing its validity at the time it will be considered by OEMs.

6 CONCLUSION

This deliverable is related to task 6.1 of the SUaaVE project. It is a "living document", which is to say that it will continue to be updated throughout the first phase of the project. The principle aim of the deliverable was to define the framework for the validation of project hypothesis and the first iteration test (T6.2) which will be begin M12.

The deliverable gave a detailed explanation of the methodology chosen by each partner for the evaluation activities of the project. More in details, the first loop of evaluation was described, with a detailed explanation divided for each aspect under evaluation and the partner responsible for it. The objective, methodology and expected results were listed and described.

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8 APPENDIXES

8.1 Motion Sickness Susceptibility Questionnaire Short-form (MSSQ-Short)

Motion Sickness Susceptibility Questionnaire Short-form (MSSQ-Short)

1. Please State Your Age .... Years. *2.* Please State Your Sex (tick box) **Male** [ ] **Female** [ ]

This questionnaire is designed to find out how susceptible to motion sickness you are, and what sorts of motion are most effective in causing that sickness. Sickness here means feeling queasy or nauseated or actually vomiting.

Your CHILDHOOD Experience Only (before 12 years of age), for each of the following types of transport or entertainment please indicate:

3. **As a CHILD (before age 12), how often you Felt Sick or Nauseated** (tick boxes):

	Not Applicable - Never Travelled	Never Felt Sick	Rarely Felt Sick	Sometimes Felt Sick	Frequently Felt Sick
Cars					
Buses or Coaches					
Trains					
Aircraft					
Small Boats					
Ships, e.g. Channel Ferries					
Swings in playgrounds					
Roundabouts in playgrounds					
Big Dippers, Funfair Rides					
	t	0	1	2	3

Your Experience over the LAST 10 YEARS (approximately), for each of the following types of transport or entertainment please indicate:

4. **Over the LAST 10 YEARS, how often you Felt Sick or Nauseated** (tick boxes):

	Not Applicable - Never Travelled	Never Felt Sick	Rarely Felt Sick	Sometimes Felt Sick	Frequently Felt Sick
Cars					
Buses or Coaches					
Trains					
Aircraft					
Small Boats					
Ships, e.g. Channel Ferries					
Swings in playgrounds					
Roundabouts in playgrounds					
Big Dippers, Funfair Rides					
	t	0	1	2	3

8.2 Weekly Stress Inventory (WSI) - Inventaire du stress hebdomadaire

Exigence Mentale
Dans quelle mesure des opérations mentales et perceptives ont-elles été requises (par ex : penser, décider, calculer, se rappeler, regarder, chercher, etc)? La tâche était-elle plutôt facile ou difficile, simple ou complexe, abordable ou exigeante?

○ ○ ○ ○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6 7 8 9 10

Exigence Physique
Dans quelle mesure des opérations physiques ont-elles été requises (par ex tourner, superviser, activer, soutenir, fixer, etc.) ? Avez-vous trouvé la tâche plutôt facile ou difficile, lente ou rapide, lâche ou vigoureuse, reposante ou ardue ?

○ ○ ○ ○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6 7 8 9 10

Exigence temporelle
Quelle quantité de pression liée au temps à cause du rythme ou de l'allure des tâches ou de l'apparition des éléments de la tâche avez-vous ressenti? L'allure était-elle lente et tranquille ou rapide et frénétique ?

○ ○ ○ ○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6 7 8 9 10

Effort
Quelle a été la difficulté d'accomplir (mentalement ou physiquement) la tâche avec un niveau de performance tel que le vôtre?

○ ○ ○ ○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6 7 8 9 10

Performance
Quelle réussite vous attribuez-vous en ce qui concerne l'atteinte de buts de la tâche fixés par l'expérimentateur (ou par vous-même) ? Dans quelle mesure êtes-vous satisfait de votre performance dans l'accomplissement de ces buts ?

○ ○ ○ ○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6 7 8 9 10

Frustration

8.3 Nasa-TLX

Au cours de la tâche, quel sentiment d'être peu sûr de vous, découragé, irrité, stressé et agacé avez-vous ressenti contrairement au fait d'être sûr de vous, satisfait, content, détendu et complaisant ?

○ ○ ○ ○ ○ ○ ○ ○ ○ ○

1 2 3 4 5 6 7 8 9 10

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Exigence physique Performance

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Performance Frustration

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Effort Performance

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Effort Exigence physique

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Exigence physique Exigence temporelle

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Exigence temporelle Effort

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Exigence temporelle Frustration

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Performance Exigence temporelle

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Exigence temporelle Exigence mentale

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Exigence physique Frustration

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Performance Exigence mentale

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Exigence mentale Exigence physique

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Exigence mentale Effort

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Frustration Exigence mentale

Cliquez sur la composante qui a le plus participé à la charge mentale dans la tâche

Frustration Effort

8.4 Horne and Östberg's questionnaire

1

ÊTES-VOUS COUCHE-TÔT OU COUCHE-TARD ?
Questionnaire de typologie circadienne de Horne et Ostberg

Instructions :

1. Lisez attentivement chaque question avant d'y répondre.
2. Répondez à toutes les questions.
3. Répondez aux questions dans l'ordre.
4. Vous pouvez répondre aux questions les unes indépendamment des autres. Ne revenez pas en arrière pour vérifier votre réponse.
5. Pour les questions à choix multiples, mettez une croix devant une seule réponse. Pour les échelles, placez une croix au point approprié.
6. Répondez à chaque question aussi sincèrement que possible. Vos réponses et *les résultats de ce questionnaire resteront confidentiels*.
7. Faites les commentaires que vous jugerez nécessaires dans la partie prévue sous chaque question.

Si vous viviez à votre rythme (celui qui vous plaît le plus), à quelle heure vous lèveriez-vous étant entièrement libre d'organiser votre journée ?

5h | 6h | 7h | 8h | 9h | 10h | 11h | 12h

< *5* >< *4* >< *3* >< *2* >< *1* >

Si vous viviez à votre rythme (celui qui vous plaît le plus), à quelle heure vous mettriez-vous au lit étant entièrement libre d'organiser votre journée ?

20h | 21h | 22h | 23h | 0h | 1h | 2h | 3h

< *5* >< *4* >< *3* >< *2* >< *1* >

Si vous deviez vous lever à une heure précise, le réveil vous est-il indispensable ?

- pas du tout ☐ *4*
- peu ☐ *3*
- assez ☐ *2*
- beaucoup ☐ *1*

Dans des conditions adéquates (environnement favorable, sans contraintes particulières, etc.), à quel point cela vous est-il facile de vous lever le matin ?

- pas facile du tout ☐ *1*
- pas très facile ☐ *2*
- assez facile ☐ *3*
- très facile ☐ *4*

Réseau Morphée

Comment vous sentez-vous durant la demi-heure qui suit votre réveil du matin ?

- pas du tout éveillé ☐ *1*
- peu éveillé ☐ *2*
- relativement éveillé ☐ *3*
- très éveillé ☐ *4*

Quel est votre appétit durant la demi-heure qui suit votre réveil du matin ?

- pas bon du tout ☐ *1*
- pas bon ☐ *2*
- assez bon ☐ *3*
- très bon ☐ *4*

Comment vous sentez-vous durant la demi-heure qui suit votre réveil du matin ?

- très fatigué ☐ *1*
- relativement fatigué ☐ *2*
- relativement en forme ☐ *3*
- très en forme ☐ *4*

Quand vous n'avez pas d'obligations le lendemain, à quelle heure vous couchez-vous par rapport à votre heure habituelle de coucher ?

- rarement ou jamais plus tard ☐ *4*
- moins d'1heure plus tard ☐ *3*
- 1 à 2 heures plus tard ☐ *2*
- plus de 2 heures plus tard ☐ *1*

Vous avez décidé de faire un sport. Un ami vous suggère de faire des séances d'une heure et ceci deux fois par semaine. Le meilleur moment pour lui est de 7 à 8 heures du matin. Ne considérant que le rythme qui vous convient le mieux, dans quelle forme penseriez-vous être ?

- bonne forme ☐ *4*
- forme raisonnable ☐ *3*
- vous trouvez cela difficile ☐ *2*
- vous trouvez cela très difficile ☐ *1*

A quel moment de la soirée vous sentez-vous fatigué au point de vous endormir ?

20h 21h 22h 23h 0h 1h 2h 3h

< 5 >< 4 >< 3 >< 2 >< 1 >

Réseau Morphée

Vous souhaitez être au meilleur de votre forme pour un examen qui vous demande un effort intellectuel considérable durant deux heures. Vous êtes entièrement libre de le passer quand vous le souhaitez, quelle est l'heure que vous choisiriez ?

- de 8 à 10 heures	☐	6
- de 11 à 13 heures	☐	4
- de 15 à 17 heures	☐	2
- de 19 à 21 heures	☐	0

Si vous alliez au lit à 23 heures, à quel niveau de fatigue seriez-vous ?

- pas du tout fatigué	☐	0
- un peu fatigué	☐	2
- relativement fatigué	☐	3
- très fatigué	☐	5

Pour une raison quelconque, vous vous couchez quelques heures plus tard que d'habitude, mais vous n'êtes pas obligé de vous lever à une heure précise le lendemain. Laquelle des propositions suivantes choisirez-vous ?

- vous vous réveillez comme d'habitude et vous ne vous rendormez plus	☐	4
- vous vous levez comme d'habitude mais vous vous recouchez par la suite	☐	3
- vous vous réveillez comme d'habitude mais vous vous rendormez	☐	2
- vous vous réveillez plus tard que d'habitude	☐	1

Pour effectuer une garde de nuit, vous êtes obligé d'être réveillé entre 4 et 6 heures du matin. Vous n'avez pas d'obligation le lendemain. Laquelle des propositions suivantes vous convient le mieux ?

- vous n'irez au lit qu'une fois la garde terminée	☐	1
- vous faites une sieste avant et dormez après la garde	☐	2
- vous dormez bien avant et faites une sieste après la garde	☐	3
- vous dormez ce qu'il vous faut avant d'effectuer la garde	☐	4

Vous devez faire deux heures de travail physique intense, mais vous êtes entièrement libre d'organiser votre journée. Laquelle des périodes suivantes choisirez-vous ?

- de 8 à 10 heures	☐	4
- de 11 à 13 heures	☐	3
- de 15 à 17 heures	☐	2
- de 19 à 21 heures	☐	1

Vous avez décidé de faire un sport. Un ami vous suggère de faire des séances d'une heure et ceci deux fois par semaine. Le meilleur moment pour lui est de 22 à 23 heures. Ne considérant que le rythme qui vous convient le mieux, dans quelle forme penseriez-vous être ?

- bonne forme	☐	1
- forme raisonnable	☐	2
- vous trouvez cela difficile	☐	3
- vous trouvez cela très difficile	☐	4

Réseau Morphée

Supposez que vous pouvez choisir les horaires de votre travail. Admettons que vous travaillez 5 heures par jour et que votre travail est intéressant et bien payé. Quelle séquence de 5 heures consécutives choisirez-vous ?

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	0

MINUIT **MIDI** **MINUIT**

< *1* >< *5* >< *4* >< *3* >< *2* >< *1* >

A quelle heure de la journée vous sentez-vous dans votre meilleure forme ?

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	0

MINUIT **MIDI** **MINUIT**

< *1* >< *5* >< *4* >< *3* >< *2* >< *1* >

On dit parfois que quelqu'un est un « sujet du matin » ou un « sujet du soir ». Vous considérez-vous comme celui du matin ou du soir ?

- tout à fait un sujet du matin	☐	*6*
- plutôt un sujet du matin	☐	*4*
- plutôt un sujet du soir	☐	*2*
- tout à fait un sujet du soir	☐	*0*

CALCULEZ VOTRE SCORE

Au dessus de 70 vous êtes	TOUT A FAIT DU MATIN
Entre 59 et 69 vous êtes	DU MATIN MODERE
Entre 42et 58 vous êtes	NEUTRE
Entre 31 et 41 vous êtes	DU SOIR MODERE
Moins de 30 vous êtes	TOUT A FAIT DU SOIR

Réseau Morphée

8.5 Epworth Scale

ANNEXE 4

Échelle de Somnolence d'Epworth

Johns MW (Sleep 1991; 14:540-5) «A new method for measuring day time sleepiness : The Epworth Sleepiness Scale.Sleep».

La somnolence est la propension plus ou moins irrésistible à s'endormir si l'on est pas stimulé.
(Nb. Ce sentiment est très distinct de la sensation de fatigue qui parfois oblige à se reposer).
Le questionnaire suivant, qui sert à évaluer la somnolence subjective, est corrélé avec les résultats objectifs
recueillis par les enregistrements du sommeil.
Prénom : .... Nom : .... Date de naissance:.................................
Date du test :................................ Ronflement? .... oui .... Non..........
Vous arrive-t-il de somnoler ou de vous endormir (dans la journée) dans les situations suivantes :
Même si vous ne vous êtes pas trouvé récemment dans l'une de ces situations, essayez d'imaginer comment
vous réagiriez et quelles seraient vos chances d'assoupissement.
notez **0** : si ***c'est exclu.*** «Il ne m'arrive jamais de somnoler: **aucune** chance,
notez **1** : si ***ce n'est pas impossible.*** *«Il y a un petit risque»*: **faible** chance,
notez **2** : si ***c'est probable.*** *«Il pourrait m'arriver de somnoler»*: chance **moyenne**,
notez **3** : si ***c'est systématique.*** *«Je somnolerais à chaque fois»* :**forte** chance.
- Pendant que vous êtes occuper à lire un document 0 1 2 3
- Devant la télévision ou au cinéma 0 1 2 3
- Assis inactif dans un lieu public (salle d'attente, théâtre, cours, congrès ...)...................... 0 1 2 3
- Passager, depuis au moins une heure sans interruptions, d'une voiture ou d'un transport en commun (train, bus, avion, métro ...) 0 1 2 3
- Allongé pour une sieste, lorsque les circonstances le permettent 0 1 2 3
- En position assise au cours d'une conversation (ou au téléphone) avec un proche............... 0 1 2 3
- Tranquillement assis à table à la fin d'un repas sans alcool 0 1 2 3
- Au volant d'une voiture immobilisée depuis quelques minutes dans un embouteillage 0 1 2 3

Total (de 0 à 24) :
- En dessous de 8: vous n'avez pas de dette de sommeil.
- De 9 à 14: vous avez un déficit de sommeil, revoyez vos habitudes.
- Si le total est supérieur à 15: vous présentez des signes de somnolence diurne excessive. Consultez votre médecin pour déterminer si vous êtes atteint d'un trouble du sommeil. Si non, pensez à changer vos habitudes.
NB. Ce questionnaire aide à mesurer votre niveau général de somnolence, il n'établit pas un diagnostic.
Apportez le à votre médecin pour discuter avec lui des causes et des conséquences de ce handicap dans votre vie.

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8.6 Tiredness Scale

ANNEXE 5

Échelle de fatigue de Pichot **(pour l'évaluation de la Fatigue)**
(Ref. « Echelles et outils d'évaluation en médecine générale » J. Gardenas et Coll. -Le Généraliste-Supplément du N°
2187; Mars 2002).

La fatigue est une sensation d'affaiblissement physique ou psychique qui survient normalement à la suite d'un effort soutenu, et qui impose la mise au repos.
On parle de fatigue pathologique lorsque la personne se sent handicapée par rapport à son
niveau de forme habituel pour effectuer ses activités quotidiennes.

L'échelle subjective de Pichot a été proposée pour mesurer l'importance de ce handicap.
Prénom : .... Nom : .... Date de naissance:.................................
Date du test :.................................. Traitement en cours ....
....
.

Parmi les huit propositions suivantes, déterminez celles qui correspondent le mieux à
votre état en affectant chaque item d'une note entre 0 et 4:

(0 = pas du tout; 1= un peu, 2 = moyennement, 3= beaucoup, **4** = extrêmement)
- Je manque d'énergie.. 0 1 2 3 4
- Tout demande un effort.. 0 1 2 3 4
- Je me sens faible à certains endroits du corps......... 0 1 2 3 4
- J'ai les bras ou les jambes lourdes 0 1 2 3 4
- Je me sens fatigué sans raison.................................. 0 1 2 3 4
- J'ai envie de m'allonger pour me reposer.................. 0 1 2 3 4
- J'ai du mal à me concentrer 0 1 2 3 4
- Je me sens fatigué, lourd et raide 0 1 2 3 4

Total (sur 32) :..............................

Un total supérieur à 22 est en faveur d'une fatigue excessive, vous souffrez peut être d'un sommeil inefficace.
NB. Ce questionnaire aide à mesurer votre niveau général de Fatigue et n'établit pas de diagnostic.
Apportez le à votre médecin pour discuter des causes et des conséquences de cette fatigue dans votre vie.

8.7 Cybersickness questionnaire

Questionnaire sur les cybermalaises*

Laboratoire de Cyberpsychologie de l'UQO
(Traduit de Kennedy, R.S.et al., 1993)

Numéro______________________________ Date_____________________

Consignes : Encerclez à quel point chaque symptôme ci-dessous vous affecte présentement.

1. Inconfort général	Pas du tout	Un peu	Modérément	Sévèrement
2. Fatigue	Pas du tout	Un peu	Modérément	Sévèrement
3. Mal de tête	Pas du tout	Un peu	Modérément	Sévèrement
4. Fatigue des yeux	Pas du tout	Un peu	Modérément	Sévèrement
5. Difficulté à faire le focus	Pas du tout	Un peu	Modérément	Sévèrement
6. Augmentation de la salivation	Pas du tout	Un peu	Modérément	Sévèrement
7. Transpiration	Pas du tout	Un peu	Modérément	Sévèrement
8. Nausées	Pas du tout	Un peu	Modérément	Sévèrement
9. Difficulté à se concentrer	Pas du tout	Un peu	Modérément	Sévèrement
10. Impression de lourdeur dans la tête	Pas du tout	Un peu	Modérément	Sévèrement
11. Vision embrouillée	Pas du tout	Un peu	Modérément	Sévèrement
12. Étourdissement les yeux ouverts	Pas du tout	Un peu	Modérément	Sévèrement
13. Étourdissement les yeux fermés	Pas du tout	Un peu	Modérément	Sévèrement
14. *Vertiges	Pas du tout	Un peu	Modérément	Sévèrement
15. **Conscience de l'estomac	Pas du tout	Un peu	Modérément	Sévèrement
16. Rots	Pas du tout	Un peu	Modérément	Sévèrement

* Les vertiges sont vécus comme une perte de l'orientation par rapport à la position verticale.
** L'expression « conscience de l'estomac » est habituellement utilisée pour désigner un sentiment d'inconfort sans nausée.

Dernière version : Mars 2013

***Version originale : Kennedy, R.S., Lane, N.E., Berbaum, K.S., & Lilienthal, M.G. (1993). Simulator Sickness Questionnaire: An enhanced method for quantifying simulator sickness. *International Journal of Aviation Psychology, 3*(3), 203-220

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