AutoHabLab

Addressing Design Challenges in Automotive UX

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Human Centred Design
Human Centred Design

Involves techniques which empathise with, interact with, and stimulate people, achieving an understanding of their needs, desires and perspectives which often transcends that which they themselves knew and realised.

Leads to products, systems and services which are physically, perceptually, cognitively and emotionally intuitive.
### Some Human Centred Design Tools

<table>
<thead>
<tr>
<th>Facts Regarding Humans and Society</th>
<th>Capture of Meanings and Needs</th>
<th>Simulation of Possible Futures</th>
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</thead>
<tbody>
<tr>
<td>- Anthropometric data sets and models</td>
<td>Verbally based</td>
<td>- Role playing</td>
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<tr>
<td>- Biomechanical data sets and models</td>
<td>- Ethnographic interviews</td>
<td>- Focus groups</td>
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<td>- Psychophysical data sets and models</td>
<td>- Questionnaires</td>
<td>- Co-design</td>
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<tr>
<td>- Cognitive data sets and models</td>
<td>- Day-in-the-life analysis</td>
<td>- Experience prototypes</td>
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<tr>
<td>- Emotional data sets and models</td>
<td>- Cognitive task analysis</td>
<td>- Para-functional prototypes</td>
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<tr>
<td>- Psychological data sets and models</td>
<td>- The five whys</td>
<td>- Real fictions</td>
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<tr>
<td>- Sociological data sets and models</td>
<td>- Conceptual landscape</td>
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<tr>
<td>- Philosophical data sets and models</td>
<td>- Think aloud analysis</td>
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</tbody>
</table>

Non Verbally based

- Game playing
- Cultural Probes
- Visual journals
- Error analysis
- Fly-on-the-wall observation
- Customer Shadowing
- Body language analysis
- Facial coding analysis
- Physiological measures
- Electroencephalograms
Human Centred Design Process

- meaning/metaphor elicitation
- co-design
- construct
- technical specification
- prototyping
- customer testing

(time)
The current trend is a reduced emphasis on matters of “physics”, which are now minimum requirements, and a greater emphasis on matters of “metaphysics”.
Challenges Arising From The Context

Response (n=20 participants) to the question “what would you like now?”

Giuliano, L., Germak, C., and Giacomin, J. 2017, Effect of Driving Context On Design Dialogue, 8th Int. Conf. on Applied Human factors and Ergonomics (AHFE), 17 to 21 July, Los Angeles, California, USA.
Challenges Arising From Human Nature

- role of emotion

- attention narrowing under intense emotion (Easterbrook effect)

- fading affect bias

- errors caused by encoding to, and recalling from, long term memory

- gaps caused by the event horizon
Challenges Arising From Previous Experience

When you were in a car…

Describe a time you were in a car and something happened that made you respond emotionally.

Where specifically did the story happen? (i.e. motorway? country road? car park? etc.)

What did you do? (Tell us what were your actions)

What or who were involved in the story? (i.e. intelligent technology, animals or human?)

At the time of the story, you felt…

(Choose as many as you like)

- Anger
- Fear
- Disgust
- Happiness
- Sadness
- Surprise
- Other
Challenges Arising From Previous Experience

Themes from the emotion survey (n=245 respondents):

- Theme 1. Road violations (i.e. Overtaking, Insulting, Forcing to give way)
- Theme 2. Car accident (i.e. Bumping into another car or obstacle, Memory of the accident)
- Theme 3. External environment conditions (i.e. Heavy traffic, Road infrastructure, Other road users)
- Theme 4. Infotainment (i.e. Music on the radio, News from the radio / calls)
- Theme 5. Car hardware system malfunction (i.e. Warning alerts, Broken down, Partial system malfunction)
- Theme 6. Abrupt manoeuvring of driver (i.e. Sudden stop, Sudden road entry, Sudden lane changing)
- Theme 7. Lack of awareness in driving (i.e. Mistakes/confusion, First time driving in conditions)
- Theme 8. Driving with a loved one (i.e. Driving with family, Driving with friends)
- Theme 9. Generous driving behaviour on the road (i.e. Getting help, Giving way)
- Theme 10. Driver's in-car experience (i.e. Experience with car features, Feeling relaxation)
- Theme 11. Car software system malfunction (i.e. Navigation/GPS error, Flat phone battery)
- Theme 12. Driving landscape (i.e. Seeing incredible scenery, Night driving with stars)
- Theme 13. Usability (i.e. Adjusting angels of mirrors)
Virtual Workshops: a new tool for automotive HCD
Addressing Emotion
Ekman (1971) concluded that at least some emotions are “basic”, “universal” or “innate”. It is now generally accepted that there are at least six basic emotions which are of rapid onset and which last only a few seconds at a time.
Real-Time Emotion Measurement
Emotion Road Circuit

Drive time of 40 minutes

Distance of 15.2 miles

City of 4.5 miles (23%)

Country of 4 miles (26%)

Highway of 6.7 miles (44%)
Driving Emotion Study

Naturalistic Setting
- Familiar Environment
  - In people’s own cars
- Familiar Route
  - Route familiar to Participant
- Min. 20 participants covering different driver types
- Real-time FEA of 6 basic emotions and facial action units

Partially-controlled Setting
- Unfamiliar Environment
  - In JLR car
- Predefined Route
  - Emotion road circuit
Driving Emotion Statistics: setting

Naturalistic Setting
Average Of One Emotion Event Every 2 Minutes

- SADNESS: 2%
- DISGUST: 28%
- FEAR: 0%
- SURPRISE: 26%
- ANGER: 5%

Partially Controlled Setting
Average Of One Emotion Event Every 1.5 Minutes

- SADNESS: 9%
- DISGUST: 22%
- FEAR: 2%
- ANGER: 20%
- SURPRISE: 21%

JOY: 39%
Driving Emotion Statistics: roads

Average emotion rate for all roads was 2.16 facial expressions per minute.

<table>
<thead>
<tr>
<th></th>
<th>Total Time (Sec)</th>
<th>Total FE</th>
<th>FE/Sec</th>
<th>Relative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway</td>
<td>16340</td>
<td>465</td>
<td>0.028</td>
<td>0.80</td>
</tr>
<tr>
<td>City</td>
<td>19163</td>
<td>687</td>
<td>0.036</td>
<td>1.00</td>
</tr>
<tr>
<td>Country</td>
<td>10273</td>
<td>434</td>
<td>0.042</td>
<td>1.19</td>
</tr>
</tbody>
</table>
Driving Emotion Statistics: causes

**City**
- 14% NAVIGATION ALERT
- 11% ENJOYING CAR
- 10% NO CAUSE ASSIGNED
- 7% HIGH TRAFFIC DENSITY
- 7% CHECKING NAVIGATION
- 5% INTERACTION WITH PERSON

**Highway**
- 23% CHECKING NAVIGATION
- 17% HIGH TRAFFIC DENSITY
- 6% NO CAUSE ASSIGNED
- 5% BAD ROAD CONDITIONS
- 5% ROUNDABOUT
- 4% NAVIGATION ALERT

**Country**
- 27% BAD ROAD CONDITIONS
- 13% LIMITED VISUAL FIELD
- 9% CHECKING NAVIGATION
- 4% CAR PASSING CLOSE
- 3% NO CAUSE ASSIGNED
- 3% SUN BLINDING DRIVER
Addressing Co-Design
Communication Requirements

For people in automobiles the real-time communication is effected by the screen size, screen resolution and sound volume of the in-car interface.

Tests of achievable combinations of these three parameters were thus performed in a driving simulator.

<table>
<thead>
<tr>
<th>Screen Options</th>
<th>Size (inches)</th>
<th>Pixels*</th>
<th>Speaker Options</th>
<th>Volume**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.8 x 5.8</td>
<td>854 x 480</td>
<td>1</td>
<td>55 dB</td>
</tr>
<tr>
<td>2</td>
<td>5.6 x 4.2</td>
<td>320 x 180</td>
<td>2</td>
<td>67 dB</td>
</tr>
<tr>
<td>3</td>
<td>4 x 3</td>
<td></td>
<td>3</td>
<td>77 dB</td>
</tr>
</tbody>
</table>

*images at 25 frames per second

**sound at driver’s left ear.
Communication Requirements

For each of the nine combinations (3 screens x 3 volumes) each participant (n=24) was asked to drive in a driving simulator while performing secondary tasks:

- follow a route involving five road junctions which was presented on screen;
- detect and count the ball passes which occurred in a thirty second sports video presented on screen;
- detect and count a specific word from within a two minute speech emitted from the speaker;

Measurements were made of the cognitive workload (WL*), perceived media quality (PMQ**) and error rate (ER***) at the end of each secondary task.

The secondary tasks were repeated three times for a total driving time of approximately 45 minutes.


***Rümelin, S. and Butz, A. 2013, How to make large touch screens usable while driving, Proceedings of the 5th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI13), ACM, October 28th to 30th, Eindhoven, The Netherlands, pp. 48-55.

The optimal combination was:
- screen size: 7.8 x 5.8 inches
- frame resolution: 854 x 480 pixels
- speaker volume: 77 dB
Participants (n=24) were grouped into couples with one person assigned the role of driver and the other the role of collaborator. The driver was located in the driving simulator while the collaborator was located in a control room.

Each couple was connected through either a voice+video channel or by a voice channel alone, and was asked to perform tasks as a team while driving a city route:

- **co-navigation task where both driver and collaborator had a map (10 minutes);**
- **co-navigation task where only the collaborator had a map (10 minutes);**
- **riddle resolution task where the couple talked their way through a problem of logic (10 minutes)**

Self-reported copresence, reported others copresence and social presence* were measured at the end of each task.

Telepresence Requirements

Greater telepresence was reported in the case of the voice channel alone.
Co-Design Requirements: general

Open Questions -> to stimulate creative responses

Narrow Questions -> to ground responses via a predetermined experience or concept

Experience Questions -> to ground responses via past experiences of the individual

Descriptive Questions -> to solicit longer and more detailed articulations

Co-Creation Questions -> to facilitate brainstorming
# Co-Design Requirements: specific automotive

<table>
<thead>
<tr>
<th>Discussion Context</th>
<th>Discussion Target</th>
<th>Discussion Rhetoric</th>
<th>Discussion Objective</th>
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<tbody>
<tr>
<td>Road And Traffic Conditions</td>
<td>Interaction With The Vehicle Or With Other Agents</td>
<td>Unexpected Events, Errors Or Emergencies</td>
<td>Component</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Q1</th>
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Automotive Habitat Laboratory
Modem
Streams data live back to the control room.

Microsoft Surface
behind driver’s seat controls all software, including iMotions.

Cameras
Driver camera
iMotions camera
Interior camera
Dashboard camera

Three Raspberry Pis
CAN bus outputs via USB to the Raspberry Pis, which transfer the data to the communications laptop via an IP network.
Looking To The Future
Human Centred Design Of Autonomous Vehicles

- Vehicle Concept Metaphors and Architectures
- Communication with Occupants and Road Users
- Vehicle Emotion Management Systems
- Trust Strategies and Brand Strategies
- Ethical Design Framework
- Customer Acceptance Tests
- Inclusivity and Disabled Mobility
- Traffic Management Systems
- Infrastructure and Urban Planning for Autonomy
- Co-design Frameworks
Thank you.