The Design Journal
An International Journal for All Aspects of Design

ISSN: 1460-6925 (Print) 1756-3062 (Online) Journal homepage: http://www.tandfonline.com/loi/rfdj20

An Exploratory Design Workshop to Elicit what Feels Natural when Interacting with an Automobile's Secondary Controls

Simon Ramm, Joseph Giacomin, Alessio Malizia & Bennett Anyasodo

To cite this article: Simon Ramm, Joseph Giacomin, Alessio Malizia & Bennett Anyasodo (2017): An Exploratory Design Workshop to Elicit what Feels Natural when Interacting with an Automobile's Secondary Controls, The Design Journal, DOI: 10.1080/14606925.2018.1395228

To link to this article: https://doi.org/10.1080/14606925.2018.1395228

Published online: 22 Nov 2017.

THE DESIGN JOURNAL

REPRINTS AVAILABLE DIRECTLY FROM THE PUBLISHERS

PHOTOCOPYING PERMITTED BY LICENSE ONLY

Check for updates

An Exploratory Design Workshop to Elicit what Feels Natural when Interacting with an Automobile's Secondary Controls

Simon Ramm, Joseph Giacomin and Alessio Malizia
Human Centred Design Institute, Brunel University, Uxbridge, UK

Bennett Anyasodo
Jaguar Land Rover Research, Warwick University, Coventry, UK

ABSTRACT Exploratory design workshops were conducted using five participatory methods with 10 automobile drivers in order to understand what characterizes natural-feeling interaction with automobiles' secondary, comfort, and infotainment controls. Hands-on, artefact-focused methods were selected for their potential to understand these familiar but characteristically silent and private interactions. 'Think Aloud' analyses, flexible modelling, breaching, focus

The Design Journal DOI: 10.1080/14606925.2018.1395228

Routledge
Taylor & Francis Group

groups, and ‘future fictions’ were conducted in an immersive automotive workshop using real automotive controls. Some sessions took place in a parked automobile. Grounded theory thematic analysis suggested a framework with 11 themes: Familiarity and predictability, Driver in full and ultimate control, Communication with reality, Weighty physical sensations, Cabin comfort and sanctuary, Uncluttered cabin architecture, Low visual demand, Low cognitive demand, Humanlike partnership, Humanlike sentience and learning, and Humanlike verbal–auditory communication. Natural-feeling interaction may be more likely perceived in an automobile, system, or individual control that exhibits as many of the 11 themes as appropriate.

KEYWORDS: automobile secondary controls, driver–automobile interaction, natural interaction, exploratory design workshop, Think Aloud, flexible modelling, mixed methods, thematic analysis

Introduction

Some evidence suggests that automobile drivers’ current user experience may be perceived as confusing and cluttered (e.g. Meschtscherjakov et al. 2011), distracting (Wynn, Richardson, and Stevens 2013), or disconnected (Walker, Stanton, and Young 2006). At the same time, technology is fundamentally changing the nature of the driving task (Banks, Stanton, and Harvey 2014a) through ‘drive-by-wire’ and a plethora of intelligent driver support systems which together could almost be described as a ‘self-driving car’. While familiar primary controls determine the automobile’s motion, secondary controls play an important role supporting safe driving, for example by operating wipers, indicators, and the horn. A growing number of *infotainment* controls now access information and entertainment, for example GPS, music, internet, and telephone, while a variety of comfort controls keep occupants comfortable and alert, for example ventilation, seat adjustment, and mood lighting (Kern and Schmidt 2009).

Successful interface design requires deep understanding of how humans perform tasks (Jaspers 2006) but the private, silent, and often unconscious execution of driver–automobile interactions makes this very challenging. Perhaps as a result, cognitive and quantitative approaches to driver–automobile interaction dominate the literature, essentially ‘human performance testing’, but these risk underestimating human emotions, moods, needs, and values systems (Gomez, Popovic, and Bucolo 2008). In particular, automotive user interface development is often informed by simulator studies which can poorly recreate real-world scenarios and contextual factors (Meschtscherjakov et al. 2011).

Qualitative approaches, however, have the potential to 'derive fruitful explanations' and 'conceptual frameworks' (Miles and Huberman 1994, 1) yet are relatively rarely applied in automotive interface research (Meschtscherjakov et al. 2011). A naturalness approach (O'hara et al. 2013) may have the potential to further enhance driver user experience, emotional connection, and even safety (Giacomin and Ramm 2013). While interaction naturalness is a broad and sometimes blurred notion (Bérard and Rochet-Capellan 2015), there is some consensus over its core positive concepts of sensory-motor skill transfer (Bérard and Rochet-Capellan 2015), learned expertise (Wigdor and Wixon 2011), mimicry of the natural world or body (Jacob et al. 2008), coherence of metaphor (Celentano and Dubois 2014), or mimicry of human–human interaction (van Dam 1997). While the popular motoring press frequently alludes to 'naturalness' of automobile controls, the same cannot be said of academic research. Very little research exists on naturalness of interacting with an automobile's controls, and the meanings and feelings drivers attribute to them have rarely formed an explicit research topic since Black (1966) more than half a century ago. Occasional recent work has recognized the importance of meaning and metaphor in automotive interfaces but has tended to focus on novel advanced safety systems of the type rarely deployed in normal driving (e.g. Kazi et al. 2007; Vadeby, Wiklund, and Forward 2011) rather than common secondary, comfort, or infotainment controls.

Structuralists and philosophers may consider abstract concepts such as 'naturalness' to be inherently unstable – changing over time according to experience, culture, and prevailing stereotypes (e.g. Gentner and Grudin 1985) just as language may be appropriated for the specific purpose at hand and is distinct from meaning (Hintikka 1979). The notion of automotive naturalness may be especially unstable at a time of rapid advancement in consumer and automotive electronics. However, a valid research need exists for basic understanding of what ordinary drivers perceive as natural or unnatural at this crucial time when technological change is reconfiguring the driving interface and the driver's relationship with it.

There would appear to be a number of candidate qualitative approaches to address this gap. Ethnography, the scientific description of peoples and cultures with their customs and habits (Wolcott 1999), particularly at work, would appear to be a logical starting point and has indeed been undertaken as part of the wider project. However, ethnography has been found to be challenging in the confines of the automobile, because of limited space, researcher intrusion, and the risk of causing accidents (Meschtscherjakov et al. 2011). It also requires extensive research time. Moreover, ethnography's mainstay of *in vivo* participant observation would appear to be inappropriate for solo, silent machine interactions that are often executed apparently 'automatically' and semiconsciously (Dogan, Steg, and Delhomme 2011).

A previous exploratory study (Ramm et al. 2014) interviewed drivers seated in their driving seats about their automobiles' controls using ethnographically derived questions (Spradley 1979) in a form of

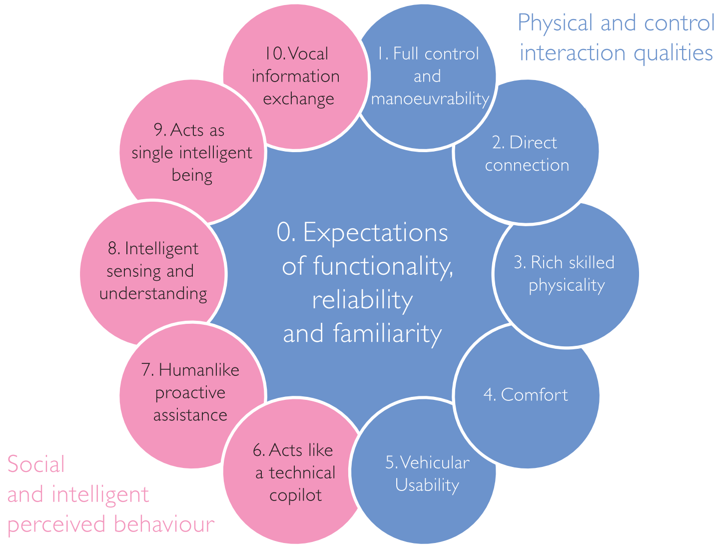

Figure 1.
The 10 constructs of driver–automobile naturalness from Ramm et al. (2014).

contextual inquiry (Beyer and Holtzblatt 1999). It suggested 10 factors that foster natural-feeling driver–automobile interaction (see Figure 1). Five constructs concerned physical characteristics, and five concerned apparent socio-intelligent 'behaviours' of the automobile. Because such narrative interview formats risk creating post-rationalized or socially mediated accounts (Mruck and Breuer 2003), complementary methods were sought. Human-centred design methodology (e.g. Hanington and Martin 2012) and design anthropology (Gunn and Donovan 2013) sometimes employ activity-based participatory methods involving artefact stimuli and future visioning with product and service users. Such methods have potential to reduce narrative bias (Patton 1990) and provide an alternative account of 'private silent' interactions. Such an approach also appeared novel in automotive research.

The purpose of this study was therefore to attempt such activity-based exploratory methods with automobile drivers in an immersive workshop environment. This would explore in a bottom-up way the poorly understood subject of drivers' current perceptions and stereotypes around 'natural-feeling' interaction with secondary, comfort, and infotainment controls. For readability, these will be referred to simply as 'secondary controls' hereafter.

Research Question

Research question: What are the characteristics of natural-feeling driver–automobile interaction with secondary controls?

Objective: To use an activity-based exploratory methodology with automobile drivers in a workshop environment to elicit their perceptions of secondary control naturalness.

Methodological Review

A method selection shortlist was compiled by scoring the human-centred design methods of Hanington and Martin (2012; well known in its field) and of Giacomin (2014), which include additional future simulation methods, against six criteria (three essential, three desirable) that had been selected by the researchers in accordance with the research objectives. In order of priority, with most important at the top, the six criteria for shortlisting methods were as follows:

(1). Must be qualitative.
(2). Must be exploratory in nature.
(3). Must involve or permit hands-on artefact-focused activity.
(4). Ideally should have potential to elucidate 'private, silent' interactions.
(5). Ideally should be applicable to the physical scale of the automobile dashboard/cabin.
(6). Ideally should allow immediate data capture during interactions.

Ethnography and interview-based methods were excluded because they had already been attempted (e.g. Ramm et al. 2014). The six highest scoring methods outlined in the following were each considered to meet four or five of the six criteria.

'Think Aloud' Protocol

'Think Aloud' Protocol (TAP) testing was first described by Ericsson and Simon (1984) as a way of eliciting users' thoughts, mental models, reflections, and affective responses during interactions (e.g. Goodman, Kuniavsky, and Moed 2013). Users are literally asked to 'think aloud' during or just after key interactions (Makri, Blandford, and Cox 2011). It has on occasions been used to seek to understand 'natural behaviours' (Makri, Blandford, and Cox 2011). The TAP is rarely seen in published automotive literature, an exception being Banks, Stanton, and Harvey (2014b). There are three main variants of TAP but 'Concurrent' is the version most used in interface design, to elucidate solo interactions as they occur. The TAP can be time intensive and is typically undertaken on just 5–12 users while being audio or video recorded (Makri, Blandford, and Cox 2011). Olmsted-Hawala et al. (2010) and others have suggested adapting the method to 'probe' interactions, thoughts, and body language 'in-the-moment' to overcome possible silence and awkwardness. While the TAP is normally used in late-stage prototyping and testing, the literature does not suggest it cannot be used for exploratory purposes.

Exploratory Design Workshop

Design workshops involve facilitating a group of product users using various hands-on, engaging, reflective activities in order to gain deeper understanding of customer needs, meanings, and perceptions, usually for the purpose of improved product or service design. Some design anthropologists have suggested that the kind of knowledge essential for successful design is accessed only through such 'creative play' (e.g. Ylirisku and Buur 2007). Crucially, there is less emphasis on narrative self-reporting and post-rationalization. Thoughts arise and are elicited as a by-product of stimulating exercises. Design workshops may be used for exploratory research (Hanington and Martin 2012). A common way of doing this is to ask participants to create a representation of an 'ideal product'. Involving users as co-creators can produce ideas that are creative and highly valued (Kristensson, Matthing, and Johansson 2008).

'Breaching'

A 'breaching exercise' was recommended as a useful extension to a design workshop (in a meeting with Monica Degen on 13 May 2014). Participants are asked to create a 'worst possible' product or scenario. First described by ethnomethodologist Garfinkel (1967), breaching seeks to understand people's reactions to violations of 'norms'. The assumption is that people are not always consciously aware of the 'unwritten rules' of interactions.

Flexible Modelling

Flexible modelling is a hands-on participatory method of generative, exploratory, or evaluative research, helping users to express their needs and desires in a physical form. Given a kit of artefacts, an engaging practical task, and focused facilitation, insight can be provided into designing improved products and services (Hanington and Martin 2012). Kits may comprise either general 'non-specific' artefacts for more open-ended design tasks, or familiar 'specific' artefacts when the nature of the artefacts is relatively fixed (e.g. in an automobile) but not necessarily their arrangement (Hanington and Martin 2012).

Focus Groups

Focus groups are 'collective interviews' used in market research and applied psychology (Coolican 1990) comprising in-depth professionally facilitated discussions with a small group of consumers (Stewart and Shamdasani 2014). Focus groups are sometimes used in design research with artefact stimuli (Hanington and Martin 2012). The key difference from interviews is the group stimulation and 'negotiation' of responses, with relatively flexible questioning, which may elicit insights which might not emerge in solo interviews (Coolican 1990). A pre-exercise is often given before participants attend as a 'sensitizing' exercise to the topic in question (Stewart and Shamdasani 2014). Like ethnographic interviewing, focus group discussions commonly begin with open-ended 'grand tour' questions (Spradley 1979) that seek to obtain participants' overall orientation towards a topic.

Future Fiction

Future fiction, or science fiction prototyping, is the use of a science fiction story, film, or comic, typically based on real science and technology, to explore the real-world implications and uses of future technologies (Johnson 2011). Ylirisku and Buur (2007) and Dunne (1999) suggest creating realistic but compelling scenarios to display a future that people may have difficulty imagining unsupported. In the automotive domain, Gaspar et al. (2014) suggested using 'imagined scenarios' to make bench-testing of controls more realistic, while Gkouskos, Normark, and Lundgren (2014), 60 created two 'pre-designed futures … as inspiration to design future vehicles'.

Method

Method Selection

There are few set rules for sample size in qualitative exploratory inquiry (Patton 1990). The methodological review suggested that all of the shortlisted methods were relatively resource intensive and typically undertaken with only small groups of participants. Therefore, a small-scale, in-depth study appeared appropriate. Each method represented an opportunity to answer the research question in different ways. Equally, a variety of methods can be more stimulating for participants (Cornish, Cornish and Dukette 2009). Therefore, it was decided that the workshop should be a combination of all six methods, using a variety of automobile secondary control artefacts as stimuli. By comparing the research question with the six methods, the following methodological decisions were made:

(1). Concurrent probing Think Aloud appeared the single best method for elucidating 'private silent' interactions in the moment they occurred.

(2). An exploratory design workshop was considered logical because of the need to access minimally post-rationalized perceptions about physical interactions and interface arrangements. Since most of an automobile's secondary control interaction takes place at its dashboard, with familiar but not wholly standardized controls, a flexible modelling exercise with both 'dashboard-specific' and 'non-specific' artefacts appeared logical (Hanington and Martin 2012). A session was conceived whereby drivers would create a representation of a 'natural-feeling dashboard' on a tabletop template, choosing from a stock of familiar automobile controls removed from a variety of automobiles, and a variety of familiar non-automobile controls. The resulting representations could be photographed and participants asked to explain their choice of artefacts and arrangement. A similar breaching exercise immediately afterwards would be to represent an 'unnatural-feeling dashboard'. Post-It notes, paper, marker pens, and magazines would be made available to permit written, illustrated, or collaged representations.

(3). A focus group format was considered the most appropriate way of achieving deep enquiry. Group size would be limited to between two and four participants, to encourage sharing and discussion (Stewart and Shamdasani 2014). A sensitizing question would be sent in advance.

(4). To maintain contextual faithfulness it was decided that one focus group, one 'Think Aloud' activity, and the future fiction scenario (see next decision) should take place inside a real automobile.

(5). This study was intended to be relevant to a future involving 'intelligent' automobile secondary controls. Therefore, a small 'talking car' future fiction was devised. Participants, seated in a real automobile, would be asked to imagine it was talking to them. Six messages would be played on a speech synthesizer, based on some of the future scenarios described in Ramm et al. (2014) varying from 'personal' to 'technical' in subject matter and 'humanlike' to 'machinelike' in delivery. The six messages concerned technical problems, route guidance, assistance finding a rest stop, and diary management. Participants would immediately be asked questions about how natural or unnatural each message felt and why.

Venue

The venue selected was a large research laboratory (Figure 2) which hosts a parked test automobile (2002 Jaguar S-type; Figure 3). This was to keep the workshop's exercises psychologically grounded in automobiles and driving while minimizing effects of scenery, weather, or temperature. Tables were arranged with the various automobile controls (Figure 4).

Figure 2.
Venue for the workshops, during a focus group session.

Figure 3.
A test car parked inside the workshop being used to keep the sessions 'grounded' in automobiles.

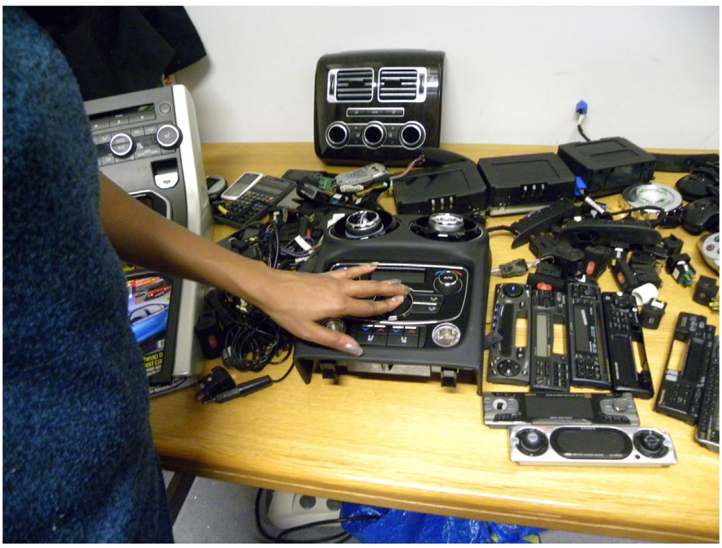

Figure 4.
Tabletop containing some of the automobile components for use in various workshop sessions.

Session Plan

The chosen methods were tested and refined in a trial workshop involving three automobile-owning designers not directly involved in the research. Accordingly, a session plan was devised and is summarized in Table 1. Drawing on the literature of usability testing (e.g. Dumas and Redish 1999), suitable prompt questions were devised and tested. Some of the prompts are also presented in Table 1. Doing the six activities was estimated to take three hours per group.

Table 1. Session plan for the workshops showing the mix of activities and prompt questions.

Exercise(time)	*Method(location)*	*Activity*	*Typical prompt questions*
1. Sensitization(20 min)	Focus group(at table)	Discussion about the way people's first automobile felt to drive	What were the sensations of first using an automobile's controls? What is the sensory experience these days?
2. Operating loose controls(15 min)	Think Aloud(standing)	Participants asked to operate various loose automobile controls	How do they feel, look, and sound? Which are most suitable for an automobile?
3. Natural dashboard creation(25 min)	Exploratorydesign-workshop with flexible modelling(at table)	Imagining and representing a 'natural-feeling dashboard' from various artefacts on a tabletop template	What does each artefact represent? What feels natural about each? Was there anything you would have liked to include? Explain choices of artefacts, layouts, and materials
4. Unnatural dashboard creation (breaching) (15 min)	Exploratorydesign-workshop with flexible modelling(at table)	Breaching exercise to represent the most 'unnatural-feeling dashboard' using artefacts on the same tabletop template	What does each artefact represent? What feels unnatural and why? How would you describe the differences to the natural dashboard previously?
5. Operating controls in a real automobile(25 min)	Think Aloud with focus group-style discussion(in test car)	Operating various fixed and loose controls in the real automobile. Probing of expectations and effects of context on perceptions	How does it feel? What do you imagine the automobile is doing? What feels natural or unnatural about it? How would motion affect that?
6. Future fiction ('speaking automobile')(25 min)	Future fiction with Think Aloud-style probing(in test car)	Audio-based future fiction. Automobile appears to be voicing six messages. Participants asked how each felt and any thoughts that occur	How did it feel to hear that? Did it feel natural? What would be your reply? What personality should the car have? How could an intelligent future automobile behave naturally?

Reflexivity

In qualitative research, it is recommended to reflect on experimental conditions and researcher intrusion to consider what biases may arise (Coolican 1990). A psychologist helped identify potential biases by considering the physical, social, and technological environments in the proposed set up. Accordingly, several measures were agreed to minimize and mitigate potential biases. They related mainly to laboratory stimuli (e.g. representing non-premium as well as premium automobiles), realistic test automobile use (e.g. activating lights and wipers to compensate for artificial venue lighting and low visibility), activity ordering (e.g. varying activities and providing breaks to avoid fatigue), and grounded topic guide questions (e.g. encouraging discussion of participants' own automobiles to ground perceptions in reality).

Sampling Strategy and Participant Numbers

A small-scale in-depth study of a specific phenomenon can be a valid strategy (Patton 1990). Saturation is achieved when no more unique verbal data 'codes' are obtained (Mason 2010). 'Purposeful sampling' (Coolican 1990) was chosen to recruit a selection of people who are fairly representative of the general population. Following a review of qualitative samples sizes in similar work (e.g. Guest, Bunce, and Johnson 2006), 10–12 participants were considered appropriate for this initial study into a poorly understood topic. Meschtscherjakov et al. (2011), for example, found that no new relevant findings were generated after the eighth participant in a contextual inquiry inside a moving automobile. Very young and very old drivers who may have perceptual shortcomings (Mc Gwin and Brown 1999) were excluded. For reasons of 'purposeful sampling', one driver for each of seven common automobile types (Ramm et al. 2014) was recruited, and at least two non-European drivers. Physical characteristics were not controlled for.

Group Size

A trial workshop suggested that having more than two participants per session would make the many activities hard to manage, especially those inside the automobile. Accordingly, the final workshops had just two participants, to promote efficient facilitation and sharing of thoughts.

Scheduling

Six half-day workshops (i.e. 12 participants) were planned for August 2014. After each workshop, a cumulative calculation was to be performed showing the total number of new codes added, in order to judge whether saturation had been achieved and a further session was warranted.

Recruitment

A 'call for participation' was placed on the Brunel University Staff and Student intranet in July 2014 seeking drivers aged 25–70. Possession of an automobile and a driving licence were essential. Screening for automobile type and participant nationality was carried out as stated earlier. Participants were told that the study was about automobile controls, but not 'naturalness', to avoid prejudicing, following recommendations by Steg, Vlek, and Slotegraaf (2001).

Selecting the Workshop Artefacts

A stock of automobile secondary controls (the 'artefacts') was required for the flexible modelling part of the exploratory design workshop, and the initial Think Aloud session. The choice was made using a simple matrix, with one axis representing the five user actions present in most modern automobiles (electronic 'click', pushing, sliding, twist/rotate, and toggle/lever) and the other axis representing four decades of interface design from 1980 to present. Three examples of each of the 20 action/decade combinations were then procured on eBay. In addition, a steering wheel and set of pedals were provided for context. No automobile brand names were visible. So as not to restrict participants' choice to automobile stereotypes, for each action/decade combination two non-automobile controls were provided as well – such as light switches, game controls, and calculators. A 'materials samples' collection was made available comprising 40 blocks of material exhibiting a variety of colours and textures. Blank Post-It notes, paper, and a stock of magazines were also provided to allow participants to reference unavailable artefacts or intangible concepts, or represent their layouts on paper rather than through artefacts if they preferred. Figures 5 and 6 show some of the controls in use.

Figure 5.
Tabletop containing some of the non-automobile components for use in various workshop sessions.

Figure 6.
Participants operating various loose controls by hand during a 'Think Aloud' session.

Experimental Procedure

The range of artefacts was grouped on a central table in random order for use in Exercises 2, 3, and 4. The test automobile's power supply was live and its secondary controls functional. Informed consent forms were presented for signature, seeking consent for still photography (not faces) and full transcription (anonymized). A preamble was read out encouraging honesty and respect. Participants were asked to think creatively and to give their honest perceptions, representations, and feelings, rather than prevailing cultural perceptions. It was explained that the dashboard flexible modelling sessions were intended to represent feelings and concepts rather than produce realistic or functional engineering prototypes. A professional audio-recording device was used to capture voices for full transcription later. A photographer assisted. Each workshop started with the sensitizing exercise.

Results

Summary

Five workshops involving 10 participants were conducted to achieve saturation (see Scheduling). The mean age of participants was 41. Seven participants were British, two were South Korean nationals, and one participant was an Indian national. Between them the participants owned two small cars, two family cars, two premium cars, one large car, one luxury car, one SUV, and one sports car. Three hours was sufficient to complete the activities with each of the groups. The mixture of exercises and methods elicited much data directly related to the research question.

Data Analysis

Thematic analysis (Braun and Clarke 2006) was used on full transcriptions because this allows rich interpretation and pattern identification from verbal data (Saldaña 2015). In addition, because so many data were obtained (13 hours, around 200 pages of transcript), content analysis (Krippendorff 2012) was also used, counting occurrences of similar semantics to estimate commonality. Analysis used principles of 'grounded theory' (Glaser and Strauss 2009).

Following the procedures recommended by Braun and Clarke (2006), the full audio-recording was listened to after each workshop and tentative pre-coding notes made on full paper transcriptions in the 'eclectic' manner (Saldaña 2015), coding fully not partially (i.e. 'splitting' not 'lumping'; Saldaña 2015). Data were then 'pattern coded' (Saldaña 2015) at a concept level (usually 'X is associated with natural-feeling interaction'). Coding was done on paper because for small in-depth studies this can give more control and preserve nuances (Saldaña 2015). All statements apparently relating to naturalness or unnaturalness of secondary controls were coded. Other statements were ignored. Similar codes were combined, and prolific codes subdivided where possible to make nuances and patterns of meaning more

Table 2. The 10 most frequent 'naturalness' codes in the data, with most frequent at the top.

Rank	Naturalness-related code (statement)
1.	Driver being in full control feels natural; driver should not delegate or cede control
2.	Natural-feeling interactions should not distract from the primary driving task
3.	Minimum utility on the move feels natural; not too much input or adjustment required on the move
4.	Natural-feeling controls are highly physically discernible (well spaced/easy to locate by touch)
5.	Old-fashioned controls feel natural in an automobile, these should be kept even if skeuomorphism
6.	Low visual demand (generally) feels natural
7.	The control being intuitive to use feels natural
8.	General sense of ease or simplicity feels natural, relaxed feeling while driving
9.	Weightiness or resistance of controls feels natural
10.	Naturalness preference for uncluttered, simple layout, tidy, not too many buttons

apparent (Patton 1990). Codes that appeared only once were ignored. This formed a master code list (Saldaña 2015) for final coding using acronyms for each code on fresh paper transcripts.

In summary, the five transcripts together provided 1770 relevant codeable statements. After each workshop, a saturation check was made. For example, the fourth workshop added four codes to the cumulative list of 175 derived from the first three workshops, making 179. The fifth workshop added no new codes. Saturation was considered to have been achieved and no further workshops were held after the fifth. The number of codes is within the range suggested by Friese (2014). Table 2 presents the 10 most frequent codes.

Thematic Clustering

The codes were tentatively grouped into logically similar clusters (i.e. 'themes') in an Excel spreadsheet, noting their frequency. These clusters were based on 'ergonomic' categorizations (e.g. 'low visual demand') revealed in the literature review. This resulted in 11 distinct themes of roughly equal frequency. To maintain objectivity in clustering, various attempts were made to cluster the 179 codes into alternative themes. Codes were printed and cut into paper strips (Hanington and Martin 2012; Saldaña 2015) to attempt alternative taxonomies such as the human need apparently served by each code, and which sensory channel each code related to (recommended by sociologist Monica Degen in an email dated 14 April 2014). Codes were also grouped using themes from related published frameworks such as Jordan (2002) and Gaspar et al. (2014). However, none of these efforts provided usable thematic frameworks because about 30–40% of codes could not be allocated anywhere in the taxonomy.

Independent Code and Theme Checking Process

It is recommended in thematic analysis to use independent coders (Braun and Clarke 2006; Saldaña 2015). Five independent researchers completed the following procedure:

(1). Free (eclectic) coding of three pages of transcript using only the research question. The coders were encouraged to write all their codes and thoughts on the printed papers.
(2). Next they were asked to group the codes they identified into higher-level themes. Again, thought processes were captured on paper.
(3). Only after stages 1 and 2 were completed were participants sent the working list of 11 'ergonomic' themes, with each concisely explained and numbered. Participants were asked to write the number on the transcript every time they thought that theme occurred.

A final thematic grouping check involved giving a different independent psychology researcher from another university all 179 codes on paper strips in the form of a 'card sorting exercise' (Hanington and Martin 2012). Although a plausible alternative grouping of four themes resulted, it did not offer any advantages over the 11 'ergonomic' theme framework and was rather less descriptive.

Final Thematic Framework

A desirable quality of any thematic framework is a manageable number of descriptive themes (Coolican 1990) each representing roughly equal proportions of responses. Each of the chosen 11 'ergonomic' themes were found to be of roughly equal 'weight' in terms of their number of constituent codes and overall frequency of occurrence. These 11 themes are summarized in the following using example quotations about naturalness from participants to 'ground' the findings (recommended in thematic analysis; Braun and Clarke 2006).

1. Familiarity and Predictability

Secondary controls and automobile responses that are familiar, recognizable, predictable, safe, and not alarming appear to feel natural. These qualities can also be 'learned' – for example, skilled driving with its strategic coordination of multiple controls may feel highly unnatural at first but become highly natural-feeling once learned and familiar – and ultimately 'automatic':

> I get in and drive, I don't go through a series of processes. I just get in the car and come out somewhere else and the rest is done sort of automatically.

> It would just have to be instinctive […] I think on most cars the wiper controls are in the same place and stuff so a set format between manufacturers would be convenient.

2. Driver in Full and Ultimate Control

Secondary controls and features that make the driver feel fully in control, and the driving task feel easy, appear to feel natural. The driver should always be 'in the loop' and ultimately feel in control even if control is temporarily delegated to technology. Arranging important secondary controls around the steering wheel or master display may help this feeling:

> And it's just a sense of achievement that when you've completed the journey, you've done it safely and you've done it exactly how you want to do it, including controlling the radio, all the other comfort things, yeah.

> So you have the basic controls nearer in, so steering wheel controls on the central part and … all within easy reach. And the more peripheral things get further out.

3. Communication with Reality

It may feel natural for an automobile to communicate certain 'real-world' information – about its mechanicals, the road, and the environment – through its secondary controls and systems. There was a strong sense that this information was a 'reminder' that driving is a serious interaction with the real world rather than 'a computer game' (which would feel unnatural):

> You could forget that you're actually in control of, you know, a two or three-ton car. And I think that you should remember that. You're not controlling just a go-kart.

> You need some sort of resistance from the wheels to know that you're having a physical effect outside otherwise it feels like you're playing a game.

4. Weighty Physical Sensations

These appeared to be a collection of related physical sensations and perceptions at the interface that feel natural, mainly felt through the hands and categorized by feelings of weight and precision. Examples include sensations of heaviness (rather than light-feeling), tightness (rather than loose-feeling), directness (rather than delayed-feeling), precision, robustness, and tactility (which was defined by participants as 'not too hard or shiny feeling'):

> There [is] a nice amount of resistance and when you adjusted them it stays put where you've put it.
>
> You want to be able to feel that you're doing something.

5. Cabin Comfort and Sanctuary
A comfortable, dark, protected, relaxing, homely, aesthetically pleasing automobile cabin with good visibility outwards, but adequate privacy from strangers, appears to be associated with natural-feeling interaction. A natural-feeling car cabin would promote sharing and community within it:

> I think metal should be on the outside of the car, not the inside [laughs] … from outside [the car is] a sort of metal lump and then I sort of expect when I go inside the car to feel cosy, to feel sort of more soft.
>
> [Driving] is usually a chance to interact and that would feel unnatural if everyone was isolated and cut off from each other.

6. Uncluttered Cabin Architecture
A natural-feeling dashboard may be simple and uncluttered, with distinctive secondary controls located logically and discernible by touch alone, ergonomically optimized for fingers and arm reach. Logical control locations and mappings will mean that unintended inputs are rare. Switches and rotary controls may feel more natural than digital or touchscreen 'clicks':

> It's got to be so you can operate it by feel.
>
> So many controls could be quite overwhelming, so just a bombardment of information and just too much button controls, that would be unnatural.

7. Low Visual Demand
Natural-feeling secondary controls demand very little visual attention away from the primary driving task. Non-visual modalities are used for feedback, such as sound and physical feel (e.g. position of a control). Natural-feeling secondary controls may be operated without looking. Some analogue dials may be more natural-feeling than alpha-numeric displays:

> Without even looking at it, it's easy to distinguish the ways, you know, whether it's forward or backward, whether it's open or closed.

> It feels like it's working, I've got sound as well so if I'm concentrating on driving [...] being able to hear it is helpful.

8. Low Cognitive Demand

Natural-feeling secondary control interaction appears not to cause significant cognitive distraction from the primary driving task. Minimal information and choices are presented to the driver when in motion. A secondary control's shape and movement are logically mapped to its function. Switchgear inputs are therefore obvious or, at worst, clearly labelled:

> Too many conscious decisions will be unnatural.

> The controls are there to serve a purpose but the purpose is so you can concentrate on driving safely and enjoying that. So the controls need to disappear effectively and so you're focused on what you're doing.

9. Humanlike Driver–Automobile Partnership

In the future, intelligent secondary features and automation may feel more natural if the automobile as a whole behaves as a trusted 'helpful subservient co-driver' – competent, informative, polite, and proactive:

> Rather than it just being simply a machine, it would be something that you might sort of have some faith in.

> This isn't my friend, this is going to do what I want it to do.

10. Humanlike Sentience and Learning

A future intelligent automobile might feel natural if it sensed, processed, understood, and learned things in a more humanlike way. Such an automobile would remember preferences and routines in secondary system use, predict situations, adapt behaviour, and appear to be socially and emotionally empathetic:

> Empathy … so it understands what you're trying to achieve [...] so that it kind of interacts well and it has the same objectives as what you're trying to achieve.

> [If] you've got road rage or things like that, if your car could kind of pick up on it, it would be, 'Alright, now calm down'.

11. Humanlike Verbal–Auditory Communication
A future intelligent automobile could naturally be instructed and directed by the human voice alone, and may talk back to its driver too. It would understand natural language perfectly, but speak mainly only when spoken to, keeping its messages brief, timely, polite, concise, and unambiguous. The tone of voice would be neither too humanlike nor too machinelike:

> Voice control is improving, it might be quite a natural way to communicate with something that is communicating back to you.
>
> I personally quite like it sounding a bit like a computer, I think it's quite unsettling when … it is trying to sound [informal] like 'Hiya, you know your oils levels are low'.

These themes were then arranged into the framework shown later in Figure 7 to reflect higher order clustering of logically related themes.

Discussion

Participants' natural-feeling dashboard representations tended to be sparse, simple, convenient, proactively assistive, with large mechanical controls in addition to screens, and predominantly matt and dark textures (Figure 8). Their unnatural-feeling dashboard representations tended to feature many small identical poorly labelled buttons (e.g. from 1990s radio bezels), overly complicated settings (e.g. a window control that required dialling in an exact opening percentage), unnecessary alpha-numeric readouts, loose wires, rough or metallic textures, few mechanical or analogue controls, and distracting reflections or flashes (Figures 9 and 10).

General familiarity and predictability of an automobile's secondary controls appeared central to them feeling natural, as did the driver's sense of being in full control. Despite the occasional inclusion of digital devices and touchscreens, physical buttons, dials, and switches generated much more naturalness-related discussion. This explains why three of the final 11 characteristics were 'physical' aspects. The most frequently cited naturalness characteristics, however, were the 'usability' aspects – 'low cognitive demand' followed by 'uncluttered cabin architecture' and 'low visual demand'. The three remaining characteristics represent natural-feeling humanlike intelligence of future automobiles. Many of these have parallels with those obtained through the contextual inquiry-style interviews in Ramm et al. (2014). Some parallels in wider research findings and higher order observations will now be suggested.

Familiarity and predictability are often considered important in 'natural' interaction (O'hara et al. 2013; Wigdor and Wixon 2011) and may perhaps elevate naturalness above a standard 'usability' approach. In real-world user testing of 3D automobile instrument displays, Broy et al. (2015) also found that meeting expectation and retaining familiarity were important. Skeuomorphism, whereby new technology imitates

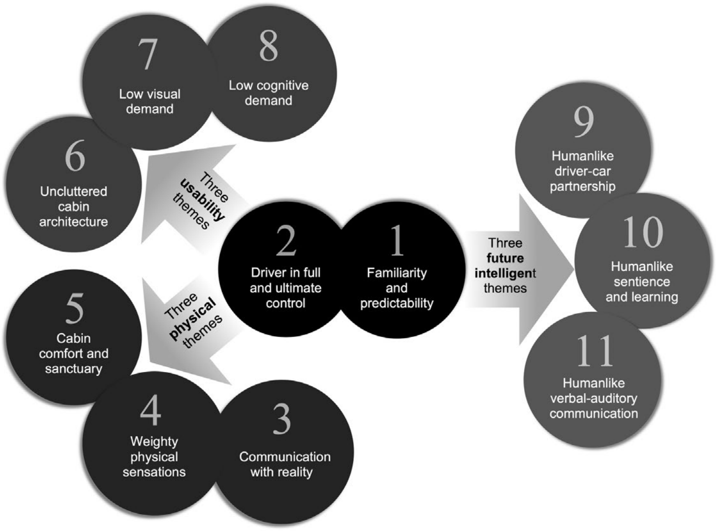

Figure 7.
The final 11-themed framework of driver–automobile naturalness derived from thematic analysis.

Figure 8.
An example 'natural-feeling dashboard' creation, demonstrating a 'sparse' layout with predominantly dark and matt materials.

older familiar controls, is a recognized approach to digital interaction design (Shedroff and Noessel 2012).

Improving the physicality or tangibility (Dourish 2004) of digital interfaces is the subject of much recent research. Visions of automotive futures (e.g. those of Mercedes; Fowler 2015) often show no physical controls at all, other than a steering wheel and pedals. Yet Ford's customer experience with its first MyTouch touchscreen system (Lanks 2015) suggested that entirely digital secondary controls may not feel entirely natural. Ford's reaction was to reintroduce some physical knobs. The role of comfort is unclear because several participants commented

Figure 9.
An example 'unnaturalfeeling dashboard' creation, exhibiting many small identical buttons, rough and metallic textures, and sources of visual distraction.

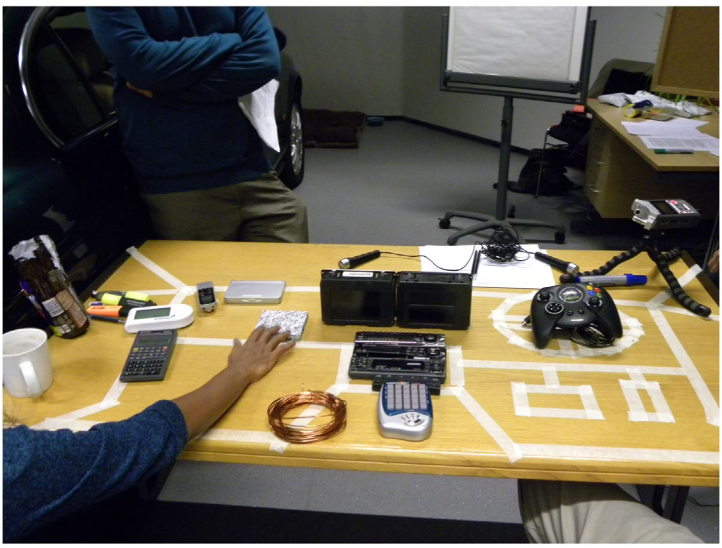

Figure 10.
Participant explaining features of a dashboard creation in the flexible modelling session.

that a natural-feeling automobile should not be too comfortable. Comfort is generally not considered significant in naturalness by the wider literature. It may be that participants' basic human need for comfort and privacy was misinterpreted as a naturalness requirement.

Usability issues were very salient perhaps because drivers were operating controls new to them, and using an unfamiliar dashboard. In the literature, usability is sometimes considered an important precept to naturalness, but the relationship may be more complex (O'hara et al. 2013). For example, too much naturalness may hinder usability

(Pieraccini and Huerta 2008) or naturalness may lead to perceptions of usability rather than the other way round (Susini et al. 2012). The inclusion of the breaching exercise helps explains why all of the usability characteristics are expressed as the lack of a negative quality, for example 'uncluttered'. Participants appeared to prefer this form, and in practice it was difficult to find adequate positive equivalents. For example, participants readily engaged with the concept of natural-feeling dashboards being 'uncluttered' whereas 'well-spaced' brought about unintended connotations.

The voice-based activity may have prejudiced answers towards verbal–auditory communication, but this characteristic did often arise spontaneously before that exercise (which was at the end). There is a parallel with van Dam's (1997) interpretation of human–computer naturalness as mimicking human–human interactions. The use of a synthesized computer voice for the 'talking automobile' future fiction exercise provided much discussion, uninhibited criticism, and insight, generating some useful naturalness perceptions relating to intelligence, politeness, humanlikeness, and agency. The resulting humanlike intelligence characteristics suggest how interaction might still feel natural in a world where automobile systems have greater intelligence than their drivers. Using the metaphor of a single 'humanlike co-pilot' in autonomous driving may feel more natural than multiple semi-autonomous systems.

Overall, these findings have many similarities with those of Gkouskos, Normark, and Lundgren (2014), one of the few comparable studies which explored 'what drivers really want' from their automobiles. More generally, there are parallels with other well-known heuristics for human-centred interface design such as those of Nielsen (1994). In many respects, then, the results are not especially novel or paradigm-shifting, but it must be reiterated that there have been very few attempts at developing evidence-based human-centred design heuristics for the automobile. If the data suggest that what feels natural in an automobile's secondary controls is not very different from what feels natural on a good smartphone or website, then this is still an important finding.

Some of the naturalness characteristics permit, or presuppose, quite modern technologies. For example, touchscreens, voice control, machine learning of driver behaviour, data monitoring, and even conversational monitoring were all considered 'natural' by some participants in some scenarios. This suggests naturalness is not a stable perception and will continue to evolve over time according to culture, consumer electronics, and automotive trends. Where drivers once reached for a rotary lever to control their window, they now instinctively hunt for a switchpack on their armrest. Repeated exposure to novel secondary controls may become familiar and thereby natural.

In summary, it can be proposed that an automobile, secondary system or secondary control which complies with as many of the 11 characteristics as appropriate will be perceived as more 'natural' than one that does not. Not all characteristics will be applicable to every system and attempting to do so may undermine the more essential qualities of 'familiarity' and 'predictability'. Some of the characteristics may exist in dynamic tension – for example, too many physical controls may lead to a cluttered cabin, and too much communication with the road and automobile may undermine comfort. The 11 characteristics are felt to be suitable for professionals to use as a heuristic and the research question has been answered appropriately.

In terms of the methods used themselves, and meeting the secondary research objective of using activity-based exploratory methodology in the automotive domain, the study suggests that exploratory design workshops, flexible modelling. and Think Aloud analyses with non-experts in small groups can be successful in generating initial understanding of interactional perceptions and stereotypes. Specifically, the stock of automobile controls and materials was appropriated very creatively by participants to represent abstract feelings and sensory preferences as well as physical concepts. The 'materials database' with its many textures and colours appeared particularly stimulating and was often appropriated to represent feelings and emotions. Drivers' explanations of their choice of artefacts and layout tended to be highly relevant to the research question. Several participants commented after the breaching exercise that it was easier to specify what aspects and situations felt unnatural than what felt natural. As was the intention, the breaching exercise appeared to reveal unspoken design norms by deliberately violating them.

There was no evidence that participants were inhibited by working with physical artefacts and their arrangement. No participant used the paper or magazines provided as an alternative means of expression. Perhaps the inclusion of controls from the 1980s and 1990s was overly conservatizing because it may have evoked a sentimental reaction. However, natural-feeling dashboard creations included touchscreens and wireless smartphone charging for example, whereas the tiny buttons on radio bezels of the 1990s were uniformly ridiculed and formed part of almost every 'unnatural-feeling' dashboard representation.

The group size of 10 participants is small in comparison with typical automotive studies but is considered appropriate for developing an initial framework of a poorly understood subject. The rigorous procedures described achieved the criteria set for purposeful sampling and data saturation. Seen in the context of related previous studies, the group size appeared acceptable.

Conclusion

In order to explore the characteristics of natural-feeling interaction between automobile drivers and their secondary, comfort, and infotainment controls, an activity-based exploratory design workshop used five artefact-focused methods to elicit the perceptions of 10 automobile drivers. The data were analysed into 11 themes using thematic analysis. The resulting framework describes the data-set using largely ergonomic terminology. The study has demonstrated the feasibility of using activity-based exploratory methodology with drivers in a workshop environment to elicit perceptions of interaction naturalness. The framework will be used to triangulate findings with related contextual enquiry and participant observation studies.

Further research should convert the themes into bipolar rating scale questionnaire items to test the framework's validity quantitatively on real automobile controls with a much larger sample of drivers, to discover which correlations with naturalness are strongest and what factors underlie the themes. As perceptions of naturalness appear unstable, similar studies should be performed in future years.

Funding

This research was fully funded by a research grant from Jaguar Land Rover [JLR3702].

Disclosure Statement

No potential conflict of interest was reported by the authors.

References

Banks, Victoria A., Neville A. Stanton, and Catherine Harvey. 2014. "Sub-Systems on the Road to Vehicle Automation: Hands and Feet Free but Not 'Mind' Free Driving." *Safety Science* 62: 505–514.

Banks, Victoria A., Neville A. Stanton, and Catherine Harvey. 2014. "What the Drivers Do and Do Not Tell You: Using Verbal Protocol Analysis to Investigate Driver Behaviour in Emergency Situations." *Ergonomics* 57 (3): 332–342.

Bérard, François, and Amélie Rochet-Capellan. 2015. "The Transfer of Learning as HCI Similarity: Towards an Objective Assessment of the Sensory-Motor Basis of Naturalness." In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 1315–1324. New York: ACM.

Beyer, Hugh, and Karen Holtzblatt. 1999. "Contextual Design." *Interactions* 6 (1): 32–42.

Black, Stephen. 1966. *Man and Motor Cars: An Ergonomic Study*. London: Secker & Warburg.

Braun, Virginia, and Victoria Clarke. 2006. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology* 3 (2): 77–101.

Broy, Nora, Stefan Schneegass, Mengbing Guo, Florian Alt, and Albrecht Schmidt. 2015. "Evaluating Stereoscopic 3D for Automotive User Interfaces in a Real-World Driving Study." In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*, 1717–1722. New York: ACM.

Celentano, Augusto, and Emmanuel Dubois. 2014. "Metaphors, Analogies, Symbols. in Search of Naturalness in Tangible User Interfaces." *Procedia Computer Science* 39: 99–106.

Coolican, Hugh. 1990. *Research Methods and Statistics in Psychology*. London: Hodder & Stoughton Educational.

Cornish, David and Diane Dukette. 2009. *The Essential 20: Twenty Components of an Excellent Health Care Team*. Pittsburgh, PA: Dorrance Publishing.

van Dam, Andries. 1997. “Post-WIMP User Interfaces.” *Communications of the ACM* 40 (2): 63–67.

Dogan, Ebru, Linda Steg, and Patricia Delhomme. 2011. “The Influence of Multiple Goals on Driving Behavior: The Case of Safety, Time Saving, and Fuel Saving.” *Accident Analysis & Prevention* 43 (5): 1635–1643.

Dourish, Paul. 2004. *Where the Action is: The Foundations of Embodied Interaction*. Cambridge MA: MIT press.

Dumas, Joseph S., and Janice Redish. 1999. *A Practical Guide to Usability Testing*. Exeter: Intellect Books.

Dunne, Anthony. 1999. *Hertzian Tales: Electronic Products, Aesthetic Experience, and Critical Design*. Cambridge MA: MIT press.

Ericsson, K. A., and H. A. Simon. 1984. *Protocol Analysis: Verbal Reports as Data*. Cambridge MA: MIT press.

Fowler, S. 2015. “CES 2015: Mercedes F 015 Shows Its Vision of the Future.” *Auto Express*, January 6. http://www.autoexpress.co.uk/mercedes/89925/ces-2015-mercedes-f-015-shows-its-vision-of-the-future

Friese, Susanne. 2014. *Qualitative Data Analysis with ATLAS.Ti*. London: Sage.

Garfinkel, Harold. 1967. *Studies in Ethnomethodology*. Englewood Cliffs, NJ: Prentice-Hall.

Gaspar, José, Mihail Fontul, Elsa Henriques, and Arlindo Silva. 2014. “User Satisfaction Modeling Framework for Automotive Audio Interfaces.” *International Journal of Industrial Ergonomics* 44 (5): 662–674.

Gentner, Dedre, and Jonathan Grudin. 1985. “The Evolution of Mental Metaphors in Psychology: A 90-Year Retrospective.” *American Psychologist* 40 (2): 181–192.

Giacomin, Joseph. 2014. “What is Human Centred Design?” *The Design Journal* 17 (4): 606–623.

Giacomin Joseph, and Simon Ramm. 2013. “There’s More to Safe Driving than Information and Decisions.” Paper presented at the Fleet Safety Conference & Awards, Solihull, June 13–14.

Gkouskos, Dimitrios, Carl Jörgen Normark, and Sus Lundgren. 2014. “What Drivers Really Want: Investigating Dimensions in Automobile User Needs.” *International Journal of Design* 8 (1): 59–71.

Glaser, B. G., and A. L. Strauss. 2009. The Discovery of Grounded Theory: Strategies for Qualitative Research. New Brunswick, NJ: Transaction Publishers.

Gomez, Rafael Ernesto, Vesna Popovic, and Sam Bucolo. 2008. “Emotional Driving Experiences.” In *Design and Emotion Moves*, edited by P. Desmet, J. van Erp and M. Karlsson, 141–164. Newcastle UK: Cambridge Scholars Publishing.

Goodman, Elizabeth, Mike Kuniavsky, and Andrea Moed. 2013. “Observing the User Experience: A Practitioner’s Guide to User

Research." *IEEE Transactions on Professional Communication* 56 (3): 260–261.
Guest, Greg, Arwen Bunce, and Laura Johnson. 2006. "How Many Interviews Are Enough? An Experiment with Data Saturation and Variability." *Field Methods* 18 (1): 59–82.
Gunn, Wendy, and Jared Donovan. 2013. *Design and Anthropology*. Farnham: Ashgate Publishing Ltd.
Hanington, Bruce, and Bella Martin. 2012. *Universal Methods of Design: 100 Ways to Research Complex Problems, Develop Innovative Ideas, and Design Effective Solutions*. Rockport Publishers.
Hintikka, Jaakko. 1979. "Language-Games." In *Game-Theoretical Semantics*, edited by Esa Saarinen, 1–26. Dordrecht: Springer.
Jacob, Robert J. K., Audrey Girouard, Leanne M. Hirshfield, Michael S. Horn, Orit Shaer, Erin Treacy Solovey, and Jamie Zigelbaum. 2008. "Reality-Based Interaction: A Framework for Post-WIMP Interfaces." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 201–210. New York: ACM.
Jaspers, Monique W. M. 2006. "A Comparison of Usability Methods for Testing Interactive Health Technologies: Methodological Aspects and Empirical Evidence." *International Journal of Medical Informatics* 78 (5): 340–353.
Johnson, Brian David. 2011. "Science Fiction Prototyping: Designing the Future with Science Fiction." *Synthesis Lectures on Computer Science* 3 (1): 86–88.
Jordan, Patrick W. 2002. *Designing Pleasurable Products: An Introduction to the New Human Factors*. London: Taylor and Francis.
Kazi, Tarannum Ayesha, Neville A. Stanton, Guy H. Walker, and Mark S. Young. 2007. "Designer Driving: Drivers' Conceptual Models and Level of Trust in Adaptive Cruise Control." *International Journal of Vehicle Design* 45 (3): 339–360.
Kern, Dagmar, and Albrecht Schmidt. 2009. "Design Space for Driver-Based Automotive User Interfaces." In *Proceedings of the 1st International Conference on Automotive User Interfaces and Interactive Vehicular Applications*, 3–10. New York: ACM.
Krippendorff, Klaus. 2012. *Content Analysis: An Introduction to Its Methodology*. London: Sage.
Kristensson, Per, Jonas Matthing, and Niklas Johansson. 2008. "Key Strategies for the Successful Involvement of Customers in the Co-Creation of New Technology-Based Services." *International Journal of Service Industry Management* 19 (4): 474–491.
Lanks, Belinda. 2015. "What Drivers Want: Design Lessons from Ford's MyTouch Debacle." *Bloomberg*, January 8. http://www.bloomberg.com/news/articles/2015-01-08/what-drivers-want-design-lessons-from-fords-mytouch-debacle.
Makri, Stephann, Ann Blandford, and Anna L. Cox. 2011. "This is What I'm Doing and Why: Methodological Reflections on a Naturalistic Think-Aloud Study of Interactive Information Behaviour." *Information Processing & Management* 47 (3): 336–348.

Mason, Mark. 2010. “Sample Size and Saturation in PhD Studies Using Qualitative Interviews.” *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research* 11 (3). Article 8, http://nbn-resolving.de/urn:nbn:de:0114-fqs100387.

Mc Gwin, Gerald Jr, and David B. Brown. 1999. “Characteristics of Traffic Crashes among Young, Middle-Aged, and Older Drivers.” *Accident Analysis & Prevention* 31 (3): 181–198.

Meschtscherjakov, Alexander, David Wilfinger, Nicole Gridling, Katja Neureiter, and Manfred Tscheligi. 2011. “Capture the Car!: Qualitative in-Situ Methods to Grasp the Automotive Context.” In *Proceedings of the 3rd International Conference on Automotive User Interfaces and Interactive Vehicular Applications*, 105–112. New York: ACM.

Miles, Matthew B., and A. Michael Huberman. 1994. *Qualitative Data Analysis: An Expanded Sourcebook*. Thousand Oaks, CA: Sage.

Mruck, Katja, and Franz Breuer. 2003. “Subjectivity and Reflexivity in Qualitative Research—A New FQS Issue.” *Historical Social Research/Historische Sozialforschung* 4 (2): 189–212.

Nielsen, Jakob. 1994. “Heuristic Evaluation.” *Usability Inspection Methods* 17 (1): 25–62.

O’hara, Kenton, Richard Harper, Helena Mentis, Abigail Sellen, and Alex Taylor. 2013. “On the Naturalness of Touchless: Putting the ‘Interaction’ Back into NUI.” *ACM Transactions on Computer-Human Interaction (TOCHI)* 20 (1): 1–25, Article 5.

Olmsted-Hawala, Erica L., Elizabeth D. Murphy, Sam Hawala, and Kathleen T. Ashenfelter. 2010. “Think-Aloud Protocols: A Comparison of Three Think-Aloud Protocols for Use in Testing Data-Dissemination Web Sites for Usability.” In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2381–2390. New York: ACM.

Patton, Michael Quinn. 1990. *Qualitative Evaluation and Research Methods*. Newbury Park, CA: Sage.

Pieraccini, Roberto, and Juan M. Huerta. 2008. “Where Do We Go from Here? Research and Commercial Spoken Dialog Systems.” In *Recent Trends in Discourse and Dialogue*, edited by L. Dybkjær and W. Minker W, 1–24. Dordrecht: Springer.

Ramm, Simon, Joseph Giacomin, Duncan Robertson, and Alessio Malizia. 2014. “A First Approach to Understanding and Measuring Naturalness in Driver-Car Interaction.” In *Proceedings of the 6th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*, 1–10. New York: ACM.

Saldaña, Johnny. 2015. *The Coding Manual for Qualitative Researchers*. London: Sage.

Shedroff, Nathan, and Christopher Noessel. 2012. *Make It So: Interaction Design Lessons from Science Fiction*. New York: ACM Press, 7.

Spradley, J. 1979. *The Ethnographic Interview*. New York: Holt, Rinehart and Winston.

Steg, Linda, Charles Vlek, and Goos Slotegraaf. 2001. “Instrumental-Reasoned and Symbolic-Affective Motives for Using a Motor

Car." *Transportation Research Part F: Traffic Psychology and Behaviour* 4 (3): 151–169.

Stewart, David W., and Prem N. Shamdasani. 2014. *Focus Groups: Theory and Practice*. Newbury Park, CA: Sage.

Susini, Patrick, Nicolas Misdariis, Guillaume Lemaitre, and Olivier Houix. 2012. "Naturalness Influences the Perceived Usability and Pleasantness of an Interface's Sonic Feedback." *Journal on Multimodal User Interfaces* 5 (3–4): 175–186.

Vadeby, Anna, Mats Wiklund, and Sonja Forward. 2011. "Car Drivers' Perceptions of Electronic Stability Control (ESC) Systems." *Accident Analysis & Prevention* 43 (3): 706–713.

Walker, Guy H., Neville A. Stanton, and Mark S. Young. 2006. "The Ironies of Vehicle Feedback in Car Design." *Ergonomics* 49 (2): 161–179.

Wigdor, Daniel, and Dennis Wixon. 2011. *Brave NUI World: Designing Natural User Interfaces for Touch and Gesture*. Burlington, MA: Elsevier.

Wolcott, Harry F. 1999. *Ethnography: A Way of Seeing*. Walnut Creek: Rowman Altamira.

Wynn, Tony, John H. Richardson, and Alan Stevens. 2013. "Driving Whilst Using in-Vehicle Information Systems (IVIS): Benchmarking the Impairment to Alcohol." In *Driver Distraction and Inattention Advances in Research and Countermeasures*, edited by M. A. Regan, J. D. Lee and T. W. Victor, Vol. 1 253–275. Farnham, UK: Ashgate Publishing.

Ylirisku, Salu Pekka, and Jacob Buur. 2007. *Designing with Video: Focusing the User-Centred Design Process*. London: Springer-Verlag.

Biographies

Simon Ramm is a human-centred automotive designer specializing in voice control and future cars' user experience. His PhD concerned natural-feeling interaction between drivers and their cars.

Joseph Giacomin is the Director of the Human Centred Design Institute (HCDI) of Brunel University, UK. He has more than 80 publications and is an editor of *Ergonomics* and *International Journal of Vehicle Noise and Vibration*.

Alessio Malizia is an ACM Distinguished Speaker and Professor of User Experience Design in the School of Creative Arts at University of Hertfordshire, UK.

Ben Anyasodo is a human–machine interaction specialist whose work involves applying human factors principles and practices to the development of new technology concepts. He worked at Jaguar Land Rover for seven years.

Address for Correspondence
Simon Ramm, Human Centred Design Institute, Brunel University, Uxbridge UB8 3PH, UK. Tel: +44 7899 792319.
Email: simonramm@yahoo.co.uk