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Information, cybernetics and the second industrial revolution

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review of

Kline, R.R. (2015) *The cybernetics moment. Or why we call our age the information age*. Baltimore: Johns Hopkins University Press. (HB, pp. 336, $54.95, ISBN 9781421416719).

The aim that motivates Ronald R. Kline's *The cybernetics moment* is an attempt to answer the question of 'why we came to believe that we live in an information age' [6]. Kline works towards this by tracing the history of the concept of information from the early days of cybernetics and information theory in the 1940s and during the Second World War, through the 'cybernetics craze' of the 1950s, the decline of cybernetics in the 1960s, the counter-culture hype around information in the 1970s and, ultimately, the advent of the 'information age' in the 1980s. The book presents a compelling historical narrative that illustrates how the highly technical accounts of information in the work of Norbert Wiener and Claude Shannon extended into the popular imagination. Kline's book is important because of the historical detail it brings to the development of cybernetics and information theory. Kline, professor in History and Ethics of Engineering at Cornell University, weaves together an in-depth study of the technical aspects of cybernetics and information theory while at the same time taking care to situate these in the political context of the day. The story he tells is animated by the personal relationships, hang-ups, feuds and challenges that the originators of these ideas were involved in and faced.

Information as quantity and information as data

Central to Kline's account is the history of how information was transformed as a concept. In the hands of Wiener and Shannon, information referred to the amount of randomness or potential uncertainty that the source of a transmission has in selecting a message to transmit. Wiener worked on radar tracking systems during the Second World War but came out after the war as an anti-militarist and focussed on automated feedback processes in mechanics and early robotics. Shannon, who had studied under Wiener briefly, was an electrical engineer and his work dealt with information channels and how to make them more efficient in transmitting signals. After the concept of information was defined by Wiener and Shannon, it came to refer popularly to the content of transmissions, the data that is sent between a transmitter and a receiver or, importantly, stored on a drive.

'In adopting the language and concepts of cybernetics and information theory', Kline writes, 'scientists turned the metaphor of information into the matter-of-fact description of what is processed, stored, and retrieved' [6]. While in 1972 there were at least thirty-nine meanings of information in play, over time it 'was reduced in popular discourse to a transmission of commodified, equally probable bits in computer networks' [*ibid.*]. It is, of course, in this sense that we use information today. Paul Mason, in his recent book *Postcapitalism* (2015), understands information as a resource akin to matter, but with the important difference that information is not subject to scarcity and can be copied ad infinitum (Mason, 2015). Wiener was scathing of this approach to information, stating that

> Information is information, not matter or energy. No materialism which does not admit that can survive at the present day. [14]

The point for Wiener is that information is not something that is produced either by the human brain or by an electrical or mechanical system when communicating. So what is it?

While there were differences between the theories of Wiener and Shannon, what they agreed on was that information should be understood as a measure of 'what was communicated in the messages flowing through feedback control loops that enabled all organisms, living and nonliving, to adapt to their environments' [12-13]. Rather than measuring the content of these messages (what the message says), the agreement between Wiener and Shannon came down to what can be described as the non-semantic element of the message. Information, they argued, was the measure of uncertainty in the message as it is transmitted or, in other words, the amount of choice the transmitter has in constructing the message. As Kline writes [16]:

> Shannon defined information as the amount of uncertainty involved in the selection of messages by the information source, not as the amount of data selected to be transmitted. The greater the uncertainty of what the information source will select from an ensemble of messages, the more information it produces. The maximum amount of information is generated when the choice of message is random (i.e., when there is an equal probability of choosing any message). No information is generated when the selection of messages is known.

This may seem an odd way of characterising information, but from an engineer's perspective it is vitally important. In designing or evaluating the suitability of the channel that will carry a signal, the potential uncertainty or randomness in the message will determine the maximum capacity of the channel. If the transmitter has low information (i.e. it is highly certain what the message will be) then the channel can be designed accordingly. If the transmitter has higher information (i.e. it is less certain what the message will be) the channel will require a higher capacity.

While critics often reject this way of thinking about information, it should be noted that for both Shannon and Wiener, other more encompassing definitions did have broad relevance, just not specific relevance to the engineering problem about which they were concerned. Shannon, on the one hand, acknowledged different concept of information, even arguing that the word should not be used for his quantitative concept but failing to find a suitable replacement [60]. Wiener, on the other, was clear that signals had semantic content as well as information content [80]. Kline's book helps highlight the fact that critiques of Wiener and Shannon must take into account the precise nature of their work: they were not aiming at an overall theory of what was important in communication; rather, they sought to define the quantity of uncertainty in signals and did so as electrical engineers. This account of information is often credited to Shannon (and Warren Weaver who helped popularise it (e.g. Weaver, [1949] 1973)) [112] but at the time both Wiener and Shannon agreed that it was developed independently but by both more or less simultaneously and, as Kline notes, many refer to this as the 'Shannon-Wiener' or 'Wiener-Shannon' model of information and communication [16].

Throughout the book, Kline argues that this definition of information was at some point replaced in both scientific and popular imaginations with the idea of information as data, as that which computers, brains and other systems process. Sociologist Daniel Bell, for example, picked up on the hype around information and the information society in the 1970s, and while he discussed Shannon's work, he redefined information as 'data processing in the broadest sense' [224]. However, there is much in Kline's book to suggest that this was less of a shift in the definition of information and more a symbiotic relationship in which the technical and scientific importance of Wiener's and Shannon's work on

cybernetics and information theory, and the subsequent development of electronic computers, allowed the concept of information as data to become the rhetorical reference point of the late-20th Century. Kline notes, for instance, that the idea of information as data or content was prevalent around the time Wiener and Shannon were working on their respective quantitative information theories [73]. Indeed, as early as the late 1940s, just after the publication of Wiener's *Cybernetics*, computer scientist Edmund Berkeley 'spoke extensively about "storing information" and the "handling of information"' [121]. What we have then is not a shift from information as quantity to a notion of information as data that had more traction but, as Kline puts it, a popularisation of writers like Wiener and Shannon (Wiener's *Cybernetics* was a surprise hit [68-69]) who were associated with 'an information discourse that arose to explain the newly invented electronic computers to the public' [121].

This is not to say that those working on cybernetics and information theory brought nothing to wider debates about information and the idea of the information society. Wiener, for example, is credited in the book with introducing the connection between information and the idea of a second industrial revolution. Kline describes this as 'creating the rhetorical basis for what would later be called the "information age"' [73]. While Shannon was much more humble and reluctant to talk about applications of his work outside of his own field, Wiener was a keen publicist and populariser of both cybernetics and information theory. For him, while the industrial revolution of the 19th Century was based on the transmission of energy, the industrial revolution of the 20th Century was based on the transmission of information [14].

The rise, decline and rise again of cybernetics

A core focus of Kline's narrative about how we have come to live in what is commonly referred to as the information age is the story of how cybernetics rose with the hype associated with information but ultimately lost out and was left behind. So while the concept of information, in one form or another, has gone on to inform many of the understandings of contemporary society, cybernetics was discredited in the 1950s and 1960s. How cybernetics became initially popularised and then later rejected is one of the ways in which Kline situates the narrative around cybernetics and information theory in broader changes in society and, importantly, in the political climate of the Cold War. Introduced by Wiener, the term cybernetics refers to the study of the control and communication processes at work in organisms, machines and social groupings. It grew out of Wiener's work on automated radar tracking during the Second World War and quickly became involved in work on robotics and even, in the Soviet Union, economic planning.

Ultimately, the value of cybernetics lies in how it aims to shed light on processes of self-organisation that eschew the need for centralised controllers, be they brains, planning committees or governments.

As well as a general uptick in the discourse around information and electronic computing having a hand in cybernetics' penetration in the 1940s and early 50s, Kline highlights how both the military funding structures of US science research and the popularity of science fiction helped cybernetics along. On the latter, Kline writes of the work of authors such as Isaac Asimov and Kurt Vonnegut being advertised alongside books like Wiener's *Cybernetics*. Asimov's *I, Robot* and Vonnegut's *Player Piano*, furthermore, are singled out (along with Bernard Wolfe's *Limbo*) as drawing on cybernetics in their storylines [88-89]. While Kline doesn't mention it, the work of Frank Herbert, although writing later in the late-1950s and 60s, could also be counted here. Wiener himself (not very successfully) wrote sci-fi but despaired over the trivialisation of cybernetics as a science fad. Kline quotes him as saying, '[I] watched carefully through a period where what I intended as a serious contribution to science was interpreted by a considerable public as science fiction and as sensationalism' [88]. Wiener was similarly sceptical when cybernetics was taken up by scientology founder L. Ron Hubbard, demanding through his lawyer that the Dianetics Foundation stop using his name and remove him from a list of its associate members [91-92]. As Kline notes, Shannon was of a different opinion and 'thought highly' of Hubbard. Shannon cited Hubbard as a friend and facilitated connections between him and Warren McCulloch, one of the grandees of cybernetics in the US [92-93].

This was not the only difference of opinion between Wiener and McCulloch. While cybernetics is linked to military funding for research, particularly during the Second World War, Wiener considered himself an anti-militarist, penning an article in *Atlantic Monthly* (1947) denouncing the use of science in war. He met with trade union leaders in the US to discuss applications of cybernetics [73] and was monitored by the FBI over his anti-militarist statements and friendship with communists [87]. When writing of the potential for factory automation that cybernetics brought, Wiener was clear to focus on the social side of this and devoted his second book, *The human use of human beings*, to 'a protest against [the] inhuman use of human beings' on assembly lines [quoted at 80]. In this book, as Kline puts it, 'Wiener criticized the dehumanizing effects of fascism, big business [and] big government' [*ibid.*]. Perhaps Wiener was closer to the radical politics that later strands of cybernetics have been linked to (e.g. Duda, 2013; Swann, 2014) than one might at first sight assume. On these points Wiener saw himself as distinct from others in the cybernetics community, notably the anti-communist McCulloch but also Shannon, whom he described as a cold warrior [86]. While there also seems to be personal reasons behind the clash between Wiener and

McCulloch [66-67], McCulloch's dominance in the US academic cybernetics circle due to his links with government and the military certainly didn't sit easily with Wiener and the feud was maintained until the latter's death in 1964.

The connections Kline maps between government/military and cybernetics, on the one hand, and sci-fi and cybernetics, on the other, go further. Cybernetics faced decline in the late 1950s and 1960s. Kline highlights the irony of the role of sci-fi in this, as cybernetics came to be linked to the fear of top-down, automated control and, more importantly, in the scientific community it was regarded as a science fad [183], something Wiener had shown concern about. More generally, cybernetians such as Grey Walter and those close to the movement such as Margaret Mead, reflecting wider academic opinion, saw cybernetics loosing face as a quantitative science [180-182]. Kline quotes Walter as saying that 'so rarely has a cybernetic theorem predicted a novel effect or explained a mysterious one' [quoted at 181]. In an odd turn, it was in government and military support that again bolstered cybernetics. Cybernetics, in the US, was revived, as Kline discusses, in response to its adoption in the Soviet Union and a lot of the financial backing came from the CIA [185]. Both the American Society for Cybernetics and the journal *Information Society* (launched much later in 1981 as part of the more general hype around information) are linked to the CIA in the book, as is Wiener's rival McCulloch [185, 222]. On the other hand, however, cybernetics and information theory also enjoyed some popularity among the New Left of the 1960s [216] and counter culture figures such as Stewart Brand picked up on the theories, often through the work of Gregory Bateson.

Overall, cybernetics' partial rehabilitation was not enough to fix it into popular consciousness and the discourse around information and the information society swamped cybernetics in the 1980s and later. As Kline writes, '[t]he alternative discourse of cybernetics had many fewer proponents, despite the role of cybernetics in creating the information discourse' [227]. Cybernetics is now commonly reduced to the prefix 'cyber' (in 'cyberspace' and 'cyberpunk'). '*Cyber'*, Kline points out, 'became a favourite adjective to describe the world of information flowing in a vast computer network'. He goes on to note that this is 'a truncated residue of what remained of the rich discourse of cybernetics in the information age' [228]. A combination of these factors – the negative image in sci-fi and public consciousness, the rise of the narrative of the information society, Wiener's position as an outsider and its failure in cementing its position as a quantitative science – led to the ultimate decline of cybernetics in the US.

Cybernetics and organisation

Kline focusses the book on developments in the US, and one possible criticism is that this misses much of what is most interesting about how cybernetics developed outside of its initial field of electrical engineering and mechanics. On the one hand, cyberneticians like Wiener and Shannon were adamant that their accounts of information and feedback could not be applied to other disciplines, namely social sciences. While anthropologists Mead and Bateson were present at the Macey Conferences that launched cybernetics, the leaders in the field were opposed to including social scientists. Wiener, for example, declared that, in Kline's words, 'social science did not have long enough runs of consistent data to which to apply his mathematical theory of prediction' [37]. Wiener was keen to extend cybernetics to deal with social issues [81], but for him this should not mean extending it to social science. Wiener's opposition, it should be noted, was not to social sciences using cybernetic principles. It was, rather, an opposition to social sciences using the mathematics of cybernetics [153]. Nevertheless, there is a rich seam running through the history of cybernetics of applications to the fields of social sciences and, more importantly given the focus of this journal, to questions of organisation.

Kline mentions the work of Karl Deutsch on cybernetics and government, and notes that Deutsch appealed directly to a letter he received from Wiener in which he had stated that, as Kline puts it, 'even though social systems had more complex communication process than did machines, both cases abided by the "same grammar"' [144]. This signalled a way in which the principles of cybernetics could be applied to social science questions such as organisation. More than this, however, Kline does not delve into these applications. Management and participatory self-organisation are discussed briefly, as are information management systems [206-208], but Stafford Beer, for example, who in Europe stands out as one of the most important figures in cybernetics and developed it as a theory of organisation (e.g. Beer, 1972), is mentioned only once, and only in relation to 'the intractable problem of modelling [...] complex, nonlinear feedback systems' such as populations and resources [193]. Of course, it is unfair to raise this as a criticism as Kline is quite clear about focussing on the discourse of information and the information society and his account of cybernetics is rightly limited to this context. Where the book will be of use to organisation scholars, I would suggest, is in providing a rich picture of the development of cybernetics and information theory in the US and filling in much of the background to how cybernetics has been applied elsewhere and in other fields. So while Kline might focus predominantly on public discourse and electronic computing in so far as they relate to cybernetics, his book will be of interest and genuine use to those examining the potential in cybernetics for a theory of organisation. Central to such

a project, of course, are the developments in second-order cybernetics that, again, feature only briefly in Kline's book [196-101].

While *The cybernetic moment* has neither the narrative spine of a single historical situation to focus the discussion (as Eden Medina's *Cybernetics revolutionaries* (2011) does) nor the theoretical examination that might make clear the importance of talking about cybernetics and information theory (as in the cases of Katherine Hayles' *How we became posthuman* (1999) or Andrew Pickering's *The cybernetic brain* (2010)) it nonetheless manages to tell a story that highlights the development and change of the concept of information and its use in cybernetics and information theory through to the everyday usage in the context of the so-called information age.

Much of what is fascinating in the book, however, are not the technical detail or the grander historical narrative but the personal stories and the primary sources Kline draws on in illustrating these. These present the context that is not only the background to cybernetics and information theory but also the scaffolding within which they were constructed. Some of the most interesting elements of the book are those that are fleeting in the story. I mentioned above the role of sci-fi in the rise and fall of cybernetics, but more important are the social and political constraints that, during the Cold War, were applied to those working in cybernetics. In one telling case, Kline writes of how Margaret Mead, who had been involved in cybernetics from the very beginning (and indeed is the first historical character we encounter in the book), was denied funding to attend a key conference on information theory. Transport would have been provided by the Office of Naval Research and regulations excluded women from being passengers. In the end Mead had to fund her own travel. It is these personal (yet also political) stories that run through Kline's larger narrative and that give the book much of its depth and richness and that force us to read cybernetics and information theory not as abstract academic theories but as thoroughly situated in their specific context.

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