CHAPTER 12

Digital

The Three Ages of the Digital

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Introduction

Digital technology is all around us—in our streets, workplaces, and bedrooms. Yet, speaking of the digital challenge, we usually refer to microchip-based devices such as laptops, smartphones, home appliances, and automated factories. This chapter provides a broad historical perspective on the concept of the digital and shows its intrinsic links with human nature and education. In this perspective, the digital challenge is roughly divided into three ages. The First Digital Age covers relationships between human understanding of the world and the analog-digital continuum, introduces the problem of representation, and outlines some digital transformations in education and radical social action. The Second Digital Age describes the so-called Information Revolution and its aftermath with an accent to struggles over transformations in our social arrangements. These days we witness the first signs of the Third Digital Age, where digital technology has become taken for granted, and where the so-called postdigital challenge refocuses our attention from physics to biology. These changes have always been dialectically interconnected with education, which is simultaneously one of the main drivers of technological development (early computer development has taken place at research universities such as Stanford and MIT) and one of the main respondents to technological development (one of the main goals of education is preparing workforce for digital reality).

The three digital ages are deeply intertwined and cannot be understood in isolation. Instead of describing neat scientific progress characteristic for natural sciences where each new theory (broadly understood as Kuhn's paradigm [1970]) resolves some problems in preceding theories, each consecutive digital age has merely piled up new problems on top of existing ones. This shows the immaturity of our social sciences, which reflects the immaturity of social phenomena they grapple with. In the timeline of human history, digital transformations are very recent and far from complete; they carry significant potential to develop in unforeseen and unpredictable directions. When attempting to neatly describe the keyword 'digital,' therefore, it is necessary to warn that our contemporary descriptions will be at least as fluid as the described phenomena.

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However, this should not prevent scientists from trying to make sense of the contemporary human condition, its history, and possible futures. While we labor to make sense our present, we need to accept that our efforts will merely serve as stepping stones for more developed theories in the future—and we need to be aware that these theories might easily negate today's insights.

The First Digital Age: Analog World and Its Digital Representations

We are surrounded by an infinite number of sounds, colors, textures, and smells. Between any pair of sounds and colors, no matter how similar, we can always insert one more sound and one more color which is slightly different than its neighbors. Our physical world consists of infinite continua of similar items—and such reality is called analog. However, differences between similar sounds are indiscernible to our ears, and differences between similar colors are indiscernible to our eyes. Therefore, we have devised various systems such as sound notes and color spectra which represent our infinite reality within a finite number of discrete items. The average human ear can hear sounds between 20 to 20,000 Hz, and this translates to approximately 10 octaves or 80 whole tones (Meyer, 2009). The standard color spectrum consists of 6 basic monochromatic colors (red, orange, yellow, green, blue, and violet); depending on the physical characteristics of their eyes, the average human can see about 10 million colors (Wyszecki, 2006, p. 824). By the act of naming, we classify the infinite number of natural (sound and light) wavelengths into a finite number of discrete bands we are able to sense.

These representations are raw data about our reality. We observe: *this table is red; that note is G minor*. Soon after, we write down our observation and share it with others. Of course, we can just say or write the sentence: *This table is red*. However, human languages are complex systems burdened with many problems including but not limited to universality of meaning. Therefore, philosophers and mathematicians have always sought (more) universal ways of communication. The simplest way of representing data is the binary code which uses a two-symbol system. Forms of binary code are found in ancient texts in China and India. Since the beginning of humankind, binary code has been used in various forms of communication such as smoke signals and drums. In 1689 Gottfried Leibnitz explained the basis of modern binary number system in 'Explication de l'Arithmétique Binaire' (Leibnitz, 1703/1863). Two centuries later, George Boole published *The Mathematical Analysis of Logic: Being an Essay Towards a Calculus of Deductive Reasoning* (1847) where he described a simple algebraic system based on a binary approach to the three basic operations: AND, OR, and NOT.

At the dawn of the Second World War, Claude Shannon (1938) noticed stark similarities between the binary number system/Boolean algebra and electronic circuits. An electronic circuit can have one of the two states ON (or 1) and OFF (or 0). These states can be added, subtracted, and negated—with these operations, we can describe any logical operation. Following Shannon, the combination of binary code and Boolean algebra called digital logic has become the basis of modern computing. Digital computers store information in long lines of simple two-state devices which can have only two values: 1 or 0. Resulting binary digits (portmanteau: bits) are basic units of information. It takes 8 bits to represent any letter in the Roman alphabet. Commonly used units of digital information, which consist of eight-bit units, are called bytes. Modern computers and programming languages are based on manipulating bits and bytes using Boolean algebra. From here onwards, there is nothing conceptually new under the sun. Within clumsy, storage-sized Electronic Numerical Integrator and Computer (ENIAC) and within our the latest and sleekest 'smartphones,' digital logic remains exactly the same. Welcome to the world of digital computers.

In the late 20th century, we experienced a vast wave of 'digitalization.' Pictures and textures are digitally scanned; gramophone music is recorded on digital hard drives. Following a short historical period of pixelized images and poor sounds caused by low memory and calculating power of early computers, at the brink of the 21st century digital images and digital music have reached the level of indiscernibility to human senses. Theoretically, a digital image recorded in sufficient resolution will provoke exactly the same reaction in human eye as its analog counterpart. In a sense, digital technologies are doing the same thing that our ancestors did when they said *this table is red*: they merely classify an infinite number of indiscernible natural colors into a finite number of colors humans can discern. At the cost of losing invisible information, digital technologies translate visible information into the simple binary number system which can be easily manipulated by Boolean algebra.

Philosophically, digitalization is merely the newest extension of the problem of representation. In *Sylvie and Bruno Concluded* Lewis Carrol says that a perfect map must be exactly of the same size as the described territory and plays with absurdity of its realization. Such map "has never been spread out, yet," said Mein Herr: "the farmers objected: they said it would cover the whole country and shut out the sunlight! So we now use the country itself, as its own map, and I assure you it does nearly as well" (1996/1893). One century later, in the short literary forgery entitled *On exactitude in science*, Borges continues Carrol's play and writes that "the following generations, who were not so fond of the study of cartography as their forebears had been, saw that that vast map was useless, and not without some pitilessness was it, that they delivered it up to the inclemencies of sun and winters" (1975).[1] Mapping and digital encoding of analog data, always causes a certain loss of information. While some people argue that losing invisible information in the process of digitalization is unimportant, not everyone is happy with this exchange. Many people argue that analog technology provides a different and more natural feeling than digital technology: many electric guitarists still prefer analog valve amplifiers over digital transistor amplifiers, and analog photography continues to attract significant attention.

The problem of representation is just a tip of the large iceberg of digitalization. Only a few decades ago, our houses were packed with different machines. We had gramophones and cassette players for reproduction of music; TV sets for reproduction of moving images; photo cameras for production of images; video cameras for production of films…However, digitization has turned all these different analog formats into simple (albeit very long) lines of zeros and ones. In this way, a full room of different machines has been replaced by only one machine—the computer—which can sometimes fit in the palms of our hands. And that ubiquitous machine, which is "the medium of the most general nature" (Carr, 2011, ch. 5), has played a crucial role in economic, political, and social transformations of our times.

As computers slowly made their way from research laboratories of the military-industrial complex to the general public, computer enthusiasts have developed do-it-yourself (DIY) communities gathered around magazines and conferences. They assembled hardware, produced software, and learned together (see Turner, 2006). According to Richard Barbrook, dominant politics within these circles was "a seductive combination of 1960s counterculture and 1990s neoliberalism (…) The central person in the *Wired* mythology was the entrepreneur, for whom the creation of the Internet was a great new business opportunity" (Jandrić, 2017, p. 80). People such as Steve Jobs and Bill Gates, who abandoned college to start their businesses in their parents' garage and made fortunes, have thus become the new heroes of the new world of opportunity which Howard Rheingold (1995) describes as "the electronic frontier." Following Barbrook and Cameron's famous article, this ideological agenda is usually known as the Californian ideology (Barbrook & Cameron, 1996).

However, not everybody was into the entrepreneurial spirit of Silicon Valley and the Californian ideology. For various reasons, a diverse group of people known under the common name "hackers" have sought other forms of engagement with computers. One of the most prominent members of the free software movement, Linus Torvalds, describes their motivation in his seminal chapter 'What Makes Hackers Tick? a.k.a. Linus's Law':

> Linus's Law says that all of our motivations fall into three basic categories. More important, progress is about going through those very same

> things as 'phases' in the process of evolution, a matter of passing from one categories to the next. The categories, in order, are 'survival,' 'social life,' and 'entertainment.' (…)
>
> A 'hacker' is a person who has gone past using his computer for survival ('I bring home the bread by programming') to the next two stages. He (or, in theory but all too seldom in practice, she) uses the computer for his social ties—e-mail and the Net are great ways to have a community. But to the hacker a computer is also entertainment. (Torvalds, 2001, pp. xiv–xvii)

Apolitical hackers, such as Kevin Mitnick, are well described by Linus's law; they break into computer systems purely for their own edification. Mitnick's "activity, which was part of the hacker underground, is a form of social practice and type of knowledge that also disrupted dominant economic logic at some level" (Coleman & Jandrić, 2019). Other hackers, such as Richard Stallman, have reached beyond entertainment and have gone full-on political. "In some ways, Richard Stallman is a bit like Don Quixote; when he came with this idea of free software, he was like a mad man who was going against the grain of the capitalist direction that software was going" (ibid.). Whatever their motivations, early hackers planted seeds of hacking as political resistance, and created technical and human infrastructures for today's online political activism.

Computers have been used in education at least since mid-20th century. Developed within the marriage of the military-industrial complex and academia, their early usage had been limited to experimental classrooms, training simulators, and similar purposes. By the end of the century, as computers made their entrance to almost every home in the First World and got connected to ubiquitous hi-speed Internet, educational usage of computers has extended to all aspects of education. This usage goes in hand with larger social changes such as globalization, McDonaldization (the tendency of all globalized companies to acquire increasingly similar models of organization) (see Ritzer, 2004), and others. In order to understand the relationships between computers and education, therefore, we first need to understand the relationships between computers and society.

The Second Digital Age: The Information Revolution and Its Aftermath

In the second part of the 20th century humankind embarked into the era of reasonably cheap oil, efficient transportation, and rapid industrial automatization. Around the 1970s, production and ownership of information sharply rose in relative importance against production and ownership of material goods. Cheap transportation enabled detachment of industrial production from its intellectual base, and First World countries have started to outsource dirty and low-income industries to Third World countries. This process started with relatively simple products such as clothes and shoes, moved to more complex products such as home appliances and consumer electronics, and ended with the most sophisticated products such as cars and ocean ships. These days, it is almost impossible to find an electronic product such as smartphone and tablet computer without a disclaimer such as 'Designed in America/Germany/European Union, made in China/Malesia/Taiwan.' The world has become increasingly global, yet the old social and economic divisions inherited from the colonial period have become even stronger. While the First World designers develop new shirts and smartphones in their shiny offices, the Third World suffers in sweatshops and toils in lithium mines for less than a dollar per day (Peters & Jandrić, 2018).

These processes have inspired a new wave of social theory. In 1971, Alain Touraine describes the advent of the post-industrial society where "investment results in the production of symbolic goods that modify values, needs, representations, far more than in the production of material goods or even of 'services'" (Touraine, 1988, p. 104). Similarly, in 1973, Daniel Bell claims that "a post-industrial society is one in which the majority of those employed are not involved in the production of tangible goods" (Bell, 1976, p. 348). Jean-François Lyotard emphasizes that the production of symbolic goods is based on knowledge. In *The Postmodern Condition: A Report on Knowledge* (1979/1984) Lyotard claims that useful knowledge in the post-industrial society is necessarily digital; he also argues that universal narratives have lost legitimacy, proclaiming that the main feature of the postmodern condition is its "incredulity towards meta-narratives." Such argumentation gave rise to the ecosystem of concepts such as 'knowledge society,' 'knowledge economy,' 'knowledge-based economy,' and similar. Some critics argue that our society has always been based on knowledge, and that these concepts are misleading if not meaningless (see Peters & Jandrić, 2018, ch. 2). However, the size and scope of digital changes have soon silenced these critiques, and the world has faced probably the most rapid change in human history which was dubbed, perhaps clumsily but not unjustly, as the Information Revolution.

In the 1990s, the next generation of thinkers have shifted their attention from changes brought about digital information to networked ways of its production and dissemination. In this spirit, one of the pioneers of the networked paradigm Manuel Castells writes:

> the Internet is the fabric of our lives. If information technology is the present-day equivalent of electricity in the industrial era, in our age the

> Internet could both be linked to the electrical grid and the electric engine because of its ability to distribute the power of information throughout the entire realm of human activity. (Castells, 2001, p. 1)

This gives rise to the concept of the network society, where the majority of processes are organized around digital networks. Jan van Dijk extends Castells' theory from economy to nature, and claims that the network principle extends into all aspects of human life (van Dijk, 1999).

By and large, critiques by Castells, van Dijk, and other mainstream theorists have described changes brought about by the networked society without reaching the core question of capitalism. By the virtue of not questioning capitalism, it could be argued, they implicitly accepted famous Francis Fukuyama's notion of "the end of history" within a capitalist mode of production (Fukuyama, 1992). However, the Left started to pick up steam and reinvent critiques by Karl Marx, the Frankfurt School of Social Science, and other connected traditions for the context of the network society. Theorists such as Antonio Negri and Michael Hardt, David Harvey, Christian Fuchs, Jodi Dean, and others, have developed the notion of immaterial labor and analyzed its consequences through various (neo)-Marxist perspectives. These perspectives are well summarized by Jodi Dean's notion of communicative capitalism, which

> designates a new version of capitalism in which communication has become central to capital accumulation. This means that communication is playing a different and more fundamental role at the level of production, consumption, and circulation of goods and natural resources. (Dean, Medak, & Jandrić, 2018)

Technologically, communicative capitalism was made possible by the development of user-friendly Web 2 technologies (and later even more user-friendly mobile technologies) which allow all Internet users to participate in flows of information. However, technology development is more complex than ever and is therefore still firmly situated in the hands of techno-elites. Software development has undergone rapid corporatization, and small garage-based companies have turned into vast global corporate conglomerates such as Microsoft, Apple, and Facebook. This equally applies to new companies, as Silicon Valley startup culture has been almost fully appropriated by corporations. Through 'angel investments' and 'startup incubators,' large companies immediately buy off new ideas and incorporate them into their portfolios. Yet digital technology, in all its versatility, is also very hard to control—(more) user-friendly technologies have allowed various acts of Internet-based resistance without (a lot of) technological knowledge. Social uprisings such as the Arab Spring, and more radical groups such as the Anonymous, have now been made possible by simple (and often proprietary) technologies such as Facebook and chat rooms (Coleman, 2013, 2014; see also Coleman & Jandrić, 2019). In 2018 more than half of world's population is online—and many of these people use Internet access for various forms of resistance.

In communicative capitalism education has undergone numerous transformations. During the 1990s, the first wave of 'informatization' of schools and universities had been largely conducted in the 'lone ranger' style. Not unlike early hackers, technology-savvy teachers had developed own technologies for instruction and pedagogies to boot. Following incorporation of software companies, however, educational technologies have also gone towards dominance of a few (proprietary or high-maintenance open source) software systems (Jandrić & Boras, 2012). Conducted in parallel with general trends of commodification and the McDonaldization of education, this has resulted in audit, assessment, and publish-or-perish cultures, unprecedented levels of student debt, precarization of teaching profession, and many other symptoms of late capitalism (Peters & Jandrić, 2018).

An especially interesting case in point, which is also one of the best examples of radical direct action at the intersections of digital technologies, education, and capitalism, is academic publishing. Academia has always been a reputation-based field, yet the rise of publish-or-perish culture facilitated by digital technologies has brought increasing pressure on academics. At the same time, the world of academic publishing has undergone the same transformations as many other fields of production—globalization, incorporatization, and monopolization. Blending ancient intellectual property legislation with digital technologies, academic publishers have brought about a highly dubious model where academics give up their intellectual rights, write and review content for free, and then buy back fruit of their work. Today,

> five for-profit publishers (Elsevier, Springer, Wiley-Blackwell, Taylor & Francis and Sage) own more than half of all existing databases of academic material, which are licensed at prices so scandalously high that even Harvard, the richest university of the Global North, has complained that it cannot afford them any longer. (Jandrić, 2017, p. 256)

While some academic authors may gain cultural and social capital from this reputation game, the majority cannot even afford to access material needed for their research. In this way, it has now become commonly accepted that the current model of academic publishing is detrimental for various important values from social equality to development of scientific research (Peters et al., 2016; Jandrić, 2017, ch. 12).

In response to these trends, activists, hackers and academics have developed a network of 'shadow libraries'—illegal repositories of pirated books (i.e. Library Genesis) and academic articles (i.e. Science Hub), which offer academic material through simple Internet searches, and where everyone with an Internet connection can access and contribute. Shadow libraries are made possible by a large group of activists with diverse skills: programmers and hackers, who make websites happen, a large academic community, who upload pirated material and make it available to everyone, legal experts, who defend those who get caught at courts of law, political influencers, who push free access agenda into mainstream politics, and various other people. Unlike the early days of computing, where lone ranger hackers could profoundly influence the world, today's online resistance requires a complex combination of digital and non-digital, technical and non-technical, online and offline skills. In the Second Digital Age, digital activism has gone communal.

The Third Digital Age: The Postdigital Challenge

In 1960 Manfred E. Clynes and Nathan S. Kline published a seminal article 'Cyborgs and space' in the journal *Astronautics*. Discussing the future of space travel, they wrote:

> The biological problems which exist in space travel are many and varied. (…) there may be much more efficient ways of carrying out the functions of the respiratory system than by breathing, which becomes cumbersome in space. One proposed solution for the not too distant future is relatively simple: Don't breathe! (1960, p. 27)

In order to resolve the problem of human survival in deep Space, Clynes and Kline propose development of an entity which "deliberately incorporates exogenous components extending the self-regulatory control function of the organism in order to adapt it to new environments" (ibid.)—the cyborg. Clynes and Kline's cyborg

> was a clear result of focused bio-engineering aimed at human survival in unfriendly conditions. For theorists within the media theory tradition, the cyborg is a 'natural' outcome of technological and social development. This development creates important differences in the nature of cyborg's

> agency. In the digital age, human self-regulatory control functions have surely been modified. Yet, unlike Clynes and Kline's astronauts, many of us are not completely aware of the effect and extent of these modifications. Speaking of the digital self, therefore, we are not just speaking of enhancing our natural ability of calculating by using computers, or enhancing our natural ability of communicating by using the Internet, or enhancing our natural ability to breathe by using artificial lungs. Instead, we are immersed in deep uncertainty in regards to where our 'natural' abilities end, and when our 'artificial' abilities arrive into play. In the contemporary technological and social reality, the digital cyborg is not (any more) in full control of his or her cyborg nature. (Peters & Jandrić, 2018, pp. 321–322)

In 1998 Nicholas Negroponte predicted that the digital and "its literal form, the technology, is already beginning to be taken for granted, and its connotation will become tomorrow's commercial and cultural compost for new ideas. Like air and drinking water, being digital will be noticed only by its absence, not its presence" (Negroponte, 1998). After two decades, Negroponte's prediction has become reality. "We are increasingly no longer in a world where digital technology and media is separate, virtual, 'other' to a 'natural' human and social life" (Jandrić et al., 2018, p. 893). Digital information, and digital devices, have become intrinsic to the contemporary human condition. We have arrived to the postdigital world—and navigating this world, as can easily be seen from the example of shadow libraries, consists of complex interactions between the digital and the non-digital. These days, we are dealing with a wide array of complex questions in the field of (online) privacy, algorithmic decision-making, and (networked) learning in these environments (Jandrić & Boras, 2015). We have arrived in the age of 'algorithmic cultures' (Knox, 2015), which "are instrumental in building 'the digitally saturated and connected world' (Bell, 2011, p. 100), where issues of identity are intertwined with issues of community and issues of technology" (Peters & Jandrić, 2018, p. 311).

Arguably, some of the biggest postdigital challenges are related to human labor.[2] Digital revolution has started with things which are easy to digitize—such as spreadsheets, images, music. For many years, however, we had been convinced that many human activities cannot be digitized. In *The Glass Cage: Automation and Us*, Nicholas Carr uses the (nowadays very popular) example of automation of work to describe this conviction:

> In assessing computers' capabilities, economists and psychologists have long drawn on a basic distinction between two kinds of knowledge: tacit

> and explicit. Tacit knowledge, which is also sometimes called procedural knowledge, refers to all the stuff we do without thinking about it: riding a bike, snagging a fly ball, reading a book, driving a car. (…)
>
> Because a software program is essentially a set of precise, written instructions—do this, then this, then this—we've assumed that while computers can replicate skills that depend on explicit knowledge, they're not so good when it comes to skills that flow from tacit knowledge. How do you translate the ineffable into lines of code, into the rigid, step-by-step instructions of an algorithm? (Carr, 2014)

Recent advances in fields from automated cars to genetic engineering clearly indicate that our collective beliefs in uniqueness of human experience require significant corrections. As the sheer amount of available computer memory and power has allowed us to digitize things which, up to very recently, were considered impossible to digitize, the postdigital society shifts its focus from physics (transistors, chips, bits, bytes) to biology (bioengineering, cloning, human enhancement). Thus, concludes Dyson,

> It has become part of the accepted wisdom to say that the twentieth century was the century of physics and the twenty-first century will be the century of biology. Two facts about the coming century are agreed on by almost everyone. Biology is now bigger than physics, as measured by the size of budgets, by the size of the workforce, or by the output of major discoveries; and biology is likely to remain the biggest part of science through the twenty-first century. Biology is also more important than physics, as measured by its economic consequences, by its ethical implications, or by its effects on human welfare. (Dyson, 2007)

In the postdigital world, we are all cyborgs. We are connected not only to each other, but also to the world at large (Fawns, 2019; Sinclair & Hayes, 2019). In the age of the Anthropocene, human beings cannot be thought of without the whole planetary ecosystem (Wark & Jandrić, 2016). In the age of biotechnology, shows Paul B. Preciado (2013), human identity becomes increasingly liquid. "Born as Beatriz Preciado, the author has deliberately changed own bodily functions through (illegal) testosterone treatment" which eventually led to a full change of gender. "Preciado is in control of own testosterone intake (at least until addiction kicks in), yet its physical and psychological consequences (such as different smell of sweat and mood swings) remain beyond Preciado's control." (Peters & Jandrić, 2018, p. 322). In the digital world, the dichotomy between the willing and the non-willing is predominantly about compulsion:

I feel the urge to check my Facebook page for the 25th time within an hour, although I know that is probably not the best idea… (Arndt et al., 2019). In the postdigital world, shows Preciado's example, the dichotomy between the willing and the non-willing goes fully physical. Arguably, this physical change goes even deeper than usual scaremongering examples such as heroin addiction: an addict can eventually hook off drugs, but the effects of something like genetic manipulation are by and large irreversible.

How do we make the leap from individual case of biotechnological resistance, such as Preciado's, to a collective case of biotechnological resistance, modelled similarly to shadow libraries? Examples from Ali Hassan al-Majid a.k.a. Chemical Ali (Iraqi defense minister notorious for using chemical weapons against the Kurds during 1990s) to numerous science fiction stories, strongly speak against some types of large scale bioengineering. Yet, we have been using other types of large scale bioengineering such as vaccination for ages. Where should we draw the line between the two? Contemporary education is faced with similar challenges. In *Drugs 2.0: The Web Revolution That's Changing How the World Gets High,* Mike Power (2013) problematizes the use of prescription drug Modafinil for better concentration and studying and makes a more general claim that 'legal highs' of all hues and colors are in sharp rise; we are now routinely treating an ever-increasing number of children with medicines against attention deficit hyperactivity disorder (ADHD) (Freedman, 2015). It is by and large unclear how teachers should deal with the challenge of having more children under ADHD treatment in the classroom, and with children who (sometimes with the help of parents!) try to pharmaceutically enhance their results at increasingly competitive assessments. We all know what to do with a drunk student, but how should we treat a student who is obviously high as a kite on a legal substance? These are examples of unresolved issues with individualized identity and behavior, yet an (arguably even more) important question remains: How do we make biotechnology political on a large scale?

Conclusion

Human beings have always been digital—we have always classified sounds, colors, textures and smells in certain categories which roughly correspond to 'resolution' of our senses. However, the computer has brought about a significantly different form of digitalization, which has significantly contributed to recent transformations of our being and society. While we tried to make sense of these transformations using concepts such as cyborg, information society, knowledge society, network society, and others, and while we developed various (social) theories such as accelerationism, the digital has seamlessly intertwined with the biological. This created the postdigital turn, where digital technologies have become intrinsic parts of the contemporary human condition. The postdigital era has exacerbated old problems such as non-sustainability of unlimited capitalist growth on a limited planet and has created new problems such as the incursions of big data and algorithms into our privacy and ethics of genome engineering.

At the brink of the postdigital era, we are still grappling with questions pertaining to preceding digital eras (such epistemology, representation, labor, and inequality) and constantly adding new ones (such as the biotechnological challenge). Learning from history, we can easily see that the three digital ages have not been shaped exclusively by superstructures such as mainstream research laboratories, government legislation, or corporations. On the contrary—from hostility of academic environment to Charles Babbage's attempts to construct the analytical engine, through Silicon Valley college dropouts who conquered the world of computer business, to illegal shadow libraries, digital development has always worked on the fringes between mainstream and its periphery and has always been shaped by political activism (Jandrić & Hayes, 2019).

While we have a fairly good understanding of online political struggles which correspond to the First and the Second Digital Age, such as the Free Software Movement and the Anonymous, we still don't know how to resolve them. Arriving into the Third Digital Age, we are even more clueless about what should be done with questions such as the biotechnological challenge. However, the broad historical overview of the three ages of the digital presented in this chapter does indicate that we should succumb neither to determinist rhetoric of 'the end of history,' nor to the 'disruption' theories of the Silicon Valley. Paraphrasing McKenzie Wark (Wark & Jandrić, 2016, p. 157; see also Jandrić, 2017), we need solutions which are neither old wine in new bottles nor new wine in old bottles. In the Third Digital Age we need to embrace the postdigital challenge, stand on the shoulders of our ancestors, and develop new postdigital modes of radical struggle.

Notes

1 Analyses of these metaphors are slightly reworked from (Jandrić & Kuzmanić, 2016, pp. 39–40).
2 This topic will be explored more closely in Peters, Jandrić, and Means (2019).

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