

Creating Inclusive HMI Concepts for Future Cars Using Visual Scenario Storyboards Through Design Ethnography

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Abstract. His paper illustrates the use of scenario writing and storyboard visualisation methods based on ethnographic study of diverse personas, narratives, and user experience to guide automotive engineers and designers for creating innovative ideas and developing inclusive Human Machine Interface (iHMI) concepts for future cars in 2025 and beyond. This paper documents the importance of continuing visual research process based on anthropological case studies that looked into diverse persona, cultural and geographical attributes. These methods are used to visually analyse situational car use, thereby leading to scenario-based HMI tasks that can be applied to generate innovative user oriented future car designs. Storyboard visualisation of narratives is a method that derives from ethnographic interviews with strategically chosen car users from around the world. This is a powerful tool for analyzing situations, describing feelings, and evaluating the usability of functions within the car. With this visual process, future scenarios can be drawn in order to create new and inclusive HMI ideas and design concepts embedded within the storyboards to help engineers and designers' to understand users' different needs, exploring their expectations, emotions and motivations. The realistic details on the character illustrations of each persona are essential for better understanding of the users' including older people, the visually impaired and wheelchair users, child and parent, technophobic or technophile persons. Each HMI concept can be sketched as required in task sequences, with detail and scaled paper model produced for detailed step-by-step design. The required interactions can be observed, photographed and captured on video for in-depth design thinking workshops. A series of HMI working design concepts for future cars will emerge from this pipeline for prototyping and engineering.

Keywords: Human machine interface · Inclusive design · Visual narrative · Scenario storyboards · Concept visualization · Design thinking · User research · User-Centred design · Design ethnography

1 Introduction

The exploration of creative and realistic inclusive Human Machine Interface (iHMI) ideas for future cars requires an understanding of how people around the world drive, travel and use cars of today. Tools of scenario visualization based on ethnographic studies on diverse personas, narratives, and user experience are proven to be beneficial for automotive engineers and designers for creating innovative ideas and developing realistic automotive iHMI concepts. We examine how specific car models could accommodate drivers and passengers who have varying physical, mental and cognitive abilities, as well as varying in their age, gender and culture. Ethnographic research investigates real people with different experiences, lifestyles and needs. Visual representation of such ethnographic findings provides a good understanding of users' behavioural patterns to the designer. Personas set in scenarios (environments and situations) within the context of the persona's response are used in the design process to represent user archetypes.

Rapid growth in population ageing increasingly requires the inclusion of participants from older age groups as well as disabled and less-abled users in the design process. This rise in activity and profile has been catalysed in part by the ten year *i~design* programme of research (2000–2010) funded by the EPSRC and led by Cambridge University's Engineering Design Centre (EDC) in partnership with the Helen Hamlyn Centre for Design at the Royal College of Art. Scenarios set out for the research are benefiting from the experience of *i~design 3* project that has promoted active living through more inclusive design [1].

Inclusive design does not imply that one product fits all nor that there is not a need for specialist products and services for those with particular capability loss or losses. It does however provide an approach to ensure that the accessibility of a designed product or service is maximised, with the attendant reduction in requirements for specialised adaptation and increase in uptake of use.

The need for inclusive design is increasing in an ageing developed world due to the relationship between ageing and capability loss. Currently, half of the adult population in the UK are over the age of 45, a large proportion of these individuals have some form of significant capability loss, whether it is, for example, physical, visual, auditory or cognitive. The iHMI approach assumes that any human user can be impaired (disabled) in their effectiveness by characteristics of their environment, the task, and the design of the user interface they are presented with [2, 3]. Such impairment may take the form of perceptual, cognitive and physical movement functional limitations that then translate into inability. It can arise out of capability limitation or from excessive demands of new technology interfaces.

The purpose of an exclusion audit is to estimate the percentage of the UK adult population excluded from completing a task. It provides a method to estimate the severity of each demand hurdles (e.g. vision, hearing, dexterity) that prevent users with

mild capability impairments from achieving, through a metric system using percentage of exclusion to indicate demand magnitude. The audit breaks down a goal into tasks and sub-tasks to enable the demand to be assessed at each step against standard tasks asked from participants.

2 Approach and Methodology

Pruitt and Grudin [4] suggest that the use of personas may be considered ‘too arty’ for science and engineering based enterprises yet cite the power of fictional characters to engage. This is made even stronger when the narrative is placed alongside visual representations. The place, environment and the situation in which the persona carries out the narrated tasks set the context of the persona. This provides a key set of actions that the persona can undertake. These narratives are known as scenarios and offer a ‘sketch of use’ in the design process [5]. Present time scenario illustrated frame by frame inspires believable and stimulating new design concepts that are further illustrated in future narrative storyboards to help validate them. It is more effective to show a human face rather than providing abstract data for the user. Scenarios provide the story in which the persona is set, and a sequence of actions that the persona undertakes. They provide the opportunity for wider communication of the user’s possible actions. In engineering, the scenario is set as a list of steps and known as a ‘usage case’.

3 Design Ethnography and Visualisation

This research is by nature qualitative, as it sets out to grasp the subtleties and details of people’s everyday routines. It is concerned with personal experiences, daily rituals, and individuals’ understandings of the world set in the broader socio-cultural context [6]. Initial character illustrations provide the viewer with a detailed look of the persona and the clothing. In most cases the photographs provided work to help the visualiser draw as realistic image of the persona as possible, perhaps capturing the important details more effectively than the photographs. It is very important that the personas should not be based just on the designer’s own assumptions and experience. Personas require proper details of the users through ethnographic methods that enable to draw out the richness, diversity and nuances of real life experience [7].

The approach taken here developed the persona and usage cases based on interviews with people representing that particular context. Based on these and because of resource limitations a new deliverable format of “Doculets” was proposed. Each persona would generate a small pamphlet/document consisting of professionally printed set of around 5–10 pages. Content consisted of general introductory material on inclusion and future HMI and the Persona description with some illustrations. Key HMI elements of the usage cases were then illustrated with relevant text from user interviews, HMI and the proposed design response. This was accompanied by images in the form of photographs, schematics, interior vehicle sketches illustrating future HMI and the inclusive audit comparisons (Fig. 1).



Fig. 1. Doculet covers depicting each persona within geographical settings using specific car models based on ethnographic research conducted on real people and real places (originals in colour).

In order to gain the most relevant information from the user such as the daily life and routines, needs and desires, experiences and inspirations, questions need to be prestructured by the interviewer to help building a realistic picture of the participant as a persona. Davies [8] tells us that research based mainly on semi-structured interviewing has become a very popular and important form of qualitative research across the social sciences, especially in anthropology (Edgerton 1993; Spradley 1979); sociology (Cockburn 1991; Laws 1990), psychology and other applied social sciences.

During this research, interviews are transcribed and analyzed for keywords and related descriptions; fieldwork generates detailed diary entries on observations of participants [9]. Ethnographic research conducted in strategically targeted different parts of the world within Brazil, USA, Europe, India and China looks for answers for the most likely and diverse personas linked to major car user locations in the world. Each persona appears in a narrative for a typical present day scenario that happens in one geographical place. Every present day scenario is overlapped by the future vision of the same scenario with the innovative HMI concepts likely to change the way cars are being driven or used by the user. Narrative scripts are visualized in storyboard format for the flow of user actions and movements (Fig. 2).

4 Design Thinking /User-Centred Design

One of the key challenges facing designers is to unlock the tacit understanding of how they believe things should be, so that these ideas can be shared, discussed, critiqued and eventually operationalized. Nowhere is this more difficult than in the design of physical interactions, where critical aspects of a design are often neither verbalized nor materialized. And yet, physical movement, behaviors and gestures can be critically important in the design of everyday objects—of cars, of robots, of doors and drawers—where autonomous motion is increasingly being incorporated, and where inexpensive controllers and batteries enable products that can lock and unlock, open and close, move around, wave, hide—act on their own [10].

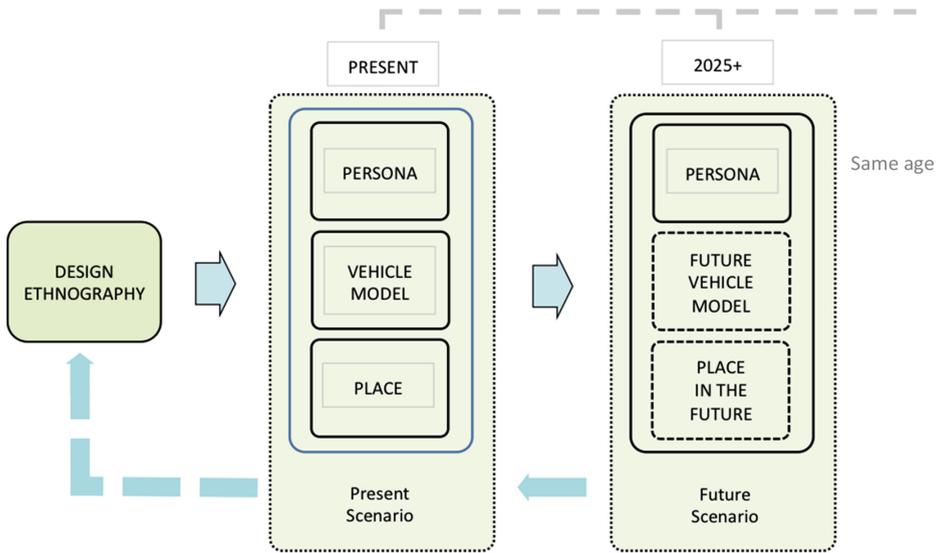


Fig. 2. Diagram of present day user-centred scenario leading to future scenario based on design ethnography.

Each persona, either a driver or a passenger is considered to be associated with an existing car model during the design thinking interaction workshop. Key project engineers, researchers and visualisers discuss and build a realistic storyline around the persona, car, place and environment in a set of tasks and situations (Fig. 3).



Fig. 3. Exploring an executive saloon car from the business user perspective and capturing the sequence of tasks that can be evaluated as potential HMI concepts to be later illustrated in scenario storyboards. Researchers here act as observer-participants.

4.1 Usage Cases Developed from Personas

The example given below is one of the several scenario cases developed based on the personas.

4.2 Scenario Case: Retired Couple Hiring a Car Abroad

After many years of hard work, in Jim and Rosie's newly retired status they want to take advantage of their freedom and have the income to do so. Part of the baby boomer generation, Jim and Rosie have rapidly adapted to new advances in technology and engage with the latest devices with ease. Both have iPads and smart phones. Jim and Rosie equally expect to experience the high levels of service and respect that they found at the top of their professional careers to now come across all other aspects of their daily lives. During their retirement, Jim and Rosie travel frequently. When it comes to car rentals, they expect to encounter vehicles that match the advances in technology in their home country and across other devices (e.g. smart phones). When this is not met, they compensate with more analogue solutions (e.g. a real map instead of the satnav) or their existing devices (e.g. an iPad) (Fig. 4).

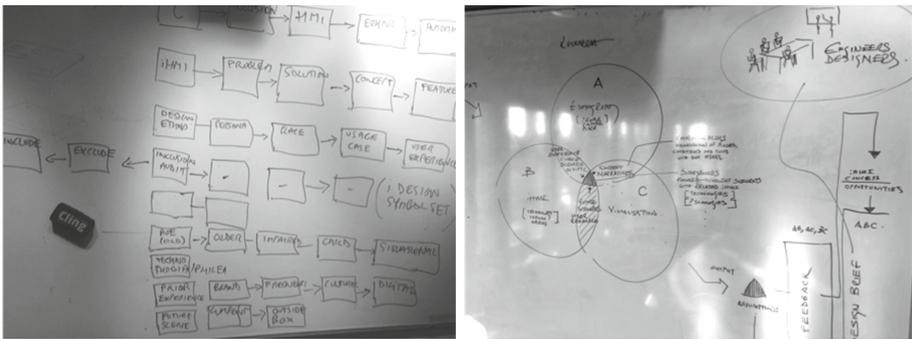


Fig. 4. Inclusive HMI workshops allow the team to analyse narrative scripts, produce visual scenarios and conceptual sketches of iHMI ideas through design thinking and user journey mapping activities. Input from these group sessions feeds into ethnographic research and scenario storyboards for the final validation of realistic automotive HMI design opportunities.

4.3 Scenario Storyboarding and Concept Ideation Process

The advantage of using storyboards is the quick changes and additions to the visual flow of the story build-up. In this respect, it is a powerful tool as narrative sequences can be seen altogether; present and future scenarios can be compared almost instantly whether the storyboard frames are laid on the table or stuck on the wall, allowing the project participants to use sticky notes either creating more storyboard frames or moving around or removing them where necessary. One or more visualisers may help capturing ideas by drawing very quick sketches and diagrams that is part of the

research phase storyboarding. Thus, during this visual process, each user experience or interaction within the scenario can be broken into its more specific components over time, which allows the group to analyze more closely. Therefore, this visual brainstorming prompts attendees to come up with inspiring and innovative ideas that can be further captured in the future storylines.

A storyboard is a visual narrative of an interaction scenario. With origins in cinema, it is a story-telling device that describes characters, the activities they engage in, the objects that they need and/or use, their motivations, emotions and reactions to interactions, and an environment for those interactions [11].

After completing the initial storyboards through design thinking workshops conceptual ideas emerge. These ideas are drawn in more detailed storyboards to represent the design details as well as the user interactions to reflect the user's action, experience, emotion, feelings and thoughts in many ways leading to storyboard prototypes. Sections of the storyboard that relate to each design idea are discussed within the group. The final working designs that the users would take to overcome the needs or the problems are selected through this decision process. Each project prototype solution becomes a tangible design module used in the overall automobile design. The user remains as the main character to interact with the vehicle [12] (Fig. 5).



Fig. 5. Designers, engineers and researchers going through the storyboard sketches frame by frame in developing the narrative with proposed iHMI design ideas for a specific car model (on the left). Two of the case studies are being presented current and future scenarios in the company technology exhibition 2014.

Final presentation of the storyboard shows each design solution throughout the visual scenario in more detailed and colour drawings focusing on how the user interacts with the car in a specific environment and reveals the experience of certain users due to their age, ability, gender, personality and culture. Thus, engineers and designers have

better understanding of creating innovative and inspiring automotive designs that are more inclusive.

4.4 Validity of the Concepts Through Visual Narratives

Visual narratives are quick to draw and sequences of the storyboards can be rearranged and changed where necessary either in the early stages with paper and pencil sketching or scanned digital images on screen in developing stages. Details in drawings, colour, line quality, view angles, pan movements, speech bubbles and other explanatory texts within the storyboards are in continuous progress to capture the most realistic iHMI design ideas that can be well understood and executed by the design engineers. Therefore, the final presentation provides valid design proposals integrated in visual future narratives that are easy to follow. One of the benefits of storyboarding is to understand how technology reshapes human activity and influences the understanding of the reaction to a system [13]. The team analyses the final presentation of visual scenarios and develop further conceptual sketches of iHMI ideas through design thinking and user journey mapping activities. Where necessary paper prototypes and 3D models are produced to provide better feedback from the project team where ethnography and iHMI researchers review the final validation of realistic design proposals.

4.5 The iHMI “Pipeline” to Concepts

The iHMI “pipeline” is a research approach, which allows developing key concepts that take into account the needs of real customers. This approach includes the following steps (Fig. 6):

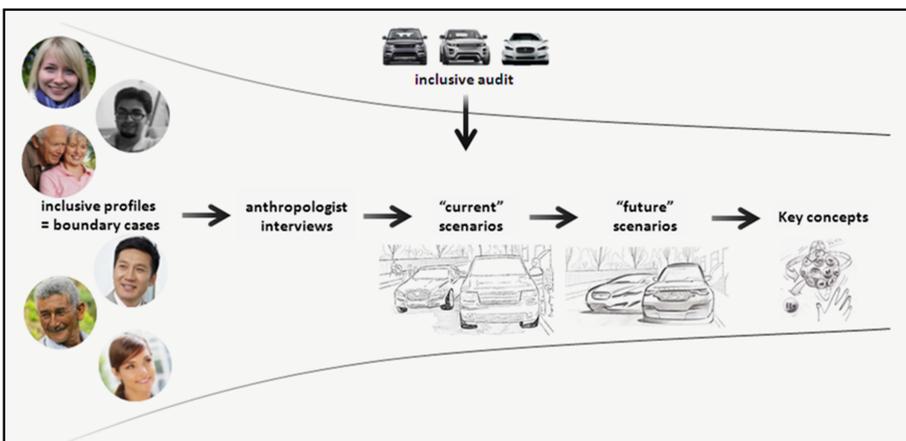


Fig. 6. The inclusive Human Machine Interaction (iHMI) “Pipeline” to concepts

- Persona selection,
- Identification of user needs and usages (anthropology interview),
- Understanding of the current product (inclusive audit),
- Current scenario based on anthropology and inclusive outputs,
- Future scenario,
- Selection of key concepts.

Persona Selection. Marketing departments generally develop one or several persona per products in order to illustrate their typical customers.

Anthropologist Interview. Anthropologists on the team conducted interviews with individuals representative of the persona. Through these conversations, the real lived experience of that individual and as a result their needs in that particular usage case were identified. This enabled us to detail the persona profile based on real feedback, rather than based on the assumptions of designers and engineers.

Inclusive Audit. An inclusive audit is conducted in order to identify the most difficult functions to operate/use.

“Current Scenario”. The current scenario illustrates the usage and the needs of each persona and details the outputs of the inclusive audit. The persona is represented using a current vehicle.

“Future Scenario”. The future scenario illustrates the same persona using a 2030 vehicle. This methodology allows presenting future concepts and visualising their value for the customer. At this stage, concepts are created without technical limitations.

Concept Selection. As a group, engineers and designers select the key concepts taking into account value for the customer and business priority.

5 Conclusion

At the present time scenario presented with its future version next to it helps us to have a good comparison of the two timelines. The importance of the storyboarding tool lies on the visual execution techniques to explore and understand drivers and passengers, automotive technologies and the interactions in between especially from the inclusive design perspective. Scenario boards provide the necessary visual language that the researchers, visualisers, automotive designers and engineers communicate in a more effective way [11].

Therefore, in this ongoing project, the aim is to create visual material such as a series of booklets that are self-explanatory brief documents each focusing on one persona case, design sketches and drawings of the future design ideas and interfaces. It also includes CAD drawings of future vehicle detailing the interiors, door apertures, seating, driver and passenger areas, and set of storyboards for each scenario. The storyboards show how each user interacts with the vehicle and its environment. These may differ inclusively from each other due to different needs and expectations. A consistent visualization for a number of inclusive design based personas using cars with future HMI interfaces are being generated.

Storyboards executed to date are twofold: present day scenarios where the persona is interacting with a current vehicle and environment, and future scenarios where the same persona is visually tested against an imaginary future car. Storyboards mainly focus on two elements: (1) user perspective that portrays the characteristics of the user including age, gender, profession, cultural background and disability, and (2) the vehicle perspective that combines components and devices within the vehicle where the user interacts with the interface of controls and displays. This arrangement of the storyboards allow the team some potentially useful design thinking in order to resolve the issues; whether through redesign of the interface, or perhaps through changing the order of tasks. It is expected that more investigation will be required for better understanding of the user's expectations of the right layout and right location of controls and displays as well as other components, such as: seats, storage, arm, head and foot rests, cup holder, sound, light, air units and work stations. The usage cases will be matched to design using inclusive design metrics [14].

At the end of the initial phase of the project 2 scenario cases were introduced during the company technology exhibition 2014. Each case study illustrated the users' relationship with the vehicle and the surrounding environment. The success of the approach has been measured through the feedback from the company automotive engineers and during the company technology exhibition. This has demonstrated the effectiveness of this type of technique in relating user needs to engineered technology and design.

References

1. Waller, S.D., Langdon, P.M., Clarkson, P.J.: Using disability data to estimate design exclusion. *Univ. Access Inf. Soc.* **9**(3), 195–207 (2010)
2. Bichard, J.-A., Coleman, R., Langdon, P.: Does my stigma look big in this? considering acceptability and desirability in the inclusive design of technology products. In: Stephanidis, C. (ed.) *HCI 2007. LNCS*, vol. 4554, pp. 622–631. Springer, Heidelberg (2007)
3. Sears, A., Lin, M., Jacko, J., Xiao, Y.: When computers fade... Pervasive computing and situationally induced impairments and disabilities. In: *Proceedings of HCI International*, pp. 1298–1302 (2003)
4. Pruitt, J., Grudin, J.: Personas: practice and theory. In: *Proceedings of the 2003 Conference on Designing for User Experiences*, pp. 1–15 (2003)
5. Rosson, M. B., Carroll, J.M.: Scenario-based design. In: Jacko, J., Sears, A. (eds.): *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications*. Lawrence Erlbaum Associates, pp. 1032–1050 (2002)
6. Geertz, C.: *Available Light: Anthropological Reflections on Philosophical Topics*, pp. 11–17. Princeton University, New Jersey (2001)
7. Cooper, A., Reimann, R., Cronin, D.: *About Face 3: The Essentials of Interaction Design*, pp. 77–86. Wiley, Indianapolis (2007)
8. Davies, C.A.: *Reflective Ethnography: A Guide to researching Selves and Others*, pp. 169–170. Routledge, London (1999)

9. Bichard, J.-A., Gheerawo, R.: The designer as ethnographer: practical projects in industry. In: *Design Anthropology Object Culture in the 21st Century*. Springer, Wien, New York, USA, pp. 45-55 (2010)
10. Sirkin, D., Ju, W.: Embodied design improvisation: a method to make tacit design knowledge explicit and usable. In: Plattner, H., Meinel, C., Leifer, L.J. (eds.) *Design Thinking Research. Building Innovators*, pp. 195–210. Springer, Heidelberg (2015)
11. Van der Lelie, C.: The value of storyboards in the product design process. *Pers. Ubiquit. Comput.* **10**(2), 159–162 (2006)
12. Sirkin, D., Ju, W.: Using embodied design improvisation as a design tool. In: *International Conference on Human Behaviour in Design*. Center for Design Research, Stanford University, Stanford, Ascona, Switzerland (2014)
13. Truong, K.N., Hayes, G.R., Abowd, G.D.: Storyboarding: an empirical determination of best practices and effective guidelines (2006)
14. Langdon, P.M., Johnson, D., Huppert, F., Clarkson, P.J.: A framework for collecting inclusive design data for the UK population in applied ergonomics. *Appl. Ergon.* (2013). pii: S0003–6870(13)00050-1. doi:[10.1016/j.apergo.2013.03.011](https://doi.org/10.1016/j.apergo.2013.03.011)