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Abstract

In this article, I shall examine the way in which information was central to the development of cybernetics. I particularly contrast the different uses of the concept by two key participants in that development – Norbert Wiener, who argued that information was a quasi-physical concept related to the degree of organisation in a system; and Gregory Bateson, who considered information to be a process of human meaning formation. I suggest that these two authors exemplify a hard and a soft strand of cybernetics, present from the start of the field. I trace through these two different interpretations of information as they developed in the cybernetics movement, and on the way they have fed into more recent understandings of information within cybernetics and related fields, especially in family therapy and sociology. I also relate these ideas to the cyborg theory of Donna Haraway and others.

Keywords

Information; cybernetics; history of ideas; Norbert Wiener; Gregory Bateson; cyborgs

Introduction

The concept of information has many versions and antecedents, but one of the most influential roots of the concept is the field of cybernetics. This highly interdisciplinary and eclectic enterprise sprang into life, almost fully-formed, in 1942 and 1943, was refined in the late 1940s through a series of influential conferences, and came to public prominence around the same time. Through its association with the early development of the digital computer, it quickly became associated in the public mind with a highly technocratic and anti-humanistic worldview. Yet cybernetics has been hugely important in shaping several disciplines, many of its most important early theorists were highly humanistic in their personal outlook, and (crucially for this article) it is important to realise that cybernetics has never been a uniform discipline and that it has existed in several strands since its inception.

It is hard to over-state the importance of the concept of information or of the importance of cybernetics as a body of knowledge. Information is pervasive in our society, and very many things once experienced in a material form – from music to money – now have their principal existence as information. The pervasiveness of information, and the ease of its transmission, are at the root of a large number of contemporary debates and crises. These including the current recession (partly driven by the treating of money and property as flows of information, and the creation of over-complex financial instruments building upon that disembodied information); the surveillance enabled by monitoring of largely digital communications traffic and analysis of CCTV images; and the control (for good or ill) enabled by the reconceptualisation of the human body not in terms of a physical object but in terms of the information content of its genome.

In each of these cases, 'information lost its body' (Hayles 1999, p.2) – human beings and their activities became treated as abstracted entities composed of information flows rather than as existing principally within their bodies and in the material world. Cybernetics was at the heart of the rise of information to prominence, and many of the key theorists of early cybernetics were driven by a focus on information in their work.

Early cybernetics and its two strands

In this article I shall focus on two strands of cybernetics, referred to here as 'hard cybernetics' and 'soft cybernetics' and on the theorists who most clearly personify those strands: Norbert Wiener and Gregory Bateson. My key point of differentiation between these two strands is their treatment of the crucial concept of information, which Wiener treated as a quasi-physical concept whose meaning was not significant, while Bateson treated information as a process of human meaning formation. I have chosen information as the key differentiator between these strands because of the importance of the concept of information in the development of society as informed by the digital computer, and the importance of cybernetics in developing the concept of information. Both Wiener and Bateson, and those who drew upon their work, saw close links between the concept of information and that of communication, and the two concepts will be intertwined throughout this article.

Others have distinguished multiple strands of cybernetics in different ways – for example, Umpleby and Dent (1999) distinguished between 'Wiener's cybernetics', 'McCulloch's cybernetics' and 'Turing's cybernetics'; and Heims (1993) distinguished between the 'cyberneticians' and the 'human science cluster'. Krieg (2005) has also used the terms hard and soft cybernetics, although in a slightly different way from this article.

A further key distinction between types of cybernetics is the distinction between first-order and second-order cybernetics. The latter term was coined by Heinz von Foerster (1979) to refer to the ‘cybernetics of cybernetics’, a phrase originally used by Mead (1968), and is discussed further later in this article. Second-order cybernetics applied the methods of cybernetics to itself, focusing on the feedback and information of the process of observation (and of the observer) as much as the phenomenon being observed. It is important to realise that second-order cybernetics, although historically arising later, should not be thought of as a second phase of the field (an unfortunate mistake sometimes made by those writing about cybernetics); the ‘second-ness’ of the term refers to logical rather than historical ordering. Hard and soft cybernetics are not the same as first-order and second-order cybernetics, although they do bear a certain resemblance in their approaches.

I am not suggesting that Bateson and Wiener were the sole originators either of the particular views of information considered here, or of the broader traditions I have labelled as soft and hard cybernetics. They were crucial originators of these forms of cybernetics, but the ideas arose in collaboration with a number of others, and they have subsequently been developed in important ways. Nonetheless, Bateson and Wiener serve as key exemplars of these approaches, and their lives and ideas are of particular interest. In the case of each author, I shall discuss other researchers with whom they worked and who followed them; the lives and work of many of these are discussed in Ramage and Shipp (in press).

Cybernetics is the study of processes of information, communication and control within animal, human and machine systems. The term was coined by Wiener, from the Greek *kubernētēs*, ‘steersman’ (the navigator of a ship), to refer to ‘the entire field of control and communication theory’ (Wiener 1948, p.11). It was also intended to refer back to the ‘governor’, the portion of an engine that regulates its speed. The word ‘governor’ (in both its engineering and political senses) is derived from a Latinized form of *kubernētēs*, and the French physicist André-Marie Ampère even used the term ‘*cybernétique*’ in the early 19th century to describe a theory of government. Wiener was unaware of this use when he coined the modern term, although he acknowledged it in later work (Wiener 1954).

Cybernetics is especially concerned with *feedback* as a mechanism for communication and control. Feedback arose as a concept within engineering, referring to the behaviour that occurs when the output of a process is fed back in as one of the inputs to that process. However, the concept of feedback and circularity gradually grew in usefulness, and by the 1940s, as Margaret Mead later said, ‘there wasn’t a person in the country who was thinking hard about problems who didn’t have a folder somewhere marked something like “circular systems”’ (Brand 1976).

Mead’s use of the phrase ‘the country’ here illustrates a notable fact about the early development of cybernetics: that it was largely an Anglo-American enterprise, although seasoned with a number of refugees to the United States from central Europe. This partly reflects its origins during and immediately after the Second World War, with the culture of collaboration between the United States and Great Britain. The interdisciplinary nature of cybernetics was also affected by the war, given the strong emphasis on team-working among both physical and social scientists, and consequent blurring of disciplinary boundaries (Heims 1993). Of course, many of the ideas about circular systems to which Mead refers developed before the war: to take one example, Bateson’s concept of ‘schismogenesis’ (positive feedback leading to increasing destruction of relationships) was originally published in Bateson (1936).

The development of cybernetics as an explicit discipline took place throughout the 1940s, beginning with a short conference in 1942 on ‘Cerebral Inhibition’, which brought together neurophysiologists and social scientists, and first identified questions of feedback as crucial to a growing understanding of common patterns between many academic fields. The following year, some of the attendees at this conference published a crucial paper which forms the first printed record of cybernetics, which draws out common principles of feedback within human and animal physiology on the one hand, and on the building of control systems for anti-aircraft weaponry on the other, and argues that 'all purposeful behaviour may be considered to require negative feedback' (Rosenbleuth *et al*. 1943, p.19). Two other papers can be thought of as crucial to the development of early cybernetics – an article on a computational model of mind (McCulloch and Pitts 1943); and an even earlier paper which clearly links negative feedback with the capacity of a system to adapt to its environment (Ashby 1940). Authors of these three papers would later write the first book to introduce the concept of cybernetics (Wiener 1948); would chair a long-running conference series on the subject (Warren McCulloch); and would write the first textbook in the field (Ashby 1956).

Thus by the end of the Second World War, the pieces were in place for cybernetics to come together as an explicit discipline. This occurred through a series of ten two-day conferences held in New York City from 1946 to 1953, funded by the Macy Foundation and chaired by the neurophysiologist Warren McCulloch. The first of these conferences had the title of 'Feedback Mechanisms and Circular Causal Systems in Biological and Social Systems', which clearly illustrates the themes in the whole series. The list of participants in the conferences is extraordinary: simply among the more famous ones are Norbert Wiener, Gregory Bateson, Alex Bavelas, Heinz von Foerster, Ralph Gerard, Kurt Lewin, Margaret Mead and John von Neumann (with guests including Claude Shannon and Wolfgang Köhler). This list of participants justified their dual focus on both biological and social systems, and on common mechanisms between them.

McCulloch and Wiener dominated the conferences between them, although in quite different ways. As Heims (1980, p.206) recounts, Wiener was ‘the dominant figure at the conference series, in his role as brilliant originator of ideas and enfant terrible’ – it was Wiener’s vision of the common patterns between human and machines that formed the theme of the conference; it was during the conference series that Wiener’s book *Cybernetics* (1948) was published, which brought the ideas to public attention; and after 1949 the conference series was even retitled as the ‘Conference on Cybernetics’.

McCulloch, in his role as the conference chair, kept a very tight grip on the topics discussed, exercising ‘considerable control over who was allowed to speak and who was not’ (Hayles 1999, p. 57). Indeed, Gregory Bateson and Margaret Mead in a dialogue remarked later that ‘McCulloch had a grand design in his mind … on how the shape of the conversation would run over five years – what had to be said before what else had to be said’ (Brand 1976). Bateson too was a crucial figure in the way the conferences operated – in the words of Heims (1993, p.30), he ‘entered into the dialogue on nearly every topic, sometimes with a perceptive question and at other times with an assertion’.

The Macy conferences on cybernetics became very celebrated even as they were occurring, written about in popular journals such as *Time* and *Newsweek*, both for their discussion of the strange new world of the digital computer but also for their striking interdisciplinarity. The conferences created more than one new discipline – as well as cybernetics itself, the fields of artificial intelligence, computational linguistics, complexity theory and family therapy owe much to the discussions in the Macy conferences. The conferences were full of strong argument by people from very different backgrounds, who all saw the importance of the newborn field of cybernetics but wanted to shape it in quite different ways. Nonetheless, the conferences were hugely influential, and especially so in their influence on the developing concept of information. It is this concept that I will now take forward, and especially its quite different treatments by Wiener and Bateson.

Norbert Wiener and hard cybernetics: information as object

Norbert Wiener was an extraordinary man, famous for his very wide interests, extremely incisive mind and personal warmth, but also for his absent-mindedness, low self-esteem, and severe mood-swings. He was born in Missouri in 1894 to a Jewish family, who had emigrated from central Europe. Wiener was a child prodigy, who learnt his alphabet at 18 months, obtained his bachelors degree at age 14, and his PhD at age 18. This was partly due to his own great ability, but also to the teaching regime of his father. After carrying out postdoctoral work in Europe with a number of prominent mathematicians, Wiener started work at the Massachusetts Institute of Technology (MIT) in 1919, where he remained for the rest of his life, dying in 1964.

He was notable as a walker and a traveller, spending brief periods at many other universities. At MIT, he would walk around the corridors endlessly, talking to everyone he met (regardless of status or academic discipline), absorbed in his own thoughts. He was also an intellectual traveller, forging close working links with biologists, physiologists, engineers and social scientists. Two of his most important collaborations were with biologists, Arturo Rosenbleuth and Warren McCulloch, and these led directly to the founding of cybernetics.

Wiener principally thought of himself as a mathematician and he was largely based in the Department of Mathematics at MIT. He made important contributions to applied mathematics, extending the theories of Lebesgue, Gibbs and Einstein to construct a technique for the statistical analysis of wave patterns, still known as the Wiener measure. This work led him to the statistical analysis of control systems and of communication, which were highly important in the development of cybernetics.

Wiener's work on cybernetics began with two research projects, on feedback within human and animal physiology, on the building of control systems for anti-aircraft weaponry during World War 2. Wiener and his collaborators brought together these ideas in a crucial article in 1943 (Rosenbleuth *et al.*, 1943), and he subsequently developed them in his book *Cybernetics* (Wiener (1948). The subtitle of this book was 'control and communication in the animal and the machine', and these two pairs of linked concepts were key to his understanding of the new field.

First, he saw *control* (in physiological and engineering terms) and *communication* as highly related phenomena, which could be expressed in terms of feedback. He wrote that they 'centred not around the technique of electrical engineering but around the much more fundamental notion of the message, whether this should be transmitted by electrical, mechanical, or nervous means' (Wiener 1948, p.8). This concept of the message was crucial to the early development of communications theory, formalised on similar lines by Shannon (1948). Wiener regarded negative feedback as leading to stability and effective control; by contrast he saw positive feedback as dangerous and unstable.

Second, he drew close parallels between the behaviour of *animals* (including human beings) and *machines* (initially arising from his work on the targeting of guns, but increasingly focusing on the computer). He argued that 'the physical functioning of the living individual and the operation of some of the newer communication machines are precisely parallel in their analogous attempts to control entropy through feedback' (Wiener 1954, p.26). The parallel between human and machine activities was particularly important to the development of digital computers, then in its early stages, and subsequently influenced a wide range of disciplines, including computing, psychology and management.

Wiener had a highly humanistic sense of his responsibilities as a scientist and of the role of cybernetics. He devoted much of his time in the last twenty years of his life to discussing the social and political implications of cybernetics, automation and the modern role of science. Although he had been actively involved in military research during World War 2, he refused to co-operate with military work after the war or to accept military funding for his research, writing in a public statement that 'the experience of the scientists who have worked on the atomic bomb has indicated that in any investigation of this kind the scientist ends by putting unlimited powers in the hands of the people whom he is least inclined to trust with their use' (Wiener 1947). This stance led to his being investigated by the FBI during the American political purges of the early 1950s led by Senator Joseph McCarthy, although his public profile as an independent intellectual, separate from political processes, protected him.

Moving on to Wiener's understanding of information, he defined it as 'a measure of [the] degree of organization' of a system (Wiener 1948, p.11). Mathematically, he viewed it as the negative of entropy (which measures disorder in a physical system), referring to this as 'negentropy'. He noted that information 'is a name for the content of what is exchanged with the outer world as we adjust to it, and make our adjustment felt upon it' (Wiener 1954, p.17).

Wiener's work on information had a profound effect on Claude Shannon, who developed the concept of information theory at Bell Labs (the research arm of the American telephone company AT&T). In a famous equation, Shannon defined information in terms of the capacity that a communications channel (such as a telephone line) is able to carry. For Shannon, information was separated from its meaning – he wrote that the 'semantic aspects of communication are irrelevant to the engineering problem' (Shannon 1948, p.379).

As Hayles (1999) observes, this was an appropriate choice in the context of telephone communications, because of the need to ensure that information remains stable as it moves from one context to another. In the process, however, information 'lost its body' (Hayles 1999, p.2) – it became separate from its context of use, and treated instead as a entity in its own right.

This view of information as something separate from its sender, receiver or intended meaning has persisted in a number of fields, such as computer science and economics to the current day. An example of this can be found in the work of the ecological engineer Howard Odum, who wrote that 'information can depreciate with dispersal of its carrier. Books are lost, people forget, and disks develop errors. … information depreciates and has to be continually recopied and readapted' (Odum 1988, p.25).

Wiener argued that this entity was not material as such: 'information is information, not matter or energy; no materialism which does not admit this can survive at the present day' (Wiener 1948, p.155) but in practice he treated as a quasi-physical concept. Hayles has argued that for Wiener, 'cybernetics was a means to extend liberal humanism, not subvert it' (Hayles 1999, p.7). Nonetheless, the effect of his work was to contribute to the separation of human beings from the information they create and use.

In Wiener's later work (1954; 1964) he combined a discussion of the forthcoming cybernetic developments for a popular audience with a humanistic stance, arguing that technologies can never be neutral. It may seem paradoxical that he could simultaneously combine such a technocratic, machine-centred view of information with a strong moral fervour. Some of this combination came from his self-contradictory personality, and the fact that he was ultimately a mathematician, but much of it came from the climate of his times, in the military focus of the war and the postwar anti-communist paranoia, both of which stifled dissent. This culture has led to much of Wiener's humanistic message being lost, while his view of information has prospered.

The approach of hard cybernetics, treating information as an object and drawing close parallels between humans and machines, is widely viewed as the primary impact of cybernetics upon intellectual life and society. There is, however, an alternative way of viewing the human subject and their information, just as present within cybernetics, and this will be the subject of the next part of this article.

Gregory Bateson and soft cybernetics: information as process

Gregory Bateson was a highly original and eclectic thinker who crossed multiple disciplines: he worked at one time or another in zoology, anthropology, cybernetics, communications theory, psychiatry, ethology (animal behaviour) and philosophy; and he also had a strong impact on family therapy, the environmental movement and organisational theory. His contribution to each of these fields was profound, but he was always ready to move on – as his biographer put it, he 'posted himself to the margins of not one, but multiple disciplines from which he secluded and then absented himself' (Lipset 2005, p. 911). He was born in 1904 in Cambridge, the youngest son of William Bateson, first professor of genetics at Cambridge University, was married for more than ten years to the great cultural anthropologist Margaret Mead, and died in 1980.

Although he began his academic career by following his father into biology, he moved to anthropology in his twenties, carrying out significant fieldwork in New Guinea and Bali. With Mead, he developed important new techniques in anthropological fieldwork, particularly the use of photography and film. He never settled in a single institution or in a single field of study –

over time he worked with psychiatric patients, with porpoises and dolphins, and on environmental issues.

Very slowly, his ideas came together in what he called the ‘ecology of mind’, which considered issues of information, mind and nature, and the relationships between them. In particular, he became concerned with epistemology, which for him had become corrupted by centuries of Cartesian dualism (and which he saw in later years as leading to potential ecological catastrophe); with cognition, which he viewed as a fundamental process in nature, spread across animals as much as humans, and even in humans not confined to events occurring in the brain; and with patterns between mental and physical processes in different parts of nature. He summed up the last of these in his search for ‘the pattern which connects’ all living creatures, the relationship between their similarities and differences (Bateson 1979).

Bateson’s view of information is summarised in a famous aphorism, ‘the difference that makes a difference’, which he first formulated in a lecture in 1970, ‘Form, Substance and Difference’ (Bateson 1972, pp.448-465), which brought together a range of his disparate ideas into a coherent whole. Building on the concept that ‘the map is not the territory’ (a phrase originally said by Alfred Korzybski but made famous by Bateson), he observed that what appears on a map is difference, whether of altitude, vegetation, size of population or some other factor. He wrote that:

> Kant, in the *Critique of Judgment* – if I understand him correctly – asserts that the most elementary aesthetic act is the selection of a fact. He argues that in a piece of chalk there are an infinite number of potential facts. The *Ding an sich*, the piece of chalk, can never enter into communication or mental process because of this infinitude. The sensory receptors cannot accept it; they filter it out. … I suggest that Kant’s statement can be modified to say that there is an infinite number of *differences* around and within the piece

> of chalk. … Of this infinitude, we select a very limited number, which become information. In fact, what we mean by information – the elementary unit of information – is a *difference which makes a difference*, and it is able to make a difference because the neural pathways along which it travels and is continually transformed are themselves provided with energy. (Bateson 1972, p.453)

The phrase 'the difference that makes a difference' has become so widespread, almost a cliché, that it is worth reflecting on how strongly it diverges from Wiener's conception of information. In Bateson's version, information exists only when two levels of difference have been fulfilled. There must be a difference from the existing state, a change in the environment (equivalent to a change in the signal of a communications channel); but there must also be a difference in the perception of someone who is attributing meaning to the first level of difference. Thus information is inexorably bound up with mental processes (although for Bateson 'mind' was a complex concept that went on far beyond the individual brain).

Although this particular description appeared in 1970, Bateson's ideas on information developed somewhat earlier, and in particular were important to his development (with colleagues) of the double bind theory of schizophrenia in the 1960s. The double bind theory looks at multiple levels of communication (and thus of the information that is being communicated), and argues that when these are strongly in conflict with each other but all are required to be held true simultaneously, then the result can be pathological behaviour. The notion of multiple levels of information, and the crucial role of meaning attribution, are very clear here, as is the importance of feedback as an element of communication.

Just as Wiener's concept of information had a strong effect upon other fields, so did Bateson's. The field of family systems therapy, which treats problems in a family as problems of the whole system rather than particular individuals, was very strongly influenced by Bateson's ideas, and has at its heart a view of information at multiple levels and as part of a process of meaning-attribution. This has especially been so in the work of the Mental Research Institute in Palo Alto, California, founded explicitly upon Bateson's work and by his former collaborators (e.g. Watzlawick et al., 1967). A further prominent school of family therapy, founded in Milan by Mara Selvini-Palazolli and her colleagues, although quite different in its techniques from those of the Mental Research Institute, drew extensively on Bateson's ideas (Stagoll, 2005).

In a different domain, the work of the sociologist Niklas Luhmann (1990) is focused on communication, arguing that communication must involve three parts: the information (the 'what', the content of the message), the utterance (the 'how' and 'why' – the manner in which it is sent and the intention behind the message), and the understanding (the meaning attributed to it by the receiver). These three parts cannot be separated, and all three must be present for a communication to be said to be occurring. Drawing explicitly upon Bateson's work, Luhmann observed, in a lecture originally given in 1991, that 'information is information only if it is not just an existing difference; it is information only if it instigates a change of state in the system' (Luhmann 2006, p.40).

While not so directly inspired by Bateson's work, a further important strand in the area of soft cybernetics which takes a similar view of information is that of second-order cybernetics. This approach was developed by a group at the University of Illinois led by Heinz von Foerster, who attended the last five Macy conferences as a comparatively young man. Von Foerster was interested in the role of the observer within science, believing that this had been ignored in the interests of an unreachable goal of complete objectivity, since there is always an observer present in any situation. The importance of feedback in cybernetics makes the idea of taking the role of the observer as part of the feedback to be a quite natural one. Thus second-order cybernetics has become associated with applying the cybernetic principles of feedback, information and communication to the observer as much as to the system being observed – in Scott's terms (2003), a *reflexive* cybernetics. Krieg (2005), who also draws on the terms 'hard' and 'soft' cybernetics, argues that von Foerster's group at Illinois was the centre of soft cybernetics for many years (while MIT acted as the heart of hard cybernetics) – von Foerster drew together such important figures as Humberto Maturana, Ross Ashby and Stafford Beer, all of whom can be thought of part of the soft cybernetics strand.

Bateson's work provides us with a concept of information which has been just as present as the Wiener/Shannon model since the start of cybernetics, and forms a crucial part of a number of important areas today.

Transcending dualism: the two strands interwoven

I have discussed in this article two strands of cybernetics: hard cybernetics, which focuses on information as a quasi-physical object, exemplified by the work of Norbert Wiener; and soft cybernetics, which focuses on information as a process of meaning attribution, exemplified by the work of Gregory Bateson. Each of these approaches has proved extremely useful and significant within their areas of application – artificial intelligence, telecommunications and robotics on the one hand; and family therapy, psychology and sociology on the other.

There is a certain split in the usefulness of the hard and soft strand between human and technical disciplines. Within the human sciences, the soft cybernetics approach seems more appropriate. Luhmann (1990, p.21) argued that meaning was the 'basic concept' of sociology, and as such an approach that takes account of the attribution of meaning seems to have more utility than one which chooses to ignore meaning. However, it is clear that the hard cybernetics approach has considerable utility within technical disciplines – Shannon's definition of the capacity of a communications channel has been fundamental to telephone and network design for sixty years, something on which the working of our whole society rests.

However, this approach is still essentially a dualist one: it separates all forms of cybernetic discourse into one of the two strands, and privileges one or the other approach as more authentic, or more useful, or more comfortable for the reader. Within different academic and practitioner communities, one or the other of the terms 'hard' and 'soft' are treated with considerable reverence. On the one hand we can see the use of the term 'hard science' within the physical sciences to indicate all that is rigorous, true and experimentally-focused. By contrast the term 'soft' has been taken up within systems thinking and related fields to indicate an approach that is based on multiple perspectives and an appreciation of messy complexity rather than clean problem-solving (Ramage and Shipp, in press).

I have presented these two strands as if they were largely discrete, but it is clear from my discussion and from other evidence that in fact they are (at least in their origins) closely intertwined. The two figures of Wiener and Bateson, in particular, are slightly more nuanced in their relationship to hard and soft cybernetics than it first might seem. Wiener, argued Bateson and Mead, was aware of the importance of the observer (Brand 1976); and as Bernard-Weil (1994) discusses, concepts that form the core of second-order cybernetics such as autonomy, dialogue and self-organization can be found in nascent form in Wiener's work. For his part, Bateson always acknowledged his debt to Wiener, and there are clear aspects of Bateson's work which take a somewhat technocratic stance (his discussion of learning derives strongly in part from a behaviourist approach, for instance).

How might we address this soft/hard dualism? One approach is to draw upon Donna Haraway's feminist analysis of cyborgs, as have other articles in the Key Thinkers series (Franklin 2002; Wyatt 2008). Haraway argues that 'cyborg imagery can suggest a way out of the maze of dualisms in which we have explained our bodies and our tools to ourselves' (Haraway 1991, p.181). Haraway takes the image of the cyborg, a contraction of the phrase 'cybernetic organism' coined by Clynes and Kline (1960) in the heat of the space race, as a template for human-machine relations in the information society: 'we are all chimeras, theorized and fabricated hybrids of machine and organism; in short, we are cyborgs' (Haraway 1991, p.150).

In many ways, adding cybernetic organisms to a consideration of cybernetics is a quite natural step, which enables us to focus on a number of issues that of embodiment discussed above. Katherine Hayles has analysed this phenomenon at length and observes in the context of Shannon's work that 'abstracting information from a material base meant that information could become free-floating, unaffected by changes in context' (Hayles 1999, p.19). This free-floating nature of information, disembodied from the humans creating and using it but reified into an entity in its own right, is at the heart of the hard strand of cybernetics, giving it great power to treat information as something quite new but also leading to many risks. Indeed, Katherine Hayles argues that various aspects of cybernetics have imperilled the human subject as generally understood, leading to what she refers to as the posthuman view, which 'privileges informational pattern over material instantiation, so that embodiment in a biological substrate is seen as an accident of history rather than an inevitability of life' (Hayles 1999, p.2).

For Bateson, the lessons to be learnt directly from cyborgs are perhaps fewer – his concern for meaning-attribution makes his understanding of information more like that of Haraway, although cyborgs, who have 'no truck with … seductions to organic wholeness through a final appropriation of all the powers of the parts into a higher unity' (Haraway 1991, p.150) would perhaps not be comfortable with Bateson's essentially organic approach. Bateson's 'difference that makes a difference' also brings to mind a remark by Letiche that Haraway espouses, and cyborgs embody, '*différance* – complex relationships of individual, mechanical, natural, synthetic and cultural activity that would lead to indeterminate identity and dynamic interaction' (Letiche 1999, p.150).

It is worth remarking that both Wiener and Bateson omit any consideration of power issues in their analysis of information and communication, something that is powerfully present in Haraway's approach, both in terms of class and of gender. As Franklin (2002, p.593) observes, 'the Cyborg Manifesto sets out a radical – cyborg – response to exploitative gender-power relations emerging under neoliberal global restructuring'. Haraway (1991, p.161) refers to the 'informatics of domination', the process by which information systems can be a means to entrench power relations, to give extra strength to the powerful (in terms of income, gender, race or nationality). I have discussed briefly at the start of this article some key ways in which information and feedback, the core concepts of cybernetics of both strands, are at the heart of some of today's key issues, but undoubtedly a concept of power must also be present to understand these phenomena.

It is not comfortable to be a cyborg, although as I have argued elsewhere (Ramage 2004), it may sometimes be necessary. But the life of the cyborg – transgressing boundaries, neither machine nor human but both at once, challenging ideas of what it means to be a human being surrounded by technology – is the creation of the field of cybernetics, and an understanding of the roots of cybernetics and its different strands help us to make sense of the information age.

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