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Journal Item

Link(s) to article on publisher's website:
http://dx.doi.org/doi:10.1353/lac.2016.0004

WORKING PAPER, PRE-PUBLICATION

For final text, please see *Information and Culture*, volume 51, no. 1.

Brains, tortoises and octopuses: post-war interpretations of mechanical intelligence on the BBC

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Introduction

This article concerns the early coverage of what might be called 'machine intelligence' on BBC radio during approximately the first decade after the Second World War. This period saw the emergence of the first stored-programme digital computers, the birth of cybernetics, and the investigation brains by monitoring their electrical activity. Computers, cybernetics and brain research might seem to have little connection with each other, but, as I will show, during this period they formed a nexus for interdisciplinary discussion of machine and animal intelligence.

I claim no originality for bringing together computers, cybernetics and brain research. Recent studies of cybernetics have explored the overlap between these three fields in the immediate post-War period.[1] However, there are good reasons to concentrate on BBC radio in this period rather than, say, press coverage. In the first place, the BBC often commissioned presentations from the scientists, engineers, mathematicians, biologists and cyberneticists concerned, rather than from journalists or commentators. The broadcasts I cover were produced by the Talks department and would typically have been in the region of 20 minutes long and billed in advance in listings. Such talks were relatively plentiful (see Appendix for a selective list), and although hardly any audio recordings survive, many text transcripts exist at the BBC's Written Archives Centre at Caversham in the UK; and some talks were published, albeit abridged, in the weekly BBC magazine *The Listener*.

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[1] See, for example Andrew Pickering, *The Cybernetic Brain*, University of Chicago Press, Chicago and London, 2010; Owen Holland and Phil Husbands, 'The origins of British cybernetics: the Ratio Club', *Kybernetes*, vol. 40, no. 1/2, 2011, pp. 110–123; Philip Husbands, Owen Holland, and Michael Wheeler (eds), *The Mechanical Mind in History*, MIT Press, Cambridge, Mass. and London, 2008; Rhodri Hayward, '"Our friends electric": mechanical models of mind in postwar Britain', in Geoff. C. Bunn, Alexander D. Lovie and Graham. D. Richards (eds.), *Psychology in Britain: Historical Essays and Personal Reflections*, British Psychological Association, London, 2001, pp.290-308.

Another reason for concentrating on the BBC is its status within British society. It attempted to cater for all tastes (though how successfully is debatable), enjoyed an enhanced reputation following the Second World War, and had no significant broadcasting competition within Britain. Its broadcasting activity was therefore outside the market system of mass media. This does not mean that the BBC was indifferent to popular tastes, but the content of its programmes taken as a whole could be extraordinarily wide ranging, as the present article demonstrates.

Radio exceeded television in popularity at this time, although television's popularity was accelerating fast during the later 1950s. Many (but by no means all) of the broadcasts discussed below were transmitted on the new Third Programme, a national radio network inaugurated in September 1946. The Third Programme supplemented two already existing national radio networks, the Home Service and the Light Programme (hence the name 'Third'), and its remit was avowedly intellectual and cultural in character. Audiences for broadcasts on the Third were much smaller than audiences for broadcasts on the Light and Home.[2]

Technology

Before looking at the broadcasts themselves, I offer some reflections on the interpretation of technology. Numerous socio-historical case studies have shown that during the early phases of a technology there is often a good deal of uncertainty about what the technology is for and what it signifies.[3] Contemporaneous interpretations of new technologies have often differed from those of later commentators, who have sometimes been guilty of anachronistically reading present-day attitudes into the past. From such anachronisms, 'Whig' histories of technology are constructed that lead deterministically and progressively from the past to the present.

A corollary of this deterministic view is a tendency to think that the meaning of a technology is embedded in its functional attributes. Blondheim, writing in the context of communication technology, expresses this idea as:

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[2] In 1949 the relative sizes of audience for the BBC's three domestic radio networks were estimated as: Light Programme, 60%; Home Service. 39%; Third Programme, 1%. (BBC Written Archives Centre, R6/186, General Advisory Council paper 148, Report of a Special Subcommittee to consider Broadcasts on Science.)

BBC Written Archives Centre, Caversham, Reading, UK: R6/186

[3] Donald MacKenzie, and Judy Wajcman, (Eds.) *The Social Shaping of Technology*, Maidenhead: Open University Press, 1999. Also Carolyn Marvin, *When old technologies were new : thinking about electric communication in the late nineteenth century*, Oxford, Oxford University Press, 1988.

> ....a tendency to consider media technologies as lucid and unambiguous, and to interpret them on their own terms.[4]

The trouble with this view is that:

> [it] tends to overlook the mutability of technologies, their potential adaptation, transformation and reinvention in the course of their diffusion and use.[5]

Among the contextual factors that bear on the form and usage of technology are:

> ... state policy, law, the business environment, even other ... technologies, ... let alone less tangible aspects of the environment such as ideology and cultural patterns [6]

The virtue therefore of looking at early accounts of computers and associated technologies is that we see interpretations of the technology being created as the technology itself is created (and even before it is created).

The multiple interpretations of emerging technologies are aspects of what Pinch and Bijker refer to as interpretative flexibility.[7] A shared interpretation can become the marker of a 'relevant social group':

> The key requirement [of a relevant social group] is that all members of a certain social group share the same set of meanings, attached to a specific artefact.[8]

In the following narrative we see particular groups and individuals alluding the new machines in support of particular views about the nature of intelligence and thought.

Darwin and ACE

One of the first broadcasts related to computers was a short talk by Sir Charles Darwin (grandson of the evolutionary biologist) on the Home Service on 9 November 1946, announcing the project to build the Automatic Computing Engine (ACE) at the UK's National Physical Laboratory. Other British computer projects to create a general purpose

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[4] Menahem Blondheim 'Narrating the history of media technologies: pitfalls and prospects', in Michael Bailey (Ed.) *Narrating Media History*, London and New York: Routledge, 2009, pp. 212–228: p. 216.

[5] Blondheim, ibid., p. 216)

[6] Blondheim, ibid., p. 216

[7] Trevor J. Pinch and Wiebe E. Bijker, 'The social construction of facts and artefacts: or how the sociology of science and the sociology of technology might benefit each other', *Social Studies of Science*. 1984, 14:3, 399-441: p.421.

[8] Pinch and Bijker, ibid. p. 414.

computer were begun at around the same time, although none was operational until about two-to-four years after this broadcast announcement.

Darwin framed the new ACE machine as a tool for mathematics, both theoretical and applied. Regarding the theoretical aspect, he related the ACE to a hypothetical concept Alan Turing had invoked in a paper published in 1937[9] as part of Turing's thought experiment to solve a problem in mathematical logic. Turing's hypothetical device could be programmed to perform any algorithmic task (i.e. a task capable of being formulated in a finite set of instructions, which we would now call a program). Turing did not require that any such machine should actually be built as part of his proof, but Darwin now alluded to it in the context of the new machine:

> For a long time mathematicians have been occupied in getting better logical foundations for their subject, and in this field, about twelve years ago, a young Cambridge Mathematician by name Turing, wrote a paper which appeared in one of the mathematical journals, in which he worked out by strict logical principles, how far a machine could be imagined which would imitate the processes of thought.[10]

Darwin here gives an early characterization of computers that was to pervade much further discussion, namely that they were 'electronic brains'. From the announcement of the ACE project and for a few years afterwards the British press had had a tendency to refer to the new computers as 'brains', or 'electronic brains'.[11]

Comparing the proposed British machine with the electronic computational devices already in use in the USA Darwin observed:

> We are ambitious enough to hope that we are going to get a machine which will be able to do more things than theirs, that in fact it will correspond to a rather higher level of the brain.[12]

In other words, the British machine was expected to have a more sophisticated repertoire of operations than the American ones. Darwin gave as an example the potential of the ACE to

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[9] Alan M. Turing, 'On computable numbers, with an application to the Entscheidungsproblem', *Proceedings Of The London Mathematical Society*, 1937, Volume: 42, pages: 230-265.

[10] *The Listener* 14 November 1946, p.663

[11] See for example 'An Electronic Brain,' *The Times*, 1 Nov. 1946, p. 2; 'The Mechanical Brain,' *The Times*, 11 June 1949, p. 4; and 'The Mechanical Brain,' *The Times*, 16 June 1949, p. 2.

[12] *The Listener* 14 November 1946, p.663

take alternative actions depending on whether the result of a calculation was, for example, greater than 7 or not. This modest-sounding capability turned out to engender a lot of discussion in later broadcasts.

The outlines of much subsequent discussion of computers were laid out by Darwin. Firstly, the devices perform calculations very quickly. Secondly, there is an allusion to 'brains'. Thirdly, there is the esoteric aspect: these devices in some way related to deep mathematical issues. Darwin even referred to the ACE machine as a realisation of Turing's hypothetical machine: '... Turing, who is now on our staff, is showing us how to make his idea come true.' There is, as yet, no suggestion of anxiety associated with these machines. They are presented as unproblematic tools.

Hartree

A month after Darwin's broadcast, on 11 December 1946, the mathematician Douglas Hartree spoke on computers in the Home Service's regular topical scientific series *Science Survey*. In the immediate prewar period Hartree had been associated with developments in analogue computing at Manchester University.[13] Analogue computers, unlike digital computers, represented real-world systems physically as specially configured electrical, mechanical or hydraulic systems that were expected to behave analogously to the systems under investigation. A slide rule is a very basic form of analogue computer. Analogue computers arrived at answers to problems by emulation rather than calculation. At the time of his 1946 broadcast (and of his 1951 broadcast referred to later) Hartree was Plummer Professor of Mathematics at Cambridge University.

In his 1946 *Science Survey* broadcast Hartree gave a lineage for the new digital computers. This lineage included adding machines, and the work of the nineteenth-century British mathematician Charles Babbage. Analogue computers were mentioned as a separate but related branch.[14]

According to Hartree, the computing machines in development at the time of his talk, of which the ACE was an example, would be capable of conditional operations where the course taken depended on the outcome of a test on an intermediate result, such as whether it was

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[13] M. Croarken, *Early Scientific Computing in Britain*, Oxford Univ. Press, 1990, pp. 50-53.

[14] Transcript of talk at BBC Written Archives Centre, Caversham, Reading, UK. A shortened transcript appeared in *The Listener*, 26 December, 1946; pg. 932.

bigger than another number. He conceded that he was indulging in anthropomorphism, but considered it excusable:

> This faculty endows the machine with what I think is not unfair to call a limited amount of judgement. [15]

But Hartree objected to the term 'electronic brain' being attached to such machines because the programmer (as we would now say) had to determine in advance all the program's possible courses of action. The computer's apparent autonomy was illusory. As for the practical applications of computers, Hartree was clear. Their role was to do existing calculations quicker, or to make unfeasible calculations feasible. The possibility of entirely new applications was not mentioned.

Working computers

The three main British computers under development during the second half of the 1940s – at Manchester University, Cambridge University and the National Physical Laboratory, London – became operational within about a year of each other. Manchester University's Mark 1 Prototype was functioning between April 1949 and August 1950, having been developed from an earlier test machine. It was replaced in February 1951 by the Ferranti Mark 1. Cambridge University's EDSAC (Electronic Delay Storage Automatic Computer) was operational in May 1949; and the ACE machine announced by Darwin was not completed until late 1951 (although a pilot device was operating experimentally in 1950). [16]

The appearance of these new machines in the early 1950s prompted several broadcasts focusing on their potential for human-like behaviour. No broadcaster claimed that that the existing machines could seriously be described as 'brain-like'. The point at issue was whether machines of this type might one day be capable of brain-like behaviour, or whether they were in principle incapable of such behaviour.

The physicist, information theorist, and reconciler of science and faith Donald MacKay did not think that computers of the kind being developed at this time could ever plausibly described as mind-like. In his 1986 Gifford Lectures, Mackay said of his outlook at this time:

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[15] *The Listener*, 26 December, 1946; pg. 932.

[16] M. Campbell-Kelly, "Programming the Mark I; Early Programming Activity at the University of Manchester," *Annals of the History of Computing*, vol. 2, no. 2, Apr. 1980, pp. 130-131. M. Campbell-Kelly, "Programming the EDSAC: Early Programming Activity at the University of Cambridge," *Annals of the History of Computing*, vol. 2, no. 1, Jan. 1980, p. 7. M. Campbell-Kelly, "Programming the Pilot ACE: Early Programming Activity at the National Physical Laboratory," *Annals of the History of Computing*, vol. 3, no. 2, Apr. 1981, p. 133.

> As an analogue computer man I felt strongly convinced that the brain, whatever it was, was not a digital computer. I didn't think it was an analogue computer either in the conventional sense. But this naturally rubbed under my skin the question: well, if it is not either of these, what kind of system is it?[17]

In the two-part 'Mind-like Behaviour in Machines' (10 and 16 June 1950, Third Programme) MacKay, by way of demonstration of the non-brain status of the digital computer, adopted the tactic of explaining binary representation of numbers and the internal storage used by computers. This approach, by showing that computers' fundamental operations were banal and elementary, was presumably intended to emphasize the mechanistic, non-human character of computers. However, given the prevailing ignorance of how human brains worked, it is unclear why this tactic should be thought to have demonstrated anything about the capacity of machines for thinking, or whether a similar exposition of the fundamental processes of the human brain would have revealed anything conclusive about the capacity of human brains for thought.

MacKay considered that even when a computer performed higher-level tasks, such as 'choosing' from alternative actions and deducing conclusions from premises, one should not be deceived:

> [Computer operations] are all mind-like activities in a sense, and it is not difficult to design a computer in which they are so co-ordinated that it appears to think... [18]

Implicitly MacKay makes a crucial distinction between thinking and the appearance of thinking. MacKay then went on to give further characterisations of computers that implicitly distinguished them from humans:

> Its opinions are not its own; it lacks imagination; the purposes it pursues are those specified by the designer; its reasoning, even if it could in principle cover a much wider field than that of chess, is entirely 'black-and-white', and takes no account of subtleties of meaning...[19]

If it occurred to MacKay that humans sometimes display these qualities too, he did not mention it. His tactic for showing that computers could not be brain-like was an often used

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[17] D. M. Mackay, *Behind the Eye*, Oxford: Blackwell, 1991, p. 40. Quoted in Husbands, Philip, Holland, Owen and Wheeler, Michael (eds) *The Mechanical Mind in History*, MIT Press, Cambridge, Mass. and London, 2008, p. 104.

[18] Transcript of talk at BBC Written Archives Centre, Caversham, Reading UK.

[19] Transcript of talk at BBC Written Archives Centre, Caversham, Reading UK.

one: to outline some of the fundamental mechanisms by which computers work, and to point to their inability to emulate certain aspects of human behaviour, such as creativity, originality or empathy.

In MacKay's second broadcast in the series, on 16 June 1950, he envisaged a type of machine closer to that implemented in the neural-networks used in present-day artificial intelligence. He spoke of a:

> ...pattern of behaviour which we can define statistically in terms of probable reactions to given situations,[20]

A machine showing such behaviour could more convincingly imitate humans, he suggested. MacKay envisaged this kind of behaviour being implemented at the level of the hardware, rather than, as in present-day artificial intelligence, at the level of the program:

> We can have gates which open only if the intensity of a signal exceeds a certain bias level. We can cause the bias level to fluctuate in a random way and so for a given intensity of signal and range of fluctuation, we can say that the electrical bias is directly related to the improbability that the gate will open.[21]

Thus MacKay appears to have envisaged this probabilistic behaviour as requiring an entirely new type of machine, different in kind from those which were coming into existence at the time of his talk.

'Automatic Calculating Machines' and Turing

Further computer-related broadcasts followed during 1951, notably the series of five talks on 'Automatic Calculating Machines', broadcast from 5 May to 5 June and given by Douglas Hartree, Max Newman, Alan Turing, Freddie Williams and Maurice Wilkes.[22] Apart from Freddie Williams (an engineer associated with the Manchester University machine), the speakers said little about the hardware, concentrating instead on software concepts such as programs, data, subroutines, and so on. They also touched on the recurring theme of what a computer program could and could not do in principle. There are repeated assurances about the inappropriateness of attributing autonomous, intelligent behaviour to computers. Hartree, for instance, said:

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[20] Transcript of talk at BBC Written Archives Centre, Caversham, Reading UK.

[21] Transcript of talk at BBC Written Archives Centre, Caversham, Reading UK. Mackay's reference to 'bias level' here has affinities with the weightings used in current day neural networks.

[22] Allan Jones, 'Five 1951 BBC Broadcasts on Automatic Calculating Machines', *IEEE Annals of the History of Computing*, 26(2), 2004, pp. 3-15.

> But do not jump to the conclusion that ... the machine is thinking for itself. All these instructions for modifying other instructions, and for evaluating and using as the criteria of any discrimination, all have to be thought out and programmed in detail. The machine only carries out literally and blindly and without thinking, the instructions which the programmer has thought out for it.[23]

The implication here is that if the computer were to act in an unforeseeable way, one might be willing to concede some degree of autonomy to its activity. Max Newman, Professor of Mathematics at Manchester University, made a similar point in his broadcast on 8 May 1951. Alan Turing, though, in his broadcast, on 15 May 1951, took up this very point and disagreed with it. Almost a year had passed since the publication of Turing's now famous *Mind* article in which he discussed whether computers could be said to think, and proposed the test-by-imitation which bears his name.[24] At the outset of his broadcast, Turing made his position clear:

> Digital computers have often been described as mechanical brains. Most scientists probably regard this description as a mere newspaper stunt, but some do not. One mathematician has expressed the opposite point of view to me rather forcefully in the words 'It is commonly said that these machines are not brains, but you and I know that they are.' [25]

Much of Turing's talk amounts to a justification for regarding computers potentially as brains, although he was clear that existing machines, or rather the programs that ran on them, could not reasonably be described as such. In essence Turing argued that if the brain was a machine, then a machine could be a brain:

> If it is accepted that real brains, as found in animals, and in particular in men, are a sort of machine it will follow that our digital computer suitably programmed, will behave like a brain.

What did Turing mean by 'machine' as applied to a brain? Turing's biographer Andrew Hodges observes that Turing's view on this, as inferred from several of his writings, was not

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[23] Transcript of talk held at BBC Written Archives Centre, Caversham, Reading, UK.

[24] A.M. Turing, "Computing Machinery and Intelligence," *Mind*, vol. LIX, no. 236, 1950, pp. 443-460.

[25] Script held at BBC Written Archives Centre, Caversham, Reading, UK. In Turing's script the mathematician he refers to is described as 'well known', but these words are crossed out.

completely fixed.[26] The principal meaning of 'mechanical' is 'algorithmic', that is, operating according to a finite set of instructions which, in their context of use, are explicit, unambiguous, and capable of being performed. The new digital computers were algorithmic, but they were also discrete-state (that is, digital) machines engaged in computable operations. In discrete-state machines only certain states are possible (or, at any rate, only certain states matter as the intermediate states during transitions have no significance). The extent to which the working of human and animal brains could be likened to that of digital computers was unclear, but Turing held that brains must be governed by physical laws. Between computability and law-governed behaviour there was no obvious connection. For instance, might a brain, though governed by physical laws, be capable of processes that were not possible in principle for an algorithmic machine? As Hodges concludes:

> [Turing's] later writings show more awareness of the problem of connecting computability with physical law.[27]

Regarding the point made by other broadcasters – that in programming a computer all eventualities had to be catered for (as Hartree and Newman had pointed out in their broadcasts) – Turing observed that this entailed nothing about the machine's potential for thinking. Planning for all eventualities, Turing observed, is not the same as knowing in advance what those eventualities will be:

> Certainly the machine can only do what we do order it to perform, anything else would be a mechanical fault. But there is no need to suppose that when we give it its orders we know what we are doing, what the consequences of these orders are going to be.[28]

Andrew Hodges has suggested that Turing's line of argument here could have been based on personal experiences from using the electromechanical 'Bombes' to help decrypt German Enigma-coded messages at Bletchley Park during the Second World War:

> Breaking the enigma led Turing into devising the most sophisticated algorithm ever used, with the ingenious parallel logic of the Bombes. Its speed of implementation clearly outpaced the capacities of human operators. But beyond that his advanced

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[26] Andrew Hodges, 'What did Alan Turing Mean by "Machine"' in Philip Husbands, Owen Holland and Michael Wheeler (eds) *The Mechanical Mind in History*, MIT Press, Cambridge, Mass., and London, 2008: pp. 75-90.

[27] Hodges, ibid., p.88.

[28] Turing, *ibid*.

> Bayesian methods for evaluating weight of evidence showed how the application of rule-based methods could supersede reliance on intuitive judgment.[29]

According to Wolfe Mays (a philosopher at Manchester University during the 1950s) Turing's *Mind* article 'set off a debate on artificial intelligence which still continues today.'[30] Mays himself gave a broadcast entitled 'Machine Process and Thought Process' on 5 December 1956 which was a contribution to the debate. His opening sentence indicates, albeit flippantly, how the idea of a rule-following autonomous machine played to memories of recent totalitarian malevolence:

> I recently attended an International Congress on Cybernetics in Belgium. On the little yellow badge they gave us to wear there was the picture of a robot caught in the act of performing a goosestep.[31]

His purpose, though, was not scare-mongering but to present a riposte to Turing, and to ideas in the developing field of cybernetics.[32] Mays's position was that what we consider as 'thinking' in humans and animals was intimately associated with processes that were not capable of being emulated in the computing programs or cybernetic machines of his day. In particular, he was concerned with how prevailing ideas of machine-learning in cybernetics were based on a technique of reinforcing actions that were close to the desired action, as one might train an animal, leading to a progressive reduction of error.[33] Humans and animals, though, displayed the phenomenon of sudden error-reduction when learning that was not shown by machines:

> ... the errors made [by humans] during learning a task won't always gradually decrease ..., but may exhibit sudden drops, as if something akin to insight had occurred.[34]

Mays attached great weight to this distinction, but he presented the gaining of insight as a paradigm for learning in general. Some forms of learning, though, are not accompanied by

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[29] Andrew Hodges, 'Fair Play for Machines', *Kybernetes*, Vol. 39 Iss 3, 2010, pp. 441-8: p.443.

[30] Personal communication, 10 April 2004.

[31] W. Mays, 'Minds and Machines', *The Listener*, 27 December 1956, p.1065-6: p. 1065.

[32] Although Turing is not mentioned in the broadcast, Mays considered his talk to be a critical response to Turing's idea. Personal communication, 10 April 2004.

[33] Processes somewhat like this are used in present-day artificial intelligence, for example in speech recognition and other forms of recognition.

[34] W. Mays, 'Minds and Machines', *The Listener*, 27 December 1956, p.1065-6: p. 1066.

insight. For example, a diligent student of French can be expected to improve their knowledge of the genders of French nouns but will never exhibit the sudden reduction of error indicative of insight, because there is no insight to be gained into noun genders.

Brain research

From the foregoing, it can be seen that a standard ploy for denying machines the ability to think was to expose the fundamental processes of computers, on the assumption that the fundamental level was where one might ultimately distinguish between mechanical and non-mechanical behaviour. Even as the new computing machines were coming into existence, however, brain researchers were suggesting that at the fundamental level animal brains appeared to be somewhat machine-like.

In October, November and December 1950, the influential British zoologist and neurophysiologist John Zachary Young delivered the annual BBC Reith lectures ('Doubt and Certainty in Science; a Biologist's Reflections on the Human Brain') on the Home Service, repeated a few weeks later on the Third Programme. The second lecture of the series was entitled 'Brains as Machines'. Young introduced his topic as follows:

> I want here to describe the parts that makeup the nervous system and to show how we can speak about them by comparison with machines [35]

and in the third lecture ('The Human Calculating Machine') Young observed

> ...it is not at all impossible that [the brain] acts like an adding machine in some ways.[36]

Much of Young's experimental work involved octopuses, and the sorts of behaviour they manifested:

> ... what makes the octopus steer towards a crab but away from a shark? Some of the most recent calculating machines come close to making such decisions. I shall show in later lectures what hints we can get from the way that they do it.[37]

So whereas other commentators thought decision making ability of computers gave a false impression of intelligence, Young thought that it offered a useful model for intelligent behaviour in animals.

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[35] John Z. Young, 'Brains as Machines', *The Listener,* 9 November 1950, p. 489.

[36] John Z. Young,'The Human Calculating Machine', *The Listener* 16 November, 1950, p. 534,

[37] John Z. Young, 'Brains as Machines', *The Listener,* 9 November 1950, p. 490.

Again unlike other commentators, Young did not think that invoking fundamental processes allowed one to conclude much about thinking ability. He commented on the dangers of reductive thinking when living subjects were under investigation:

> One of the most obvious ways of speaking about plants, animals and men is to assume that they can be investigated by dividing into parts. ... We feel that it is natural that if we cut up a body and look inside it we shall find what is 'really' there. ... I am an anatomist by profession and should be the last to deny this. What I want to criticise is the idea that by dividing and dividing one will ultimately find in some way the real or true unit, which gives full knowledge of the body.[38]

In view of the above, Young would presumably have been unsympathetic towards attempts to deny machines the ability to think by reference to their fundamental processes; and also unsympathetic to claims that the thinking ability of brains was explicable by reference to their fundamental processes. For Young, such reductive approaches were valid in neither biology nor physics:

> Biology, like physics, has ceased to be materialist. Its basic unit is something non-material, namely normally an organisation.[39]

On this view, an ability to think would be a something like an emergent property arising from complex interactions between processes in the brain. However, Young was wary of attributing what he called 'occult qualities' to organisms. These were qualities that were not directly observable. 'Consciousness' was one such occult quality, and he speculated that psychology traded heavily in such qualities:

> May it be that the terminology of psychology consists of a series of occult qualities?[40]

Although Young does not cite 'thinking' as an occult quality, it fits his description. Occult qualities were at best provisional forms of explanation, justifiable for their utility in the absence of anything better:

> [Occult qualities] are models, if you like, used for convenience of description; we can do without them when we get better ones. Take the case of consciousness. In

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[38] John Z. Young, 'The Mechanistic Interpretation of Nature,' *The Listener*, 14 December 1950, p. 728.

[39] John Z. Young, 'The Mechanistic Interpretation of Nature,' *The Listener*, 14 December 1950, p.730.

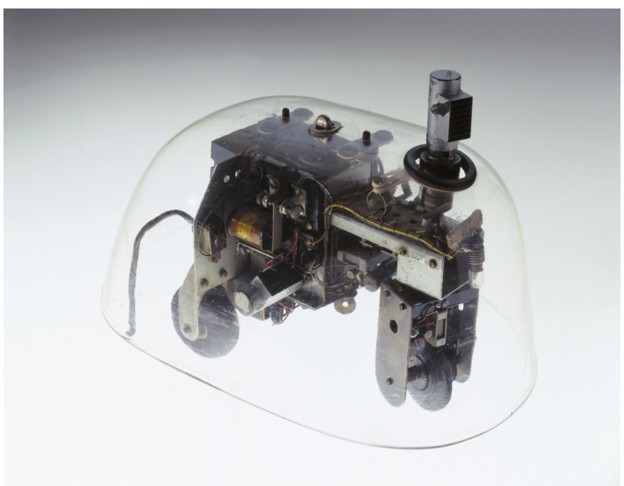
[40] John Z. Young, 'Made in What Image?', *The Listener*, 21 December 1950, p 781

> order to talk we postulate this entity [i.e. consciousness] as a kind of something within ourselves.[41]

Young's approach to intelligent behaviour in this series was thus at odds with those of several of the mathematicians and physical scientists. Unlike them, he saw a virtue in likening a brains and a computer to each other, and considered that reducing each to its fundamental processes did not illuminate their differences or similarities. Such reductive approaches eliminated the crucial issue of organisation. Young, presumably because of his biological background, was more inclined to take a systems view, and to see that systems could be similar even when their elementary components were very different.

Cybernetics

Another broadcaster from with a biological background in brain was the neurophysiologist and cyberneticist W. Grey Walter. In the mid-1930s, following the lead of other pioneers, he had constructed and used electroencephalographic equipment at the Maudsley Hospital in London.[42] In 1939 he moved to the Burden institute in Bristol, and while working there he developed, during 1948 and 1949, the electronic 'tortoises' that he is mainly remembered for.



One of Grey Walter's 'tortoises, now at the Science Museum, London. Courtesy of the Science Museum/Science and Society Picture Library

The tortoises were battery-powered autonomous wheeled devices.[43] The back wheels, driven by an electric motor, propelled the tortoise forwards, and sometimes backwards. Another

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[41] 'Made in What Image?', *The Listener*, 21 December 1950, p 781

[42] Peter F. Bladin, 'W. Grey Walter, pioneer in the electroencephalogram, robotics, cybernetics, artificial intelligence', *Journal of Clinical Neuroscience*, vol. 13, 2006, pp.170-177.

[43] A video clip of Grey Walter and two of his tortoises can be seen here a video clip can be seen here https://www.youtube.com/watch?v=lLULRlmXkKo

motor steered the tortoise by steadily turning the front wheel's plane of rotation about a vertical axis, continually changing the tortoise's direction of motion. In a free-running state, the tortoise progressed in 'a kind of cycloidal wandering,'[44] or in non-overlapping loops. Two conditions would change this behaviour. Striking an obstacle would activate a switch on the body of the device, resulting in the tortoise moving alternately backwards and forwards until free; and a source of illumination near the tortoise was detected by a photocell above the front wheel causing it to steer straight towards the source, although as the tortoise got near the source it would turn away. The tortoise's behaviour seemed purposeful and, within a narrow range of activity, intelligent.

Walter's tortoises were not computers. Compared with the new computers they were simple devices, operating on entirely different principles from computers. Nevertheless, in a context where many people were exercised about the potential of machines for brain-like behaviour, the work of Grey Walter and other cyberneticists often seemed to be akin to that of the early computer builders. However, as Andrew Pickering points out, what the cyberneticists sought to emulate with their devices was not the knowledge or reasoning ability of the animal brain but its ability to adapt to and act within its environment.[45] This is a distinctively biological approach to the brain.

A few months before building his tortoises, Grey Walter gave his first radio broadcast during which he spoke about the devices he intended to make. His broadcast endowed the tortoises with many more capabilities than they turned out to have:

> In shape it would be rather like a tortoise, you could tell that it disliked cold, damp weather, because it would moan pitifully at temperatures below 40°, and humidities above 80%. What is more, it would run towards any source of warmth, but would avoid great heat and bright lights. In the evening, it would come out from under the sofa and sit by the fire, or nestle against your leg, but it would scuttle back to its hiding place at a loud sound or sudden movement and could only be enticed out again by a low whistle. [46]

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[44] Andrew Pickering, *The Cybernetic Brain*, University of Chicago Press, Chicago and London, 2010, p.43.

[45] Andrew Pickering, ibid. p. 6

[46] Grey Walter, Mind and Machines, BBC West of England Home Service, 25 February 1948; BBC transcript at BBC Written Archives Centre, Caversham Reading. According to Andrew Pickering, *The Cybernetic Brain*, p. 43, Grey Walter began constructing the first tortoises at Easter 1948, so this talk would have preceded to start of construction by a few weeks.

Grey Walter went on in this fanciful vein, saying the machine would register a ring at the door, demonstrate a preference for women over men, give intruders electric shocks, and so on. He referred to it as a 'mechanical pet', and even hinted at something like Turing's imitation test:

> ... when it is finished I challenge anyone to tell whether or not it is living, without prolonged observation.[47]

In due course Grey Walter made further tortoises with additional capabilities, although none of them was as versatile as his broadcast claimed they would be.

Andrew Pickering points out that despite their simplicity, the tortoise's interactions with its environment was often surprising and unpredictable, although usually explicable afterwards:

> ... a reductive knowledge of components does not necessarily translate into a predictive understanding of aggregate performance – one still has to run the machine [i.e. the tortoise] and find out what it will do.[48]

This echoes Turing's comment (earlier) that the programmer of a computer sometimes did not know what the program's outcome would be.

Grey Walter went on to give over 20 broadcasts for the BBC (including television and overseas broadcasts).

Sir Geoffrey Jefferson, a British neurologist and neurosurgeon responded to Grey Walter in a Third programme broadcast on 14 September 1949, though without naming him.[49] Jefferson was a sceptic on mechanical intelligence, and adopted the tactic of belittling Grey Walter's work, whilst indulging in a degree of anthropomorphism regarding real tortoises:

> ... it should be possible to construct a simple animal such as a tortoise that would show by its movements that it disliked bright lights, cold and damp, and be apparently frightened by loud noises.... [It] might cause the credulous to exclaim

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[47] W. Grey Walter, 'Mind and Machines', BBC West of England Home Service, 25 February 1948. Transcript at BBC Written Archives Centre, Caversham, Reading, UK.

[48] Andrew Pickering, *The Cybernetic Brain*, University of Chicago Press, Chicago and London, 2010, p.50.

[49] Geoffrey Jefferson, 'The Mind of Mechanical Man', *The Listener*, 22 September 1949, pp. 479–483. Jefferson also participated in a BBC discussion on 'Can Automatic Calculating Machines Be Said To Think?' on 14 January 1952 (repeated 23 January 2915) with Alan Turing, philosopher Richard Braithwaite and mathematician Max Newman, transcript available online at www.turingarchive.org/browse.php/B/6 (retrieved 10 June 2015).

> 'This is indeed an animal'. I imagine, however, that a real tortoise would quickly find it a puzzling companion and a disappointing mate.[50]

One might agree with everything Jefferson says and still accept that Grey Walter's tortoises revealed a remarkable truth: that apparently intelligent behaviour can be created by relatively simple mechanisms following simple rules.

The leading American cyberneticist at this time was Norbert Wiener. He broadcast on the BBC on 30 April 1951 on 'The New Industrial Revolution'. He was the only broadcaster I am aware of who recognised that the new computers potentially raised social issues. The new machines were emerging into a world of conflicting interests and unequal distributions of power, and would therefore be capable of appropriation for socially contentious ends. He also recognised the crucial role of economics in determining how the machines would be exploited industrially:

> As to the cost of these machines, it will probably go down ... to the level perhaps of hundreds of pounds. When you consider that this is the order of price, not of the whole factory ... of labourers, but of the single labourer, you will see that the machine has a great economic argument for it
>
> .... factories used by a few people to make a quick fortune while [former employees] have no jobs. That is not a socially safe situation.[51]

Conclusion

The forgoing discussion shows that attempts to attach significance to the newly emerging mechanical 'brains' (whether computers or cybernetic machines) began even as the machines were under development. Naturally the fact that computers could perform complex calculations quickly was not itself contentious. Rather, there was a sense that these machines could have a significance over and above their prosaic functions, and this was related to their apparent autonomy and ability (in some people's opinion) to give at least a semblance of intelligence. This stimulated the debates discussed here.

I mentioned earlier concepts of interpretative flexibility and relevant social groups in relation to newly emerging technologies. In connection with the newly developing computers and cybernetics we see from the foregoing two pronounced trends in the way computers were

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[50] Geoffrey Jefferson, op. cit. p. 480.

[51] Norbert Wiener, 'The New Industrial Revolution' 30 April 1951, transcript at BBC Written Archives Centre, Caversham, Reading, UK.

framed in popular expositions. One way is as an uncontentious tool for calculation. The other is as a basis for conceptual explorations of thought and intelligence. In this latter framing, the value of the computer lay in what it might suggest about the way humans and animals thought, or what the limits of artificial intelligence might be. For example, in a letter to the cyberneticist Ross Ashby in 1946, Alan Turing wrote:

> ...in working on the ACE [the National Physical Laboratory computer] I am more interested in the possibility of producing models of the action of the brain than in the practical applications of computing. [52]

For cyberneticists such as Grey Walter the devices they constructed had no other purpose than to elucidate possible brain processes by emulating aspects of the brain.

When we look at the backgrounds of the broadcasters, we can discern two 'relevant social groups'. There were those from a background in mathematics, physics or engineering (whom I will refer to as physical scientists), and those from a more interdisciplinary background that included a strong component of biology or neurology.[53] For the physical scientists such as Hartree, Newman and MacKay, the new computers were essentially calculating machines, and further speculations about their potential for thinking was fanciful and misleading. They argued their case reductively, by referring to the fundamental processes on which computers operated, and by emphasising the deterministic nature of algorithmic programs. Turing, though a physical scientist, was an exception. His reluctance to accept such reductive arguments, and his interest in the computer for modelling brain processes, aligns him more closely with the more biologically informed cyberneticists. (It is possibly relevant to note here that Turing's last few years were devoted to computer-based biological research.) Similarly Geoffrey Jefferson was an exception from the neurological camp. He took a sceptical line on cybernetics and computers as models of brain behaviour.

Many more BBC broadcasts related to computers and brain-like behaviour were given in the immediate postwar period than I have been able to discuss here, but I would contend that these conclusions are largely upheld when they are taken into account, though with many further nuances. The Appendix to this article lists the broadcasts I am aware of.

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[52] Philip Husbands and Owen Holland, 'The Ratio Club: A Hub of British Cybernetics' in Philip Husbands, Owen Holland, and Michael Wheeler (eds), *The Mechanical Mind in History*, MIT Press, Cambridge, Mass. and London, 2008, pp.91–148: p. 135

[53] Andrew Pickering, op. cit. pp. 58–9, makes this point about the background of British cyberneticists.

Appendix

Broadcasts, 1946–56, for which texts survive

Broadcast date	Speaker	Title	BBC Service
9 Nov. 1946	Sir Charles Darwin	The Automatic Calculating Engine (news talk)	Home
11 Dec. 1946	D. R. Hartree	The New Giant Calculating Machine	Home
25 Feb 1948	W. Grey Walter	Mind and Machines	West of England Home
28 April 1948	W. Grey Walter	The Enchanted Loom	Third
11, 14, 19, 21, 26, 27 May, 1 June 1949	H. Dale, C. Sherrington, W. LeGros Clark, S. Zuckerman, W. Penfield, V. Samuel, A. J. Ayer, G. Ryle	Physical Basis of Mind	Third
14 Sep. 1949	G. Jefferson	The Mind of Mechanical Man	Third
26 Sept. 1949	S. Lilley	Electronic Calculating Machines	Overseas
4 May 1950	W. Grey Walter	Brains: Electronic and Human	Home
10 June 1950	D. M. Mackay	Mind-like Behaviour in Machines: 1 Mechanising Thought	Third
16 June 1950	D. M. Mackay	Mind-like behaviour in Machines: 2 Machines and the 'Mind-body Problem'	Third
20 Oct to 17 Dec. 1950	J. Z. Young	Doubt and Certainty in Science	Home
3 March 1951	C. Cherry	Communicating Information – Languages and Codes	Third
2 April 1951	D. M. Mackay	Measuring Information	Third
30 April 1951	N. Wiener	The New Industrial Revolution	Third
5 May 1951	D. R. Hartree	Automatic Calculating Machines	Third
8 May 1951	M Newman	Automatic Calculating Machines	Third
15 May 1951	A. M. Turing	Can Digital Computers Think? (No. 3 of 'Automatic Calculating Machines')	Third
2 June 1951	F C Williams	Automatic Calculating Machines	Third
5 June 1951	M. V. Wilkes	The Use of Automatic Calculating Machines (No. 5 of 'Automatic Calculating Machines')	Third
1, 8, 15 Nov. 1951	W. Grey Walter	Patterns in Your Head	Home
14 Jan. 1952	Turing, Newman, Jefferson and Braithwaite	Can Automatic Calculating Machines be Said to Think?	Third
8 May 1952	C. Strachey	Control Without Men. Part 2 Calculating Machines and the brain. (Part 1 missing)	Home
7 Oct. 1954	D. M. Mackay	On Comparing the Brain with Machines: Part 1 Motives and Methods	Third
14 Oct. 1954	D. M. Mackay	On Comparing the Brain with Machines: Part 2 Progress and Perspective	Third
5 Dec. 1956	W. Mays	Machine-like Processes and Thought Processes: The Likenesses and Differences Between Machines and Men	Third

10 Dec. 1956	C. Cherry	On the Present State of Brain Models	Third
12 Dec. 1956	F.H. George	Machines and Human Behaviour: Reproducing Human Behaviour in Machines	Third