Ergonomics, 2013
http://dx.doi.org/10.1080/00140139.2013.816375

Taylor & Francis
Taylor & Francis Group

Automation: how much is too much?

P.A. Hancock*

MIT^2 Laboratory, Department of Psychology, University of Central Florida, 4000 Central Florida Boulevard, Suite 301D, Orlando, FL 32816, USA

(*Received 9 January 2013; final version received 2 June 2013*)

The headlong rush to automate continues apace. The dominant question still remains whether we can automate, not whether we should automate. However, it is this latter question that is featured and considered explicitly here. The suggestion offered is that unlimited automation of all technical functions will eventually prove anathema to the fundamental quality of human life. Examples of tasks, pursuits and past-times that should potentially be excused from the automation imperative are discussed. This deliberation leads us back to the question of balance in the cooperation, coordination and potential conflict between humans and the machines they create.

Practitioner Summary: The reason for this work is to examine how much automation is too much. The investigational form is synthetic in nature. The major finding is – it depends? Each design decision of practitioners as to what to automate and when is, therefore, critical and fateful.

Keywords: automation; limitations; design restrictions

1. Introduction

In 1987, the International Committee of the Red Cross (ICRC) opined that 'All predictions agree that if man does not master technology, but allows it to master him, he will be destroyed by technology' (ICRC 1987). This study is set within this theme of mastery and destruction by asking one simple question, how much automation is too much? It is no surprise that automated systems writ large across the micro-, meso- and macro-levels have, since their earliest modern instantiations, increased in their penetration of almost all forms of human activity (see for example 'As we may think' *Atlantic Monthly*, July 1, 1945). This is especially the case in highly complex technical systems at the macro-scale, many of which are now simply inoperable without the requisite level of automated support. In a world driven and riven with the aspiration of, and mandate for, profit and efficiency, the behemoth of automation (at all levels) has marched forward essentially unchecked and unchallenged (perhaps with the exception of a small number of communities and constituencies such as our own, see for example Stanton and Young 2005). While the productivity of human work has increased substantively over the immediate past decades (see Figure 1), this pattern of sustained growth experienced on a global scale has, to a non-trivial degree, been dependent upon the introduction of automated technological systems. Under the commanding forces of capitalism, we often design, fabricate, construct and implement automated systems, because we can, not necessarily because we should (Hancock 2009). The present work addresses this question of *can* versus *should*.

To begin the present commentary, let us take a historic example which may prove less polemical than other examples that I use later. At one time, lifts (or elevators as they are termed in the USA) used to be manned systems. Inside more reputable establishments, a smartly dressed individual would manipulate the wired gates as well as manually select each target floor. Operating a lift was almost exclusively a human occupation. We can well imagine that for some individuals this was indeed telestic work (Csikszentmihalyi 1990); for some it was hedonic in character and may well have represented their whole life's vocation. There were obviously social dimensions to this profession also, with the cheery greeting between the lift's attendant and their colleagues, co-workers and customers an important element of reaching one's vertical destination. Those same essential ingredients are shared with the occupation of doorman, of which a few vestigial examples still remain in modern western society. One rather doubts whether committed and content lift-operators were ever consulted when major companies decided to introduce the automated elevator. The de-humanised system was in certain vital financial respects more efficient, and with that the argument was sealed. But is this truly all? Are there not critical dimensions of human life which are not, cannot and should not be made subservient to automation as a result of financial considerations alone? This work therefore questions the assumptive nature of automation adoption. In particular, how and when do we, as a collective society, get to deliberate upon this issue at any of the micro-, meso- and macro-levels identified? Most

*Email: peter.hancock@ucf.edu

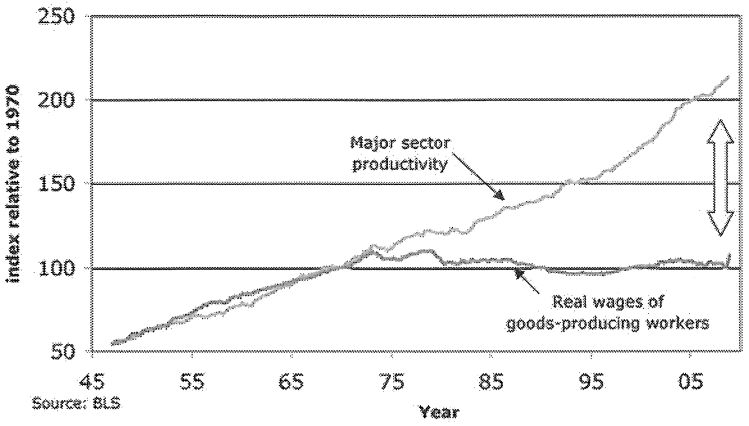

Figure 1. Productivity and average real earnings for the last seven decades (Bureau of Labor Statistics). While a portion of increasing productivity is a result of the implementation of automation, it is clear that the distribution of the outcome benefits of automation is not equitably distributed.

particularly, how could this stampede towards the automation of all human life be tempered, even if we wish it to be so? These are the issues which occupy the current discourse.

2. Information constipation and the lure of automation

The evolution from analogue to digital systems was accompanied by a form of transcendental temptation. Specifically, this temptation was to digitise everything. Humans thrive on challenge, especially technologists. Scientists, software developers, computer engineers and many of their associated professional colleagues were quick to find motivation in the daunting challenges of digitising the world. Similarly, many other professions fell under the spell of the same appeal that somehow 'solutions' to a vast array of problems must reside in the collection and processing of ever more data. Intriguingly, a sufficient number of solutions do present themselves through this process. Indeed certainly enough to encourage the general propensity in this direction, as for example in the case of librarians' aspirations to digitise all of human knowledge. This grail of the alluring solution is still held out to many who march to the digitised drum. As a result, we are drowning in data. Up the progressive ladder of semantic labels, we have moved through kilobytes, megabytes, gigabytes and terrabytes to now petabytes, exabytes, zettabytes and even yottabytes; we are now in danger of even running out of these storage size superlatives. The argument concerning 'levels' of automation, of course, co-varies with these progressively larger states of storage. At the same time, solutions themselves rarely appear by any form of natural osmosis from this cataract of numbers. At the very best, data are presented as a cascade of information which then somehow has to be 'processed'. We are presently stuck in this fragmented peristalsis of processing gridlock. Collectively then, contemporary society suffers from *information constipation*. The steps from information to knowledge and from knowledge to wisdom, and thence to insight and understanding, are held captive to the nominal insufficiency of processing capacity. Such is the prohibitive nature of the situation that we turn, almost unconsciously then, to the chimeric anodyne of automation. The fact of many manifest failures, but the seduction of the continuing illusion of graspable success, feed upon each other to fire the automation temptation. We live, at the present time, in an era in which computational capacity has created this seeming impasse but has failed to deliver on most promised solutions. Examples of this condition abound in the multiple failures of implementation (see for example '£12bn NHS computer system is scrapped' *Daily Mail*, September 22, 2011). In the specific case of our own ergonomics science, we live in a world of hybrid control in which a palimpsest of residual manual accomplishment is mixed mostly with unthinking automation. It is true that there exist rare soupcons of human-centred success, but in reality most extant systems proceed with little or no input from our science, even after disaster has struck (Casey 2006). Thus, the march of automation continues unabated. But is this necessarily a bad thing? After all, in certain realms automation has demonstrated certifiable benefits.

3. Can technology induce stupidity?

While we may decry the general movement towards insensate automation, is this actually a neutral fait accompli? I once asked the question as to whether technology could cure stupidity (Hancock 2000). However, with respect to automation, the antithesis of this question is perhaps more relevant, that is, does current technology actually induce stupidity? In less stark

terms, does the presence of automated technological support actually inhibit the growth of knowledge on behalf of the human operator? To a degree, the answer must be in the affirmative. As we have each become aware, internet search engines leading to various source locations have more and more become the keepers of factual truth. Most individuals are now more liable to trust an internet source of fact, even though they are aware of low website reliability rates. In essence, many people are now more and more outsourcing their memory (particularly for simple factual information) to the web or other convenient portable and portal technologies (Sparrow, Liu, and Wegner 2011). But if the facts are not resident in an individual, to what extent can they reason about ideas and concepts if certain base sources are exogenously stored? The pessimist would say they cannot and the optimist would posit that such thinking is now itself a hybrid form between humans and various facets of technology.

Such issues, however, demand that we distinguish between terms such as computation, technology, automation and autonomous machine systems. These terms possess necessary but not exclusive relations. They are not synonymous and require differentiation in the arguments which follow. I here take technology to be the most inclusive term and that much, but not all, of modern technology requires computational capacities. Automation, in virtually all modern forms, requires computational support however, little if any current automation is autonomous in a full sense. While the growth vector of human individual capacity seems almost flat, the comparable growth of automation self-determination is steep by comparison. On an absolute level, numerous dimensions of human capacity still exceed automated systems, although the gap is closing. When the transition will occur is contingent upon the specific performance skill under consideration. And despite the more superlative assertions of optimistic futurists, it cannot be denied that within the present century we shall see what might be appropriately termed 'the crossover' in which exogenous computational capacities will exceed individual human abilities in almost all dimensions. As to whether that technology will reside within the human body, outside the human body or in a synergistic hybrid form will be directly contingent upon the process of cognate automation design and most especially the constraints placed upon automated growth as examined here (see Boyce and Hancock 2012).

4. Searching for a happy medium: is there an optimal level of automation?

In terms of specific tasks and capacities we might well ask what functions there are that we do *not* want to automate. Typically, we might want to exclude many of our more hedonic activities from automation. For example, would we really want to delegate a nice stroll along the beach to a surrogate robot? Would an avid mountaineer want to replace their own effort with an automated mountain climbing system? Indeed, I personally can climb mountains, but only if that involves technological assistance by funiculars, helicopters and the like. While I might personally experience the wonderful view from the top, I do not get the same fulfilment that the conquering mountaineers experience. But then again, as I am sure many would point out, neither do I suffer some of the associated risk. In respect of risk, one of the most controversial dimensions of automation is the outsourcing of killing to progressively more autonomous systems (Krishnan 2009). In his treatise on the nominal perfect society, Sir Thomas More advocated that 'utopians' outsource their killing, (in particular by using mercenary-based targeted assassinations). Our modern *autopia* (the automated utopia) is proceeding towards this same vision except that instead of hired mercenaries, we are positing, advocating and creating evermore autonomous weapons. From the present day forms of drone technology, vision statements of many modern militaries are now actively considering the use of robotic killing machines to replace human war-fighters (Human Rights Watch 2012). Again, the question here is twofold. The first part involves the technical challenge, i.e. is it technically feasible to produce such weapons. The answer here is that it is certainly feasible and research to achieve this goal is already underway. The second question is one of a much more moral flavour; should we create these forms of automated weapons? Here, the motive is not the purely financial one of profit (although there is little doubt that the vending of these weapons will be a highly lucrative business), but the question is often framed as one of national defence (see Hobbes 1651). We can produce such systems, but it would seem to be to the collective good of humankind in general that we do not do so. However, there are few if any mechanisms in place which effectively will limit their production. Unlike other semi-abjured forms of warfare (e.g. nuclear and biological), drone technology and associated automated forms of control already exist and the use of these weapons is already sanctioned (see for example 'When drones go rogue' *Homeland Security Today Magazine*, October, 2012). Consequently, 'killer robots' do not represent forms of banned weapon, but refinements, improvements and extensions to already existing systems (Barnes and Jentsch 2010). Like many other global problems, nation states seek to optimise their own particular circumstances but in so doing they do not merely sub-optimise all others but place the whole existence of civilisation itself in jeopardy (Hancock 2012). Such states must also always remember that fabricated weapons can always be turned upon the fabricator. If we are uncomfortable with and even seek to ban the outsourcing of killing to automation, what of other dimensions of human activity would we wish to excuse?

Perhaps one of the most difficult aspects of human discourse concerns discussion of sexual relations. Sadly, even with the confines of scientific journal we cannot engage in thoroughly rationale, dispassionate and non-emotive interchange about this issue, although it is gratifying to see that some scientists do have the courage and moral fortitude to broach such

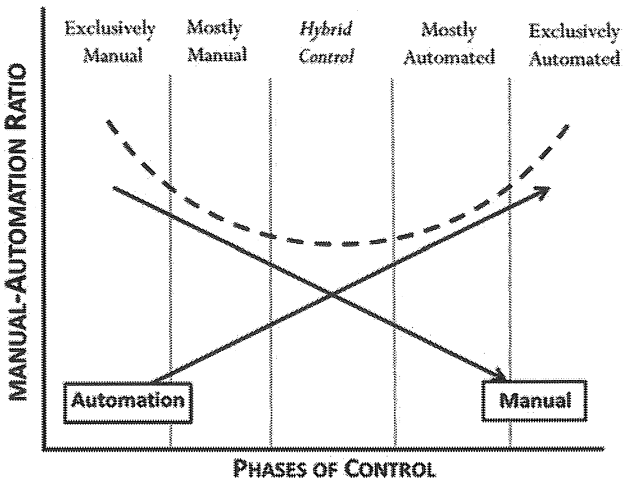

Figure 2. A generalised pattern of growth of automation and reduced manual contributions to all forms of human activity. Is the central 'hybrid' control the optimal distribution between human and machine control?

concerns (see 'Greater pleasure by design' *The Ergonomist,* February, 2013). Indeed, it is perhaps this emotional dimension itself which actually characterises one of the aspects of human behaviour from which we may wish to exclude automation. For good or bad, sex is one topic that is ubiquitous throughout human society. It cannot be ignored, for example, that a significant percentage of the internet is given over to nominally 'pornographic' sites and images (Lawrence 1930). And now we are seeing a comparable growth in robotics in which sexual functionality is a primary driver. It is also clearly the case that there is an enormous market for such 'products' (Yeoman and Mars 2012). Independent of one's views on sexual activity, promiscuous or otherwise, the central question here is: do we want to abrogate this emotional facet of human existence to a form of automation, however sophisticated it may be? From the point of view of future human society, whither social intercourse when the temptation is to engage with one's 'perfect' robot as opposed to other flawed human beings? Automated systems could potentially replace one's friends, or one's family. After all, these may be programmed never to argue with you, never to contradict, always to act in a warm and supportive manner. Why with such alternatives would one want to hazard the 'real' world? But if this vision becomes reality, as it may well do, what does it mean then to be human? In a similar way, would we wish to abrogate the fostering and development of our children to an 'automated' but surrogate parent? Will somehow the 'invisible hand' of the market pronounce upon these respective technologies? Indeed, most pointedly, should that mechanism be the one by which we decide our collective future? Is there really no prospect of a designed and intentional intermediate state of balance, even when the precise degree of such a balance is necessarily context contingent? (See Figure 2). With respect to such balance, in ergonomics we have pointed to the importance of human-centred design, but our appeal that this should be the design principle adhered to is underwritten by Hendrick's (1996) assumption that 'good ergonomics is good economics'. Sadly, as is evident even only from Figure 1 alone, good economics has proved presently not to support the collective good but rather the good of only the few. It is this element of automation benefit that I now briefly consider.

5. Automation: *Cui Bono*

When we look back at Figure 1, it is clear that vast gains in productivity have been had in the last five decades. Much, but certainly not all, of that productivity has accrued through the use of computational capacities and associated automated functions. But where has this collective 'good' gone? What is very evident from Figure 1 is that such value has not been passed on to the majority of those who have produced it. The talk of the 1970s was of progressively diminishing working hours (the 'freeing' of time being one manifest outcome of such increased productivity). It was confidently anticipated that working weeks of 30 and even 20 h would become 'standard'. But collective gain was not distributed in this fashion. Rather, the socio-political exploitation of these manifest gains was skewed to the benefit of an increasingly fewer number of individuals. This trend is very obvious in a simply survey of the changing coefficient of the Gini curve which is specifically designed to link the respective percentage of all income to the respective percentage of the population who receive it (see Hancock and Drury 2011). The evident outcome is that the move towards automation has disproportionately benefitted the few while generally only maintaining the level of income, and the correlated quality of life, of most individuals. Statistically, the answer then to the question of who benefits from automation is not you! This being so, why do we generally

remain enamoured with such technological advances? The answer is at least twofold. First, we should never underestimate the role of challenge and intellectual curiosity in driving individuals to find technical improvements. Second, the population of the globe has increased by some 46% in those previous five decades and much of the general benefit has been taken up by sustaining the quality of life of at least some of these additional individuals, although again as the global distribution of the Gini Coefficient shows, the quality of life varies quite staggeringly across the whole human population. If purely economic considerations should not solely drive this issue, what else should? The global answer must refer more to the notion of a collective good and this implies a state of dynamic global balance (see Hancock 2012; Mill 1861). To achieve this improved state of balance, one issue is whether we can amend, direct, stop, reverse or even substantively influence this proliferation of automation. The answer to this question, by apparent fiat, would seem to be no. To what degree then is ergonomics a determinative rather than derivative science with respect to this question? By that I mean to what degree contributions, as discussed in the current issue of our Journal, for example, implicitly or explicitly support the present vector of development in which economic progress and global technification appear to be assymptoting towards the destruction of human civilisation; what I have termed *civicide*. Could ergonomics act as a facet of science which leads and determines progress, such that it plays its role in serving to design the global 'system of all systems'. Clearly, I favour the latter, but that persuasion is a debatable one. What is of more short-term concern is what is left for human beings to do after automation has exerted its effect? It is to this that I now turn.

6. Automation: what work remains?

One of the important empirical questions concerning the ever-greater penetration of automation and eventually of autonomous systems (which I have previously termed 'self-intentioned machine systems'; Hancock 1999) is what is left then for the human operator. Are they fated to devolve to the 'subsystem of last resort?' Even in the so-called human-centred circumstances will they, in reality, only be left in the loop in order that blame can be attached to some living entity? Or, perhaps even more problematically, are they to be condemned to the perdition of vigilance for which humans, in general, are 'magnificently disqualified' (see Hancock 2013). As I have previously noted, if you build systems where people are rarely required to respond, they will rarely respond when required. Thus, while it is easy to advocate for challenging, elaborative, involving and interesting work, to date the vector of automation penetration into the overall workplace has relatively rarely generated these involving and stimulating tasks. Surely, however, this is a matter of design. Can we not think of ways in which to make even the mundane at least tolerable if not positively hedonomic (Hancock, Pepe, and Murphy 2005)? The answer to this question is of course we can, but the question is whether we will. Given the pluralism of forms of social organisation across cultures and nation states, it might well appear that at least some will look to engage in this human-centric vector of progress for automation implementation. But that is to underestimate the vast influence of convergent evolutionary patterns of global progress under the driving impact of technology and its penetration. While the earth is by no means 'flat' (Friedman 2005) and we have not yet reached the 'end of history' (Fukuyama 1992), there are patterns of development that impede the persistence of independent spheres of organisation and influence. Automated or not, our way forward is necessarily a more collective one.

7. Summary and conclusion

In this study, I have concatenated many forms of 'automation' such that, in essence, my argument ranges across the levels at differing junctures of discourse. Some might argue that this agglomeration negates some of the questions that I have raised as specific technologies therefore, may not or will not progress in the manner suggested. This would be a misdirected criticism, however, since the fundamental question is one of the patterns of overall progress and our conscious deliberations and actions to control our collective future. In contrast, others may accuse me of the Luddite heresy of technological abandonment, but this also is incorrect as I do not advocate for the remission of automation either in part or in whole. What I am asking is whether human society collectively can produce a considered, cognate policy by which the design of our future environment will proceed. While some have noted 'top-down' forms of influence such as international standards or even wide diplomatic forms of agreement as well as 'bottom-up' persuasions derived from public opinion, these are rather prosaic proposals and seem, from precedent, to be unlikely to be efficacious. Rather, what we have to seek is to resolve the invidious calculus of utilitarianism upon which modern market-driven liberal capitalist structures are erected (Mill 1861). This will require a much more precise formulation as to what connotes collective good, defined as the promotion of happiness alongside the prevention of pain. But surely, ergonomics as a discipline has now for decades, if not centuries (Jastrzebowski 1857; Murrell 1949, http://en.wikipedia.org/wiki/Human_factors_and_ergonomics, accessed January 1, 2013) been arguably one of the leading disciplines and proponents of pain and injury mitigation. And further, recent developments have begun to focus on the positive promotion of pleasure, under the general title of 'hedonomics' (see e.g. Hancock, Pepe, and Murphy 2005; Helander and Tham 2003). Surely then, with both arms of the Benthamite calculus of utility, we are centrally placed to engage in this

essential quest. The present vector of general development makes very clear that globally we can no longer afford the parochial attitudes which define the interests of the individual nation state, or even corporations. It argues that our technology must now serve to profoundly change what it is to be individually and socially human in this world, and automation can and must play a central role in any such metamorphosis. Sadly, in general, I am not sanguine about us achieving any such change. It is one of life's persistent sorrows that there is very rarely anything that is truly novel. Many of the concerns for over-automation have been expressed before, and more poetically. To conclude, consider Lamport's 'A sigh for cybernetics' (*Harper's Magazine*, January, 1961) contribution in response to Norbert Wiener's cybernetic insights of now more than 60 years ago:

'A Sigh for Cybernetics'

Thinking machines are outwitting their masters,
Menacing mankind with ghastly disasters.
These mechanized giants designed for compliance
Exhibit their open defiance of science
By daily committing such gross misdemeanors
That scientists fear they'll make mincemeat of Wieners.

Automation itself may be mandated by the democracy of stupidity, and perhaps our fear of over-automation is indeed misplaced. Or perhaps totally untrammelled, uncontrolled, unregulated and unwelcomed automation looms ever closer to reality.

Acknowledgements

I am very grateful for the helpful comments of John Senders on an earlier version of this paper as well as those of the Editors themselves and the respective reviewers for the Special Issue.

References

Barnes, M., and F. Jentsch, eds. 2010. *Human–Robot Interactions in Future Military Operations*. Farnham: Ashgate.
Boyce, M., and P. A. Hancock. 2012. "The Interpenetration of Mind and Machine." *Proceedings of the Human Factors and Ergonomics Society* 56 (1): 178–182.
Casey, S. 2006. *The Atomic Chef*. Santa Barbara, CA: Aegean.
Csikszentmihalyi, M. 1990. *Flow: The Psychology of Optimal Experience*. New York: Harper & Row.
Friedman, T. 2005. *The World is Flat: A Brief History of the 21st Century*. New York: Farrar, Straus & Giroux.
Fukuyama, F. 1992. *The End of History and the Last Man*. New York: Free Press.
Hancock, P. A. 1999. "Life, Liberty and the Design of Happiness." In *Automation, Technology, and Human Performance: Current Research and Trends*, edited by M. Scerbo and M. Mouloua, 42–47. Mahwah, NJ: Erlbaum.
Hancock, P. A. 2000. "Can Technology Cure Stupidity?" *Human Factors and Ergonomics Society Bulletin* 43 (1): 1–4.
Hancock, P. A. 2009. *Mind, Machine and Morality*. Chichester: Ashgate.
Hancock, P. A. 2012. "Ergaianomics: The Moral Obligation and Global Application of Our Science." *The Ergonomist* 503: 12–14.
Hancock, P. A. 2013. "In Search of Vigilance: The Problem of Iatrogenically Created Psychological Phenomena." *American Psychologist* 68 (2): 97–109.
Hancock, P. A., and C. G. Drury. 2011. "Does Human Factors/Ergonomics Contribute to the Quality of Life?" *Theoretical Issues in Ergonomics Science* 12: 416–426.
Hancock, P. A., A. Pepe, and L. L. Murphy. 2005. "Hedonomics: The Power of Positive and Pleasurable Ergonomics." *Ergonomics in Design* 13 (1): 8–14.
Helander, M., and M. P. Tham. 2003. "Hedonomics: Affective Human Factors Design." *Ergonomics* 46 (13–14): 1269–1272.
Hendrick, H. 1996. *Good Ergonomics is Good Economics*. Santa Monica, CA: Human Factors and Ergonomics Society. Accessed January 1, 2013. http://www.hfes.org/Web/PubPages/goodergo.pdf
Human Rights Watch. 2012. *Losing Humanity: The Case Against Killer Robots. International Human Rights Clinic*. Cambridge, MA: Harvard Law School.
Hobbes, T. 1651. *Leviathan*. Cambridge Edition, 1991: Cambridge University Press.
International Committee of The Red Cross (ICRC). 1987. *Commentary on the Additional Protocols of 8 June 1077 to the Geneva Conventions of 12 August 1949*. Geneva: Martinus Nijhoff.
Jastrzebowski, W. 1857. *An Outline of Ergonomics, or the Science of Work Based Upon the Truths Drawn From the Science of Nature*. Warsaw, Poland: Originally Published in Nature and Industry (1857). Reprinted by the Central Institute for Labour Protection (1997).
Krishnan, A. 2009. *Killer Robots: Legality and Ethicality of Autonomous Weapons*. Farnham: Ashgate.
Lawrence, D. H. 1930. *Pornography and Obscenity*. New York: A. Knopf.
Mill, J. S. 1861. *Utilitarianism*. New York Edition, 2005: Barnes & Noble.
Sparrow, B., J. Liu, and D. M. Wegner. 2011. "Google Effects on Memory: Cognitive Consequences of Having Information at Our Fingertips." *Science* 333 (6043): 776–778.
Stanton, N. A., and M. S. Young. 2005. "Driver Behaviour With Adaptive Cruise Control." *Ergonomics* 48 (10): 1294–1313.
Yeoman, I., and M. Mars. 2012. "Robots, Men and Sex Tourism." *Futures* 44 (4): 365–371.