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When Systemizers Meet Empathizers: Universalism and the Prosthetic Imagination

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In his study of cross-cultural universals and relativities, Professor Lloyd considers a range of 'styles of inquiry' that might be used to construct an experimental situation, a research perspective or a theoretical analysis. These styles of inquiry cut across subject boundaries, rather than corresponding directly to particular categories of subject matter. Nevertheless, they are all firmly within the domain of (natural) philosophy. In this paper, I wish to consider themes of cognitive variation from an alternative epistemological standpoint, one more associated with practical than with intellectual discourse. This standpoint is that of technology design — not only the study of technology design and designers as an area of human activity, but also processes of making as a way of understanding the world for those who engage in them.

Design, in its most general sense, is a matter of imagining how the world should be changed, and then making it that way (Simon 1996; Blackwell 2010). Design can thus be considered a fundamentally normative perspective, involving judgements of what is good, or rather what will be good in the future, or even more precisely the good future as constructed in the imagination of the designer. This necessary combination of imagination and utilitarianism in design can be contrasted with the kinds of normative perspectives in academia that are often regarded with suspicion for imposing observed, recovered or consensual ideals onto empirical scientific or humanistic enquiry.

The imagination of the designer is engaged directly, in the moment of making, with bringing into existence a very particular object (or assemblage of objects). This object functions as a kind of universal, because every person encountering the result will experience a particular product, and will participate in a network of globalized standards and systems (Michael 2000). Nevertheless, a skilled designer must also anticipate diversity, because every user of the product will have an individual experience, and the success of the product will be determined by the sum of these experiences, rather than by the qualities of the object itself. Professional design, then, dwells both in a (technical, engineering, systematic, universal) 'object world' and also in a

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(human, subjective, empathetic, diverse) social and interpretive world. This dichotomy represents a permanent tension in design work, and is at the core of my argument in this paper.

There are several ways in which professional design engages with the human. One, as expressed from the perspective of a systems engineer, is the 'man-machine interface' — the technical specification of the ways in which a user will observe, control or feed information to the product. A second mode of engagement with human concerns is the design process of 'requirements capture', where a complex human context must be reduced to a finite set of defined 'features' that should be implemented in the eventual product. A third, and one that is particularly relevant to my argument, is the analysis of those ways in which human life or experience are deficient, and might be improved by the application of technology. This article will return to that theme at some length.

Finally, in an approach that is not a specific goal of professional design, but is characteristic of some 'design research', a technologist can create devices that change our understanding of what it means to be human. Such projects often arise directly from the imagination of the designer, as curiosity-driven research, or as practice-based art research, and might highlight aesthetic, idealistic or critical aspects of the 'product' rather than direct user need. In the modern era, technical objects arising from such open-ended design exploration have initiated conceptual change at least as great as those arising in the sciences and humanities — in particular, the new media technologies of broadcast, film and the internet have homogenized and universalized significant spheres of human experience.

From augmentation to prosthesis — when engineers romanticize dysfunction

The technologies of the Internet and the World-Wide Web extended directly from visions of human augmentation promoted by post-war US Directors of defence research. Vannevar Bush's famous 1945 article *As we may think* (Bush 1945) promoted a web-like vision of Memory Extension. His successor J.C.R. Licklider extended this to digital communications technology when writing in 1960 on *Man-computer symbiosis* (Licklider 1960). Substantial funding from defence research agencies was invested in institutes such as the 'Human Augmentation Research Centre' at Stanford, where many aspects of today's internet were first demonstrated. However, the challenge for augmentation often arises in the interface. If symbiosis is to be achieved, then the 'man' part and the 'computer' part must be connected by an interface specified in standardized engineering terms.

The great interface achievement of Engelbart's Augmentation Research Centre was the invention of the computer mouse, a far more efficient pointing device than earlier light-pens and track-balls. Pointing devices allowed a crude form of deixis in computer interaction, whereas prior interaction via typewriter keyboards alone had emphasized abstract symbolic language having only internal referents. In addition to making the mouse, Engelbart's team also wished to replace the keyboard, partly because the QWERTY layout seems almost perversely inefficient, and partly because typing was at the time associated with menial secretarial labour rather than technology, science and management. Nevertheless, textual language continued to resist efficient standardization, despite mathematical formulations of human text use that make it more amenable to a simple interface specification.

A central theme of this paper is that when the technical model of the user and of the anticipated system use becomes overly universal, then a technical vision originally conceived as an opportunity for human augmentation may shift to one of human prosthesis, when the universal objective turns out to be more complex than it first seemed.

As an illustrative case study of this shift from augmentation to prosthesis, I was involved in a relatively recent project creating another alternative to the keyboard for computer text entry. The invention of *Dasher*, a system that predicts what the user will write (when guided by a mouse), was developed mathematically as an augmentation that would be more efficient than the keyboard (Ward *et al.* 2000). When in use, however, users were unable to control the system at the high speeds that it might theoretically have achieved. Dasher has not replaced the keyboard, but it has been a valuable aid to people with disabilities who are unable to use one (Mackay 2003). Dasher can be controlled, albeit slowly, by moving an eyelid, by blowing, or with any single muscle movement. The more profound the disability, the more dramatic the prosthetic achievement, despite the fact that normal users find Dasher at best a novelty, and at worst frustrating, rather than providing a superior direct replacement for the keyboard.

An extreme prosthetic vision is exhibited through sustained interest in Dasher from the field of brain-computer interface research (BCI), where researchers appear to be inspired by science fiction cyborg fantasies of human augmentations such as data storage brain implants or 'jacking-in' to the internet from direct brain connections (in William Gibson's cyber-punk literature, found in *Johnny Mnemonic* (1981) and *Neuromancer* (1984) respectively). For BCI researchers, the ultimate prosthetic target for a system like Dasher would be a person who has no voluntary muscle movement at all. This frightening condition, known as 'locked-in syndrome' (LIS), has been dramatized in cases such as *The Diving Bell and Butterfly*. There are numerous conferences on BCI, and sustained popular interest in LIS.[1] However, it seems that LIS itself may be extremely rare. The number of documented cases of LIS appears to be fewer than the number of researchers developing BCI systems. Indeed, the majority of BCI researchers have never met or been in the presence of a person with LIS, and all literature on the syndrome refers repeatedly to the same three or four celebrated cases.[2]

Locked-in syndrome provides a medical condition where the user is sufficiently deficient in normal human capabilities to become a well-defined engineering component, able to be connected to a computer via a relatively standardized interface. This is the key dynamic of the 'prosthetic imagination' in technology design, and one that encourages, through the normal processes of design engineering, increasingly universal conceptions of the human.

The best engineering interface specifications are simple ones. The computer mouse is an efficient interface between computers and humans precisely because it reduces the complexities of deictic reference to a simple pair of X and Y coordinates. However, the technical ambition to integrate computers into human affairs is constantly frustrated by the complexity and diversity of those affairs. New sub-fields of computer science such as 'ubiquitous computing', 'pervasive computing' or 'tangible and embodied interaction' are continually established to address those frustrated ambitions. But the attempts in these fields to establish suitable engineering standards for new interfaces is problematic. The term 'context' is often used in these research fields to describe the remaining elements yet to be addressed in some situation, in order to complete an engineering interface. But critical attention to use of the word 'context' (Dourish 2004) makes it plain that the term often hides lack of understanding, rather than a technically feasible or even intellectually coherent ambition. 'Context' reveals diversity, where design for a mass market requires uniformity.

Universal emotion and affective computing

To further investigate the themes of unity and diversity in this technical design setting, I wish to explore one particular kind of contextual problem, which addresses an area of human experience considered by Lloyd himself in *Cognitive variations* — that of emotion (Lloyd 2007, chapter 4). The field of 'affective computing' was developed in response to an analysis by Rosalind Picard at the MIT Media Lab, that computers often respond in ways inappropriate to the needs of their users because the computer is unaware of the emotional context of the user's instructions. Her 1997 book *Affective computing* established the field, arguing that if computers could be provided with emotional intelligence, they could be integrated more effectively into human contexts.

The contemporary field of affective computing often draws on the same tropes of symbiosis and augmentation that I have described above, proposing scenarios in which computers and humans can act together to achieve results not available without technical augmentation. In order to do this, the engineering interface between the user and computer must define, in a standardized way, the information that is relevant to emotion. However, each of these statements, regarding both the means and the end of affective computing, immediately appears problematic when considered in the light of Lloyd's concerns.

The proposed engineering interfaces for affective computing rely on the definition of emotional states that can be labelled and differentiated from each other. The definition of these states must be universal, insofar as they lie in the domain of the machine, rather than in reference to any particular person or society. The technical definition, once complete, can be transferred to any computer in the world, and would have the same technical meaning in any human context. Affective computing researchers are able to justify the feasibility of this goal by reference to the work of Ekman (building on the earlier work of Charles Darwin), setting out a universal set of emotions (Ekman 1973). Successful technical implementations have directly applied Ekman's research tool, the Facial Action Coding System, to infer emotional state from the movement of the eyebrows, cheeks, nose and mouth, which are automatically detected in real time by analysing images from a video camera pointed at the user's face.

Prototype affective computing systems are able to output one of Ekman's basic emotions (Happy, Sad, Afraid, Disgusted, Angry, Surprised) when presented with an input image of an actor portraying one of those emotions. It is also possible for a non-actor, with very little practice, to successfully control these prototypes, causing the system to recognize a given emotional state, by arranging his or her own face appropriately. When used in the context of a user interface, the term 'recognize' need not imply intelligence on the part of the system, but can be considered in the same sense that a computer keyboard will 'recognize' a word after the user has arranged her fingers on the keyboard in an appropriate manner.

Even where a system relies on an overly simplistic model of human behaviour, users are easily able to shape their actions in a manner that compensates for its deficiencies, thus making the system's responses appear intelligent (a dynamic described by Collins and Kusch (1998) as Repair, Attribution and all That — R.A.T.). Rather than accepting the appearance of a machine participating in an emotional dialogue, the R.A.T. dynamic implies that affective computing systems may be seen as closely analogous to a new kind of keyboard, albeit operated with the user's face rather than the fingers. To adapt Ekman's terminology, operating a computer via facial gestures is achieved via a set of conventional facial 'display rules'. If widely deployed in computer products, these facial displays could be described as 'technically dictated obligations' in comparison to the 'socially dictated obligations' that Ekman observes when people pose or simulate facial expressions rather than showing natural emotional expressions (Ekman 1973, 185).

The research publications describing affective computing prototypes tend to confirm the finding of Ekman and of Darwin, which is that there are a small number of emotions for which a particular set of facial gestures are generally understood to correspond to a consistent interpretation of emotional state. The emotional states as recognized by the computer are labelled with the same words used by Darwin and Ekman. The field of affective computing was founded and is mainly based in the USA, and conducts and publishes its research in English, thereby avoiding the questions raised by Wierzbicka (1999) of whether these English terms are completely adequate characterizations of the relevant emotion, or indeed whether the English category of 'emotion' words is completely adequate to characterize 'affect'.

The technical challenge for the field of affective computing is now to extend this work to a range of emotions that will have direct relevance to the tasks that people carry out when using computers. How can affective computing research move from the universal Darwin/Ekman categories such as disgust and surprise to affective states such as curiosity, misunderstanding, disappointment or concentration, which are more typical characterizations of user experiences when interacting with computers? Of course, these more realistic and relevant emotional terms, while perhaps able to be defined with some precision in the experience of Anglo-American academics and technologists, are less likely to have exact and accurate analogues in other cultural contexts. Furthermore, attempts to define subtler shades of emotion as graduated compositions mixed from a colour palette (or 'emotional keyboard' as Lloyd puts it) of the 'basic' differentiable emotions, move well beyond the universal findings of Ekman. The feasibility of such composition implies a digital calculus of functional affect (and a relatively extreme computational theory of mind).

Turning from the question of identifying and applying clearly differentiated and labelled emotional states, to the application scenarios for affective computing, we can ask whether the visions of human augmentation that these scenarios offer are also predicated on a universalized view of human needs. First, we might ask whether the scenarios are situated within a context that is characteristically 'emotional', and in which augmentation of emotional 'powers' might be seen as desirable. Technical research papers describing emotion recognition techniques (e.g. Cowie *et al.* 2001) imagine the benefits of enhanced emotional powers for practitioners in fields such as psychotherapy, criminal detective work, teaching, professional gambling and so on.

Purely technical research publications such as these present little evidence of demand from among the proposed beneficiary communities, or evidence that professionals in those fields are concerned by the limitations of their own 'emotional' skills. It is clear that those scenarios are constructed from within the technical frame, rather than representing any substantive consideration of the social context, let alone the possibility of diverse understandings of professional roles in different societies, and the desirability of technologizing them. Affective computing as an 'augmentation' strategy is thus inherently universalizing, to an extent that it superimposes a technical conception on the actuality of human lives. There may yet be an opportunity for 'bulk' processing of affective judgements, in the manner of an expert system, where large numbers of relatively crude classifications are made automatically. Once again, this requires a degree of consistency across many individuals, to be commercially feasible.

If proposals for affective augmentation are too distant from human needs, they will not represent plausible commercial markets for technology investment. Instead, in a manner analogous to that seen earlier in the case of devices for text entry, the more restricted capabilities of the technology that have actually been developed (rather than the idealized capabilities initially imagined) become candidates for prosthetic repair of human deficiencies, once it becomes clear that they do not offer significant augmentations over and above normal human ability. In order to become established in a prosthetic application, affective computing technologies therefore require a class of person for whom lack of normal emotional competence has been recognized — ideally with a clinical diagnosis. Where a clinical deficit exists, there would be a potential market for a prosthetic technology. As it happens, contemporary clinical neuroscience does suggest a potential market.

Autism spectrum disorders (ASD) such as Asperger's syndrome describe a class of people who are abnormal in the sense that they are deficient in their ability to recognize, understand and respond to emotion. There are often high concentrations of diagnosed ASD cases in the same geographic areas where there is a high concentration of technological research enterprise[3] (Silberman

2001). As a result, many recent research projects in affective computing have been exploring the development of prosthetic aids for those with ASD. These might be used, for example, as an emotional 'hearing aid' that would observe the faces of people in conversation with an individual having ASD. The prosthetic emotion detector could then warn or prompt the user when necessary, for example, to behave more appropriately when others display emotions that were unexpected. In this context of prosthetic correction, 'appropriate' behaviour by a person with ASD can be taken to mean 'conventional' or even 'universal' behaviour. The implication of such scenarios is that a more standardized (i.e. technical) definition of appropriate human behaviour can be used to correct those who depart from the (universal) norm.

There are two further extensions arising from this particular universal view of human behaviour. The first is a reverse characterization of computers themselves. Computers are considered to share many characteristics of humans (i.e. they are rational, communicative etc.), but are also deficient by comparison to humans, in that they are not competent emotional actors. In the ultimate ambitions of artificial intelligence, the computer would be a competent actor in every way, with this deficit corrected. Affective computing researchers therefore observe that today's computers are like autistic persons, and that the computers themselves might benefit from research into the correction of autism. Of course the trope of the golem, robot, tin man or replicant that lacks, then gains, the emotional soul that makes one truly human is hardly a new one. Nevertheless, it is unusual for those narratives to be realised so explicitly in engineering investment.

The second interesting extension derives from the characterization by autism researcher Simon Baron-Cohen of ASD as simply an extreme range within a scale of human variation that distinguishes 'empathizers' from 'systemizers', and the 'male brain' from female (Baron-Cohen 2002). A small number of studies, and a large number of anecdotes, suggest that the technical skills of programming and computer science are closely associated with one extreme on the scale of 'SQ-EQ' (systemizing quotient minus empathizing quotient) (e.g. Wray 2007). Indeed, possible hereditary transmission of SQ-EQ to the children of professional programmers appears likely to be responsible for the high incidence of ASD in areas such as Silicon Valley. Although there is still debate among autism researchers, regarding the validity and generality of the SQ-EQ score, this kind of metricated description of human variation suggests an opportunity for technical assessment and potential engineering correction. The construction of a metric provides a way of acknowledging and accommodating human variation within a standardized universal framework.

These considerations are not so extensively debated in the field of affective computing, which is primarily concerned with technical advance. Ekman's set of basic emotions are generally treated as convenient axiomatic universals, that provide a scientific foundation for a general purpose technical 'interface specification' of human emotional behaviour. Any question regarding their cross-cultural universality, or the accuracy of Ekman's English language terms when rendered in other languages, is treated with suspicion as likely to lead to a critical attack on the scientific foundations of the field. Even the universal cognitive semantics of Wierzbicka, potentially a far better technical foundation for current affective technology, especially in combination with her direct semantic account of facial gesture components, are not taken with any seriousness in the field where she is known mainly as a 'relativist' critic of Ekman, bringing disruptive perspectives from her consideration of other languages. This is despite the fact that her proposal of a 'natural semantic meta-language' is, as noted by Lloyd, radically universalist with respect to the phenomenon, however diverse she may find its lexicon.

In computer science, where the construction of a universal artificial language is the very essence of the enterprise, every reference to the diversity of human language is a potential obstacle to technical progress, and is likely either to be resisted or marginalized as belonging within the (slightly dull) specialist field of 'internationalization' or 'I19N'.[4] Even supposedly universal 'general purpose' computer languages, although assumed to be culture-free, become imbued with metaphors of power and control that are easily recognized when inspected from outside the perspective of their designers and users (Blackwell 2006a). As explored in the next section, the standardization of machine languages and interfaces both encourages and absorbs universalist and mechanistic fantasies of power, knowledge and (self) control.

Universalizing fantasies of man-machine interaction

I wish now to consider a cultural undercurrent during the recent decades in which Ekman's theory of emotion, the cyberpunk genre, awareness of autism spectrum disorders, and the microcomputer itself have been coming together in new configurations of systems engineering. This undercurrent is not a determining cause of those configurations, but represents an extreme response to them. It offers a counterpoint to the classical trope of the craftwork or machine that becomes alive through the (possibly blasphemous) skill of the human sculptor, wizard or engineer. The two main elements are, first, an intense awareness of the mechanization of human abilities, leading to perverse fantasies in which the imaginer considers himself as becoming a machine. The second is a fascination with the interface between person and machine, the awareness that this is a boundary between the personal and impersonal, or between individual and universal. Intense awareness of the interface leads to fantasies in which its mechanical elements become sexualized.

An example of the first kind of fantasy is the 'motorik' beat that was characteristic of the musical genre affectionately known as Krautrock, introduced and popularized in the 1970s by German bands such as Neu! and Kraftwerk. Motorik beats anticipated the automated rhythms later performed with drum machines in 80's and 90's techno music, but used human drummers who performed with a relentless and unaccented rhythm as though they were machines. In an echo of 1930s composer Max Brandt who dramatized the 'slavery' of machine-workers with a chorus of singing machines in his social expressionist opera *Maschinist Hopkins*, the leader of Kraftwerk insisted on describing band members as MusikArbeiter, and invited his audience to interpret their own experience as machine-like in the 1978 Kraftwerk album *Die Mensch-Maschine*.

The mechanized fantasies of this cultural undercurrent have presented singers as though they were emotionless robots (on the cover of David Bowie's 1977 *Heroes*, recorded and produced in Berlin, or Devo's 1978 *Q: Are We Not Men? A: We Are Devo!* from the manufacturing centre of Akron Ohio), or even as literal robots, seen in the popular climax of Kraftwerk's stage performances, where members of the band are replaced with actual robots topped with waxwork replica heads, and 'dancing' (the heads rotating and robot arms gesturing) in automated synchrony with synthesized beats. The heavy irony of the mechanistic dance is that the stage performances of the human band members are equally robotic, dressed identically, standing in a rigid line, each behind an identical control console from which they trigger recorded samples with minimal gestures.

Throughout the contemporary era of the microcomputer, repressed teenage angst and fear of emotional loss of control has found expression in songs such as Kraftwerk's *Die Roboter* and Ultravox's *I Want to be a Machine*. The genre reached popular heights with the release of the 1979 album *Replicas* by an adolescent Gary Numan, the most successful British synthpop star of the 1980s, who was presented to the public in pancake makeup and an affectless pose echoing Bowie's cover photo on *Heroes*. Numan's songs presented disturbing technological sublimations of teenage desire such as *I Nearly Married a Human* and *Are 'Friends' Electric?*, an elegy to robot prostitutes that technologized and computerized a dystopian fantasy of inflatable dolls recorded in 1973 by Roxy Music as *Every Dream-home a Heartache*. Numan's robotic stage persona, and his songs celebrating human isolation and robot love, were later diagnosed by himself and others as resulting from his own Asperger's syndrome, and as an adult he readily admitted that his affectless pose represented an escape from his turbulent inner life rather than the studied detachment expressed in his lyrics.

Cyborg fantasies in popular culture are not restricted to technical tropes of science fiction and of the future, such as robots, synthesizers and digital technology, but construct romanticized and transgressive accounts of contemporary technosystems. Numan's hit *Cars*, and Bowie's Berlin-period *Always Crashing In The Same Car*, both draw on the fiction of J.G. Ballard, the science fiction writer whose 1973 book (later an influential art-house movie) *Crash* portrayed the inter-penetration of crashed cars and their passengers as a transgressive eroticism. These sexual hybrids are depicted in the *Crash* movie as hidden behind a rhetoric of technological prosthesis and augmentation when 'TV-scientist' Robert Vaughan claims to be concerned with 'the reshaping of the human body through the introduction of modern technology' (Wiebe 2009). In typically idiosyncratic manner, Kraftwerk also celebrate vehicular-human hybrids, although with bicycles rather than cars, when an acclaimed performance of their *Tour de France* in the Manchester Velodrome was accompanied by the UK national cycling squad circling the audience and stage on which Kraftwerk's own robots had danced.

In these visions of humans integrated within technological systems, the point of interface between human and machine components of the system is both a locus of anxiety, and a sexualized fetish of the hybrid itself. While bicycles and cars offer crude mechanical analogies of coupling, even digital brain-computer interfaces become sexualized in science fiction fantasy, whether implicitly when William Gibson's characters 'jack-in' to cyberspace, or extremely explicitly in David Cronenberg's 1999 film *eXistenZ*, where natural perceptions are replaced by a simulated world when a connector is inserted into a 'bio-port' at the base of the user's spine.

Elsewhere I have written about the manner in which the field of Human Computer Interaction (HCI) has fetishized the eye and the hand through technical concentration on the screen, keyboard and mouse (Blackwell 2010). It may be the case that newer research fields such as affective computing and BCI are leading to fetishization of the universalized face and the brain. However, my motivation in drawing out these counter-cultural fantasies has been to show how they can be seen as a response to sublimated anxiety about universal interface.

Exhibition of the man-machine

In modern engineering research and design, demonstrating or exhibiting an operational system offers general evidence of validity for the design principles from which it was derived. Successful replication is assumed to be a simple matter of manufacture, because the components of modern technology have become interchangeable, such that a system built from a certain set of components can be built again from other equivalent components. This is even truer of software systems than mechanical ones. It was a breakthrough of mechanical precision that allowed the earliest mass-manufacture of firearms from interchangeable components by Samuel Colt. However, software components are similar to each other not only within a degree of engineering tolerance, but exactly and mathematically equivalent. Furthermore, the design principles embodied by a piece of software are expressed in software language itself, providing a text that is evidence of its own truth when the program is demonstrated to run.

Both of these routine engineering realities are implicit when digital technology is employed to demonstrate a universal understanding of humanity. At a systems level, software simulations of human behaviour can be replicated and reproduced, offering a universal account of that behaviour by 'generating' it, in the same sense that Chomsky grammars are valued according to their capacity to generate language. At a component level, the existence of suitable components, and of defined interfaces between them, demonstrates not only the feasibility of the whole, but also the possibility that such components can be 'plugged in' as prosthetic replacements or augmented alternatives to human faculties.

Although replicable and standardized software interfaces to human 'components' are a new development of the twentieth century, exhibitions of machines that generated human behaviour were achieved far earlier. The famous automata of the eighteenth century, such as Vaucanson's flute-player, the Jaquet-Droz harpsichordist and Kempelen's chess-playing mechanical Turk, were sublime craft objects that explored the limits of humanity by simulating breath, expressive performance and cognition. However, these automata were unique marvels, exhibited to the public both as philosophical objects and demonstrations of artisanal skill (Riskin 2003). Their internal workings were usually obscured if shown at all, and they were never duplicated (whether from concerns of secrecy, or because of the degree of skill involved in their construction). They were not engineering objects, for which a specification can be provided and parts procured.

The contrast between the explicitly universalized interfaces of engineered components and the marvel of an exquisitely crafted simulation remains today. An eighteenth century eulogy of Vaucanson celebrated the 'mechanician' as one who made machines 'execute operations that we were obliged, before him, to entrust to the intelligence of men' (Riskin 2003). The same definition could easily have served, in the twentieth century, to describe the enterprise of artificial intelligence research. However, the public quickly tires of novelty. An ambitious early goal of AI research was the chess-playing computer, but chess at a routine level can now be played by disposable toys — manufactured objects that standardize and reduce chess rather than being suited to public exhibition. A popular saying among students at the MIT Artificial Intelligence Laboratory was 'if it works, it isn't AI.'[5]

Affective computing similarly offers an example of transition from the (mysterious and possibly unique) context of the art object to the (explanatory and reproducible) context of science and technology. The first of a series of students coming to the University of Cambridge to work on affective computing[6] arrived just as the author was inaugurating a scheme of New Technology Arts Fellowships (NTAF) with the Arts Council of England. The student Rana el Kaliouby (now in Rosalind Picard's Affective Computing group at the MIT Media Lab) met artist Alexa Wright on the day Wright was interviewed for the NTAF Fellowship, and subsequently spent several months working with her to realize an art work that was first demonstrated in the University's contemporary art gallery, Kettle's Yard. Wright's Fellowship proposal had described a 'magic mirror' that would use a camera to watch the faces of gallery visitors, and respond to their expressions by manipulating an animated face, on a display screen in place of the mirror glass. Realized with assistance from El Kaliouby, Wright's work *Alter Ego* (2005) subsequently toured the country and internationally. The response of the face was intended to be mysterious, not predictable, drawing on Wright's earlier work *Face Value* (2001) that gave gallery visitors horoscope-like 'character readings'.[7] These works play on the unknowability of the individual mind, as contrasted with the apparent certainty of a machine.

Three years later, Rana el Kaliouby's work was again exhibited to the public, but this time without the involvement of an artist, as a scientific exhibit within the Royal Society summer show. Once again, a camera was used to monitor the expressions on the face of the viewer. But rather than the unpredictable responses of Wright's inscrutable magic mirror, the screen of the Royal Society exhibit showed a series of graph traces in the manner of a scientific instrument. Where Wright's mirror might respond to the viewer's expression of surprise with a smile, this instrument would respond didactically with a rising line on the graph curve labelled 'surprise', so that users could experiment with increasing the amount of surprise in their expression. Multiple curves on the graph corresponded to Ekman's basic emotions, providing a compelling illustration of his coding scheme.

As a purely scientific demonstration, the Royal Society exhibit could have been presented as an emotion detection instrument, confirming the validity of Ekman's universal schema. If so, the exhibition setting would rather compromise that proof, given the R.A.T. dynamic (Collins and Kusch 1998) by which the audience shape their behaviour to conform to the system's expectation. However, the greatest public interest arose from the potential application of the system to assist individuals with autism. Autism is a syndrome of enduring public interest,[8] and the 'mind-reading machine' was described as providing a possible basis for an emotional 'hearing-aid' that would help autistic individuals compensate for their disability in the perception of emotions (el Kaliouby and Robinson 2005). For the scientifically-minded public, as well as for technology researchers, prosthesis can be a more attractive proposition than augmentation. A charitable concern with correcting and standardizing those who have a disability, rather than enhancing the powers of a technical elite, is perhaps rather laudable. However, this possibility deserves further inspection.

Constructing the universal consumer/worker as an attentive component

The standardization of human life and work is often presented, within a generally Marxist analysis, as being inherently political. Taylorist automation has always been concerned with the efficient integration of human components into mechanical production lines to create man-machine systems. Although occasionally utopian, most commentary on such systems sees them as mechanisms of oppression. However, in the modern 'digital economy', production is not purely mechanical, but cognitive, with the result that the mechanisms of control and oppression become far less overt, less subject to inspection and critique. For example, the technicians who construct digital systems must invest their attention in the analytic object-world, reasoning systematically about the potential interaction between standardized components, and the consequences of prescribing system behaviours in artificial languages (Blackwell 2002). This systematic 'computational thinking' is being advocated by computer scientists as a necessary skill for all modern children (Blackwell *et al.* 2008).

Cognitive science provides a cybernetic model of the attentive human worker, through the 'spotlight' metaphor of visual attention, in which subjective awareness is assigned to a single point in the visual field. The spotlight model of attention is commensurate with a computational theory of mind, the point of focus in a human visual task being somewhat analogous to the program counter that provides the focus of control in a von Neumann computer architecture. The human mind is clearly not such an architecture, but visual attention can nevertheless be treated as a single (X-Y) location, when measured with gaze-tracking cameras that follow the saccades and fixations of a user watching a screen.

Political critics of media technology, from DeBord to McLuhan, Virilio and Johnston, have repeatedly expressed concern, not only with the mechanization of the human worker, but with the reduction of diverse human experience to a standardized universal consumer, following mechanical logics of bureaucracy and military-industrial control. According to Jussi Parikka (2006), cyborg augmentation/prosthesis fantasies of the brain-computer interface as seen in the 1995 film based on Gibson's *Johnny mnemonic* represent the masking of human subjectivity within a technological industry of film consumption. The film expresses not only the mechanically augmented intellect of the hero, but also the mechanization of the audience by the cinema industry. On this basis, one can imagine affective computing technologies being used to measure and control audience responses to entertainment products. Indeed 'neuro-marketing' already applies eye-tracking and functional brain imaging to confirm that consumers are attending to, and influenced by, advertising.

Where both technologized production and consumption rely on sustained attention from the individual consumer/producer, the focus of the attentional spotlight is an economic commodity. It should be no surprise that any inability, or unwillingness, of schoolchildren to devote sustained attention to information objects has now become a matter of medical diagnosis, with drugs prescribed to correct the newly defined syndrome of 'attention deficit disorder'. In the light of the dynamics described earlier, where affective computing might be applied to correct the emotional handicaps of those with ASD, we could predict that a new generation of prosthetic device will soon be designed to monitor and correct the unruly adult gaze.[9]

Meanwhile, HCI is turning its attention from emotional experience to creative experience (Shneiderman 2003). Advertising campaigns regularly promote the computer as a universal creative tool, not simply a consumption device. But creative and unruly customers are not compatible with the sale of standardized experiences. As a result, computer interfaces are replete with 'metaphors' that are constrained to have only one reading (Blackwell 2006b), and computer games such as *Guitar Hero* simulate the experience of musical performance, but where the player cannot change the notes. As Rob Horning (2009) comments, users are 'doomed to dilettantism' by the redefinition of diverse creative experience into a series of standardized and uniformly packaged components and consumer commodities. Despite the sales rhetoric of creative augmentation, it is worrying to consider the possibility that human creative 'deficiencies' might in future become a target for technical prosthesis.[10]

The duty of the designer

At the start of this article, I proposed design as an alternative frame of reference, to be added to the various styles of intellectual enquiry explored by Lloyd. However, in a technocratic age, design is more than an intellectual frame of reference. Design is embedded within the technological enterprise, determining the modes by which our imagination of the future becomes products and technosystems. I have argued that the engineering and market dynamics of design tend constantly towards universalized imagination, with outcomes that are often worrying when viewed from a broader critical perspective. For this reason, we must be alert to the dynamics of the relationship between science and design, and to the way that scientific explorations such as those of Darwin and Ekman are interpreted in technical work.

Lloyd notes the scientific concern with understanding the difference between humans and animals, but designers must also challenge their understanding of the difference between humans and machines. Those differences easily become elided, not only through technical expedience, but through technologized fantasies, whether augmentative fantasies of power, fantasies of control through self-determination, or the interpretive, explanatory and predictive fantasies of knowledge, that appear possible through the adoption of determinist and reductive theories of mind. Design management in technology companies has adopted some simple strategies to remind engineers of diverse users, such as the writing of fictional 'personas' to help engineers imagine the experience of others (Grudin and Pruitt 2002), but these tend to be applied as supplements or correctives to an established technical vision, rather than core analytic strategies. Furthermore, the practice of persona-driven design is often to provide a mechanism for categorizing and reducing the diversity of others, becoming an alternative to direct engagement with rich human experience (as practiced for example in Scandinavian cooperative design[11]).

The discourse of HCI is replete with implicit universalism, arising from its service role within a technology industry. One of the most frequently repeated requirements in engineering ambitions for technology is that a user interface should be 'intuitive'. When used naively, the implication is that intuition can be conferred on a machine by the designer, that intuitiveness can thereby become an attribute of a machine, and that the properties of the intuitive machine would be universally recognized — available to any (competent, or suitably corrected) user. In the context of discussing cognitive diversity, the designers of user interface components would do well to remember that users construct their own experiences, that these may be culturally specific or individually variable, and that the dynamics of mass production and component engineering can easily obscure realities of human experience.

There are examples of HCI research that integrate critical enquiry with the kind of practice-based art/design research described in the introduction to this paper. In the area of affective computing, exemplars are found in the work of Bill Gaver at Goldsmiths College and Phoebe Sengers' Culturally Embedded Computing group at Cornell (e.g. Gaver 2009; Sengers *et al.* 2008), which are situated within a broader enterprise that has been described as Critical Technical Practice (Agre 1997). These approaches remain very much a minority perspective in affective computing, despite the broad awareness of design research as a necessary component of HCI more generally. If technology research is to steer between the extremes of universal and relative accounts of human life, then design must remain an empirical, social, interpretive and humanistic discipline, not one that is subservient to engineering convenience and technological fantasies.

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Notes

1 Popular interest in LIS does not seem to be as extensive as that in BCI — at the time of writing, Google reported 1,180,000 hits for brain computer interface, but only 273,000 for locked in syndrome. However, after the initial version of this manuscript was completed, new controversy has arisen over the incidence of LIS, and particularly the possibility that many patients classified as being in a persistent vegetative state may in fact be conscious and suffering from LIS. If this turns out to be the case, then Dasher could well provide a valuable and even essential prosthetic aid for many such patients. Nevertheless, it should be remembered that the interest in Dasher as a prosthetic has *preceded* any clear medical need, and has arisen primarily from the dynamic of technical imagination that is my main theme.

2 Most notably, Johnny Ray, who was fitted with a brain implant in 1998 that allowed him to control a computer cursor (Kennedy and Bakay 1998).

3 And indeed a high concentration of affective computing researchers.

4 The corporate abbreviation 'I19N' for the word 'internationalization' (indicating an 'I' followed by 19 other letters then 'N') is so intentionally obscure that it conceals even the existence of non-Anglo-American cultures. Ignorance and philistinism are given a veneer of cleverness in some technical writing. As in the Muttonbirds' song, 'If the Queen's English was good enough for Jesus Christ, then it's good enough for me!'

5 For several years, the author of this article was employed as an 'Artificial Intelligence Engineer', a title that he privately considered to be oxymoronic.

6 These students have worked under the supervision of Professor Peter Robinson, in the Rainbow research group of the Cambridge University Computer Laboratory, where the author is also based, and is familiar with their approach. This work is representative of leading research in affective computing elsewhere — see http://www.cl.cam.ac.uk/research/rainbow/emotions/

7 That work can very usefully be compared to the 'home health horoscope' created by design researchers Gaver *et al.* (2007), a system which was presented by Gaver (2009) as a critical counterpoint to affective computing research at a recent Royal Society meeting convened by Robinson and el Kaliouby (2009).

8 A colleague in a university psychology department reports that among psychology undergraduates, autism is the single most popular topic for research project proposals.

9 In fact, Microsoft Research Cambridge has already produced software to 'correct' the gaze of videoconference users who appear to look off-screen rather than at the person they speak to.

10 The cynical might consider that this has already happened, when schoolchildren are routinely taught to compose oral presentations using Microsoft PowerPoint.

11 I am grateful to Bill Gaver for making this observation when reviewing an initial draft of this article.

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