Using participatory design workshops to identify what feels natural about using a car's secondary controls

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An exploratory design workshop was undertaken with ten ordinary car drivers using four qualitative activity-based methods rarely used in published automotive literature. The aim was to understand what characterises 'natural feeling' interaction between drivers and their secondary, comfort and infotainment controls – at a time of rapid change in the design of dashboards and increasing automation. 'Think Aloud' testing, flexible modelling, focus groups and future scenarios were conducted in an immersive automotive environment using real automotive controls and a parked car. Thematic analysis suggested 11 distinct characteristics of natural feeling interaction based around issues of control, physicality, usability and humanlike assistance. Drivers may find controls feel more natural to use if they are designed to meet as many of these 11 themes as possible. The study also showed that qualitative practical creative workshop techniques can be a valid companion to traditional usability and performance testing.

Background

With cars now mostly satisfying customers' functional requirements, and the prospect of the intelligence within the dashboard exceeding that of the driver, there is increasing research into drivers' overall user experience (Eckoldt et al 2013). Technology is changing the nature and with increasing automation, 'joy of driving' may soon be less relevant than 'joy while driving' (Meschtscherjakov et al, 2015). Research which seeks qualitative human-centred understanding of these interactions between drivers and their cars has always been rare but has increased a little in recent years. This is distinct from traditional ergonomic research into driver-car interaction which has tended to focus on 'human performance' measurement, typically measuring mathematically how well drivers perform with different interface configurations and innovations, rather than how they feel about them (Giacomin and Ramm, 2013). While the design and physical feel of the primary driving controls is relatively fixed for engineering and safety reasons, cars' secondary, comfort and infotainment controls currently exhibit a wide array of forms, actions and metaphors that may confuse or overwhelm the driver (Wynn et al, 2013). It is these controls on which we focused our attention, referred to as 'secondary controls' in the rest of the article. In particular, what design features of secondary controls feel natural or not?

Naturalness of interaction

Naturalness of interaction can seem a rather blurred and subjective notion, but it offers potential to increase drivers' user satisfaction, emotional connection and even safety (Giacomin and Ramm, 2013). It might conceivably also give rise to increased sales in a competitive marketplace. Definitions however vary over what might constitute 'naturalness' between a driver and their car. Some writers have used the term 'natural' to describe exclusively gestural interactions. However we feel that gestures have some very practical limitations in the moving car cabin. Human-computer interaction designers may think of natural interaction in terms of familiar sensory-motor action transfer (Bérard and Rochet-Capellan, 2015), or the 'natural feeling' the user experiences, similar to the feeling a concert violinist might get when playing a piece from memory on their favourite violin (Wigdor and Wixon, 2011). To avoid contrived or leading definitions, in this study we simply defined naturalness as whatever felt natural to the driver.

Method

One major challenge we faced in trying to understand what aspects of secondary control use feel natural, is that these driver-car interactions are generally private and silent. They are rarely vocalized or shared with other people in the car, so qualitatively understanding them is quite difficult for the passive observer. Perhaps because of this, qualitative driver-car interaction research is often based on 'self-reports' generated through interview or questionnaire after simulated or rather contrived interactions. Such self-reports may be prone to post rationalizing and 'people pleasing' biases.

Indeed many design researchers would say that the most useful insights can only be discovered through co-creation and 'making' activities with users (Ylirisku and Buur, 2007). Therefore we sought out various exploratory research methods that could capture drivers' feelings about interactions whilst using real automotive controls in a collaborative, practical, scenario based workshop setting, in order to better understand these interactions and what makes them feel natural or not.

The four methods we used were drawn from the fields of product design, human-computer interaction and usability testing, and were:

1. Think Aloud – in which users are asked to say out loud the thoughts going through their minds while using a product. If they fall silent, the observer may prompt them. (Makri et al, 2011).
2. Flexible Modelling – in which users are given a kit of physical artifacts and a practical task, and asked to create representations relevant to the research topic. (Martin et al, 2012).
3. Focus Groups – in which users are asked to explore in depth their feelings about product use in small facilitator-directed groups. (Stewart and Shamdasani, 2014)
4. Future Fictions – in which users are asked to immerse themselves in a realistic future scenario in order to gauge how they might feel during future product interactions that they may have difficulty imagining otherwise. (Ylirisku and Buur, 2007).

These methods were chosen from a survey of over 100 human centred design methods by shortlisting to a checklist of desired and essential criteria.

Workshop design

A small scale, in-depth workshop was designed which used all the methods above with five groups of two drivers in an automotive laboratory setting. The drivers were all ordinary drivers recruited to encompass a mixture of car types and car usage patterns. Very young and very old drivers were excluded in case of perceptual limitations.

The dashboard was chosen as a focus for all the exercises because it is familiar to all drivers, it is the principal location of most of a car's secondary controls, and the dashboard's size and two-dimensionality made it suitable for workshop exercises with non experts. Central to the workshop was the presence of a large selection of automotive secondary controls placed on a table. These were sourced from various car manufacturers and different eras from 1980s to present. They were chosen to represent all the common input actions (mainly push button, rocker switch, digital click, rotary dial, toggle and slide).
A collection of materials samples and common household controls (like light switches and calculators) were also provided to provide alternative stimulation.

The laboratory was arranged using guidelines of Contextual Inquiry (Beyer and Holtzblatt, 1999) which is based around contextual faithfulness. Therefore all components used in the modelling exercises were sourced from real cars, and a real test car was parked inside the laboratory so that two of the exercises could take place inside it. Each workshop took about three hours and the schedule was as according to Tab. 1. The sessions were audio recorded, photographed, and transcribed in full.

Fig. 1
Table containing some of the automobile and non-automobile components.

Tab. 1
Session Plan for the workshops showing the mix of activities and questions

Exercise (duration)	Method (location)	Activity	Typical prompt questions used
1. Operating loose controls (15 minutes)	Think Aloud (standing)	Participants asked to operate various loose car controls	How do they feel, look and sound? Which are most suitable for a car?
2. 'Natural dashboard' creation (25 minutes)	Flexible Modelling (table)	Imagining and creating a future 'natural feeling dashboard' from loose controls on a tabletop template.	What does each element represent? What feels natural about it? Was there anything else you would have liked to include? Explain choices.
3. 'Unnatural dashboard' creation (15 minutes)	Flexible Modelling (table)	Breaching exercise. Assembling the most 'unnatural feeling dashboard' on the same tabletop template.	What does each element represent? What feels unnatural and why? How would you describe the differences to the natural dashboard?
4. Operating controls in a real car (25 minutes)	Think Aloud with Focus Group style discussion (in-car)	Operating various controls in the real car. Looking for expectations and effects of context on perceptions.	How does it feel? What do you imagine the car is doing in response? What feels natural or unnatural about it? How would being in a moving car affect that?
5. Future fiction ('speaking car') (25 minutes)	Future Fiction with Think Aloud style probing (in-car)	Audio-based future fiction. Car appears to be voicing six messages. Participants asked how each felt and what thoughts occur.	How did it feel to hear that? Did it feel natural? What would be your reply? How could an intelligent future car still behave *naturally*?

The five workshop sessions

Before the first exercise there was a 'sensitisation' on a topic tangentially related to the research question (memories of first driving experiences) in order to relax participants and start them speaking openly about their perceptions of operating a car.

First, participants also used the various loose automotive controls in a Think Aloud exercise (1) to describe the various perceptions and sensations they experienced as they used them. Next, in the Flexible Modelling exercise (2) the participants were asked to use the stock of controls to create a very 'natural feeling dashboard' on a tabletop template that had been pre-drawn in masking tape. Participants were then asked to explain their choice of components, materials and layouts and were prompted for naturalness related perceptions. Immediately following this, participants were asked to create their most 'unnatural feeling dashboard' (3) on the same template. This was based on the theory of 'breaching' (Garfinkel, 1967) which aims to explore people's reactions to violating social norms. It is believed that only by 'breaching' what is considered normal, do people notice the 'unwritten rules' around interaction. Next, a further Think Aloud session (4) took place in the parked car inside the laboratory which was powered up so that all its secondary controls functioned. The final future fiction exercise (5) asked participants to imagine their future intelligent car was talking to them. Six messages concerning mechanical issues, route guidance and diary management were played on a speech synthesizer while participants were seated inside the car.

Fig. 2
Operating various loose controls by hand during a 'Think Aloud' session

Immediately after each message, participants were asked how it felt and what felt natural or unnatural about it.

Observations from the workshop

Some raw observations were made during the workshop that were directly related to the topic of interest – i.e. what aspects of secondary controls feel natural or unnatural. They will be presented below before the results of the full analysis.

'Natural dashboard' creation

Much activity and creative reflection was observed in the 'natural dashboard' task. The stock of automobile controls and materials were used to represent physical concepts as well as more abstract feelings and sensory preferences. 'Natural feeling dashboards' tended to be sparse, simple, convenient and assistive (e.g. helping people with their daily tasks like phone charging and drink holding), with large mechanical controls (e.g. swivel air vents) and predominantly matt and dark textures.

'Unnatural dashboard' creation

Much activity and collaboration was noted and several participants commented that it was easier to specify what aspects and situations felt unnatural than what aspects felt natural. By enquiring as to the semantic opposite of these 'unnatural' descriptors, an additional source of naturalness characteristics was captured. 'Unnatural feeling dashboards' tended to feature small buttons (e.g. from calculators), overly complicated settings (e.g. a window control that required dialling in an exact opening percentage), unnecessary alphanumeric readouts, loose wires, rough or metallic textures (potentially injurious), distractions (e.g. bright flashes or reflections) but few mechanical controls.

Fig. 3
An example 'natural feeling dashboard' creation, showing a 'sparse' layout focused around the driver, with dark and matt materials

Results of the thematic analysis

A higher level analysis was carried out on the full transcripts from all the sessions, using Thematic Analysis (Braun and Clarke, 2006) which looked for patterns and similar themes in the verbal data. There were 179 basic beliefs or perceptions about naturalness of secondary controls. Using various sorting techniques and independent researchers, these clustered into 11 discrete themes.

1 Familiarity and Predictability

Controls that are familiar, recognisable, safe, predictable, and not alarming tend to feel natural. This facet of naturalness can also develop through repeat use or learning over time.

2 Driver in Full and Ultimate Control

Interactions that make the driver feel fully in control, and the task feel easy, tend to feel natural. The driver should always be 'in the loop' and have the last word over automation.

3 Communication with Reality

It feels natural for a car's controls to communicate certain 'real-world' information about the road, its mechanicals and environment. It is a reminder that driving is an interaction with the real world and not a game.

4 Weighty Physical Sensations

Generally, natural feeling controls tend to be perceived as heavy or weighty (rather than light feeling), tight feeling (rather than loose), direct (not indirect), precise, robust, solid, and not too hard or shiny.

5 Cabin Comfort and Sanctuary

A comfortable, private, protected, relaxing, aesthetically pleasing cabin with good visibility seems to be associated with natural-feeling interaction.

6 Uncluttered Cabin Architecture

A natural feeling dashboard is simple and uncluttered, its distinctive controls logically located and discernable by touch alone, all ergonomically optimised for fingers and arms. Unintended inputs are rare. Mechanical switches and dials may feel more natural than digital clicks.

7 Low Visual Demand

Natural feeling controls demand very little visual attention away from the core driving

Fig. 4
An example 'unnatural feeling dashboard' creation, showing many small buttons, rough textures, and 'distracting' feedback as well as many controls far away from the driver.

Car's controls

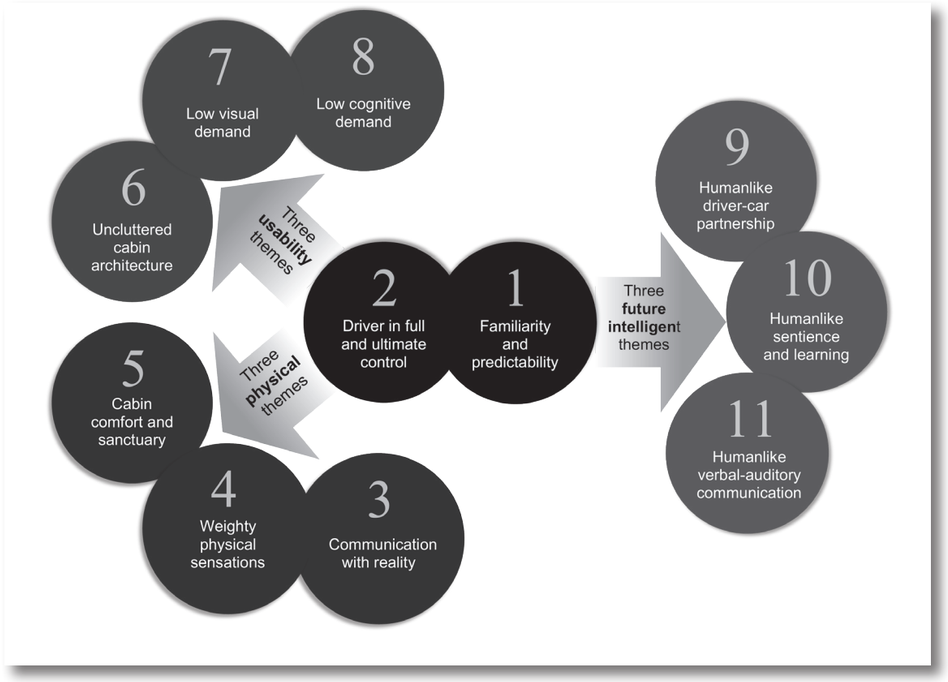

Fig. 5
The final 11-themed model of driver-automobile naturalness derived from thematic analysis

task. Non-visual channels are used for feedback such as switch sound or feel, and ideally it will be obvious that the desired outcome is being enacted without looking. Analogue dials or pictographic displays are preferred to alphanumeric.

8 Low Cognitive Demand

Natural feeling controls do not cause cognitive distraction from the driving task. Minimal information and choices are presented on the move. Control shape and action is logically mapped to its function and response. Control actions are obvious or clearly labelled.

9 Humanlike Driver-Automobile Partnership

An intelligent future car may feel natural if it behaves as, and is perceived as, a helpful co-driver - informative, polite, helpful and proactive.

10 Humanlike Sentience and Learning

An intelligent future car may feel natural if it senses, processes and understands things in a humanlike way. It would remember preferences, predict things, adapt to change and may exhibit empathy, social awareness and emotional awareness.

11 Humanlike Verbal-Auditory Communication

An intelligent future car's secondary controls may feel natural if they can be operated by the human voice. The car will understand natural language perfectly, and speak only when spoken to, keeping its messages brief, timely, clear and polite.

Arranging these 11 themes according to similarities gave the model in Fig. 5.

Discussion

The results provide potentially useful guidance on what might be perceived as natural and unnatural in the design of future cars' secondary controls. In automotive interface design, this is a time of rapid change, with huge expansion in car connectivity and computerised assistance. Maintaining a natural feel may require retention of some solid feeling physical buttons, dials and levers on dashboards, despite their already digital infrastructure. Such improved 'tangibility' of digital interfaces is seen by some as an important goal in more natural feeling human computer interaction (Dourish, 2004) to avoid confusion and errors, yet in the automotive domain, manufacturers' future concept vehicles often exhibit glass cockpits showing no physical secondary controls at all. Retaining some physical controls may also enhance overall familiarity and predictability – which appear important in overall perceived naturalness. Usability seems vital in a car, to enhance naturalness by reducing driver workload and minimising distraction and confusion. Usability in a car is predominantly about keeping the driver's attention and eyes focussed on the road. A natural feeling cabin architecture would support this by being uncluttered, optimised for weighty 'feel' and exploration by touch, thoughtfully designed around the human body. There are suggestions that, in the future, the car should behave as a likeable human co-pilot – helpful, polite, concise and contextually aware – listening to and learning from the driver.

The study also suggests that using hands-on co-creation techniques with ordinary drivers, rarely seen in published literature, can be a fruitful way of understanding otherwise 'private silent' driver-car interactions. Qualitative techniques such as Think Aloud, artefact modelling and fictional scenarios should play an important complimentary role in understanding drivers' underlying perceptions, meanings and metaphors – which are unlikely to be revealed through traditional automotive ergonomic testing.

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