Article

new media & society
2016, Vol. 18(4) 653–666

DOI: 10.1177/1461444816629476
nms.sagepub.com

Pre-hacked: Open Design and the democratisation of product development

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Abstract

This article considers the practice of hacking in terms of making and modifying three-dimensional objects. In line with the work of a number of prominent thinkers in the field, the practice is considered to be a deliberate act by end users to not only understand, make accessible, de-alienate, appropriate and personalise products but also to demystify what Latour refers to as the 'black box' effect of established product archetypes. Where hacking is typically considered a post-production process, it is argued here that upfront, design-led approaches intended to harness downstream end-user post-production hacking (pre-hack) are in line with Jones' call from over three decades ago for design divergence and continuity through collaborative processes – which we now find in the field of Open Design. This is discussed in light of the broader context of sustainability, which needs innovation from the ground up as well as top down.

Keywords

Distributed manufacturing, hacker, industrial design, Maker Movement, mass production, Open Design, post-Fordism, sustainability

Introduction

The term 'hack' has had many connotations over time, although commonly it is associated with unauthorised software-based security-breaking behaviour (Stallman, 2004–2014). However, its roots lie the late 1950s where, at Massachusetts Institute of Technology

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(MIT), the title 'Hacker' was adopted by a group of artists, computer scientists and engineers who believed innovation stemmed from taking things apart, seeing how they worked and using that knowledge to create new, innovative things (Levy, 1984: 26–27). Maker culture has recently revived this sentiment, where the term 'hacking' is again applied to tinkering activities – where small changes are made to something, especially in an attempt to repair or improve it. These activities reveal the inner workings of physical artefacts and afford transparency in underlying systems, structures and functions for subsequent alteration and improvement (Burnham, 2009; Knott, 2013; Wang and Kaye, 2011).

Maker culture, otherwise known as the 'Maker Movement' (Dougherty, 2012; Monitor, 2011), has a number of historical precedents, notably the Arts and Crafts movement, specifically the work of William Morris and his Kelmscott Press (see Naylor, 1971: 110–112); the open-source architecture of Ken Isaacs; the autoprogettazione (self-build) furniture of Enzo Mari; and fanzines, particularly those of the punk movement (see Triggs, 2006). An independence of production figures strongly in all these examples. The writings of John Ruskin, which influenced Morris, significantly speak against the alienation of man by industrial capitalism from the products of his labour. Ruskin called for a unification of manual and intellectual labour and celebrated the products of this unity (Anthony, 1983: 104). It is argued here, however, that the importance of Maker culture lies not merely with a renewed appreciation of the joy of labour but also, and more importantly, with its newly democratic, empowering and sustainable possibilities. Maker culture invites end-user participation in the development and production of artefacts and digital content. Many who engage in the activity aim to demystify information and technology to empower others to contribute to cycles of innovation. In its drive to include the end user in the development and production of artefacts, Maker culture actively works to neutralise end-user spectatorship and to collapse institutional and cross-institutional hierarchies (Atkinson, 2006; Von Hippel, 2002).

Maker culture differs from similar past movements in that it is facilitated by a remarkable shift in Internet connectivity, and in some cases, this extends into the use of small-scale, consumer-oriented, digital manufacturing technologies. Low-cost three-dimensional (3D) printing, computer numeric controlled (CNC) machining, laser cutting and robotic machines have become more prevalent in the market and have continued to markedly diminish in cost since the mid-2000s when a number of landmark initiatives became public, including the Reprap open-source, self-replicating 3D printer project, founded by Adrian Bowyer (Bowyer, 2011; Jones et al., 2011; Sells et al., 2009); the Fab Lab, a low-cost fabrication laboratory comprising digitally enabled manufacturing tools, founded by Neil Gershenfeld (2005); the Creative Commons license, established in 2001, which enables users to share source documents, digital models and intellectual property freely in a share-and-share-alike agreement (Katz, 2011); and Thingiverse (MakerBot Industries, 2016), a repository of user-generated digital 3D models that can freely be downloaded by anyone (Pettis, 2011).

These enterprises were designed to democratise the practice of making and provide equitable access to products and services for everyone around the globe. Furthermore, they have enabled hacking of physical artefacts, beginning with the upfront digital 3D master-model file, which can be modified at will and manufactured at home – with the modification often being returned to the open-source network. The impact of these separate interventions illustrates Michel De Certeau's (1984) distinction between 'tactics' – the heterogeneous, often spontaneous decisions made by individuals in everyday life – and 'strategies' – used by institutional powers as means to direct unified social, spatial and political production (p. xix). The tactical provides a means to think through the significance of new forms of hacker-led goods production.

Although these new forms of production may be explained as a moment on a continuum of manufacturing from Fordism to post-Fordism (and possibly beyond), it can be argued that trends towards the intersection of the roles of designer and maker – and, in particular, the use of Open-Source Hardware and 3D printing – represent a tactical reclamation of manufacturing. That is, it is characterised by the activities of individuals and informal, impromptu networks of individuals who are accessing new technologies to create goods in a self-directed, somewhat empowered and ultimately ad hoc way. This tactical approach often sets up an awkward, and many times oppositional, relationship with the dominant post-Fordist sociotechnical frame (outlined below). Maker culture in many instances parasitically borrows from this closed system to make open artefacts, in some cases encroaching on protected intellectual property. At ground level, Makers often break down existing artefacts into constituent parts and recompose them into new objects. Burnham (2009) refers to this as *Hackufacturing*, where the intellectual property of the source design remains with the designer, but the final product is anchored in the resources and realities of the local manufacturer who can alter and realise it in any number of ways. De Couvreur and Goossens (2011) refer to this as 'physical hacking', which requires the user-manufacturer to be creative with the resources and skills at hand, leading to reusing components and materials available in the local context.

The post-Fordist sociotechnical frame makes products that feed passive consumption, discourage end-user intellectual contribution, and, if hacked, are done so post-production by unauthorised means. Alternatively, Maker culture opens access for anyone to be involved in the process of innovation. In light of current manufacturing systems, consumption and sustainability, the relationship between hacking and mass production is discussed in section 'Sustainability, post-Fordism and functional stability'. It is argued that through open access, the evolution of more sustainable activities, products and services can be expedited by promoting more strategically organised circular systems – or balancing the tactical and strategic. In a world of Internet connectivity, a global collective of small changes can equate to large innovations over time.

Section 'Mass production, the black box and post-production hacking' explores top-down open systems that include end-user contribution as an upfront strategy and, further, rely on continuing and authorised user-driven innovation for continuing development. In many respects, this is already occurring through Open Design projects, that is, artefacts that are deliberately designed to be hacked pre-production – referred to here as 'pre-hacked'.

Sustainability, post-Fordism and functional stability

Sustainability requires broad-scale technological, sociological and behavioural shifts, and in the short term, a technological approach is limited in efficacy without support from behavioural changes that can give rise to long-term sustainable technology uptake (Chapman, 2007; Hoffert et al., 2002; Moriarty and Honnery, 2007). However, in the realm of environmental sustainability, there is a gap between environmental awareness and behavioural change (Anable et al., 2006: 20), and given a technologically led approach is not likely to engender broad-scale, short-term sustainability, social-based systems and behavioural approaches need to be devised on both macro and micro levels (see, for example, Fuller and Snyder, 1969: 24; Manzini, 1999; Morelli, 2002; Moriarty and Honnery, 2007; Thorpe, 2007).

The ability for post-Fordist systems of production to bridge the gap between environmental awareness, sustainable social behaviour and new technologies, however, comes into question. If, as Verbeek (2006: 361–366) suggests, artefacts mediate human experience, our interpretations of reality and actively contribute to moral and ethical decisions (regardless of whether it was intended by the designer or not), they need to lead end users towards sustainable behaviour. However, Jessop (2005: 151) argues that the political and moral leadership, which was present in Henry Ford's developments, is absent from post-Fordist consumptive ideals. Ford's (1922) ideological aim to democratise personal transport in a way that was previously only available to the wealthy was built on the values of service, waste reduction and generosity (p. 16), and these governed the design of both a new technology (i.e., motorised vehicles) and the production system that made them economically viable and accessible to a broad end-user base. Jessop cites Gramsci (1971) in putting forward the notion that this Fordist consolidation of accumulation, which critically depended upon the exercise of political, intellectual and moral leadership, translated into the reorganisation of an entire social formation. He goes on to say that post-Fordist approaches lack the spectrum breadth of Ford's ideological framework, relying on a more limited band of 'technological innovation coupled with specific changes in the labour process, enterprise forms, forms of competition, and other narrowly economic matters' (Jessop, 2005: 151).

As Amin (1994) states, post-Fordism broadly represents a transition from an era of mass production to a new set of organisational principles that engender a 'long wave' of prosperous and sustainable economies (p. 6). Citing Tomaney (1994), Hyman (1991) and Dankbaar (1992), he argues that this is being made possible through new technologies that encourage new forms of worker–employer cooperation and worker involvement, which culminates in 'a new industrial democracy reversing the Fordist interpretation of workers as a restraint in production' (Amin, 1994: 6).

While technology has facilitated evolving workplace structures like workforce flexibility and more adaptive, changeable (and globalised) manufacturing systems, it is questionable whether Amin's idea of post-Fordist organisations exists as he describes them as the dominant form – certainly from my experience within the automotive design field I would suggest that labour roles were not as democratised as could be expected. I left the industry in 2005, and until that time at least there remained a Fordist-like division of labour and strong expectations of where, when and how my work would be undertaken, despite new collaborative technologies. Additionally, while post-Fordist industry has seen a shift in focus from economies of scale to 'economies of scope' – a hallmark strategy since the 1970s for maintaining company resilience by increasing product choice (Hirst and Zeitlin, 1997) – product differentiation, dynamic obsolescence, stabilisation of function (explained below) and the separation of style and function for product marketability remain at the core of design for mass production.

Mass production, the black box and post-production hacking

While Henry Ford did not invent the concept of mass production (Bachelor, 1994: 66; Clarke, 1990; Norcliffe, 1997), he can be credited with revolutionising the industrial era by fragmenting tasks and standardising components to make the assembly line possible (Clarke, 1990). Through the implementation of efficient mass production, Ford was, among other things, able to achieve a sociotechnical shift in the democratisation of personal transport (Bachelor, 1994: 15). That is, his radical innovations in manufacturing facilitated widespread access to automobile technology, thus instigating the social and economic consequences of a certain type of individual empowerment. However, in order to minimise production costs, Ford opted to forego product diversity in favour of standardisation to achieve economies of scale (see, for example, Daugherty and Pittman, 1995; Langlois and Robertson, 1989; Scott and Storper, 1990). Ford's (1922) democratisation of transport through efficient mass production required a hierarchical system: where the product was the primary determinant of the manufacturing approach, followed by the production system itself, then the needs of the end user and last, the engagement of the worker (p. 15). This evoked a linear product-development-to-market pathway where workers were assigned limited tasks and end users were excluded until point of purchase. Of particular importance to this system is the stabilisation of function: an aspect of Fordist manufacturing that remains at the base level of contemporary post-Fordist product manufacturing. Design and engineering in manufacturing, which provide requisite 'centres' of innovation (Amin and Thrift, 1992), typically focus on developing artefacts as functionally complete, refined and stable units in order to best facilitate the practice of mass production (Jones, 1983: 55).

Jones (1983: 55) describes this as a function-focused method, which consists of designers and engineers engaging in a cyclical process of defining elements, defining functions, considering the alternatives, evaluating those alternatives and selecting the best solution. The strength of this approach is that the function of each part of an artefact can be designed to be stable and predictable, which means that a product's end-use reliability can be ensured upfront when investments are made for mass production tooling. This product reliability has an impact on sales and, as a consequence, on investment returns. Additionally, given the separation of engineering and industrial design input, it also allows the restyling of appearance without fully redesigning the mechanical components for every new model, thereby minimising resources and cost (Jones, 1983: 55). Long development lead times and high investment costs are required to ensure artefacts are complete and stable at the point of market release. These means companies need to maintain confidentiality during product development to ensure a competitive edge at the point of release, and again, positive returns on investment.

Knott (2013) states, however, that the function stability approach perpetuates the notion of 'passive consumerism', where the end user accepts commodities as finished articles ready for judgement, exchange, arrangement and use. Jones (1983: 55) argues that this comes with sizeable costs, as it creates inflexible, overspecialised, homogenised, unalterable, unrepairable products, which impose obligatory use and disposability. While it can result in some highly sophisticated outcomes, he argues that it relegates end-user agency to spectatorship, in many respects alienating them from the very products intended to facilitate daily life.

This can be conceptually understood through the lens of Latour's (1987) 'black box' theory, which describes how an artefact containing a large number of elements and located within a sociotechnical frame become viewed as a singular 'whole', while it actually embodies a highly complex actor-network derived from both human and non-human interactions (pp. 130–132). Over time, the appearance of unity comes to be accepted as unquestioningly self-created and complete. The underlying system is taken for granted until something goes wrong, at which point the artefact's complexity and reliance on a broader network of actors are recognised (but not necessarily understood). In this way, the styled exterior surface – literally serving as a 'box' surrounding the underlying functional technology – sends a clear message to the consumer that they are being invited to desire the whole, externally identifiable object, but not to understand its inner workings nor tinker with the complex technology inside.[1] As a result, unauthorised, often highly skilled, post-production hacker activity is necessary to crack both the confidentiality surrounding the source designs and the inner working of the designs themselves to make intellectual property available to a broader end-user base.

Openness, Open Design and pre-hacking

Jones (1983: 59–60) challenges the notion of designing for functions to be held stable within artefacts over time, given user requirements are only temporary within a continuum of sociocultural trajectories. Instead, he calls for open methods of design to encourage divergence and continuity through collaborative processes, which he argues would allow for the changing requirements of the artefacts we use day to day. To achieve this, he argues that the design 'process' should be seen as an end in itself rather than a means to an end, thus elevating it above a resulting artefact – which should merely mark a point in time rather than claim pre-eminence in its own right (Jones, 1983: 57). What he is describing here has marked similarities to the Open-Source Hardware movement, where products are intentionally designed to be understood, re-envisioned and remade – that is, an authorised pre-production hack or 'pre-hack'.

Returning to Jessop's (2005: 151) call for the reintroduction of political and moral (and by extension, ethical) leadership to instigate sociotechnical change, Kettley (2012) calls for the 'needs' at the core of the design process to be recast as 'open' in order to deepen interaction and communication among stakeholders and thus reduce repetitive consumption. Megens et al. (2012) go further to say that in order to transform industrialised economies, the notion of meaningful living needs to extend to cultivating empathy and cooperation rather than self-actualisation and the pursuit of personal aspirations. To assist this transformation, they call for design to develop new tools, skills and propositions that allow people to adapt products, systems and services over time.

For a product design system to achieve this, openness, transparency and accessibility are desirable – starkly contrasting with the post-Fordist production mentality. In order for artefacts to be continually innovated, they not only need authorised post-production accessibility, but they actively need to be designed upfront to facilitate downstream innovation. It is this sentiment that falls in line with Vallance et al.'s (2001) notion of Open

Design: a design system which in effect 'pre-hacks' physical artefacts in order to make it easier for subsequent developmental innovation to flourish. In this context, it opens possibilities for agile and wide-reaching responses to emergent issues. In the case of sustainability, perhaps critically, it needs to be approached with sustainment in mind from the beginning.

Open Design designs a product system for the co-creation of artefacts, which can be designed by a participatory group or, equally, a single project leader (Wood, 2007: 4). It is left open for the participation of end users to modify, personalise and innovate, and it often results in a personalised, one-off product (see, for example, Kadushin's (2010) Hack Chair). Open Design provides individuals with the 'source code' to make, adapt and disseminate their own products with the assistance of digitally enabled tools, such as CNC machines, 3D printers and laser cutters (Gershenfeld, 2005: 15). It is possibility-driven (Desmet and Hassenzahl, 2011) and relies on peer networks, which are characterised by their decentralised and distributed control, by an open exchange of private intellectual property and by dense rhizoid interconnectivity and high levels of diversity (Von Hippel, 2005). Ideas are free to flow through the network as they are generated, and there are mechanisms for assigning value to these (Johnson, 2012: 25–26).

The term 'Open Design' was first coined by Vallance et al. (2001), the founders of the Open Design Foundation, at the beginning of the 21st century in reference to open-source plans for making CNC manufacturing tools (Van Abel et al., 2011). It was established as a means to make design documentation of hardware available for free in its original form in the public domain (i.e. digital model files stored in an online open-access repository). This made sure originators of an open design could track the development of an artefact over time (Vallance et al., 2001: 3).

Precedents in other fields have demonstrated possibilities created by a similar approach to openness. Eco (1984) postulates openness as expressed by interpretation, for instance: an artwork is a closed object, but it is also open to interpretation, and a musical piece can be a closed recording (sheet music or a recorded performance) or an open interpretation replayed or remixed by another artist as a means of individualisation. Eco draws on the observations of Pousseur (1958: 25), who proposes that open work encourages 'acts of conscious freedom' on the part of the performer, who constructs their own form and becomes the focal point among a network of limitless interrelations (Eco, 1984: 47–50). In recent decades, digital recording and sequencing tools have provided the means to remix and subsequently remix remixes of original works – after a number of iterations, only a trace of the original remains. However, without the original, the new works would not exist. Consequently, the act of remixing stimulates a continuing conversation between artists through practice (Lessig, 2008: 17).

This demonstrates the effectiveness of the conjoined functions of the democratisation of technology, Internet connectivity and material reuse as conduits for cultural production and acceleration of innovation. In turn, it fosters what might be described as utopian impulses engendering a burgeoning culture of Do-It-Yourself (DIY) artisans, empowered by the rise of Web 2.0, social media and creative software tools, who are enabled to make and disseminate products outside normal consumer channels (Gunderson, 2004). Furthermore, within open-source ventures, these digitised channels have provided individuals with real-world agency beyond geographic, spatial and time-based constraints (Shirky, 2005: 484).

Markedly, the trend towards 'consumer-as-producer' (Gunderson, 2004) provides a framework for user-generated design, development and production. In short, '*since the publication of* The Practice of Everyday Life (De Certeau, 1984), *companies have developed strategies that mimic people's tactics of bricolage, reassembly, and remix*' (Manovich, 2009).

In this respect, the pre-hacked objects fostered by Open Design can be modified, 'mashed-up' and personalised, meaning the design process, as Jones (1983) calls for, does not set out to produce artefacts as ends in themselves, but rather facilitates the ongoing evolution of a continuous lineage. In product development terms, it is a low-risk strategy, given it involves innovation from a group of geographically distributed DIY hackers with low investment costs. The process shifts from the Fordist – and arguably current post-Fordist – notion of requiring degrees of standardisation to meet the broadest market demand via mass manufacturing (Bachelor, 1994: 15, 116). Instead, it moves towards one that generates systems of highly specific, one-off products that can be made to suit individual needs. In turn, this opens the possibility for the diversification of cultural artefacts where market testing is intrinsic to their development, and if the original idea has market appeal, it will generate its own viral dissemination.

A noteworthy example of this is the Reprap 3D printer. The Reprap is a self-replicating, rapid prototyping robot designed to be made using accessible tools and processes. The machines, which were designed by Adrian Bowyer and his team at the University of Bath, were designed to be inexpensive and hackable (Bowyer, 2011; Jones et al., 2009). While a commercial Stratasys 3D printer using Fused Deposition Modelling (FDM) made parts for the very first machines, the new machines themselves could make subsequent parts to accompany off-the-shelf components like smooth and threaded steel rods, bolts, timing pulleys and belts, bearings, stepper motors and open-source electronic controllers (Bowyer, 2011; Jones et al., 2009). Given the machines were designed to be open source and the plans were accessible online, an ever-increasing number of successful offshoots have been developed and are in widespread use – some of the early derivatives include the Mendel Prusa, Ultimaker, Printrbot, and MakerBot Industries' Cupcake, Thing-O-Matic and Replicator, to name a few. MakerBot Industries (which was partly funded by Bowyer [Pettis, 2011]) is arguably one of the most successful of these to date.

Examples such as this exhibit the hallmarks of Sternberg's (1993) new ages of capitalism, namely: a strong advocacy of the information age based on knowledge economies and information technology; global interdependence through networks and connections; 'flexible specialisation', a key post-Fordist term where new principles in specialised production and versatile workforces allow for decentralisation and greater resilience in a volatile marketplace; a social economy that strives for egalitarianism, equitability and the humanisation of capitalism; and a fundamental rejection of technocracy (Sternberg, 1993, as cited by Amin, 1994: 2–4). In contrast to Ford's economic rationalist approach to product democratisation through linear, directed product development and mass production, Open Design aspires to democratise the production process itself through rhizomatous open innovation. Product development is distributed across time and space, intermingled with the production process itself and contingent on individual approaches. This implies that the importance of the product is not just in its end use but also in its ongoing discursive involvement in innovation cycles.

Returning to the issue of sustainability, it is important to consider Maker culture's ability to effect change with discretion. The capacity for it to promote unregulated and highly distributed production of artefacts is cause for concern. While the notion of domestic-scale production may have revitalising effects for manufacturing, it should be tempered in the light of environmental and sustainability imperatives. The democratisation of personal transport by Henry Ford has led to an unsustainable proliferation of vehicles, which has had a marked effect on the development of our urban infrastructure, social interactions and cultural expectations (Sheller and Urry, 2000; Sperling and Gordon, 2009: 13–14; Whitelegg, 1997: 127). Similarly, the democratisation of design and production could lead to further unsustainable proliferation of artefacts. However, if Maker culture were to synthesise empowered production with dematerialisation strategies, it may be possible to turn new advances in manufacturing technologies and processes into viable sustainability options. It is argued here that if Maker culture were to maintain the intersection between pre-hacked, innovation-fostering Open Design and cradle-to-cradle manufacturing methods (see McDonough and Braungart, 2002, 2013; Papanek, 1984), it could provide a positive step forward for making new, more individually relevant artefacts while concurrently reducing net material volumes in circulation.

Conclusion

Hacking, in the context of this discussion, is seen as the process of opening and modifying a product's 'source code' – whether that is literal, as in the case of digital software, or figurative, as with mechanical and electronic hardware. Conceptually, this perpetuates the practice first set in the mid-20th century by a group of artists, computer scientists and engineers who used the title 'Hacker' to describe those who, for enjoyment, explored the limits of possibility through ad hoc tinkering (Levy, 1984; Stallman, 2004–2014). In current times, we can see resounding parallels with Maker culture, which aims to reignite the joy of labour and discovery through openness and making.

Jones (1983: 53–60) argues that openness in design and manufacturing, such as that shown by the Maker Movement, encourages more flexible, widespread innovation cycles. It is argued that open innovation is important if we are to tackle global issues, such as climate change, unsustainable resource management and economic uncertainty – which are likely to require the activation of new sociotechnical frames. In the current manufacturing paradigm, however, a number of things stand in the way of open innovation. Fordist production efficiency and economies of scale, which nominally carry through to post-Fordist processes, reduce the agency of individuals and ultimately result in a number of alienating qualities. These include standardisation, which reduces the ability to meet nuanced individual needs; built-in functional stability, which excludes end-use modification; product styling, which imposes short-cycle fashion that quickly relegates individuals from ingroup to outgroup; and separation of function and style, which results in what Latour (1987) refers to as a 'Black Box' where the outer skin masks the inner workings and obstructs comprehension (pp. 130–132). These limit the ability for individuals to contribute to innovation cycles, and in order to de-alienate the products of this system, downstream hacking is required.

Interestingly, there are ideological crossovers between Ford's production system (which shaped our current consumptive society) and Maker culture (which, given the right conditions, has the potential to shift us out of it). Both Henry Ford and Maker culture demonstrate the ambition for ethical democratisation, but they differ in approach. Where Ford relied on labour division to maintain the integrity of an affordable (and therefore accessible) end product, Maker culture gives priority to inclusion and diversity above designed outcomes. This is in line with Jones' (1983) theory of openness. Maker projects typically destabilise product functionality by propagating open and hackable designs from the outset – that is, Open Design – allowing cycles of innovation to be self-coordinated by community-based networks. Furthermore, many of the physical artefacts exist first as an open-source digital master-model file, meaning that designs can be easily disseminated via the Internet as intentionally pre-hacked artefacts. These files can be downloaded, modified, tested and manufactured by individuals in their own home at any given time: a process made possible by emerging small-scale, consumer-oriented, digital manufacturing technologies, such as low-cost 3D printers, CNC machines, laser cutters and robots. These open-source ventures and digitised channels have provided individuals with real-world agency without geographic, spatial or time constraints. It moves towards systems of highly specific, one-off products that can be continually hacked to suit individual needs.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Note

1. The predominance of design styling in the automotive industry, which is a key component of the current, dominant automobility sociotechnical frame, can be traced back to a critical moment in automotive history where General Motors utilised appearance and style as a means for gaining competitive edge (Bachelor, 1994: 102). In 1927, Harley Earl was contracted to visually integrate vehicles into a unified appearance, adding an aesthetic overlay to the functional underpinnings (Sloan, 1963: 274). This move marked a deliberate separation of function and form in preference for a more marketable style. For General Motors, and for many other manufacturers, styling formed the basis and means of encouraging of cyclical product renewal, or 'dynamic obsolescence', which allowed new possibilities for profit growth and product proliferation (Slade, 2009: 4–5). While styling is a powerful tool for manipulating market share, it is arguable that it can equally cause alienation, particularly with respect to the end user. First, it can socially isolate them through the cycling of fashion – where new replaces old, and the consumer is quickly relegated from ingroup to outgroup with the introduction of each new style or model. Second, it separates the end user from engaging directly with the actual functioning of the artefact, as the barrier of a stylised, outer aesthetic enclosure physically and conceptually prevents access to the inner workings of it. In some automobiles, such as the Mazda RX-8, BMW 760Li and Volvo V50, this extends to multiple layers within

the visible shell: under the hood, additional covers within the engine bay, for instance, hide all functional components except for those meant to be engaged with by the end user, such as oil and water caps.

References

Amin A (ed.) (1994) *Post-Fordism: A Reader*. Oxford: Blackwell.

Amin A and Thrift N (1992) Neo-Marshallian nodes in global networks. *International Journal of Urban and Regional Research* 16(4): 571–587.

Anable J, Lane B and Kelay T (2006) *An evidence base review of public attitudes to climate change and transport behaviour*. Report for the UK Department of Transport, Contract no: PPRO 004/006/006. London: Department for Transport. Available at: http://www.china-up.com:8080/international/case/case/1457.pdf (accessed 30 January 2016).

Anthony P (1983) *John Ruskin's Labour: A Study of Ruskin's Social Theory*. Cambridge: Cambridge University Press.

Atkinson P (2006) Do it yourself: democracy and design. *Journal of Design History* 19(1): 1–10.

Bachelor R (1994) *Henry Ford, Mass Production, Modernism, and Design*. New York: Manchester University Press.

Bowyer A (2011) Rewriting history. In: RepRap: Blog (Posted by Adrian Bowyer), 18 April. Available at: http://blog.reprap.org/2011/04/rewriting-history.html (accessed 5 June 2015).

Burnham S (2009) Finding the truth in systems: in praise of design-hacking. RSA design and society program. Available at: http://scottburnham.com/publications/design-hacking/ (accessed 5 June 2015).

Chapman L (2007) Transport and climate change: a review. *Journal of Transport Geography* 15(5): 354–367.

Clarke S (1990) New utopias for old: Fordist dreams and post-Fordist fantasies. *Capital & Class* 42: 131–155.

Dankbaar B (1992) *Economic Crisis and Institutional Change*. Maastricht: UPM.

Daugherty PJ and Pittman PH (1995) Utilization of time-based strategies: creating distribution flexibility/responsiveness. *International Journal of Operations & Production Management* 15(2): 54–60.

De Certeau M (1984) *The Practice of Everyday Life*. Los Angeles, CA: University of California Press.

De Couvreur L and Goossens R (2011) Design for (every)one: co-creation as a bridge between universal design and rehabilitation engineering. *CoDesign* 7(2): 107–121.

Desmet P and Hassenzahl M (2011) Towards happiness: possibility-driven design. Available at: http://studiolab.ide.tudelft.nl/diopd/wp-content/uploads/2012/02/happiness_desmethassenzahl_chapter_fn.pdf (accessed 5 June 2015).

Dougherty D (2012) The Maker Movement. *Innovations: Technology, Governance, Globalization* 7(3): 11–14.

Eco U (1984) *The Role of the Reader: Explorations in the Semiotics of Text.* Bloomington, IN: Indiana University Press.

Ford H (1922) *My Life and Work*. Garden City, NY: Garden City Publishing Company, Inc.

Fuller RB and Snyder J (1969) *Operating Manual for Spaceship Earth*. Carbondale, IL: Southern Illinois University Press.

Gershenfeld N (2005) *FAB: The Coming Revolution on Your Desktop – From Personal Computers to Personal Fabrication*. New York: Basic Books.

Gramsci A (1971) *Selections from the Prison Notebooks*. London: Lawrence & Wishart.

Gunderson P (2004) Danger Mouse's Grey Album, mash-ups, and the age of composition. *Postmodern Culture* 15(1). Available at: http://muse.jhu.edu/journals/postmodern_culture/toc/pmc15.1.html (accessed 5 June 2015).

Hirst P and Zeitlin J (1997) Flexible specialization: theory and evidence in the analysis of industrial change. In: Rogers Hollingsworth J and Boyer R (eds) *Contemporary Capitalism: The Embeddedness of Institutions*. Cambridge: Cambridge University Press, pp. 220–239.

Hoffert M, Caldeira K, Benford G, et al. (2002) Advanced technology paths to global climate stability: energy for a greenhouse planet. *Science* 298(5595): 981–987.

Hyman R (1991) Plus ça change? The theory of production and the production of theory. In: Pollert A (ed.) *Farewell to Flexibility?* Oxford: Blackwell, pp. 259–283.

Jessop B (2005) Cultural political economy, the knowledge-based economy, and the state. In: Slater D and Barry A (eds) *The Technological Economy*. New York: Routledge, pp. 144–166.

Johnson S (2012) *Future Perfect*. New York: Riverhead Books, Penguin Group.

Jones JC (1983) Continuous design and redesign. *Design Studies* 4(1): 53–60.

Jones R, Haufe P, Sells E, et al. (2009) RepRap–the replicating rapid prototyper. *Robotica* 29: 177–191.

Kadushin R (2010) *Open Design Manifesto*. Berlin: Ronen Kadushin Design. Available at: http://www.ronen-kadushin.com/index.php/open-design/ (accessed 5 June 2015).

Katz A (2011) Authors and owners. In: Van Abel B, Evers L, Klaasen R, et al. (eds) *Open Design Now*. Amsterdam: BIS Publishers, pp. 66–75.

Kettley S (2012) Interrogating hyperfunctionality. In: Breedon P (ed.) *Smart Design*. London: Springer, pp. 65–73.

Knott S (2013) Design in the age of prosumption: the craft of design after the object. *Design and Culture* 5(1): 45–67.

Langlois RN and Robertson PL (1989) Explaining vertical integration: lessons from the American automobile industry. *Journal of Economic History* 49(2): 361–375.

Latour B (1987) *Science in Action: How to Follow Scientists and Engineers through Society*. Cambridge, MA: Harvard University Press.

Lessig L (2008) *Remix – Making Art and Commerce Thrive in the Hybrid Economy*. London: Bloomsbury Academic.

Levy S (1984) *Hackers – Heroes of the Computer Revolution*. New York: Delta Publishing.

McDonough W and Braungart M (2002) *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press.

McDonough W and Braungart M (2013) *The Upcycle: Beyond Sustainability – Designing for Abundance*. New York: North Point Press.

MakerBot Industries (2011) Thingiverse Featured. Available at: http://www.thingiverse.com (accessed 30 January 2016).

Manovich L (2009) The practice of everyday (media) life: from mass consumption to mass cultural production? *Critical Inquiry* 35(2): 319–331.

Manzini E (1999) Strategic design for sustainability: towards a new mix of products and services. In: *Proceedings from EcoDesign'99: first international symposium on environmentally conscious design and inverse manufacturing*, Tokyo, Japan, 1–3 February, pp. 434–437. Los Alamitos: IEEE.

Megens CJPG, Peeters MMR, Funk M, et al. (2012) New craftsmanship in industrial design towards a transformation economy. In: *Proceedings of the 10th European academy of design conference: crafting the future,* University of Gothenburg, Gothenburg, 17–19 April. Available at: http://www.craftingthefuture.se/ (accessed 5 March 2015).

Monitor (2011) More than just digital quilting. *The Economist* (Technology quarterly Q4). Available at: http://www.economist.com/node/21540392 (accessed 5 March 2015).

Morelli N (2002) Designing product/service systems: a methodological exploration. *Design Issues* 18(3): 3–17.

Moriarty P and Honnery DR (2007) Australian car travel: an uncertain future. 30th Australasian transport research forum, Department of Infrastructure, Institute of Transport Studies, Monash University, Melbourne, VIC, Australia, pp. 1–15.

Naylor G (1971) *The Arts and Crafts Movement: A Study of Its Sources, Ideals and Influence on Design Theory*. London: Studio Vista.

Norcliffe G (1997) Popeism and Fordism: examining the roots of mass production. *Regional Studies* 31(3): 267–280.

Papanek V (1984) *Design for the Real World: Human Ecology and Social Change*. London: Thames & Hudson.

Pettis B (2011) Made in my backyard. In: Van Abel B, Evers L, Klaasen R, et al. (eds) *Open Design Now*. Amsterdam: BIS Publishers, pp. 76–83.

Pousseur H (1958) La nuova sensibilità musicale. In: *Incontri Musicali no. 2.* Quoted in Eco U (1979) *The Role of the Reader*. Bloomington, IN: Indiana University Press, p. 50.

Scott AJ and Storper M (1990) *Regional Development Reconsidered*. Los Angeles, CA: Lewis Center for Regional Policy Studies, University of California.

Sells E, Smith Z, Bailard S, et al. (2009) RepRap: the replicating rapid prototyper – maximizing customizability by breeding the means of production. In: *Handbook of Research in Mass Customization and Personalization*. Available at: http://scg.mit.edu/images/MCPC_Conference_proceedings/site/papers/MCPC-045-2007.pdf (accessed 5 June 2015).

Sheller M and Urry J (2000) The city and the car. *International Journal of Urban and Regional Research* 24(4): 737–757.

Shirky C (2005) Epilogue: open source outside the domain of software. In: Feller J, Fitzgerald B, Hissam SA, et al. (eds) *Perspectives on Free and Open Source Software*. Cambridge, MA: MIT Press, pp. 483–488.

Slade G (2009) *Made to Break: Technology and Obsolescence in America*. Cambridge, MA: Harvard University Press.

Sloan AP Jr (1963) *My Years with General Motors*. New York: Doubleday.

Sperling D and Gordon D (2009) *Two Billion Cars: Driving toward Sustainability*. Oxford: Oxford University Press.

Stallman R (2004–2014) On hacking: Richard Stallman's personal site. Available at: https://stallman.org/articles/on-hacking.html (accessed 3 June 2015).

Sternberg E (1993) *Transformations: The Eight New Ages of Capitalism*. Buffalo, NY: Mimeo, Department of Planning and Design, State University of New York.

Thorpe A (2007) *The Designer's Atlas of Sustainability*. Washington, DC: Island Press.

Tomaney J (1994) A new paradigm of work organization and technology? In: Amin A (ed.) *Post-Fordism: A Reader*. Oxford: Blackwell, pp. 157–195.

Triggs T (2006) Scissors and glue: punk fanzines and the creation of a DIY aesthetic. *Journal of Design History* 19(1): 69–83.

Vallance R, Kiani S and Nayfeh S (2001) Open design of manufacturing equipment. In: *Proceedings of the CIRP 1st international conference on agile, reconfigurable manufacturing*, University of Michigan, Ann Arbor, MI, 21–22 May.

Van Abel B, Evers L and Klaasen R (2011) Preface. In: Van Abel B, Evers L, Klaasen R, et al. (eds) *Open Design Now*. Amsterdam: BIS Publishers, pp. 10–13.

Verbeek PP (2006) Materializing morality: design ethics and technological mediation. *Science, Technology & Human Values* 31(3): 361–380.

Von Hippel E (2002) *Open source projects as horizontal innovation networks-by and for users*. MIT Sloan working paper no. 4366-02, June. MIT Sloan School of Management. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=328900 (accessed 5 June 2015).

Von Hippel E (2005) Democratizing innovation: the evolving phenomenon of user innovation. *Journal für Betriebswirtschaft* 55: 63–78.

Wang T and Kaye JJ (2011) Inventive leisure practices: understanding hacking communities as sites of sharing and innovation. In: *Proceedings of the CHI'11 extended abstracts on human factors in computing systems*, Vancouver, BC, Canada, 7–12 May, pp. 263–272. New York: ACM.

Whitelegg J (1997) *Critical Mass: Transport, Environment and Society in the 21st Century*. London: Pluto Press.

Wood J (2007) Designing for micro-utopias: thinking beyond the possible. Draft introduction. Available at: http://metadesigners.org/Downloadable-Articles (accessed 5 June 2015).

Author biography

Mark Richardson, formerly a senior designer at Ford Motor Company, was involved in both conceptual and global manufacturing projects, such as the R7 show car, Territory, European Mondeo and Asia Pacific Fiesta. Mark now lectures in Industrial Design at Monash University, having completed a PhD seeking evidence to support the advance of ecologically and socially sustainable mobility systems through hands-on practices of making. His research now investigates how we can transition from current design and production methods to more sustainable, resilient and accessible systems of creating, making, sharing and learning.