THE ASSEMBLAGE BRAIN

Sense Making in Neuroculture

Tony D. Sampson

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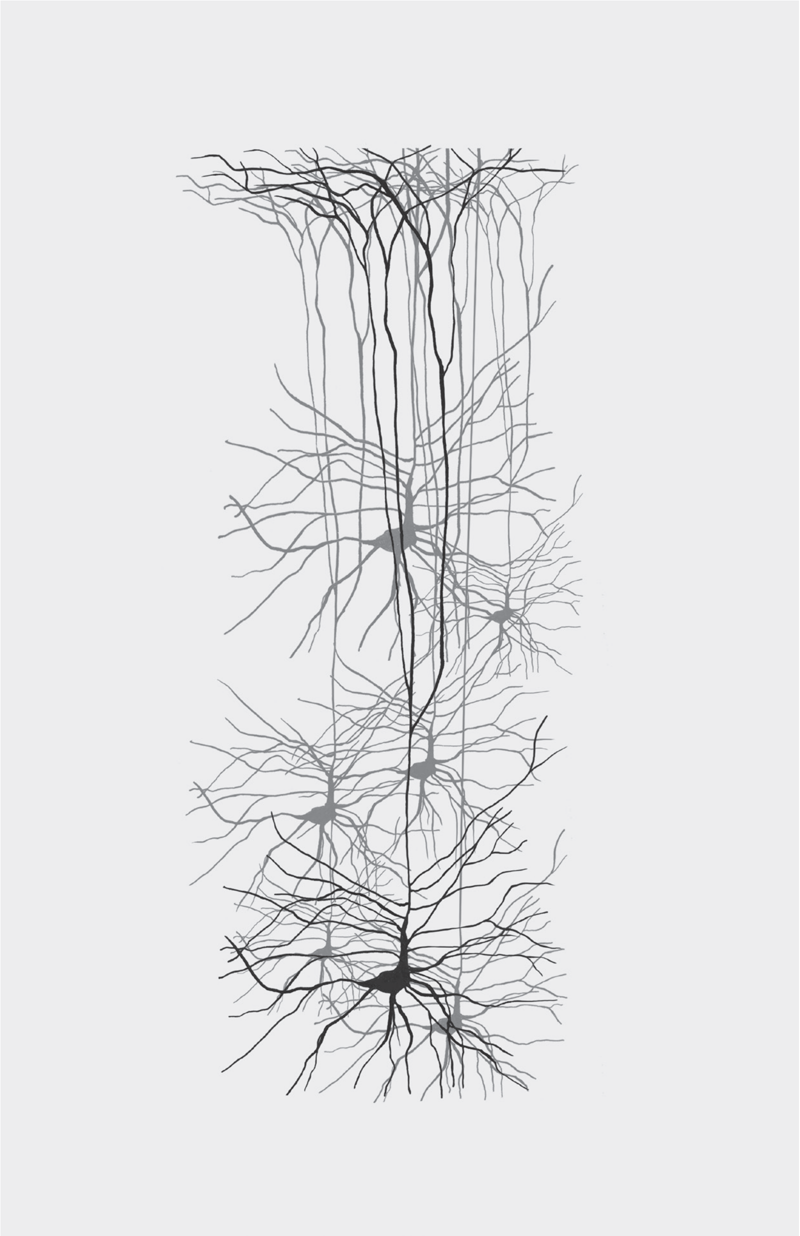

Illustration by Dorota Piekorz.

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Dedicated to John Stanley Sampson (1960–1984)

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Contents

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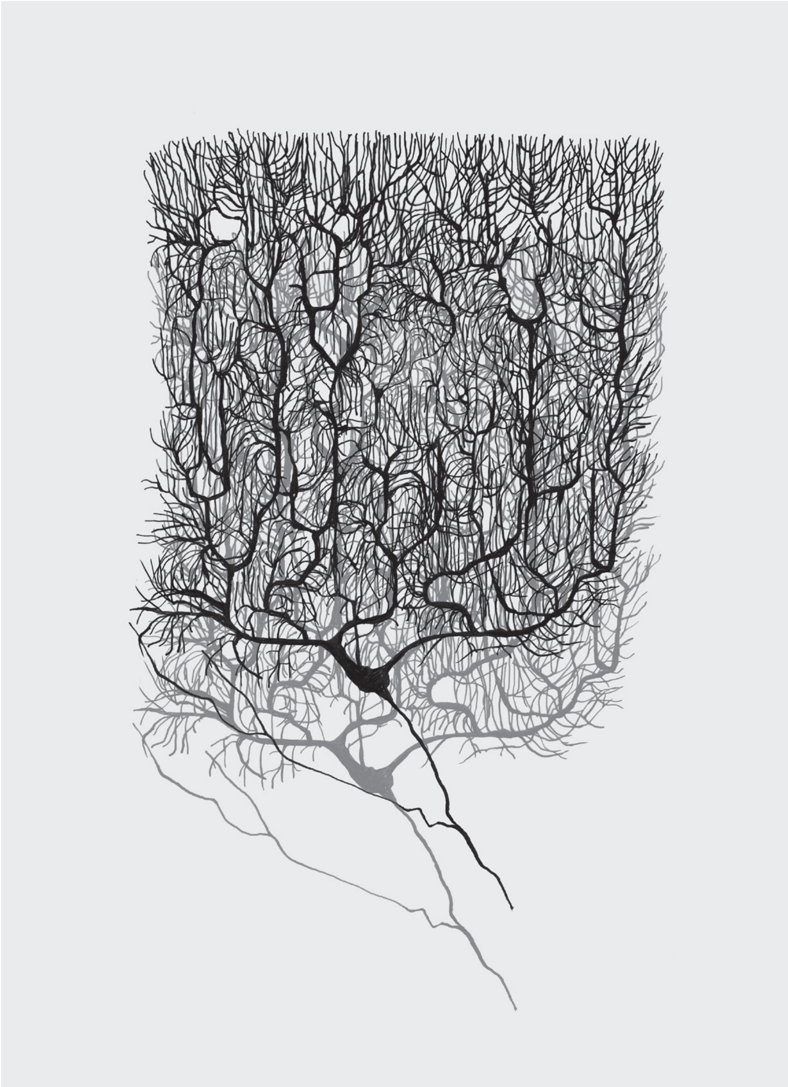

An interpretation of Cajal's drawing of the basic anatomy of a Purkinje neuron. Illustration by Dorota Piekorz.

PART I

What Can Be Done to a Brain?

THE NEURON DOCTRINE

The Spanish pathologist Santiago Ramón y Cajal's (1853–1934) pioneering anatomy of brain cells in the nineteenth century makes him one of the giants of modern neuroscience. It is, nevertheless, Cajal's apparently problematic journey from an inattentive schoolchild obsessed with art to scientific gianthood that produces a number of aesthetic figures that traverse extrinsic and intrinsic interferences between art, science, and philosophy. Not only do Cajal's intricate anatomical drawings lay down the foundations of the neuron doctrine, but his proposition that the brain is made of discontinuous cells would also go on to influence the conceptual basis of the rhizome brain. Moreover, his early childhood struggles with paying attention to authority at home and in the schoolroom, and later efforts at writing dystopian science fiction, mark him (and his aesthetic figures) out as an intrinsic interference that brings to life a society of neuroscientific control. He is, like this, an interesting catalyst for both tracing the early trajectories of neuroculture and framing the question concerning *what can be done to a brain.*

ANATOMY, FUNCTION, AND INTERVENTION

Cajal's influential anatomical work in the late 1800s lays the foundation of modern neuroscience and opens up two significant research trajectories. On one hand, this giant observed, and exquisitely sketched, the composition of nerve cells. On the other, he pondered the processes underlying the mediation of brain functions through these cell populations.

Cajal's work was complemented by contemporary improvements in microscopy and staining techniques, particularly a method developed by the Italian physician Camillo Golgi in the late 1890s. This involved a painstaking, lengthy process of exposing brain tissue to dichromate salts before impregnating it with ions made from silver or mercury, making it possible to see the various components that compose the nervous system in a full panoramic view, including the cell body, dendrites, dendritic substructures (spines), and at least part of the axon. Cajal would apparently observe the stained tissue under his microscope for long stretches of time before drawing the cells from memory with a glass of absinthe.

Gradual improvements to the Golgi method led Cajal to conclude that the brain was not, as the dominant reticularist theory had claimed, a continuous meshwork of cytoplasm (a reticulum). Following Cajal's discovery of dendrite spines in the cerebral cortex in 1891, the neuronists argued that the brain is instead made up of discontinuous cells confined to contiguous, autonomous individual neurons: the "butterflies of the soul," as Cajal referred to them.[1] At first, the reticularists rejected the authenticity of Cajal's dendritic spines, claiming that they were artifacts (or noise) produced by the Golgi method rather than genuine structures. They also tried to explain them away as sites of cytoplasmic continuity between dendrites (a form of dendro–dendrite connectivity). However, Cajal set about supporting the theory of discontinuity and rounding on his reticularist opponents, describing their notion of continuity as a "chimera"—a "contrived house of cards," this "panreticularism [is] absolutely unobservable."[2]

Along with Golgi, Kölliker, His, and other giants, Cajal was eventually reviewed in a series of papers published by Wilhelm von Waldeyer-Hartz, also in 1891, which summarized these new findings in a coherent theory. Waldeyer-Hartz concluded that "specific types of nervous system cells, called neurons or nerve cells, constitute the anatomical, physiological, metabolic and genetic unit of the nervous system."[3] So it was Waldeyer-Hartz, not Cajal, who first coined the term *neuron,* and he went on to be credited with establishing the neuron doctrine, that is to say, the proposition that individual nerve cells communicate at regions of cell-to-cell *contact* where there is no continuity between cells.

Following the neuron doctrine, the research focus shifted to the underlying processes of communication between nerve cells. By 1897, the British neurophysiologist Charles Sherrington had pointed to a possible anatomical and functional solution to Cajal's as yet unproven theory of dynamic polarization. Despite the morphological data Cajal presented, which pointed toward the "existence of synapses and the one-way property of neural data transmission[,] he was not able to realize the intraneuronal reversibility that Sherrington [using myographic recordings of the spinal reflex system of jellyfish, cats, and dogs in his lab in Oxford] proved experimentally."[4] In 1906, Sherrington published *The Integrative Action of the Nervous System,* in which he first theorized about the gap between neurons, calling it the synapse (taken from the Latin for "to clasp"), and pointed to the crucial interplay of excitation and inhibition in brain functioning.[5]

Working out how the synapse functioned became the overriding challenge for early neurophysiology. Indeed, before the 1930s, many neuroscientists, including Sherrington, regarded synaptic events to be electrical. Nonetheless, in 1921, Otto Loewi, a professor of physiology from Vienna, established an experiment demonstrating what he termed neurohumoral transmission. That is to say, Loewi produced inhibition and acceleration in hearts removed from frogs, revealing underlying chemical processes.

At this point, the trajectory of the neurosciences seemed to bifurcate in two directions, both of which would have a wider influence on life outside of the lab. First, efforts made to map neurophysiological functions to psychological states have drawn attention to the potential control of subject behavior by way of relating physiological brain matter to psychological and behavioral states. This line of flight initially became apparent in Ivan Pavlov's objective psychology and the influence it exerted on nascent Spanish brain science.[6] Even before Pavlov arrived in Madrid in 1903 to talk to the XIV International Congress of Medicine about "psychological reflexes," Spanish scientists had sought to remove the barriers separating the two. As Martín Salazar noted in 1880, although the deep-seated differences between organic and inorganic matter had been "torn into a thousand pieces by modern biological studies,"[7] there was a continuance of another barrier that separated psychology and physiology. This was a barrier that isolated the moral world from the material world. Yet, as Salazar notes, "ever since the cerebral reflex action was demonstrated . . . from this very moment, the secular wall has fallen down."[8]

Although a tardy Pavlov apparently failed to make the submission deadline for the congress proceedings, it was his theorization of the reflex system, and its apparent capacity to learn by conditioning, that eventually provided early brain science with a behavioral hypothesis to accompany Cajal's anatomical findings. In fact, Cajal was among a number of neuroscientists who attended Pavlov's talk who became interested in objective psychology and its account of conscious phenomena in terms of cellular occurrences governed primarily by mental association mechanisms.[9]

The second strand of neuroscientific research has focused on the functioning of chemical processes that occur between nerve cells, or neurotransmission, as it is now called. The possibility of direct chemical interventions into conscious and unconscious brain processes, assumed to affect mental and emotional states, looms large. Certainly this is the point at which the question concerning *what can be done to a brain* is approached through invasive experimentation at the level of neuronal interactions. Moreover, potential chemical treatments for mental disorders like depression are counterpoised with what the neuroscientist Steven Rose calls the Huxleyesque implications of chemical interventions into the brain.[10] As soon as Loewi identified the role of chemicals in neurotransmission, the potential for neuropharmacological manipulation of brain states became evident. By the 1950s, synthetic chemical interventions had been deployed to increase or decrease the strength of communication across a synapse. Indeed, much of this neurochemical research has been used to inform the business of the pharmaceutical industry, where the functions of the synaptic event have been exposed to increasingly sophisticated neurochemical products. Today, drugs like Prozac, Provigil (modafinil), and Ritalin, all of which target neurotransmitters, are designed to affect mental states associated with happiness, wakefulness, and attention. To be sure, as Rose contends, these cognitive enhancers have the potential to become the soma of the twenty-first century.[11]

CAJAL'S ATTENTION DEFICIT

Cajal's journey from artistic child to giant of neuroscience is a difficult one, complicated by a complete lack of interest in school and a seemingly compulsive obsession with drawing that infuriated his father. By his own account, as a young boy, he aspired to be an artist, but his father (a medical doctor) was having none of it and fiercely opposed the young Cajal's ambition. How could he possibly make a living from drawing? Despite this, his studies were of little interest to the young Cajal. "His attention always wandered and his hand had to doodle."[12] Cajal was eventually packed off to a school with a brutal educational philosophy of *la letra con sangre entra* (knowledge enters with pain). But he had no aptitude for strict rote learning and became a disruptive force in the classroom. He was apparently "untamable"—a lost cause—and would often escape into the countryside to draw. As a punishment for his misbehavior and inattentiveness,[13] the disobedient Cajal was treated to a reign of terror. He was whipped, starved, and locked in a dark room by the friars who ran the school.

Today, in times of neuroculture, Cajal would of course be treated very differently. He would still be, initially, disciplined for this behavior (perhaps not so violently, one would hope), but his short attention span, sustained bouts of distractibility, hyperactivity, and impulsiveness would most probably lead his teacher and parents to refer him to the family doctor, who might, in turn, refer him to a psychologist, a psychiatrist, and, eventually, a neurologist for electroencephalography (EEG) testing. Indeed, if Cajal's behavior corresponds with a certain higher ratio between two brain waves than is the norm, his condition might eventually be attributed to a problem with his brain. In short, Cajal would be diagnosed, like an increasing number of children in the United States and the United Kingdom, including those at primary school, with ADHD.[14]

Cajal eventually dropped out of school altogether and managed briefly to attend an art school in Aragon, but his father never recoiled, and the would-be artist was ultimately forced to study medicine. In his memoirs, he remembers the bitterness of his defeat: "I must exchange the magic palette of the painter for the nasty and prosaic bag of surgical instruments!"[15] Despite his earlier bouts of inattention and hyperactivity in the schoolroom, he eventually reoriented his obsession for art and became captivated by anatomy, microscopes, and the "life of the infinitely small."[16]

FOR THE ATTENTION OF DR. BACTERIA

Although his work focused primarily on anatomy and function, Cajal was, it appears, fascinated by the question of what can be done to a brain. It is here that his interest in hypnosis, Pavlov, and dystopian science fiction unleashes intrinsic interferences. It is indeed Cajal, the artist, not the scientist, who emerges, later in life, to conceivably bring together the neurosciences and a proto-Huxleyesque concern with the powerful hypnotic suggestibility apparent in Pavlovian conditioning. In his 1905 collection of short science fiction tales, Cajal (writing under the pseudonym Dr. Bacteria) introduces an outlandish aesthetic figure of his own: the bourgeois Dr. Alejandro Mirahonda, who lives in times of early industrialization, beset with aristocratic fears of violent class struggle. Mirahonda is a great hypnotizer, clever enough to realize the boundaries of his own magnetizing powers over the thieving, brawling, and drunken behavior of the newly industrialized proletarian. How then to overcome such antisocial passions as the idleness, rebelliousness, lasciviousness, and criminal instincts of the poor? Mirahonda's answer is, in part, to move away from the blood and pain of class warfare carried out on the streets and in the fields toward a mode of soft power founded in the factory, the scientist's lab, and the sociologist's study.[17] But before such remote ideals can be fully realized, suggestibility needs to be readily deployed to pacify those who "lack good brains or good fortunes."[18] To begin with, Mirahonda argues that the proletariat need to be *got at* from a very early age, their plastic cerebral centers placed under unremitting bouts of social hypnosis. But for reasons both Dr. Bacteria and Huxley similarly grasped, these hypnopedagogic programs have their limits. Mirahonda explains:

> In a group of a hundred people, selected at random, only fourteen or sixteen will be capable of being hypnotized and suffering, by way of suggestion, amnesias, paralyses, contractions, emotional transformations, hallucinations, etc. A very prestigious hypnotist, who knows how to strike deeply at the public's imagination, can increase this figure to twenty-four, maybe thirty. But despite all his efforts, he'll still be left with the remaining seventy percent:

> inattentive, open-minded, refractory to any belief in miracles, and therefore immune to suggestion.[19]

In the short term, the powers of suggestion require a conditioned stimulus, but this must go beyond the old behaviorist game of repeating the stimulus until it becomes a habit. The stimulus needs to be concealed, hidden under the white coat of a scientist or the cape of a saint. In short, Mirahonda's hypnotic suggestion is accompanied by a placebo in the shape of a sugarcoated suggestive pill, which simultaneously taps into the anticipations of the populace, drawing attention away from the trickery of the hypnosis itself, and fulfills the objective of absolute social docility. In the long term, Mirahonda's seemingly benevolent concern for the poor offers nothing short of a scientific purification and sublimation of the proletariat.

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Neurolabor: Digital Work and Consumption

In this chapter, I pursue the question of what can be done to a brain by mapping the brain's relation to recent trends in the management of efficiency in the workplace and sites of consumption. This tracing exercise will be set against the backdrop of an ostensibly familiar discourse concerning a shift from Taylorist to post-Taylorist factory models, that is to say, ongoing efficiency analysis caught in a transition from material to immaterial labor. The subsequent discussion is organized around three paradigms of computer work that are reappropriated from the study of HCI. The aim is to draw attention to the ways in which the everyday lives of workers and consumers have converged into a complex, circuitous, and exploitative mode of capitalism that increasingly makes use of the brain sciences to root out inefficiencies. It must be noted that this is a distinctly political rendition of HCI, a discipline not usually renowned for its critical interventions into unscrupulous modes of capitalist efficiency, analysis, and management.[1] In fact, my point is that HCI is more often than not complicit in initiatives directly linked to Taylorism. This chapter observes, as such, the many continuities and discontinuities associated with a shift from the muscular, rhythmic entrainments of industrialized labor (analyzed according to ergonomic, social, and psychological factors) to the introduction of cognitive and, more recently, neurological models, which have coincided with the digitalization of work and consumption and, simultaneously, drawn both into a circuitry of control.

In short, I argue that although there is a considerable shifting of ground, mainly brought about by changes in technology and scientific approaches to brain–body coupling, the goals of the efficiency management of work and consumption (to combat the evils of inefficiency and conform bodies, minds, and brains to the quickening rhythm of capitalism) remain consistent. Indeed, as ergonomics and cognitive science give ground to the neurosciences, and digital technology becomes increasingly ubiquitous, the efforts made to exorcise inefficiency and nonconformity from the workplace and sites of consumption also become more intensified. This is indeed a manifestation of neurocapitalism in which neuronal interactions, assumed to relate to emotions, affect, feelings, and decision-making processes, are put to work in the fight against inefficiency.

The chapter concludes by grasping these indices of neurocapitalism that transpire in HCI through the concept of *ersatz experiences,* that is, part of a regime of control that neurologically models and imitates the felt experiences of everyday life and reworks and recycles them to condition such things as worker motivation and consumer engagement. What this amounts to is a deepening of a technological unconscious and increasing control of the sensory environments in which people work and consume. It is indeed this reworking of experience that currently melds together the worker and the consumer in the same circuit of control.

FROM GRAMSCI'S BRAIN TO THE CYBERNETIC FACTORY: TWO CAMPS

Although cerebral labor is certainly not a newcomer on the factory floor, the digital reorganization of work in the late twentieth century has significantly intensified the open circuitry that connects the brain to postindustrial working life. The brain has, as such, been more finely tuned in to the rhythmic frequencies of what has been called cognitive capitalism. Aspects of this intensification have already been well documented in diverse literature covering the shift from manual to so-called cognitive labor. To begin with, these various approaches can be crudely located in two camps. On one hand, there are numerous popular notions of the *smart* advantages achieved through sharing knowledge on a network. These serve as indicators of the emergence of an assumed neoliberal economic model that taps in to the self-organizing hive mind. On the other, the detriments of immaterial labor have been grasped as part of a cybernetic control system that transforms activities not normally associated with work (play, chat, fashion, tastes, opinion) into products of often low-paid or even free labor.[2] Indeed, the notion of emergent collective intelligence becomes something that is exploited by the market rather than celebrated as an empowering force that might lead to mass nonconformity and potentially become an enemy of capitalism.

There are nevertheless complex subtleties apparent in this second camp that need to be cursorily acknowledged before progressing. As Terranova argues, although often portrayed in much of the Anglophone world as a crude shift from factory to information labor, the exploitation of factory labor has never gone away. The debate among Italian post-Workerists and French post-Marxist philosophers about what has changed is indeed far more complex than is often depicted.[3] For example, commenting on the work of Maurizio Lazzarato, Terranova points out that the shift he describes

> under the heading of immaterial labour [cannot] be dismissed as a simple quantitative transfer of surplus value from the factory to the "upper" floors of capitalist production. What it indicates is that the core of production now directly concerns the production of subjectivity: affects, desires, beliefs, aspirations, knowledges, ways of living.[4]

The focus in this chapter therefore aims to provide an extension of this latter approach, which specifically takes into account a series of shifts in the neurological models that inform ideas about brain–body relations in the digital workplace. Certainly the catalytic circuitry of neurocapitalism presented here must not be mistaken for a benevolent collective brain trust or an awakening of a collective cognitive consciousness. It is, rather, a mode of subjectivity in the making that not only overloads and speeds up the time of brain–body relations in the workplace but also exploits the desires, beliefs, emotions, feelings, and affective states of the worker to a point where the capacity to think independently is diminished and, worse, people drift away from nonconformist states of mind necessary to resist progressively more intensified frequency-following, routinized, and debasing working conditions.

Importantly, in times of neurocapitalism, brain labor is not simply distinguished from manual labor in the sense of the former being all about cognitive, conceptual, and nonempirical work, while the latter is all about the expenditure of physical energy. We need to further consider noncognitive components of labor. To be sure, the circuits that connect the brain–body relation to the workplace are also conditioned by managerial efficiency drives, aimed directly, and indirectly, at brain–body functions; associated with sensations, feelings, emotions, and affect; and tending to circumvent cognitive processes altogether. Indeed, today there seems to be more and more effort made to put neuronal interactions to work below the threshold of conscious cognizance. Nonetheless, this is not to say that work (or consumption) becomes wholly unconscious or, indeed, unthinking but, more exactly, affective states develop a mind of their own that more readily conforms to the punishing work rhythms of capitalism.

GRAMSCI'S BRAIN TAKES A WANDER ON THE FACTORY FLOOR

Albeit following a familiar trajectory of efficiency-driven initiatives already applied to the entrainment of bodies and brains in the industrial workplace, there is at the same time something equally novel about these recent attempts to couple neuronal interactions to labor processes. To fully explore these complex continuities and discontinuities, the discussion begins by tracing back the ongoing transformations of the brain–work relation to the early days of the twentieth-century mechanization of trades, where, surprisingly perhaps, the brain was considered to be liberated from muscular labor. As Antonio Gramsci argues—in his analysis of Americanism and Fordism—the tradesperson is modified by the scientifically managed assembly line just as a child is adapted when he learns to walk. Like the child, the worker's physical motion becomes automated and her memory is reduced to "simple gestures repeated at an intense rhythm, 'nestle[d]' in the muscular and nervous centers."[5] Significantly though, the memory of the trade is grasped by Gramsci not in terms of cognitive memory but rather as a kind of muscular *habituation*. Once a child has learned to walk, he can do so without thinking. Because thinking becomes surplus to use in the act of walking, there is a kind of emancipation of the brain. "One walks automatically, and at the same time thinks about whatever one chooses."[6] So, when the industrial adaptation of the tradesperson is complete, we do not find a worker with a *mummified* brain. Far from it: the brain "reaches a state of complete freedom," unfettered for other preoccupations.[7] This is, of course, a limited kind of freedom, but it could lead to the realization that in effect the Fordist factory model reduces the worker to nothing more than what Gramsci called a *trained gorilla*.[8] Although clearly such freedom to think does not (1) constitute absolute freedom from factory discipline or (2) help us grasp the role of habitual and cognitive memory in the workplace, it does nonetheless have the potential to lead, as Gramsci notes, to what industrialists would consider dangerous thoughts of nonconformity.

The onset of cognitive capitalism is perhaps anticipated at this point by what Gramsci identifies as the industrialists' concern with the threat posed by nonconformity resulting in a series of cautionary measures and *educative* initiatives well evidenced in Henry Ford's early experimentations with trade schools that brought together prescriptive modes of academic study and industrial instruction into one syllabus. Although, during this period of time, the Fordist factory continues to be a site of material production, these educational initiatives usher in a cognitive subjectification of the worker in terms of conditioning individual knowledge while, at the same time, ensuring proprietary skill sets and priming competitiveness in the workplace. As Ford puts it, "the man who has the largest capacity for work and thought is the man who is bound to succeed."[9] Indeed, Ford recognizes how modern systems of work required "more brains for [their] operation than did the old [systems]"; there was a need, he contended, for "better brains" to run the "mental power-plant."[10] This early example of industrialized education, focused on cognitive and manual labor, is perhaps an early indication of what would eventually become known as immaterial labor.

IMMATERIAL LABOR?

In the post-Fordist era, the notion of immaterial labor needs to be approached carefully. It has seemingly developed around the accumulation of mostly intangible goods, namely, information- or knowledge-based products, such as software, but also pharmaceuticals and genetically modified agriculture. Likewise, cognitive labor is (1) supposed to be increasingly organized around immaterial skills and activities associated with brainpower, including attention, perception, and memory, and (2) distributed through nonlinear information networks, which bring cognitive subjects into productive and competitive relation with each other. However, significantly, what has also changed in the wake of the continuous computerization and cognitivization of the workplace must not be mistaken for a generalized trend toward creative, nonroutinized knowledge work. The so-called rise of the *knowledge worker,* free from the routinized drudgery of the assembly line, needs to be seen as part and parcel of a myth created by the advocates of a new economy model intended to intensify efficiency management. Creative brain time required for new ideas, experiences, interpretations, judgments, and inventions may well be in demand in privileged regions of the world, such as Silicon Valley, but job descriptions like those associated with software engineering are of course vastly outnumbered by highly routinized, low-skill work in call centers and online retail warehouses. The need for highly skilled cognitive labor is evidently inconsistent with a global digital economy overwhelmingly dominated by a manual workforce engaged in low-skill interactions with computerized factories.

The cognitive subjectification of the post-Fordist worker was clearly never intended to encourage the freedom to think outside of the cultural circuits of capitalism. To be sure, even when creative brain time is in demand, it has become increasingly routinized by computer systems that churn out creativity and innovation as a kind of habitualization of the labor process, not unlike Gramsci's conditioning of muscular memory. In many ways, then, cognitive capitalism conforms both low-skilled, practical and creative thinking to a flexible production process. This is a network of labor that connects increasingly mobile and adaptable digital factory spaces to a globally deregulated and competitive (cheap) workforce, while also fervently using automated online software to disintermediate the middle space that once stood between the high street retail outlet and the consumer purchase.

NEW WEAPONS

Cognitive capitalism can also be conceptually grasped according to a rigid cybernetic model of the brain, transforming Gramsci's muscular rhythms of industrial work into a mode of immaterial labor consistent with the computer–mind metaphor of cognitive science. Cognitive routinization is therefore perfected by way of conforming mind processes akin to software, including perceptive and attentive functions, to inputs consigned to a memory storage or hardware system primed for action (work). However, just as there are practical limitations to the implementation of a purely cognitive workforce, there are conceptual limits to the robustness of this cybernetic model of the mind. In short, although the computer–mind metaphor becomes central to the study of cognitive digital labor, it marginalizes bodily interactions (muscular and affective) with computing that are directly related to cognition. In fact, as a model capitalist subjectification of the worker, the cognitive subject is flawed in many ways. My point is that, similar to Gramsci's brain in the Fordist factory, cognitive circuits of control have not been able to completely mummify the capacity to think nonconformist thoughts that might once have led to strikes and industrial sabotage. Indeed, within the coupling of digital networks and cognitive computer-minds, dangerous thoughts of nonconformity have managed, albeit in a narrow sense, to persist. As Deleuze profoundly argues in his influential and significant control society thesis, the digital circuits of cognitive capitalism would indeed prove to be prone to thwarting new weapons that introduce new modes of instability.[11] The potential of hacking, virus writing, denial of service attacks, digital piracy, WikiLeaks, and virtual petitions and occupations bolster, to some extent, nonconformist social movements online, which, although limited in their resistance to vigorous efficiency management, provide at least some evidence of latent disorder in digital circuitry. There is always a desire for new weapons.

NEUROLABOR AS EXPERIENCE

Although the full charge of cognitive capitalism is far from exhausted, it is important to note how developments in the neurosciences, particularly those involving an apparent deeper understanding of emotional and affective brain–somatic relations, are supplementing efficiency analysis and management. Managerial control has, it seems, switched its attention away from the software–hardware dichotomy of the immaterial mind in favor of indirect access to hardwired material brain functions. To be sure, the business enterprise has been quick to realize the potential utility of neuroscientifically inspired ideas, for example, in effecting "change management," encouraging "compassionate" corporate communication, and working with big neuroscientific ideas, such as neuroplasticity, to create a "brain-friendly workplace" in challenging economic times.[12] The business enterprise blogosphere is currently awash with neuroscience-enthused managerial techniques concerning motivation, emotional intelligence, creativity, and workplace mindfulness.

This steady production of efficient brain labor has coincided, to some extent, with what Bernard Stiegler has identified elsewhere as *neuropower*: a shift away from the biopower of the factory floor (and schoolroom), and the psychopower of marketing control, toward the creation of new markets for consumption.[13] There certainly seems to be a marked effort by the capitalist corporation to tap into the synapogentic processes of digital workers and consumers. However, it would also appear that the efficiency drives that underlie biopower, psychopower, and neuropower (the forces that control bodies, minds, and brains) have not simply been usurping each other. They have instead become even more interwoven in the cultural circuits of capitalism and its ongoing efficiency analysis. Indeed, the eventual capture of Gramsci's brain in these circuits, can, as such, be grasped here as part of an unremitting circuitry of control in which any inclination toward a nonconformist brain is increasingly confronted, exorcized, and substituted by the production of brain-friendly environments, affective atmospheres, and ersatz experiences, that is to say, a postindustrial layering of mostly artificial experiences related increasingly to brain functions associated with emotions, feelings, and affective states, in addition to muscular movements and cognitive inputs and outputs of previous industrial factory models.

As follows, neurolabor might be further conceptualized as an expansion of cognitive capitalism, typified by the attention economy model, into a noncognitive mode of capitalism, outlined, to some extent, in new economic models focused on experience.[14] We might also link this expansion to a mode of neurocapitalism, because it is the control of the sensory environment that sets the rhythm of working life and consumption that really matters. To be sure, the experience economy reconfigures the relation the computer worker and consumer have with the tangible and intangible production of commodities by way of adding to and reworking previously felt experiences. Considered as a type of post-Fordist factory, the production of these reworked, or ersatz, experiences more readily compares to a refinery or distiller model than it does to assembly-line production. This is to say, production takes the raw ingredients of previously felt experiences, like those relating to compassion, fun, or personal value, for instance, and modifies them into novel inventions that encourage more efficient production and consumption by ramping up emotional engagement. The ersatz experience is in fact more Walt Disney than it is Henry Ford,[15] or indeed, following Huxley's dystopia, we might substitute the term *post-Fordism* for *transcendental Fordism*: God of the assembly line, immaterial and experience labor.

The production of ersatz experiences becomes apparent in recent developments in HCI research and in subsequent trends in interaction design, including UX design. Here neuroscientific ideas concerning the emotional brain's role in decision-making processes relating to navigational choices and mouse clicks, for example, become indispensable to the efficiency management of computer work and consumption expressed through design, branding, and marketing.[16]

THE ROLLING PARADIGMS OF HCI

It is possible to trace the origins of neurolabor back through historical shifts in the management of computer work and consumption. Indeed, these shifts can be located in a trajectory of research identified elsewhere as the so-called *three paradigms of HCI,* which, before going on to "document underlying forces that constitute a third wave in HCI," set out two "intellectual waves that have formed the field."[17] In this section, I will call these first two waves *ergonomic* and *cognitive,* which, respectively, stem from "engineering/human factors with its focus on optimizing man-machine fit," on one hand, and an "increased emphasis on theory and on what is happening not only in the computer but, simultaneously, in the human mind," on the other.[18] The point is that these initial shifts in HCI research not only follow the transition from the Fordist to the post-Fordist factory model but also point toward a growing focus on *user experience HCI,* inspired, to some extent, by a combination of marketing and neuroscientific ideas concerning the emotionality of the brain.

Before I approach these paradigm shifts, I think it necessary to set out a series of theoretical preconditions, because mixed in with the constant paradigmatic change are a number of invariant political components that need to be accounted for:

1. The striving for Fordist and Tayloristic managerial efficiency drives remains invariable in each paradigm. What has changed is that techniques of efficiency management have been rolled out variously throughout each paradigm, affecting ergonomic bodies, cognitive minds, and emotional and feely experiences, as a kind of apparatus of capture of labor. The production of efficient bodies and minds can be accounted for by way of existing labor theory, but the latter focus on emotional experience requires, I contend, a new theory of neurolabor. To be sure, such a theory needs to include neuroscientific components, which can help explain why, for example, the neuroscientist Antonio Damasio's work has had such a profound influence on experience-processing models deployed in the UX industry.[19]
2. Even if individual components move around in the circuitry of each paradigm, the factory model, of the kind Gramsci's brain first encountered, has gained some level of fixity. Although such things as homework, mobile work, and, significantly, the work of the consumer as coproducer provide evidence of free-moving components in the capitalist circuitry, the rigid exploitations experienced in the Mexican *maquilas* or the Amazon factory model, for example, remain invariant. Certainly, as HCI practices shift further away from a focus on purely cognitive user interaction in the workplace toward affective computing and consumption, we are likely to see an intensification of worker conformity as well as subsequent novel struggles for nonconformity.
3. We need to consider carefully what it is that constitutes paradigmatic change. To this extent, my approach differs from that of *The Three Paradigms of HCI,* which, although acknowledging a sometimes noncontradictory shifting of theories and practices, concentrates more on a clash of metaphors occurring at the center

of each distinct paradigm. In this reading of transformations in HCI research, I am as interested in looking for invariant singularities as I am in the variant features of each paradigm. I will therefore approach each paradigm as an open system rather than as a closed or discrete entity. Moreover, in times of unpredictable technological change, the term *paradigm shift* has been frivolously applied to seemingly distinct and autonomous emergences (old and new). It is therefore essential to be reminded of a more complex set of diachronic emergences like those Thomas Kuhn first attributed to scientific paradigms.[20] There is, for instance, no higher deterministic authority able to capture and guide the trajectory of science. A paradigm shift is, it would appear, emergence with no downward causation. Each shift is defined by what escapes it, namely, the scientists who jump ship from normal to new science. What is more, in this analysis of the shifts assumed to be occurring in HCI, it is necessary to tread carefully by noting that a paradigm is a combination of mostly unpredictable variation alongside a gentle rolling out of undulating extensive invariance. The first ergonomic paradigm (from the Latin *ergo,* for "work," and *nomos,* for "natural laws") is, for example, a combination of physiology, psychology, and social factors that do not disappear in the ensuing paradigms but persist or reemerge in slightly different contexts. The third paradigm is similarly endemic to an enduring control circuitry that brings the territorializing forces of ubiquitous computing, emotion research, the utterances of design gurus, UX consultants, and the strategic business school inventions of the experience economy into the otherwise shifting assemblages of capitalism.[21] Each paradigm of HCI is, as such, an emergence of metric extensive properties underscored by immeasurable intensive differences—a kind of moving juxtaposition.

4. It is also important to observe a persisting trend in the natural laws of work, particularly in their manifestations in HCI, toward an accumulation of disciplinary approaches, which seems to pick up speed and mass through each paradigm shift. Initially marked out as a coming together of physiology, psychology, and, later, social factors, HCI has acquisitively expanded its reach to

> encompass sociology, cognitive science, computer science, anthropology, and industrial design, and now, in the so-called third paradigm, it is the neurosciences that are being drawn into its maelstrom to further proliferate the laws of work. On one hand, then, we have a qualitative grasping of indivisible cognition, emotion, and feeling and, on the other, a quantifiable rolling out of efficient and divisible bodies, brains, and machines.

THE ERGONOMIC PARADIGM

Efficient Bodies

The first paradigm of HCI can be defined as an "amalgam of engineering and human factors" in which interaction is grasped as a physical coupling of human and machine, the goal being to optimize the best fit between the two. Here we enter into the pragmatic world of industrial engineering inspired by Taylor's scientific management techniques already established in the early part of the 1900s but gradually expanding into more complex machine systems and early forms of computing. The objectives of Taylorism remain constant throughout this period, that is to say, to counteract the evil of inefficiency and increase worker effectiveness by way of the introduction of two major innovations: first, the division of labor according to managers and workforce, and second, the breaking down of the physical movements of the worker according to time and motion.

Social Factors and Beyond

Unlike Taylorism, though, the first paradigm is not defined by the labor of the body in isolation. It has its origins in war, specifically in the military use of advanced human–machine systems in World War II, which ushered in a new wave of technological invention requiring brains as well as brawn. After the war, the physical and mental demands of these human-operated machines found their way into the state and commercial industrial sector, requiring a new kind of managerial approach supported by military and academic research into physiological and psychological labor. Indeed, by 1949, the British Admiralty had proposed the name "ergonomics" (the natural laws of work) to describe a new kind of discipline concerned with the physical factors of work, but some three years later, the Ergonomic Society was formed, employing people from psychology, biology, physiology, and design to assist in developing this new approach to work. In the United States, too, psychological factors became of increasing importance in the study of post–World War II workplace efficiency. The Human Factors Society, formed in 1957, focused on the social role individuals played within complex industrial systems.[22] These early endeavors to bring together ergonomics and social factors permeated the working milieux of the latter part of the twentieth century in a number of ways.

First, efficiency analysis focuses on worker movement through the factory space. There are evaluations and measurements of a series of demands on the worker, including physical demands required to lift and move material objects through a space and skills necessary to operate machines to schedule. This focus on making bodies move more efficiently through the workplace comprises a consideration of bodily dimensions, competences, and physiological processes. More significantly, it concentrates on making working processes error or accident free. Indeed, error analysis leads to more reliable systems, making them, on one hand, easier to use, more comfortable, less fatiguing, and less stressful and, on the other, more profitable.

Second, each paradigm seems to have its own unique pathologies. Like this, in the ergonomic paradigm, a worker's material and immaterial interactions with tools, furniture, heat, noise, vibration, and pollutants in the industrial factory are taken into account. For instance, vibrations can be transmitted to a human body through contact with external vibrating surfaces, such as a handle or seat of a machine, making the body oscillate to the rhythm of the workplace environment, which is of course endemic to most industrial labor environments. However, certain extreme interactions with vibrating machinery are classified according to damaging whole-body or hand–arm vibrations, which can lead to conditions like white finger, resulting in long periods of inefficiency due to time off work.

Third, and together with the advent of computing technology, workers are measured according to how they move through the virtual spaces of the digital factory. Tool design processes are coordinated according to anthropometric and biomechanical data captured directly from HCI, including task-based analysis involving hardware controls and displays and software graphical user interfaces. This is the origin of HCI-based user testing research into the efficient interactions of computer work, including the measurement of tasks consistent with the number of clicks made while navigating through a software system, for example.

Finally, the ergonomic paradigm begins to focus on the social, cultural, and psychological conditioning of the worker. It initially draws on primarily behaviorist methods, such as the pace of work and training, but progressively relates analysis to the impact of collaborative work, mental workload, and information processing, in addition to a consideration of how worker motivations can be factored in to the study of labor efficiency.

Gramsci's Brain Becoming Digital

Returning to Gramsci's unencumbered brain—free to think nonconformist thoughts—we begin to see how such freedoms are still obtainable but gradually eroded by the intensification of efficiency analysis ushered in by the onset of digitalized labor. There is initially enough residual brain power to perhaps grasp the exploitative conditions of repetitive mechanical work and imagine a different future, but the routinization, fragmentation, and cumulative workload of digital labor put pressure on the brain time necessary to resist. Certainly, in the era of large-scale factory assembly lines, an organized workforce could slow down or remove physical labor from the production process. Physical force could also be used to sabotage machinery. However, coinciding with the large-scale industrial unrest of the 1970s, resulting in new curbs on union power, new digital technologies have provided employers with the wherewithal to reorganize the workforce along more distributed lines of production, while, at the same time, ergonomics has branched out from physical and social factors to encompass an increasing focus on the cognitive processes of the worker. The time and space necessary for Gramsci's brain even to contemplate, let alone plan and execute, modes of resistance in the workplace are gradually compressed.

THE COGNITIVE PARADIGM

Efficient Minds

The second paradigm needs to be seen against two shifting backdrops. On one hand, well-documented and vivid technological modifications to the assembly-line model introduce a progressively more flexible computerized production process. On the other, there is an increasing focus on psychosocial and cognitive aspects of labor realized in the advent of HCI. Although quite often embellished rhetorically as focusing on aspects of *user need,* HCI at this initial point is, arguably, a technosocial expansion of Taylorism still focused on combating the evils of inefficiency but moving away from the worker grasped as a cog in a machine to a worker coupled to the machine as an information processor. Indeed, the inception of the digital factory and its networked proliferation of routinized cognitive labor into all areas of life introduces new opportunities to analyze and manage physical and psychological labor inefficiency on-site and remotely. In the first instance, worker movement becomes even more unitized, observable, flexible, and distributed throughout the digital factory space (and beyond), making the individual ever more remote from Gramsci's desire for collective nonconformity. Various graduations of outsourcing labor processes across national regions and international borders produce fewer opportunities to collectively congregate, protest, or strike effectively in single locations. The network surveillance of worker movement is also extended beyond the factory space to locations previously outside of managerial control, including the journey to and from work, the home, and even the vacation. To be sure, computer technologies, which were once only found in the workspace, begin to spill over into domestic and leisure spaces, blurring the distinction between worker, user, and consumer.

From the 1970s onward, the influence of both the ergonomic concentration on psychosocial factors and new insights from cognitive psychology converge in the discipline of cognitive HCI. Harrison et al. grasp this second paradigm as a different kind of human–machine coupling to that expressed in early ergonomics. Computer work, they contend, is now increasingly defined and organized around "a central metaphor of mind and computer as symmetric, coupled information processors."[23] Managerial strategies become concentrated on the design of the interactions that facilitate the rapid information flow between processors (users and computers). Information flows in and out of this coupling of processors, undergoing transformations as it passes through, which can be manipulated so as to ensure more efficiently communicated flows.

The Computer Mind Goes to Work

The second paradigm marks the emergence of the cognitive subject as defined by a new instrument of labor: the computer mind. The initial aim, it would seem, was to encapsulate digital labor in an information model founded on mostly crude analogies between the seemingly unidirectional and sequential processors of the black-box mind and a computer. A worker would, for instance, encode information received from the environment as an internal representation stored somewhere in the mind and selected for comparison with other stored representations. This flow of information would act as an encoded stimulus that would trigger the organization and execution of a response as an action. These early cognitive models would later be expanded to include perception, attention, and memory, opening up a series of further questions relating to how information is perceived by perceptual processors, attended to, and stored in sensory short- and long-term memory. Indeed, the worker's *mental model* is divided up like a computer memory in the sense that only a fraction of the information that made it through a threshold sensory memory of haptic, echoic, and iconic data would be consciously attended to and moved to a rehearsal space between working memory and durable brain storage. These cognitive models supported the managerial goal of HCI to ensure that the mind and computer are put to work in the most efficient way possible. For example, the design of computer interfaces using visual metaphors is intended to rapidly relate the computer worker to the work of the computer by appealing to (1) the worker's mental model and (2) the mental model designed into the operating system (both 1 and 2 need to be perfectly matched so that there is no confusion about what is being represented). The often cited and universal trash can icon or recycle bin metaphor on most computer screens demonstrates how a worker required to take part in waste management can do so intuitively and quickly by moving information from a storage area to a location ready for it to be deleted.

It is nonetheless significant that this metaphorical rendering of cognitive labor processes misses much of what actually constitutes work in the digital factory. The efficiency of the body is not simply replaced in the second paradigm by the disciplines concerned with the efficiency of mind. Instead, the flows relating to the labor of perception, attention, and memory are intimately interconnected to the flows of physical work. The labor of attention, for example, requires abstract cognitive functions to be aligned with the physics of brain power and the physical embodiment of the worker in computing environments. Bodies need to be situated in these environments just as they do in the mechanized factory. To be sure, throughout the first two paradigms and continuing into the third, this situatedness increasingly requires the energy expenditures necessary for long periods of physical inactivity. To sustain focused attention directed at screens and the repetitive inputting of information mainly using a keyboard and a mouse, worker inertia becomes a requirement of efficiency management. Distractions that draw attention away from the screen also lead to inefficiencies. The concern of cognitive HCI is therefore, at this stage, as much to do with inattentiveness as it is with attentiveness. The problem of attention, as Jonathan Crary argues, becomes ever more interwoven with inattention, requiring us to consider distraction as part of a continuum with the management of technologies of attraction.[24] As workers become more and more situated in front of screens (and connected to networks), they are increasingly grasped by HCI experts as likely to be inattentive to the task at hand because of the vast amount of information overload they experience in digital culture. "If we know that people are distracted, often involuntarily," a prominent HCI expert asks, "how is it possible to get their attention again without allowing them to miss the window of opportunity?"[25]

New Pathologies

In addition to the health hazards of an enforced sedentary work life, computer work, like mechanized work, also produces a body that more readily oscillates to the rhythm of the workplace environment. Along with the exaggerated vibrations found on the industrial factory floor, which persist to some extent in the whirring of hard drives, the clicking and tapping of external devices, and the endless buzzing of the call center telephone, there are further threats to a worker's health from physical and psychic pathologies in the digital factory. On one hand, we find both the habituations of repetitive physical tasks, such as mouse clicks and keyboard taps, and, on the other, stress caused by the quickening rhythm and information overload of work life. Indeed, the memory of the trade is not merely a matter of cognitive function alone but involves the repetitive interactions of a muscular memory: a mechanical habit that has a direct toll on the computer worker's body and mind, as is evidenced in ongoing medical concerns with repetitive strain injury and cognitive overloads leading to emotional stress.[26]

The Cybernetic User

The nascent trajectories of cognitive HCI have generally struggled to explain aspects of digital labor outside of the computer–mind metaphor. Certainly, in conceptual terms, the metaphor fails to grasp the social aspects of computer work beyond those located in mental models and information processing. The computational approach, for example, does not break with the computer–mind metaphor at all but rather transforms the coupled human–information processor into an entire system for managing efficient input. The so-called connectionists reject the specificity of the original metaphor, moving instead toward a new image of the brain as a neural network. Like this, cognitive subjects and computing machines become interconnected parallel nodes brought together to activate one another in a process of dispersed information flows. Similarly, the distributed model views cognition not as being locked in one person's mental state but instead as distributed across a number of agents consisting of human actors and computer systems. In other words, the social in both connectionist and distributed models merely becomes part of an information system through which cognitive mental models and information are circulated and differentiating representational states are shared and transformed, across a homogeneous system of coordinated components.

It is perhaps not until the pragmatic focus of usability studies that we see how cognitive HCI begins gradually to unravel as notions of cognition and information are jettisoned to be replaced by more socially (and emotionally) situated experiences. Although still generally focused on the mental requirements of individual users, emotions like frustration begin to work their way into the design of the digital workplace. The computer user is no longer, it would seem, considered a passive receiver of information. The user's interactions with the system, and others using it, become part of a more extensive working environment in which tasks are supposed to be carried out autonomously. Indeed, in sharp contrast to the inert cog in the machine of the ergonomic paradigm, the rhetoric of user-centered approaches within cognitive HCI tends to stress the autonomy of human agents in these environments. The agent has the capacity, it is claimed, to "regulate and coordinate his or her behavior, rather than being a simple passive element in a human-machine system."[27]

Taylor's Return, or Why He Never Really Went Away

The claims made by the usability movement within cognitive HCI concerning a worker's capacity to act autonomously are not, unfortunately, concomitant with experiences in the digital factory environment, which is now directly linked to consumption. Although it may be the case that buying online using a tablet device, for example, has become a less frustrating user experience—the disintermediated purchase decision usually only a few clicks away—the seamless connection between the consumer, the brand, the product, and the purchase masks a gruesome circuitry of invisible factories and workers: the digital equivalent of William Blake's *Dark Satanic Mills.* Even in the developed world, the reality of digital labor is far removed from the rhetoric of usability concerns. The widely reported working conditions experienced by "pickers" in the online retailer Amazon's storage warehouses, for instance, point to stark continuities between the digital factory worker and Gramsci's trained gorilla. The Amazon worker collects customer orders on a trolley using a handset scanner, which allots him just a set number of seconds to find each product. This is a coupling of bodies, minds and information that requires efficient movement through real and virtual workspaces simultaneously. Workers have described their experiences with these devices as like being treated as a machine or robot:

> We don't think for ourselves. . . . We plug our scanner in, we're holding it, but we might as well be plugging it into ourselves.[28]

The brutal efficiency management of the Taylorist workplace is, it would seem, alive and well in the post-Taylor cybernetic factory, with the same increased risks of work-related mental and physical pathologies.

The Digital Gateway to Experience

Despite these bleak continuities with Taylorism, discontinuities begin to appear as computer work and consumption merge in a more generalized digital factory model in which the interests of HCI efficiency analysis and interactive design begin to overlap with the remit of experience marketing. To be sure, access to work communication systems, personal services like banking and shopping, and contact with work colleagues, friends, and family via social media begin to merge into one or two mobile devices. In the twenty-first century, these devices become the digital gateway through which worker and consumer engagements are increasingly lived through and managed, leading some HCI researchers to argue that new approaches to understanding HCI need to be developed that examine the *felt experience* of technology; that is to say, researchers should try to "interpret the relationship between people and technology in terms of the felt life and the felt or emotional quality of action and interaction."[29] The problem is that HCI research into felt experiences with technology is in perfect harmony with the marketer's evergreen pursuit of subliminal consumption. Indeed, in these latter days of the cognitive paradigm, there is an increasing interest in the unconscious processing of the emotional experiences of computer work progressively informed by new insights from HCI and the neurosciences.

THE EXPERIENCE PARADIGM

Pervasive Computing and Efficient Feelings

The arrival of a third paradigm of HCI is marked by two major trends. First, as a result of the continued miniaturization of computing components and mobility of wireless technologies, new pervasive contexts and ambient interfaces have been introduced to the digital factory. The most prominent technologies in this trend are radio frequency identification (RFID), the Global Positioning System (GPS), and a range of sensor and recognition technologies. Second, a previously marginalized set of social factors concerning emotions, feelings, and affect now figures writ large in HCI research. Both of these trends relate to novel embodiments and situated experiences of computer technology "whose central metaphor is interaction as phenomenologically situated"[30] and that are increasingly available in the workplace, the classroom, and the home.

In the first instance, the adoption of ubiquitous and pervasive computing technologies, like those using sensors and recognition software to detect active and passive interactions, brings about a new dynamic use context, aka the *Internet of things.* These new ubiquitous contexts were previously the subject of task-based heuristic user testing carried out in usability labs but now require a research focus on the cultures of usage of the kind usually carried out in ethnographic field studies. As computing continues to pervade these new social contexts, it becomes, as the interaction designer Adam Greenfield describes it, a process that is *everyware,* through which the intimate details of our lives are traded in for the convenience and accessibility of ubiquitous human–computer interactions.[31] Therefore, it is the goal of the digital business enterprise to, on one hand, provide more and more seamless interactions in the workplace through wearable RFID- and GPS-enabled computing linked to databases used by pickers in major supermarkets[32] and, on the other hand, ensure that pervasive computing reaches out to all consumer locations, including the shopping mall and the home.

It is difficult to apply conventional usability studies to these ambient interfaces because, on one hand, they are not necessarily oriented toward specific task-based interactions. In many cases, this is precisely what the system is devised to avoid—needing instead to respond to nontask interactions. On the other hand, people using ubiquitous computing are not required to contemplate, pay attention to, and view interfaces in the same way they did with conventional computing. The third paradigm claims, as such, to provide fresh insights into the way we think about interfaces. As Harrison et al. contend, the idea of embodied interaction moves on from second paradigm notions that grasp "thinking [as] cognitive, abstract, and information-based to one where thinking is also achieved through doing things in the world"[33] (the conventional notion of interface design based on seeing, hearing, and motor control of our hands is, like this, being reconsidered in light of technologies that support other senses and gestural manipulations). In fact, ubiquitous computing experiences are not necessarily supposed to have visible interfaces. They can readily dissolve into the surrounding objects and environments in which work and consumption are experienced.

In the second instance, the convergence between marketing, interaction design, and ubiquitous computing needs to be grasped in conjunction with new research interests in the changing social contexts of computing technology, primarily informed by an emotional turn in the neurosciences and digital workplace studies, wherein the focus of HCI is "pushed beyond limited domains of application and typical notions of 'work.'"[34] Initially, emotional, affective, and felt experiences were grasped as outside the remit of HCI because they could not easily be assimilated into the cognitive coupling of the human–information processor model. Questions concerning how people feel about interaction, the context of interaction, and elusive aspects of everyday life such as "what is fun?" were left at the margins of much of cognitive HCI research.[35] However, by drawing on a heady brew of phenomenological and neuroscientific interventions into what were deemed to be a naive Cartesian dualism at the core of the computer–mind metaphors of the cognitive paradigm, some HCI researchers have grasped emotional embodiment as a property of interaction outside the information coupling model.[36]

This contra-Cartesian trajectory in HCI research has been greatly influenced by Antonio Damasio's work from the mid-1990s, which positions Descartes as the straw man of an emotional paradigm in brain science. Damasio's thesis argues, in short, that emotions and feelings may not be intruders in the bastion of reason at all; they may be enmeshed in its networks.[37] Reasoning and decision-making processes are therefore not as purely cognitive as the second paradigm imagined them to be.

What Makes Them Click?

The significance of what appears to be a porous relation established between emotional and cognitive processing has been widely seized upon by business enterprises looking to steer decision making and purchase intentions relating to software and other everyday commodities. Much of this inspiration has been triggered by design gurus. Most notably, Damasio's thesis has been adapted for UX design by Don Norman, whose book *Emotional Design* argues that by factoring in user emotions, designers and marketers can capture consumer loyalty and engagement.[38] Norman points to the significant influence visceral, affective encounters with commodities can have on the processing of cognitive reflections and behavioral use. Not only do attractive things seem to work better, he contends, but a designer's appeal to emotions can bring the consumer and the brand closer together. The rise of a global UX industry can be grasped, as such, as a point where all the components of the third paradigm of HCI, including embodied interaction, felt experiences, emotion and affect, and a keen interest in the potential of neuroscientific market research, intersect with the cultural circuits of capitalism.[39] This is an intersection that becomes highly visible at the numerous industry and academic workshops that position UX as a central component of business success. UX design gurus like Norman are joined by UX consultants like Susan Weinschenk, aka the Brain Lady, whose book *Neuro Web Design: What Makes Them Click?* introduces a crude but resolutely business-friendly triangulation of the emotional brain thesis. This brings together the labor of online consumption, the unconscious processing of the old brain (mainly via the amygdalae), and a marketing-oriented mode of interaction design:

> There is an entire branch of marketing now focusing on activating the old brain and then feeding it product information. . . . Since a major job of the old brain is to keep us from harm, anything threatening our survival will get the old brain's attention.[40]

One answer to the question of what makes them click is, according to the Brain Lady, "*do something threatening.*" Significantly, though, fear is not the only emotion that can be activated to grab a computer user's attention and make her click. According to Weinschenk, access to the old brain, and subsequent admission to self-reflection, behavior, and purchase intent, can be tapped into via a gamut of emotions. A more general viscerality of felt experience associated with attractiveness, sociality, hunger, sex, and having fun can be employed to aid the experiential design of products and brands and therefore develop more intimate relations with consumers. UX design does not, for example, approach the design of an app from a functional point of view alone but rather designs for the emotional experience the application is supposed to trigger. The goal is to dissolve the product—the casing of the smart phone and the content and technical functions—into a desirable felt experience. Increasingly, access to this visceral level of experience processing is achieved by way of a range of user-centered empirical research methods intended to bring the emotional brain into the design and production cycle. These methods include ethnographic-like studies intended to tap into a user's emotional journey that can be correlated with biometric data garnered from eye tracking, galvanic skin response, and EEG. Like this, the third-paradigm focus on a computer user's felt experiences draws him into a production process that surpasses the reach of the cybernetic information flows of the second paradigm, extending outward to a far more exploitative and supple occupation of the entire sensory environment in which software is consumed. This is the emergence of neurolabor and consumption, the managerial focus of which is on efficient feelings and that is understood through the exploitation of neurological research into the diseases of the emotional brain, including attention deficit, obsessive compulsion, and addiction.[41]

The Ersatz Experience: Work Is a Theater, Business Is a Stage

Two significantly intertwined components of the experience paradigm need to be theorized in a political context. The first concerns the way in which capitalism is endeavoring to bring into play neuroscientific ideas to tap into the sensory environments of workers and consumers. Here we see the production of *mood environments* in which desirable, emotional, affective, and feely experiences can be captured and recycled so as to condition future user performance. The second revisits Nigel Thrift's use of the term *technological unconscious*[42] to describe a more neurologically oriented digital environment that combines with the experience paradigm to ensure that the conditioning of user performance is more rhythmically attuned to the needs of the market—made, as such, more seamless and, therefore, more efficient.

It is possible to comprehend how the first component encourages efficient future performances of digital workers and consumers by way of a resuscitated Tardean theory concerning the relation between desire, social invention, and imitation.[43] That is to say, there is a capture of the desires of workers and consumers associated with affective felt experiences that are subsequently appropriated by social invention and passed on (or recycled) as imitated ersatz experiences. In other words, the reinvention of experience becomes endemic to an artificial sensory environment, affective atmosphere, or imitated world in which visceral experiences are rehashed, and sold on, so as to trigger reflective thoughts and behavioral actions favorable to more efficient performances. A Tardean reworking of the experience economy can indeed be grasped, like this, as a theater of imitation in which sleepwalking performers are directed across a stage by a mesmerizing dream of action that leads them to believe that their desires and volitions are their own. To be sure, once the stage is invested with enough emotion, feeling, and affect, the performance itself escapes cognitive governance, only to be guided by a collective mood and thus managed by an *action-at-a-distance*. This production of collective moods opens up the potential for further "plumbing [of] the non-cognitive realm" of performance[44] and subsequently boosts the enthusiasms and motivations necessary to encourage future performances. This is a production line born not out of the ideas of Henry Ford but through the business of selling experiences in the same way that the experience economy pioneer Walt Disney did through the concept of the amusement park.[45]

The second component develops a previous notion of an expanding technological unconscious, which is dovetailed here with a somnambulist theory of HCI.[46] Indeed, I want to extend these ideas to more fully encompass noncognitive modes of HCI as they appear in the more advanced circuits of capitalism as forms of ubiquitous computing, specifically, a coupling between human bodies (brains, ears, eyes, thumbs, etc.) and all pervasive digital machines that manages not only to route around cognitive interactions but also to alter radically the relation a computer user establishes with her tools, typically characterized by the ergonomic paradigm. Pervasive computing is a reengineering of the human–machine coupling allowing for a much smoother, more passive, and potentially more rapid turnover of performances compared to the clunky machines of the ergonomic past. Digital ubiquity will undoubtedly help the business enterprise permeate nearly all aspects of everyday life as new modes of interactivity surreptitiously invade previously untouched social spaces. This is because human interaction with digital technology no longer requires a direct encounter with hardware or software but is experienced by way of previously unfamiliar situated experiences that further blur the distinction between production and consumption already conceived of in business literature in models of co-creation and customer made. Like this, the staging of user performances through pervasive computing potentially exacerbates the blurring effect to a point where the worker–consumer distinction dissolves altogether.

Ubiquitous computing also intensifies the managerial efficiency drives of the second paradigm by taking the principles of Web analytics outside of the networked PC environment and distributing them among the embedded objects and surfaces of *everyware*. Ersatz experiences can be filtered through ambient informatics and computational awareness (information about us) and produced by pervasive data gathering and location-aware technologies, including recognition software working on movement, sound, faces, or body heat. The question of what makes them click, once assumed by online marketing analysts to exist in the correlation between cursor movement and user attention, can now be answered by way of a coupling of neurological data about experience and the spatiotemporal location-based detection of moving bodies. This coupling presents a considerably deeper manifestation of the technological unconscious in terms of neurological mapping and the geographic location of users. Indeed, the question of user agency addressed in earlier incarnations of HCI is not so much concerned now with clicks as it is with the whereabouts and general state of the brain–somatic relation. In other words, the online marketer no longer needs to follow the intentional mouse click or a keyboard tap but instead focuses on the often spontaneous movements and emotional states detected when a person has entered (or not entered) a particular zone of interaction or leaves behind him an assemblage of personal data. Similarly, the data mining of online transactions, fed into databases and extracted as patterns for prediction and future suggestion, is superseded by systems that prompt movement in real time, speeding up the time spent between predictions, suggestions, and fast visceral thinking and action (the purchase). This unfolding of the technological unconscious sets the rhythm of work and consumption, capturing along the way the kind of brain time Gramsci once considered necessary for expressions of nonconformity.

The Gamification of Everything

The fusing together of ubiquitous computing and affective conditioning can be readily observed in the concepts and practices of gamification. A steady flow of business-focused literature has explored the idea that game mechanics can (1) create an upsurge in consumer engagement, (2) introduce behavioral change, and (3) increase productivity in the workplace. Indeed, as the technological wherewithal of pervasive computing proliferates into the sensory environment, we might expect to see the gamification of everything, or at least the wide-scale introduction of games to nongaming contexts in work and shopping situations, for example. This is a trend that the video game designer, Disney imagineer, and advocate of gamification Jesse Schell predicts will persist:

> We're, before too long, going to get to the point where every soda can, every cereal box is going to have a CPU, a screen and a camera on board it, and a Wi-Fi connector so that it can be connected to the Internet. And what will that world be like? . . . You'll get up in the morning to brush your teeth and the toothbrush can sense that you're brushing your teeth. So hey, good job for you, 10 points for brushing your teeth. And it can measure how long, and you're supposed to brush your teeth for 3 minutes. You did! Good job! . . . So you get a bonus for that. And hey, you brushed your teeth every day this week, another bonus! And who cares? The toothpaste company. . . . The more you brush, the more toothpaste you use. They have a vested financial interest.[47]

Schell goes on to imagine a future where a cornflakes packet with a Wi-Fi- and Facebook-connected Web game rewards you for eating your breakfast. There are bonus points, too, for taking the bus, where you can play a "REM-tertainment system" that "starts putting little advertisements out there to try and influence your dreams." Advergames have evolved into digital tattoos that work like Google AdSense but now use sensors to synchronize with other "tattoogles." There is also a new Kindle 3.0, which has the "eye-tracking sensor in it that can tell what you've read and how much you've read of the book." All of these seamless interactions will attract more and more rewards, while simultaneously steering attention to the ads and shopping baskets, clearly triggering a number of ethical problems for the designers of gamified systems. Nonetheless, despite these concerns about the level of transactional surveillance and clandestine management of attention, this stuff is, as Schell contends, *inevitable*:

> But these sensors that we're going to have on us and all around us and everywhere are going to be tracking, watching what we're doing forever. Our grandchildren will know every book that we read. That legacy will be there, will be remembered. And you get to thinking about how, wow, is it possible maybe that—since all this stuff is being watched and measured and judged, that maybe I should change my behavior a little bit and be a little better than I would have been? So it could be that these systems are all crass commercialization and it's terrible. But it's possible that they will inspire us to be better people, if the game systems are designed right. Anyway, I'm not sure about all that, but I do know this stuff is coming. Man, it's got to come! What's going to stop it? And the only question I care about right now is who, in this room, is going to lead us to get there?[48]

Indeed, the ubiquity of gamified experiences presents something much more than just the colonization of everyday life by information technology. It is a mode of behavior conditioning that taps into the emotional experiences of gameplay (having fun, compulsiveness, addiction, etc.) and adds them to the familiar experiences of encountering commodities like Pop-Tarts and Dr. Pepper. There will be many attempts to reproduce these kinds of experiences, some of which will dip below consciousness, by way of ubiquitous computing and affective conditioning that are not as easy to discern as those experiences we have experienced through current modes of interactive media. This is a regime of HCI defined by the way it routes around cognition. As Greenfield argues, we may perceive these different forms of interaction as part of a homogenous and continuous paradigm, so seamlessly experienced that they will "abscond from awareness."[49]

The Battle for Attention

There is a struggle for attention going on. Free, unmediated brain time is in decline. No more staring out of the window on the train to work. The time between morning and evening TV has been occupied by smart phone entertainment. The thin slice of human attention is increasingly being grabbed and managed by market forces. No more daydreaming in the schoolroom either. The teacher has to contend with students anxiously staring into the screens of their smart phones, continuously checking their notifications on Facebook. Students feel compelled, it would seem, to keep in touch on social media for fear of missing out on something occurring in these ersatz worlds. Indeed, it would seem that the old school and university model is struggling to keep up with the experience economy of neurocapitalism.

What this fear of missing out evidences is the force of a kind of marketing power Stiegler identifies as neuropower, exerted through the experiences of attentive technologies that absorb the brain time of youths, transforming attention itself into *attention engines.*[50] Neuropower further introduces a decisive split between the objectives of critical thinking—to dare to think nonconformist thoughts—and the goals of marketing power, which encourage worker and consumerist conformity by way of, among many other techniques, appropriating desires by grabbing subconscious attention, steering it toward specified windows of opportunity, and triggering restless competition. This is a dystopian mode of marketing power more akin to Huxley's reworking of a Disney-like transcendental Fordism than to the old biopower model applied to factories and schools. Instead of work life beginning with the industrial instruction Henry Ford's early apprenticeship schemes guaranteed, it now commences with earlier encounters with the emotionally charged conditioning of ersatz experiences, increasingly channeled through the sensory environments of mobile media, gamified reward circuits, wearable tech, and neurologically managed attention spans. The only way the school and university are going to keep up with the market is by Disneyfying the entire student experience! These new feely encounters are the point at which the market further pervades the freedom of Gramsci's brain to wander the factory floor thinking critically. As Stiegler points out, in this battle for attention, people lose the capacity for critical thinking and a certain resilience to market forces nurtured through intergenerational systems of care.[51] Indeed, every second of brain time, even that residual freedom Gramsci found in the Fordist factory, is, it seems, soaked up by a process of conforming to market forces.

Instead of continuing to lecture on critical thinking, it would perhaps be more productive to follow Huxley to a much more entertaining and emotional experience created by the Professor of Feelies, Helmholtz Watson.