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Automotive Habitat Laboratory: a facility for automotive co-design

Voula Gkatzidou, Joseph Giacomin
Human Centred Design Institute
Brunel University
London, UK
voula.gkatzidou@brunel.ac.uk
joseph.giacomin@brunel.ac.uk

Lee Skrypchuk
Human Machine Interface Research,
Jaguar Land Rover
Coventry, UK
lskrypch@jaguarlandrover.com

***Abstract*—Owing to the growing sophistication of digital technologies and the increasing complexity of modern social behaviours, the 21st century automobile can no longer be considered as an environment solely characterised by the performance of the driving task. In order to address the opportunities introduced by the increasingly dynamic and socially interactive environment of the modern day automobile, from a *Human Centred Design* perspective, a series of expert interviews and business discussions were held with motor industry professionals. From discussions of modern design tools which would be helpful in support of motor industry, the concept of a design-driven lab emerged. The *Automotive Habitat Laboratory* assists the discovery of experiential, psychological, sociological, behavioural and ethical aspects of new automotive product and service concepts. This paper discusses the results of the expert interviews and the preliminary definition of the *Automotive Habitat Laboratory* in terms of the specification of the human behaviour monitoring technologies, communication protocols and working methods that will allow for creative real-time dialogue between designers and people in automobiles.**

Keywords—automobile; behaviour; co-design; design; human centred design; innovation.

I. INTRODUCTION

Like most human habitats the automobile is characterised by multiple perceptions, emotions and social interactions. Drivers and passengers "live" and "socially interact" in their vehicles [1, 2], and thanks to mobile telephony and big-data they increasingly interact in a complex way with machines and with other people across both space and time [3, 4]. Given the sophistication of modern technologies and the complexity of modern social behaviours it would be simplistic to continue to consider the automobile as an environment characterised mostly by the performance of the driving task [5]. A shift in focus away from "human performance" towards instead "human behaviour" therefore appears fundamental to design success [6]. The imminent introduction of various degrees of driving automation [7] also suggests that a shift away from the concept of "driver" to that of "passenger" may be critical.

This paper addresses automobile design from a *Human Centred Design* perspective [8], i.e. in terms of methods which communicate, interact, empathise and stimulate the people involved, obtaining an understanding of their needs, desires and experiences which often transcends that which the people themselves actually knew and realised. In its most basic form *Human Centred Design* leads to products, systems and services, which are physically, perceptually, cognitively and emotionally intuitive. In its most advanced form it discovers and unlocks latent needs and desires, supporting the achievement of desired futures for society.

II. BACKGROUND RESEARCH

Over the last decade design-driven labs have been introduced by numerous organisations including digital platform companies (Apple, Google, LG, Samsung, etc.), mobile telephony companies (Orange, O2, Vodafone, etc.), design-intensive product manufacturers (Alessi, Swatch, etc.) and businesses from many other sectors. There is a growing body of evidence [9, 10] which suggests that design-driven labs are useful for organisations which depend on customer experience and long term brand loyalty. Further, there is evidence that design-driven labs are among the most effective ways to explore disruptive innovations and to reduce both the time and cost of new product or service development [11, 12].

The names given to these facilities can change depending on the aspirations of the business [13], the ideology of the business [14] or the professional vision [15] of the business. Design-driven labs can take on various forms ranging from simple virtual networks to realistic re-creations of actual

homes, offices or other human environments. While no consistent or uniform terminology and typology seems to be employed, the characteristic which unifies the various facilities is the ability to "explore human behaviour in a chosen habitat and to collect data which permits the understanding and eventual modelling of the experiential, psychological, sociological, ethical and behavioural issues involved" through the provision of tools for ideation and expression [16, 17].

Despite their growing popularity the current generation of design-driven labs appear to be developed beyond the available academic underpinnings. In particular, there appears to be a need for additional empirical evidence [18,19] regarding the possible variations in approaches and the associated degree of operational success.

A business sector which has not traditionally deployed formalised design-driven labs is the automotive industry. The size and complexity of automotive original equipment manufacturers (OEMs) are such that most are divided into multiple operating units. The individual units develop individual vehicle systems such as the drive train, interior packaging, electronic systems, etc., and the design activities are often performed in an incremental manner based on technological or user-centred innovation criteria.

In order to identify the possible constitutive elements of an automotive design-driven lab, exploratory research involving expert interviews was conducted with automotive industry professionals. This paper presents the thematic analysis of the resulting interviews and briefly describes the most obvious physical, psychological, sociological and philosophical considerations which emerged.

III. METHODS

Expert interviews were conducted due to the desire to achieve systems-level insights and strategic understanding [20]. A group of individuals with expert knowledge of the various areas of automotive design were selected, in line with best practice for expert interview studies [21].

The expert interviews were performed over a period of 2 years with 12 automotive experts (n=12). The experts were senior representatives from more than a single automotive organisation. The experts were interviewed using a semi structured interview guide [22]. The research questions discussed during the interviews were:

- How are the opinions and requirements of your customers currently obtained?
- What different or additional tools or approaches might be considered useful for obtaining more relevant and accurate information from customers?
- How do you select the aspect of the automobile to prioritise during the design process?

The interviews, which typically lasted for 45 minutes, were recorded using a digital recorder. The audio recordings were then transcribed verbatim and thematic analysis of the textual dataset was carried out by two members of the research team. Qualitative data analysis software (QSR NVIVO 10) was used to frame key topics and to code the overarching themes that existed within the transcripts. The analysis then involved identifying a list of high-priority themes and sub-themes against which summary recommendations were formulated.

IV. RESULTS

Four key themes emerged from the expert interviews: (1) automotive human centred scenarios, (2) automotive human centred design methods, (3) automotive human behaviour monitoring and (4) automotive real time interaction and communication protocols. The sections that follow describe the findings and highlight the areas for future research.

Theme 1: Automotive Human Centred Design Scenarios

Participants suggested the current lack of automotive human centred design scenarios as a key limitation of their practices. Concerns were raised regarding the lack of evaluation scenarios that are efficient towards answering a given automotive human centred design question.

Technological progress has transformed the automobile from a passive machine for moving people from point A to B into instead a "smart object" [23]. In recent years multiple additional capabilities have been added to support communication, entertainment, leisure and business [24]. Automobiles are thus no longer perceived to be a "remote space" in people's lives [25]. Despite this growth in sophistication, however, automotive human centred design does not currently benefit from standardised scenarios. This was considered problematic in light of the suggested importance of the paradigm towards the identification of target metaphors, meanings and desires.

There is currently on limited research in the literature which explores what people desire for their future automobiles, and even less regarding how to capture the emotional, psychological and sociological aspects of those desires. Further, it is an established truism that hidden needs and future aspirations are notoriously difficult to ascertain because most people struggle to fully articulate what they really want [26].

The current findings suggest that additional ethnographic, observational and contextual probing is required within automobiles, and that detailed scenarios need to be defined to capture the most critical moments of automobile habitation in terms of the emotions and meanings involved.

Theme 2: Automotive Human Centred Design Methods

The toolbox of available human centred design methods has grown continuously in recent years by borrowing techniques from fields such as psychology or sociology [27] and by defining new approaches based on applied practice. Several

books [28], handbooks [29] and card decks [30] currently exist which summarise the most frequently deployed methodologies by means of short descriptions and representative case histories. Unfortunately, the literature highlights the limited and slow adoption of new methods [31] and the frequent misuse of traditional techniques [32, 33].

Published research has suggested that none of the existing *Human Centred Design* techniques specifically addresses the automotive context in regards to capturing human needs [26]. This suggestion was confirmed in the current study. The participants highlighted the need for methods that are optimised for the automotive context, and their statements suggested that it is not currently immediately obvious which human centred design methods are the most efficient towards answering a given automotive design question.

Despite the implications in terms of complexity and cost, the current findings suggest that the suitability of each method towards the design of each major automotive component, system or complete vehicle concept should be evaluated in some manner. Metrics of appropriateness and their associated hierarchies of usage therefore appear to be required.

Theme 3: Automotive Human Behaviour Monitoring

Interviewees highlighted the need for human behaviour monitoring to better understand the constraints and affordances of the automotive environment. Emphasis was placed on the collection of human emotion data via non-intrusive means. Various statements appeared to imply that safety and efficiency characteristics of the interaction between the driver and the automobile were relatively well understood, but that much less was known about the real time emotional responses of the people in the automobile, particularly the emotions and actions of the passengers.

In recent years technological advances such as big data and the internet of things have produced a dramatic increase in the amount of information about customers which is available to designers. A new era of data-driven design seems to be emerging. A vast array of new sensors, devices and algorithms can provide partial clues about human emotional responses and behaviours. Beyond the traditional contact-based measurements such as heart rate, skin temperature, skin conductance and electroencephalograms, recent years have seen a proliferation of non-contact measurements such as body posture recognition, motion tracking, eye tracking, facial expression recognition, emotion estimation and other capabilities which provide clues to human physiological, emotional and social state [34].

In addition to independent technologies, the evolution of the automobile itself has provided a rich set of new electronic data channels which can be monitored for signs of human intervention, human intention and human emotion. Sensors associated with the steering wheel, throttle pedal, brake pedal, clutch pedal, seat, safety belt, secondary controls, infotainment and other on-board interfaces provide valuable clues to patterns of intervention, intention and emotion.

The current research has suggested the desire for further evaluations of the usefulness of the existing measures. Interviewee opinions suggested a richness of offerings from the technology market, but only a limited understanding of the potential usefulness of the individual technologies towards the purpose of better interpreting the people who inhabit the automobile.

The international research community has taken some steps in this direction [35, 36]. Nevertheless, further activity appears to be required to better understand the suitability, reliability, intrusiveness, and robustness of the new technologies, particularly of those which estimate emotional state [37]. Further research appears to be needed regarding the best ways to use the new items of information [38].

Theme 4: Automotive Real Time Interaction

Interviewees highlighted a gap in current practices caused by the inability to solicit the opinions of drivers and passengers during routine activity. A direct line of communication between people in automobiles and design professionals was referred to as an essential element of the design of future automobiles. Some interviewee statements also alluded to the need to establish trust between the designers and the people, as a fundamental prerequisite of any co-design process.

Computer mediated communication protocols currently exist in military and civilian applications [39], most noticeably in areas such as drone operations, air traffic control [40] and emergency command and control. The primary purpose of the existing communication protocols is not however to support a creative conversation as part of a co-design approach.

The information gathered in the current study suggested instead that a creative conversation is required between designers and people in automobiles, and that such co-design interaction requires tailored hardware systems, software systems and dialogue protocols. Additional research therefore appears to be required to optimise the on-board hardware to support real time communications and to achieve the "virtual presence" of the designer within the automobile. Further, additional research appears to be required to define the control room conditions within which the designer operates, and the linguistic and cultural protocols needed to achieve creative conversations with drivers and passengers in real time.

V. Conceptual framework

The themes and observations which emerged from the expert interviews lead to a draft specification for an automotive facility which is here referred to as the *Automotive Habitat Laboratory*. It will provide a platform for real-time creative dialogue and co-design between designers and people who are in their automobiles.

The *Automotive Habitat Laboratory* will consist of a set of automobiles which are equipped to permit real-time interactions between designers in a control room and the

people who are going about their affairs in the automobile. For each automobile the *Automotive Habitat Laboratory* will be based on the following elements:

- Software which monitors the automobile's systems and interfaces, and which extracts in real time the most behaviourally relevant events for consideration.
- Software which monitors body postures and emotional states of the occupants, and which extracts in real time the most behaviourally relevant events for consideration.
- Communication hardware and software which enables the real time link between the automobile and the control room.
- Control room in which the design professionals interact with the data streams and with the people in the automobiles to perform contextual enquiries and co-design.
- Automotive human centred design evaluation scenarios, which specify the most critical usage patterns and social situations for investigation.
- Prioritised hierarchy of automotive human centred design methods, which suggests the most efficient techniques to deploy in response to a general category of issue.

Figure 1 *Automotive Habitat Laboratory* Concept.

So conceived, the *Automotive Habitat Laboratory* provides a "virtual design workshop" with the people in the automobile as events occur. The real time nature permits customer interactions which do not suffer the biasing effects of time-from-event and distance-from-context [41]. The ability to co-design using human short term memory, rather than the long term memory usage which typically characterises current automotive design activity, is a critical advantage of the *Automotive Habitat Laboratory*.

The distorting effects of human long term memory are well known [42] and it is widely recognised that accuracy and verifiability of testimony decays with increasing time-from-event [43]. Cognitive affordances [44] which influence opinions can be lost with after-the-fact questionnaires, surveys, interviews, focus groups or workshops [45]. In addition, the nonlinearity of perceptual stimuli can be distorted in memory when considered in isolation rather than within the original real-time multimodal context [46].

The addition to the more obvious and direct co-design advantages, the *Automotive Habitat Laboratory* should also provide an excellent avenue for investigating matters such as the conversational capital [47] which can be achieved via the current or future designs.

VI. Conclusions

This paper presents the design-driven innovation laboratory which emerged from interviews and discussions with motor industry professionals. The *Automotive Habitat Laboratory*, which is currently under development, will allow for real-time design workshops and co-creation with customers who are engaged in driving or otherwise using their automobile. It can be considered a human centred design approach to both incremental and disruptive innovation in the automotive sector. The background to the research has been discussed, the main elements of the approach have been identified and some of the possible benefits have been discussed.

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