User-intensive Cars: Design Contributions for More Sustainable Approaches to Personal Transportation

Alexandre[CTH1] Rodrigues

PhD Candidate

CIE-MAP Research Centre

Nottingham Trent University

Burton Street

Nottingham NG1 4BU

United Kingdom

Tim Cooper

Professor of Sustainable Consumption

Nottingham Trent University

Burton Street

Nottingham NG1 4BU

United Kingdom

Matthew Watkins

Senior Lecturer in Product Design

Burton Street

Nottingham NG1 4BU

United Kingdom

Abstract (up to 150 words - optional)

Social changes in Europe and increase in urban population globally may generate new opportunities to develop different [CTH2]forms of personal transportation and ownership models, e.g. reducing the number of cars. Different solutions have been suggested in order to reduce their environmental burden. There is currently little evidence on whether user-intensive cars are fit for purpose or overcome issues such as ownership, cleanliness, and performance under different driving styles.

This paper presents initial findings from ten interviews concerning user-intensive passenger [CTH3]cars with industry representatives such as car designers and engineers. It identifies, mainly from a design and development point of view, the barriers and opportunities to user-intensive vehicles. This will contribute to a better understanding of the car as a user-intensive product shared by a number of consumers as opposed to the dominant model of private ownership.

Introduction

Household products such as passenger cars create environmental impacts in the ecosystem. From the extraction of raw materials, from the transport of energy to and transformation of materials into final [CTH4]products through to consumption and disposal. Packard (1963) highlighted excesses in production and consumption. He argued that business strategies such as planned obsolescence are responsible for the world's vanishing resources and the accumulation of waste. Similarly Cooper (1994) proposed longer life options for household products in order to create more sustainable patterns of production and consumption, delaying recycling and waste. Nieuwenhuis (1994) suggested that doubling lifespans of cars from, at the time, an average of ten years to twenty would potentially reduce the number of vehicles produced and dismantled and the associated environmental impacts. More recently Kagawa, Tasaki et al. (2006), Kagawa, Nansai et al. (2011) and Kagawa, Shigemi et al. (2013) concluded that extending the life of vehicles can be beneficial in reducing CO_2 emissions, both at manufacturing and user-stage level.

Despite still limited research in the design area, Rodrigues, Cooper et al. (2015) assert that designing a longer lifespan passenger car will face important barriers in several areas, such as material increase, disruptive technologies, modularity or safety regulations. Rogers and Rodrigues (2015) suggest that may be cost-effective and environmentally beneficial [CTH5]to increase the lifespan of cars. Nonetheless Van Nes and Cramer (2006) and Vezzoli and Manzini (2008) argue that, for products with high environmental impacts during user-stage (e.g. passenger cars), designing a user-intensive product should be the preferred option. This implies early replacement, which will allow subsequent generations of the product to be replaced earlier, reaching environmental efficiencies quicker. However, it is not clear if early replacement of cars will be environmentally beneficial. It has, nonetheless, potential to become less impactful than the current passenger car usage; higher occupancy rates may lead to fewer cars on the roads reducing the impact of production-stage demand for materials and energy.

Methodology

This paper is based on the analysis of ten in-depth interviews with automotive designers and engineers. The interviews explored two design options: longer lifespan and user-intensive cars Experts[CTH6] came from different automotive companies and countries, ranging from mass-market, premium (luxury and sports cars) and high premium manufacturers (highly bespoke vehicles), a large multinational tier-one supplier and a vehicle testing consultancy, reflecting different company cultures and approaches to design. For confidentiality reasons they will be named D1 (Designer 1), E1, (Engineer 1), and so on (annex [CTH7]I). A balance of four designers and six engineers was achieved in order to provide an appropriate breadth of expertise. The interviews were made on location where possible, or via video-call. The duration of each ranged from between forty minutes to one and a half hours. A semi-structured interview approach was used in order to explore the requirements of designing for intensity of use. Interviews were voice-recorded and transcribed. The analysis was performed by clustering the answers against the codes chosen as appropriate [CTH8]from the literature (Bryman 2008). The questionnaire addressed the adoption of user-intensive and longer lifespan passenger cars in the design process and was divided into four broad questions to explore the design options towards both concepts. This paper is focused on user-intensive cars only. The opportunities described here are not exhaustive but were considered the most significant. These interviews explored the different design strategies proposed by Vezzoli and Manzini (2008) for intensive use:

- design for shared use[CTH9];
- design for multi-functionality
- products/service on demand and on-availability
- integrated functions.

The quotations presented in this paper were transcribed *verbatim.*

Findings

The results presented are divided into the four different strategies suggested above for clarity and consistency. However, a demographic context was added. Demographic aspects were often raised during the answers provided; they help to understand what the potential market may be and, specifically, the buying behaviour of populations.

The findings are not exhaustive but help to understand the general standing of the automotive industry with regard to novel solutions for personal transportation. Some of the views reflect the interviewees' expertise in their professional area. However it was also found that interviewees gave personal opinions based on their expertise, sometimes diverging from mainstream views. Nonetheless they represent a broad view of automotive expertise on user-intensive cars.

Demographics

In order to be attractive to the market most interviews suggested user-intensive vehicles need to offer some economic advantage over the traditional ownership model, and ideally offer a more sustainable form of transportation with an emphasis on material and energy reduction. They also have to be attractive to a certain target market interested in such form of transportation.

> *"But, I think what you need to look at is what would drive those people to want to share a vehicle. It has to give them some advantage over owning one today."* E3
>
> *"So for infrequent usage there's a tipping point where there makes no sense to buy a car, if your usage is low enough. It's actually not only more convenient but more economic to rent a car occasionally." E2*
>
> *"If you know, people know that what you're travelling around in is helping to keep CO2 low, is helping to keep local people employed, then actually that's quite nice."* D1

Essentially any new alternative form of transportation may help to provide consumers with the right choice for their real needs instead of the current 'one-size-fits-all' the industry offers (Wells 2010).

> *"So the customer can really take the product, the vehicle or type of ownership that works for them."* E6

But who could these consumers be and what would be the target market? During the interviews a particular group was described as *"the young generation"* E4 and D1*.* It was implied that the interviewees were mentioning the so-called millennial or Y generation, people born from around 1980 to 2000, who have different consumption attitudes compared to previous generations (Valentine, Powers 2013). Conversely "among other things, Generation Y consumers are seen as tolerant and compassionate towards social causes" (Valentine, Powers 2013 p605)[CTH10]. Furthermore Smith (2012) notes that this generation has considerable spending power and are growing up in a digital world. Their shopping and socialising is predominately done through the internet. Exchanging information about products and voicing their opinions strongly impacts on their purchasing decisions. Another trait of millennials is individualism and therefore a preference for personalisation, be it advertising messages or products enhancing a sense of specialness (Smith 2012). Interactivity and also "fluidity between work and play" (Ng, Schweitzer et al. 2010 p289)[CTH11] is appreciated as part of their multi-tasking skills (Barnes, Marateo et al. 2007). The socially oriented nature of millennials means that they prefer to engage in more group-based activities (Lowe, Levitt et al. 2008), reflecting a sense of belonging during their formative years (Ng, Schweitzer et al. 2010; Benckendorff, Moscardo et al. 2010).

The industry is aware of this societal change in attitude towards consumption and social responsibility:

> *"There's more altruism these days amongst a much younger age group." D1*
>
> *"There's a few interesting things going on with the young generation at the moment (…) I think there's a change in how people are interacting so that having mobility of a car in past*

generations were critical to even being able to almost have a social life. And yet so much social life now is actually done online." E4

Design for shared use

Car sharing schemes such as Zip Car or City Car Club rely on standard vehicles bought from a manufacturer or a retailer. These cars are then retrofitted with card recognition and tracking devices that will unlock the doors allowing the company to [CTH12]know where the car is in real time (City Car Club 2015). Other schemes such as Grenoble's 'Smart City' rely on small, single or twin seat electric vehicles that are used for short journeys not able to be taken by public transport (Autopartage 2015). The view of some of the interviewees was that user-intensive cars could be built for purpose, despite current hire and car-sharing vehicles being standard. [CTH13]

[CTH14]Design opportunities for user-intensive cars were mainly found in interior layout, especially if equipped with autonomous technology. Autonomous vehicles enable the elimination of interfaces inside the vehicle such as steering wheel and pedals, and will allow passengers to face each other, and also spend the journey time in activities other than driving such as working or socialising *en-route.*

"You could probably play around with the interior of the vehicle significantly and change the seating set-up, perhaps provide more usable [space] (...) but they want more of a desk type set-up as opposed to just a traditional seat" (…) Cos it would be more like you were sat in a train, a bus, a plane. Cos you may be not facing the direction of travel like you normally are in a car D4.

Further, the interior must be hardwearing, easy to clean, but comfortable at the same time. D3, who had experience of public transportation (trains and aeroplanes), described the need for this.

"It really had to be bomb-proof because the use, the damage that suffers an interior (…) it's huge" D3*.*

"I mean it need to be durable, easy to clean, I suppose." E2

Car designers may have to redefine [CTH15]cars' scope; they will be less personalised because each car will have a broader range of users. [CTH16]However, particular settings such as the passenger compartment temperature, interior lighting or music will be set up by the user moments before usage. The interviewees suggested that shared rides with strangers – as in a bus - are seen as less desirable by the industry; they suggested a preference for time-shared cars. Time shared rides are trips made individually through a booking system – similar to hire cars.

Design for multi-functionality

Multi-functionality may be related to what the user can do if, for example, an autonomous user-intensive vehicle is used for meetings in-transit, in which case its interfaces and interior layout will play a significant part in achieving multi-functionality. Cars, by design, already have different characteristics and serve more than one function: in addition to being a form of transport, they incorporate other products such as radios, satellite-navigation and air-conditioning. However, if designed and produced to be exclusively a means of transport (e.g. for commuting) then some multi-functionality may be lost.

"So, you may not need to be engaged with the active driving at all times, fascinating from an interior architecture point of view in particular, create something that works for you as a work space, living space whilst you're in transit." D2

Products/services on-demand

There is a distinction between products/services on-demand and on-availability (Vezzoli and Manzini 2008). The first is characterised by a service that is requested by the user and, generally, is provided in real-time. The second means one type of vehicle during the week, to commute, and another for the weekend or holiday away from home. Both would have to rely on distinctive logistics, technologies and designs. The on-demand service could potentially generate a different design from current vehicles. On the other hand, the on-availability service may not change design so much, similar to a car-hire service which is typically a standard car. This section will consider an on-demand service due to its potential implications for design changes.

Whichever car sharing routes are taken, logistics and associated technologies will play a major role to provide an on-demand service. Car sharing is based on the premise of a choice of cars in pre-determined parking points or car hubs in a city and available on-demand and online. The logistics of such a complex system needs to be supported by technology in order to avoid clogging up cars in certain hubs where people tend to gather[CTH17]; the London bike sharing scheme, for example. [CTH18]This could be a greater issue with normal cars because, even if small, they will be bigger than a bike.

> *"Because it's a car and it's, you know, it's big, even if it's a (…)even if it's a Renault Twizzy or a Smart Fortwo or something, it's still physically (…) at least four or five times as big as a bike. And you can't put a whole of them in the back of a van and transport them after to another depot. You probably have to drive them individually.* E5

Another disadvantage of normal cars is that the pool needs to be big enough for on-demand service provision and needs space to be parked. If the pools are too far apart like bus stops, such cars will start to compete with buses for passengers, losing their attractiveness as a complement to the latter. The location and costs of running such a scheme, in one designer's opinion, would be unattractive for traditional car manufacturers, and could only work if a city council was willing to take control of that business. This designer was of the opinion that the investment risk in parking spaces, logistics and vehicle technology is too high for potential – if speculative - low income returns[CTH19].

If the sharing system is to take place within the city centre with scattered hubs, then perhaps autonomous vehicles would be preferable instead of normal cars to avoid congestion at more popular hubs.

> *"Well, what's interesting, logistically, is complicated unless you talk about driverless cars. The second you talk about driverless car it makes perfect sense."* E4

The advantage of autonomous cars is that they could drive themselves away from more populated hubs to other stations and could pick up other users *en-route*, reducing idling times. If electric cars - or another time dependant fuel-charging technology - is used then caution must be taken to avoid battery depletions and allow for fast charging devices to avoid cars being parked for too long during critical hours of the day.

Autonomous technologies, under certain circumstances, could [CTH20]increase on-demand service provision by better analysing several factors:

- Current user destination
- Users waiting for service in and to destination path
- Vehicle to infrastructure communication
- Vehicle to vehicle communication.

By doing this analysis, autonomous vehicles would[CTH21] balance the best route, who to pick up and when, potentially better than humans. This has the potential to avoid creating congestion by driving vehicles through overcrowded spots unnecessarily, perhaps enabling better energy use and providing the best on-demand service possible.

Integrated Functions

The reduction of component functions into integrated functions has been addressed by automotive companies' research and development departments. For example, in interior design, a significant evolution started in the late 20th century when stereos became integrated with the dashboard to deter robbers. Further integration of car stereos and their technological sophistication has increased culminating in complex electronic media units that control the radio, Bluetooth, telephone, satellite-navigation, air-conditioning, chassis and engine settings, etc. This integration eliminated, in many cases, the use of several separate buttons and knobs.

> *"There's far more information that we can access in terms of technology and what it enables. You have to be careful actually that we don't cause distraction"* D2

This integration of functions may also have rebound effects on other areas of sustainable design such as reparability and material separation at end-of-life. Other examples of evolutionary integrated functions in cars can be seen in light clusters, especially with the use of LEDs where side lights' bulbs can change colour and turn into signalling lights.

> *"One of the goals we aim for in design optimisation is integration of function. So, modularity where it's worthwhile but where it's possible to integrate function to get more than one function from one component" E3*

The automotive industry is already taking steps through the integration of autonomous technologies in order to prevent accidents, e.g. current pedestrian impact protection systems. With such integration it is theoretically possible to reduce weight in unnecessary crash structures, currently designed for crash mitigation. The industry seems to be sceptical about the readiness of full autonomous-vehicle technology, despite being supportive as a safety enhancement. It is unknown what the transition from the current regime of post-crash mitigation to a preventive one with both autonomous and non-autonomous vehicles on roads will look like.

> *"I think, it's a really difficult area. And one of the reasons why driverless cars will take a lot longer to take to market than people expect. The reality, I think, is if you put a driverless car on the market, it must be to all intents and purposes impossible for it to crash."E4*

This particular design transition could be made with the systematic elimination of some minor low-speed crash structures such as bumpers and increase of preventive technologies such as pedestrian impact avoidance potentially leading to weight saving.[CTH22][AR23]

Conclusions

During the interviews, adjacent aspects to design often surfaced, particularly market acceptability[CTH24]. It is clear from the interviews that user-intensive cars can potentially attract the millennial generation consumers; their familiarity with and use of information technologies and their openness to group activities would potentially support such a market.

The interviewees highlighted the importance of economic incentives to introducing some of the user-intensive strategies - in line with Wells (2010)[CTH25] - but also a change in younger generations' perceptions and needs of mobility as suggested by Metz (2012), lateness in acquiring driving licenses and cars (Delbosc, Currie 2013) and changes in demography and mobility options within large cities in developed countries (Urry 2007, Metz 2013).

In the case of design for shared use, opportunities exist for new interior layouts, particularly with autonomous vehicles, and the use of hardwearing materials similar to those in public transport. However, aesthetically, such cars would have to be generic in order to capture a larger segment of the target market, despite this being contradictory to millennials' preference. On-demand provision could open new opportunities for improvement in logistics and this could impact on vehicle design, enabled by autonomous vehicle technologies and vehicle communications. However, the industry is still sceptical about the readiness of such technologies despite companies like Google and Apple investing in these technologies. [CTH26]

Several research needs were identified in order to better understand how to optimise the design and understand potential user expectations towards user-intensive cars, especially those of the millennial generation. It is not clear if such vehicles and the proposed different design layouts would be attractive enough to form a strong market - both at manufacturing and user-level. There is also a need to understand if a user-intensive car can effectively reduce energy and material consumption compared with traditional cars; comparative life-cycle assessment is needed. However scarcity of information in the public domain makes this a very challenging task. By understanding how design can enable new forms of personal transportation it may be possible to shift automotive design, leading to more sustainable forms of transport. Despite very little research in this field, some research opportunities seem to be rising fast and will contribute towards a better knowledge in this field.

References and Sources

Automotive Council, 2013-last update [Homepage of Automotive Council], [Online]. Available: http://www.automotivecouncil.co.uk/wp-content/uploads/2013/09/Automotive-Council-Roadmaps.pdf [23/02/2015, 2015].

Autopartage, 2015-last update, Cité Lib by Ha:mo [Homepage of Autopartage], [Online]. Available: http://citelib.com/citelib-by-hamo-page/ [09/14, 2015].

Barnes, K., Marateo, R.C. and Ferris, S.P., 2007. Teaching and learning with the net generation. *Innovate: Journal of Online Education,* **3**(4), pp. 1.

Bryman, A., 2008. *Social Research Methods.* Third Edition edn. Oxford: Oxford University Press.

City Car Club, 2015-last update, Frequently Asked Questions [Homepage of City Car Club], [Online]. Available: https://www.citycarclub.co.uk/faq [09/11, 2015].

Cooper, T., 1994. Beyond recycling: the longer life option. *New Economics Foundation,* .

Delbosc, A. and Currie, G., 2013. Causes of youth licensing decline: a synthesis of evidence. *Transport Reviews,* **33**(3), pp. 271-290.

Kagawa, S., Hubacek, K., Nansai, K., Kataoka, M., Managi, S., Suh, S. and Kudoh, Y., 2013. Better cars or older cars?: Assessing CO 2 emission reduction potential of passenger vehicle replacement programs. *Global Environmental Change,* **23**(6), pp. 1807-1818.

Kagawa, S., Nansai, K., Kondo, Y., Hubacek, K., Suh, S., Minx, J., Kudoh, Y., Tasaki, T. and Nakamura, S., 2011. Role of motor vehicle lifetime extension in climate change policy. *Environmental science & technology,* **45**(4), pp. 1184-1191.

Kagawa, S., Tasaki, T. And Moriguchi, Y., 2006. The environmental and economic consequences of product lifetime extension: Empirical analysis for automobile use. *Ecological Economics,* **58**(1), pp. 108-118.

Metz, D., 2013. Peak car and beyond: the fourth era of travel. *Transport Reviews,* **33**(3), pp. 255-270.

Metz, D., 2012. Demographic determinants of daily travel demand. *Transport Policy,* **21**(0), pp. 20-25.

Ng, E., Schweitzer, L. and Lyons, S., 2010. New generation, great expectations: A field study of the millennial generation. *Journal of Business and Psychology,* **25**(2), pp. 281-292.

Nieuwenhuis, P., 1994. Chapter 10: The Long-life Car. Investigating a Motor Industry Heresy. In: Wells.P. Nieuwenhuis, P., ed, *Motor Vehicles in The Environment. Principles and Practice.* Chichester: John Wiley & Sons, pp. 153-172.

Packard, V., 1963. *The Waste Makers.* 4th edn. Harmondsworth, Middlesex: Penguin Books.

Rodrigues, A., Cooper, T. And Watkins, M., 2015. Driving In The Wrong Lane: towards a longer-lifespan of cars, *Product Lifetimes and The Environment*, 17-19 June 2015, Nottingham Trent University: CADBE, pp. 311-317.

Rogers, J.G. and Rodrigues, A., 2015. Product leasing: a strategy to allow manufacturers and customers to benefit from elongation of product life, *PLATE 2015 Product Lifetimes and The Environment*, 17-19 June 2015, Nottingham Trent University: CADBE, pp. 318-323.

Smith, K., 2012. Longitudinal study of digital marketing strategies targeting Millennials. *Journal of Consumer Marketing,* **29**(2), pp. 86-92.

Urry, J., 2007. *Mobilities.* Polity.

Valentine, D. and Powers, T., 2013. Generation Y values and lifestyle segments. *Journal of Consumer Marketing,* **30**(7), pp. 597-606.

Van Nes, N. and Cramer, J., 2006. Product lifetime optimization: a challenging strategy towards more sustainable consumption patterns. *Journal of Cleaner Production,* **14**(15–16), pp. 1307-1318.

Vezzoli, C. and Manzini, E., 2008. *Design for Environmental Sustainability.* London: Springer.

Wells, P.E., 2010. *The automotive industry in an era of eco-austerity: creating an industry as if the planet mattered.* Edward Elgar Publishing.

Annexe

Reference	Job Title	Type of Company
Designer 1 (D1)	Head of Concepts	High-Premium Manufacturer
Designer 2 (D2)	Vehicle Interior Designer	High-Premium Manufacturer
Designer 3 (D3)	Senior Interior Designer	Generalist Manufacturer
Engineer 1 (E1)	Senior Manager Corporate Engineer & RD	Tier 1 Multinational Supplier
Engineer 2 (E2)	Principal Materials Engineer	Premium Sports Car Manufacturer
Engineer 3 (E3)	Chief Engineer Body Complete	Premium Manufacturer
Engineer 4 (E4)	Global Business Director - Former Technical Director	Vehicle Testing Consultancy
Engineer 5 (E5)	Principal Development Engineer	Generalist Manufacturer
Designer 4 (D4)	Technical Specialist Whole Vehicle sustainability	Premium Manufacturer
Engineer 6 (E6)	Materials Engineer and Group Leader in Sustainable Aluminium Strategies	Premium Manufacturer

Appendix I