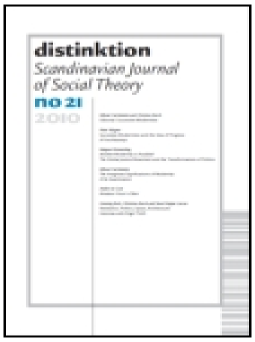

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RESEARCH ARTICLE

Cybernetic rationality

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This article interrogates the relationship between temporality, memory, and reason in cybernetic models of mind to excavate a historical shift in knowledge and governmentality. Cyberneticians reformulated ideas of reason to reimagine both minds and machines as logical circuits; in doing so, early pioneers in neural nets and computing such as Warren McCulloch, Walter Pitts, and John von Neumann also created the epistemological conditions that underpin contemporary concerns with data visualization, big data, and ubiquitous computing.

Keywords: big data; biopolitics; cybernetics; machine learning; neural nets; rationality; Walter Pitts; Warren McCulloch

> What we thought we were doing (and I think we succeeded fairly well) was treating the brain as a Turing machine; that is, as a device which could perform the kind of functions which a brain must perform if it is only to go wrong and *have a psychosis* […].
>
> Warren McCulloch (in von Neumann [1948] 1986, 422)[1]

In 1948 at a conference on circuits and brains, in Pasadena California, the prominent cybernetician and neural net pioneer Warren McCulloch introduced the idea that rationality could not only be both physiological and logical, but also *unreasonable*. Addressing a room of the most prominent mathematicians, psychologists, and physiologists of the day, all brought together to discuss the nature of mechanisms in human brains and logical machines, McCulloch sought to provoke his respectable audience by offering them a seemingly counter-productive analogy. Finite state automata, those models of calculative and computational reason, the templates for programming, the very seats of repetition, reliability, mechanical, logical, and anticipatable behavior, might be 'psychotic' just as brains can sometimes be.

These statements should not, however, be thought in terms of human subjectivity or psychology. McCulloch, while trained as a psychiatrist, *was not* discussing psychosis in relation to patients in mental clinics. Rather, he was responding to a famous paper delivered by the mathematician John von Neumann on logical automata (von Neumann [1948] 1986). The psychiatrist was not intending to argue about the essential characteristics, the ontology, of machines or minds. He recognized that computers were not the same as organic brains. The question of equivalence was not at stake.

What *was* at stake was a set of methodologies and practices, the epistemology, that might build new machines – whether organic or mechanical. And the answer both

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McCulloch and von Neumann provided was to develop a new form of logic, an epistemology they labeled 'psychotic' *and* 'rational'. Such an epistemology, they argued, might make processes usually assigned to analytic functions of the brain, perhaps associated with consciousness and psychology, amenable to technical replication.

McCulloch gave voice to an aspiration to turn a world framed in terms of consciousness and liberal reason into one of control, communication, and rationality. And he did not dream alone. At this conference where many of the foremost architects of cold war computing, psychology, economics, and life sciences sat alongside each other, we hear a multitude of similar statements arguing for a new world, now comprised of 'psychotic' but logical and rational agents.

I want to take this turn to a new discourse of cognition and rationality as a starting-point to consider the relationship between memory, reason, and temporality in cybernetic discourse. McCulloch and the works of his colleagues serve as useful vehicles to begin examining the displacement of older concepts of agency, consciousness, and autonomy into circuits, cognition, and automata. But if McCulloch was voicing the desire for a new form of thought, he was doing it through the language of an older psychology. His new model was troubled by questions of memory and time, features he assigned to human psychology:

> Two difficulties appeared [when making neurons and logic gates equivalent]. The first concerns facilitation and extinction, in which antecedent activity temporarily alters responsiveness to subsequent stimulation … The second concerns learning, in which activities concurrent at some previous time have altered the net permanently, so that a stimulus which would previously have been inadequate is now adequate. (McCulloch and Pitts [1943] 1988)

Stated otherwise, for McCulloch, historical time presented challenges to making thought and logic equivalent. Having managed to build a new machine-mind, McCulloch continued to be troubled by problems of temporal organization, change, and perhaps even consciousness.

For cyberneticians, cognitive and neuro-scientists seeking to represent thought logically, the literal mechanisms of thinking always haunted computational models. Older histories of science, psychology, and philosophy, invested in the unrepresentable elements of human thought, troubled the new machinery of social and human science. Despite, therefore, proclaiming, 'Mind no longer goes ghostly as a ghost', and opining that psychoanalytic concepts could now be disavowed, to be replaced by neuro-physiology, McCulloch continued to be haunted – animated – by the ongoing problems of organizing time and space inside networks (McCulloch and Pitts [1943] 1988).

It is my contention that this troubled and troubling relationship between logic, history, and memory continues to animate our machines and digital networks, driving a dual imaginary of instantaneous analytics and collective intelligence, while encouraging the relentless penetration of media technologies into life through a frenzy to record and store information (Halpern 2005; Chun 2008). This paper is therefore not a theory of 'psychosis' but rather a historical investigation into the cybernetic relationship to temporality that suggests that cybernetic concerns with how time would be organized in circuits was fundamental to the reformulation of intelligence as rational, and produced a new epistemology of pragmatic behavioralism, embodied and affective logic, and non-liberal agents that continue to inform contemporary practices in fields ranging from neuro-science to finance (Pickering 2010; Heims 1991; Lemov 2010; Hayles 1999; Dupuy 2000). These practices arguably underpin the ongoing penetration and interweaving of computation and life, to support what many theorists label 'biopolitics' (Terranova 2009; Chun 2011; Clough and Willse 2011).

While today it is often assumed that collectives are intelligent, networks are smart, and swarms, clouds, and other seemingly non-rational entities operate a logic to manage our contemporary world, such reasoning was not always so easily accepted. The statements articulated by many early cyberneticians and human scientists in the late 1940s thus bridge between our contemporary concerns with agents, affect, pre-emption, networks, and collective intelligences and older historical concerns within science about consciousness, temporality, and representation. At this pivotal moment, demarcated by a catastrophic world war, these sciences were part of producing an aspiration for a new world made up of communication and control – but not without producing a novel set of conflicts, desires, and problems. Cyberneticians, having embraced the discrete logic of rationality, continued productively to struggle with problems of how systems might learn and change. I turn, then, to outlining what the conflicted relationships between memory and control, embodied within the discourse of 'psychosis', might say to our present methods and epistemologies in the social and human sciences, and to our contemporary forms of biopolitical rationality.

The logical calculus of the nervous net

It is perhaps no accident that autonomy and will were being rescripted as circuits in machines at this conference. Much of the logic that underpins contemporary ideals of intelligence emerged from the Second World War and the science of communication and control labeled cybernetics. As is well documented, cybernetics emerged from work at the Radiation Lab at the Massachusetts Institute of Technology (MIT) on anti-aircraft defense and servo-mechanisms during the Second World War. The MIT mathematician Norbert Wiener, working with the MIT-trained electrical engineer Julian Bigelow, and the physiologist Arturo Rosenblueth, reformulated the problem of shooting down planes in the terms of communication – between an airplane pilot and the anti-aircraft gun. These researchers postulated that under stress airplane pilots would act repetitively, and therefore display algorithmic behaviors analogous to servo-mechanisms, and amenable to mathematical modeling and analysis. This understanding allowed for all entities to be 'black-boxed' so as to be studied behaviorally (Rosenblueth, Wiener, and Bigelow 1943, 18–24).

In 1943, inspired by this idea that machines and minds might be thought together through the language of logic and mathematics, the psychiatrist Warren McCulloch and the logician Walter Pitts at the University of Illinois at Urbana-Champaign decided to take quite literally the machine-like nature of human beings. The pair would later go to MIT at 1952 at Norbert Wiener's behest (Kay 2001, 591–4). Their article 'A Logical Calculus of Ideas Immanent in Nervous Activity', appearing in the *Bulletin of Mathematical Biophysics*, has now come to be one of the most commonly referenced pieces in cognitive science, philosophy, and computer science. There are a series of moves by which neurons could be made equivalent to logic gates, and therefore 'thought' made materially realizable from the physiological actions of the brain. These moves reformulated psychology, but they also demonstrated a broader transformation in the constitution of evidence and truth in science.

The model of the neural net put forth in this paper has two characteristics of note that are critical in producing our contemporary ideas of rationality (Kay 2001; Abraham 2002). The first claim is that every neuron firing has a 'semiotic character'; that is, it may be mathematically rendered as a proposition.[2] To support this claim, Pitts and McCulloch imagined each neuron as operating on an 'all or nothing' principle when firing electrical impulses over synaptic separations; that is, the pair interpreted the fact that neurons possess action potentials and delays as equivalent to the ability to effect a discrete decision. This effect affirms or denies a fact (or activation). From this follows the claim that neurons can be thought of as signs (true/false), and nets as semiotic situations or communication structures (just like the structured scenarios of communication theory – see Figure 1 and Figure 2) (McCulloch and Pitts [1943] 1988, 21–4).

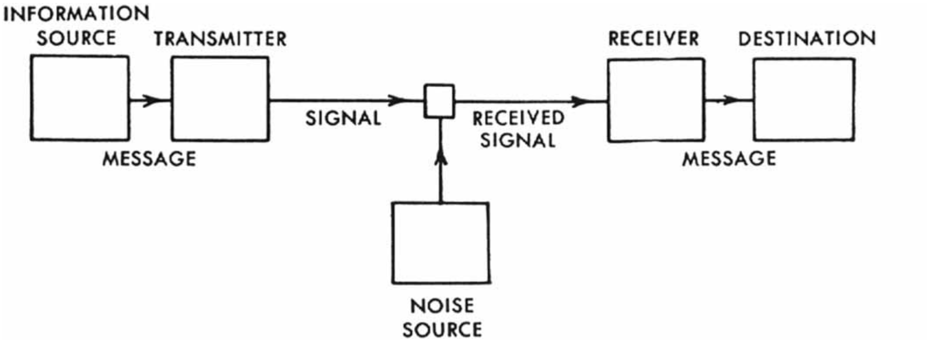

Figure 1. Mathematical Theory of Communication from *The Mathematical Theory of Communication*. 1963 ed., p. 34.

Figure 2. Neural net structures expressing the indeterminacy of the past, since signals may come through a number of different routes from "A Logical Calculus of Ideas Immanent in Nervous Activity" in Embodiments of the Mind, p.36.

This discrete decision (true or false, activate or not) also made neurons equivalent to logical propositions, algorithms, and Turing machines.

The second element of the model that is important here is the adoption of a strictly probabilistic and predictive temporality. Neuronal nets are determinate in terms of the future (they are predictive), but indeterminate in terms of the past.

In the model, given a net in a particular time state (T), one can predict the future action of the net (T+1), but not the past action. From within the net, one cannot determine which neuron fired to excite the current situation.

McCulloch offered as an example the model of a circular memory neuron activating itself with its own electrical impulses.

At every moment, what results as a conscious experience of memory is not the recollection of the activation of the neuron, but merely an awareness that it *was* activated in the past, at an in-determinant time. The firing of a signal, or the suppression of firing, can only be known as declarations of 'true' or 'false' – true, there was an impulse; or false, there was no firing – not an interpretative statement of context or meaning that might motivate such firing.

Within neural nets, at any moment, one cannot know *which* neuron sent the message, *when* the message was sent, or *whether* the message is the result of a new stimulus or merely a misfire. In this model the net cannot determine with any certitude whether a stimulus comes from without or from within the circuit; whether it is a fresh input or simply a recycled 'memory'. Put another way, from within a net (or network) the boundary between perception and cognition, the separation between interiority and exteriority, and the organization of causal time are in-differentiable. But rather than being a disadvantage for the capacity of a neural net, McCulloch and Pitt's brilliance was to see this as an advantage.

They end on a triumphant note, announcing an aspiration for a subjective science. 'Thus our knowledge', they wrote, 'of the world, including ourselves, is incomplete as to space and indefinite as to time. This ignorance, implicit in all our brains, is the counterpart of the abstraction which renders our knowledge useful' (McCulloch and Pitts [1943] 1988, 35). If subjectivity had long been the site of inquiry for the human sciences, now, perhaps, it might – in its very lack of transparency to itself, its incompleteness – become an explicit technology.

McCulloch and Pitts were explicit that their work was a *Gedankenexperiment*, a thought experiment that produces a way of doing things, a methodological machine. Cheerily, McCulloch admitted that this was an enormous 'reduction' of the actual operations of the neurons.[3] 'But one point must be made clear: neither of us conceives the formal equivalence to be a factual explanation. *Per contra!*' At no point should anyone assume that neural nets were an exact description of a 'real' brain (McCulloch and Pitts [1943] 1988, 22). In fact, nets are not representations, they are methodological models, and processes. McCulloch and Pitts discussed this logical reasoning as an experiment, a machine perhaps like the ones described by Deleuze and Guattari in *A Thousand Plateaus* (1987), that does not describe a reality, but rather helps scientists and engineers envision new types of brains and machines, and challenges what scientists thought they knew about how mental processes work. These circuits are labeled by McCulloch as 'psychotic' because they challenged scientific perspective and reformulated the boundaries of interiority and exteriority, between knowledge and practice (Figure 3).

It is perhaps no surprise that psychosis might offer the possibility of producing a logic 'spoken' directly by nerves, or that it should be related to computational machines and digital mediums. Friedrich Kittler has already suggested that the initial effect of psychoanalysis was the externalization of the psyche and its incorporation into larger discursive networks. In delineating the 'discourse network of 1800′ from the 'discourse network of 1900′, Kittler specifies the latter as being concerned with an obsession with the minute, unimportant, and indiscriminately recorded, which characterized the nascent media technologies of the time (Kittler 1999, 3). Therefore Freud's obsessive concern not with the obviously scripted 'events', but with slips of the tongue, minute details, and so forth, advances a larger technical assemblage obsessed with delivering recorded and stored events, detached from any clear referential relation to an external, and meaningful 'reality' (Kittler 1990; Doane 1996).

But cybernetic invocations of psychoanalysis, and psychosis, complicate the seamless extension of the 1900 discourse network into the present. For Freud found psychotics threatening. The classical definitions of psychosis rest on the subject's inability to organize time

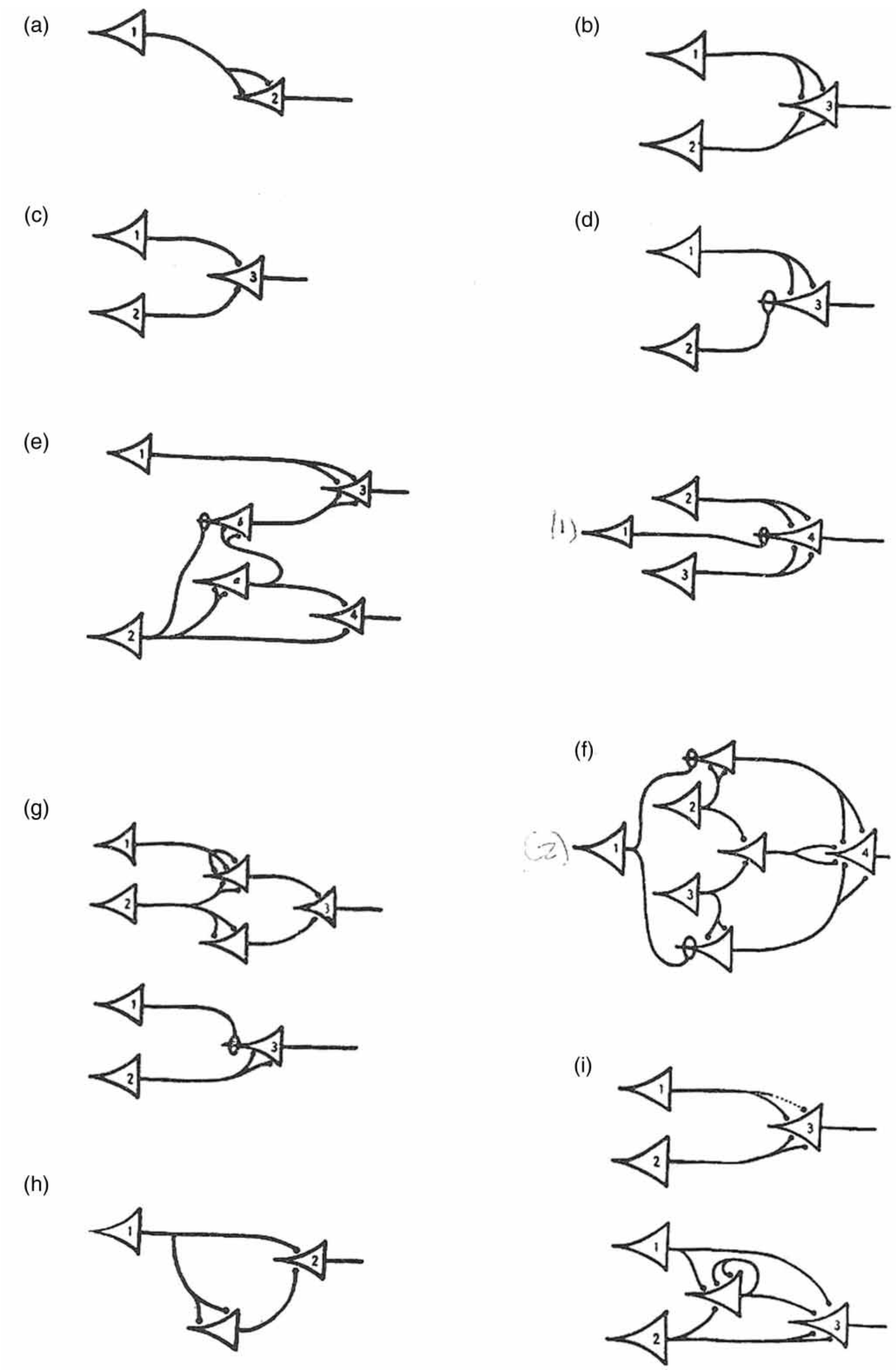

Figure 3. Images of different states of nets from “A Logical Calculus of Ideas Immanent in Nervous Activity” in Embodiments of the Mind, p.36.

and space. To cite Roger Caillois, there is a mimetic excess to these states, the subject is ‘consumed’ by the environment, unable to delineate the boundaries between the self and others (Caillois 1984). Such proximities – between the doctor and the patient, mind and body, and desire and knowledge – Freud found troubling. For the psychoanalysis of the early twentieth century, struggling for credibility under the terms of objectivity offered at the time, psychosis presented a danger to the practice of transference in psychoanalysis, and a threat to the clear-cut separation between the analyst and the analysand. Cyberneticians, on the other hand, displaced the relationship between the analyst and analysand entirely. The autonomous circuit can directly speak, thus providing the material (organic or electronic) substrate to language initially sought for in theories of telepathy, occultism, and psychosis. However, this was only made possible by deferring any encounter with historicity (Thurschwell 1999).

Reductive or not, the pair had established that a capacity for logic and very sophisticated problem-solving might emerge from small physiological units such as neurons linked up in circuits. In doing so, and by way of exploiting the amnesia of these circuits, McCulloch and Pitts were able to make neural nets analogous to communication channels, and shift the dominant terms for dealing with human psychology and consciousness to communication, cognition, and capacities. Their conception of the neural net informs a change in attitudes to psychological processes that makes visible an epistemological transformation in what constituted truth, reason, and evidence in science.

Let me outline this new epistemology briefly here. It rests on three important points that are seemingly unimportant alone, but are significant when recognized as joining a history of logic, engineering practices, and the human sciences in a new assemblage. The first is that logic is now both material and behavioral, and agents can be an- or non-ontologically defined or 'black-boxed'. The second is that cybernetic attitudes to mind rest upon a repression of all questions of documentation, indexicality, archiving, learning, and historical temporality. And third, the temporality of the net is pre-emptive: it always operates in the future perfect tense, but without necessarily defined end-points or contexts (Halpern 2005). Nets are about T+1, the past is indeterminate: McCulloch regularly argued against caring about the actual context, or specific stimulus that incited trauma in patients, or systems.[4] Together these points meant that rationality could be redefined as both embodied and affective, and good science was not the production of certitude but rather the account of chance and indeterminacy. For neural net researchers the question that turned out to be determining was not whether minds are the same or different as machines, but rather, as Joseph Dumit (2007, 7) has put it, 'what difference does it make to be in one circuit or another?'

Control and computing

Having inserted the logic of the machine into the brain, this model was then fed back into the design of machines. The model of the cycling memory neuron in fact directly refracts an earlier concept of control in the Turing machine (and would later become the model for memory in von Neumann's architecture for *EDVAC*) (von Neumann 1945). Control in the Turing machine is the head that 'reads' the program from memory, and then begins the process of executing it according to the directions in the memory. On the one hand, control directs the next operation of the machine. On the other hand, control is directed by the program. The control unit, or the reading head in a Turing machine, is directed by the tape it is reading from memory, not the reverse. Control is that function that will read and act upon the retrieved data, inserting the retrieved program or data into the run of the machine. Such machines do not operate top-down, but rather in feedback loops between storage, processing segments, and the interface for input and output. In his 1946 report on building a computing machine, the *ACE Report*, Turing reiterated that only the possession of memory 'give[s] the machine the possibility of constructing its own orders; i.e. there is always the possibility of taking a particular minor cycle out of storage and treating it as an order to be carried out. This can be very powerful' (Turing 1946, 21). If there is a feature that allows computers to act in uncanny and unexpected ways, it is this surprising capacity to change the pattern of action by way of insertion of a program from storage. Control in computers is like reverberating circuits in brains, and both are classically defined, in psychoanalysis, as psychotic insofar as they involve receiving memories without history.

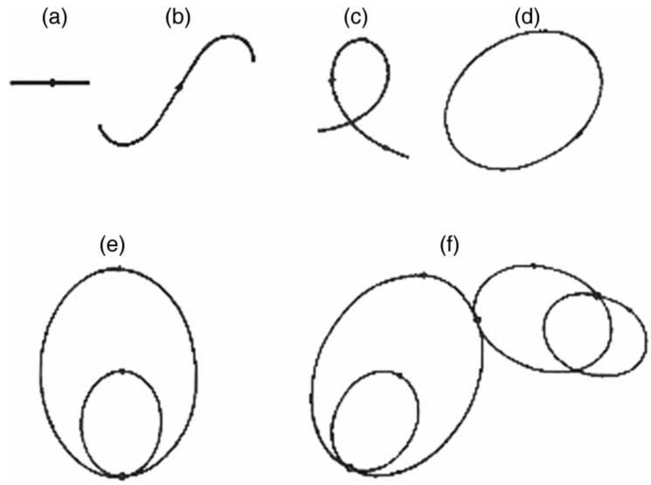

Figure 4. Diagrams of 'c' from Herman H. Goldstine and John Von Neumann, 'Planning and Coding of Problems for an Electronic Computing Instrument: Report on the Mathematical and Logical Aspects of an Electronic Computing Instrument, Part II, Volume I' (Princeton: The Institute for Advanced Study, 1948), p. 157.

The historical redefinition of rationality demanded therefore a reconsideration of what 'control' might mean. In most contemporary scholarship control was correlated with prediction, knowing the future, and command (often military) (Galison 1994; Edwards 1997). In their famous book, *Planning and Coding*, von Neumann and Goldstine introduced flow charts and circuits for stored program computers. However, in describing their circuits they wrote, '[w]e propose to indicate these portions of the flow diagram of C by a symbolism of lines oriented by arrows. … Second, it is clear that this notation is incomplete and unsatisfactory … ' (Goldstine and von Neumann 1948, 157) (Figure 4). In other words, control is not definable, its operable imagining and its explicit definition are incommensurate. But rather than treat this failure in representation as a problem, this threshold became a technological opportunity; this emergent space between the definable and the infinite provided the contours of the engineering problem – an opportunity to turn from logic to technology.

Significantly, for us, McCulloch and Pitts inverted the problem posed by the original negative proof of the *Entscheidungsproblem* that is the Turing machine. If throughout the nineteenth and earlier twentieth centuries an army of mathematicians and philosophers struggled to extend infinitely the limits of logical representation, to which the Turing machine is a negative proof demonstrating the impossibility of fully representing all statements in first-order logic, then McCulloch and Pitts had a different epistemology and frame

(Turing 1936; 2004; Russell 2009; Gödel 1962; Goldstein 2005; Reck 2002; Daston and Galison 1992). Accepting that there were many things that could not be known or computed, McCulloch inverted the question Turing had posed. If instead of seeking an absolute reasonable foundation for mathematical thought that an army of other logicians and mathematicians including Gottlob Frege, Kurt Gödel, David Hilbert, Bertrand Russell, Alfred North Whitehead, and Alan Turing had attempted, McCulloch and Pitts chose to ask instead: What if mental functioning could now be demonstrated to emanate from the physiological actions of multitudes of logic gates? What could be built? Not: What could be proven? The problem could be inverted from seeking the limits of calculation to examining the possibilities for logical nets. What had been an absolute limit to mathematical logic became an extendable threshold for engineering. McCulloch implied we should turn instead to accepting our partial and incomplete perspectives, our inability to know ourselves, and make this 'psychosis' in his words an 'experimental epistemology' (McCulloch [1943] 1988, 359).

Affective logics

What the cybernetic reformulation of logic as 'psychotic' permitted was an abandonment of ontological concern with the past and the present in the interest of focusing on future interactions. These models measured not what is happening, but prepare us for what will happen as a result of finding patterns of past data, that ironically are devoid of historical temporalities. The transformation in truth claims and epistemology opened a new frontier for study – subjective interactions in environments with incomplete information.

These nervous networks and logical rationalities proliferated in the social and human sciences. Cybernetic and communicative concepts of mind were part of a broader shift at the time in concepts of reason, psychology, and consciousness; informing everything from finance and options trading equations, to environmental psychology and urban planning programs of individuals such as Kevin Lynch, and later MIT's Architecture Machine Group and the Media Lab headed by Nicholas Negroponte, to the political science models of Karl Deutsch at Harvard, and the 'bounded rationality' introduced by Herbert Simon and widely considered the foundation of contemporary finance. The post-war social sciences were repositories of these techniques that transformed what had once been a question of political economy, value production, and the organization of human desire and social relations to problems of circulation and communication by way of a new approach to modeling intelligence and agency (Halpern 2014; Simon 1955; Crowther-Heyck 2005; Simon 1992).

This rationality is also sensible, perhaps affective; a situation that puts in considerable revision-dominant understandings of digital and computational mediums as distancing, disembodied, or abstract. And if it is one of the dominant assumptions in the study of modern history and governance that liberal subjectivity and economic agency is defined as a logic guided by a reason separate from sense, then these discourses mark a clear contrast. The historian of science Lorraine Daston reminds us that we would do well to recall that those things today considered virtuous and intelligent, such as speed, logic, and definitiveness in action, were not always so. She is explicit: rationality in its cold war formulation, despite the insistence of technocrats, policy-makers, and free-market advocating economists, is not reason as understood by Enlightenment thinkers, liberals, or even modern logicians (Daston 2011; see also MacKenzie 2006; Mirowski 2002).

If this is true, then our financial instruments, markets, governments, organizations, and machines are rational, affective, sensible, and pre-emptive, but not reasonable. To recognize the significance of this thinking in our present, it might help to contemplate Brian

Massumi's definition of 'pre-emption'. Pre-emption, he argues, is not prevention; it is a different way of knowing the world. Prevention, he claims, 'assumes an ability to assess threats empirically and identify their causes'. Pre-emption, on the other hand, is affective; it lacks representation, it is a constant nervous anticipation, at a literally neural if not molecular level, for a never fully articulated threat or future (Massumi 2007, 4).

Cyberneticians, within 10 years from the war, moved from working on anti-aircraft prediction to building systems without clear end-points or goals, and embracing an epistemology without final objectives, or perhaps objectivity (even if many practitioners denied this). Nets, taken as systems, are probabilistic scenarios, with multiple states and indefinite run times even if each separate neuron can act definitively. In cognitive and early neuroscience the forms of knowledge being espoused were always framed in terms of experiment, never definitive conclusions. 'Experimental epistemologies', as McCulloch put it, came to mean that there are never final facts, only ongoing experiments.

These human and social scientists made operative the unknowable space between legibility and emergence, and turned it into a technological impulse to proliferate new tools of measurement, diagrams, and interfaces. At the limits of this analysis is the possibility that emergence itself has been automated. As the theorist Luciana Parisi puts it, cybernetics takes hold of the space between infinity and logic, and makes it the very site of technical intervention, the very site to proliferate algorithms into life (Parisi 2013). If cybernetics initially sought to control the future, now control itself became the unclear site of emergence, an indefinable state that was part of networks operating in the future without full definition or information either about end-points or pasts. The problem of how to act under conditions of uncertainty, or how to define a man or a machine, became instead a pragmatic mandate and a focus on process. Instead of asking what is a circuit, a neuron, or a market, human scientists turned to asking what do circuits do? How do agents act? Creating an ongoing opportunity to entangle calculation and life at the level of nervous networks, by correlating the nervous system with the financial and political system.

Memory as a cyclical machine

Having supposedly exorcised the ghosts of historicity, cyberneticians, however, continued to struggle with memory and signification. In a 1952 letter to the cybernetician Norbert Wiener, Gregory Bateson spelled out the problem of memory, time, repetition, and rationality:

> What applications of the theory of games do is to reinforce the players' acceptance of the rules and competitive premises, and therefore make it more and more difficult for the players to conceive that there might be other ways of meeting and dealing with each other […] I question the wisdom of the static theory as a basis for action in a human world. The theory may be 'static' within itself, but its use propagates changes, and I suspect that the long-term changes so propagated are in a paranoidal direction and odious.[5]

Discussing the premier private consulting group to the United States government and military on national security and public policy – the RAND Corporation – Bateson makes explicit a new dilemma: violence. In this formulation, players no longer create violence because of a misdirected desire resulting in a loathing for an imagined Other, but instead are led to produce violence through a self-referential performance within the game. Bateson correlates 'static' games with paranoid schizophrenics, as a perceptual problem resulting in repetitive cycles culminating in potentially genocidal violence (nuclear war in this case) – in his language a 'paranoidal direction'. Authority emerging from the pure self-reference of the data field is psychotic and comes at the expense of futurity. Bateson fears that the performance of past data paraded as prophecy will produce only repetition without difference. In a stunning inversion of psychoanalytic concerns, Bateson recognizes that the ubiquity of computational logics makes distance impossible to achieve, and induces violence, not as a result of any misdirected object choices or imagined enemy Others – game theories have no such formulations within them – but as the result of performing and repeating commands without interpretation. In fact, it is precisely the lack of imagination that defines this condition. Bateson foresees a total war without desire.

Having displaced older terms of consciousness, reason, and desire from the algorithmic rationality of the network, these terms would return in cybernetics under the guise of visualization, time, and memory. At the famous Sixth Macy Conference on Circular and Causal Feedback Mechanisms in Biological and Social Systems in 1949 in New York City, memory was increasingly problematized in terms of the relations between its dynamic and stable elements and storage. In this instance the immediacy and temporality of the televisual came to replace the older conceptions of tapes, photographs, and films. McCulloch opened the conference with a beacon and a warning. He offered the example of a new type of tube, in development at Princeton, similar to a cathode ray tube, that beams onto a screen on which items are stored. The persistence of the 'memory' of the beam is temporary, and must be refreshed. This idea of a cycling, or scanning, memory McCulloch viewed as offering the possibility of miniaturizing and expanding machine memory (Pias 2003, 31).

His second example was a warning from John von Neumann: even the entire number of neurons in the brain, according to calculation, could not account for the complexity of human behavior and ability. McCulloch reported the finding that 'the performance of the army ant […] is far more complicated than can be computed by 300 yes or no devices' (Pias 2003, 31). But this was not to say that these capacities need be understood as illogical or analog. Rather, McCulloch turned to another model that might retain the logical nature of the neurons, but still account for the capacity to learn, and behave at scales beyond the comprehension of computation.

The answer, coming through a range of discussions about protein structure and memory within cells, involved refreshing information in time. Wiener argued, 'this variability in time here postulated will do in fact the sort of thing that von Neumann wants, that is, the variability need not be fixed as? variability in space, but may actually be a variability in time'. The psychologist John Stroud offered the example of a 'very large macro-organism called a destroyer'. This military ship has endless 'metabolic' changes of small chores throughout the day, but still retains the function of a destroyer. This systemic stability, but internal differentiation and cycling, became the ideal of agency and action in memory (Pias 2003, 35).

McCulloch and Stroud went on to present understandings of memory in terms of an opposition between perfect retention of all information with retroactive selection, and memory as a constantly active site of processing of information for further action, based on internal 'reflectors' or 'internal eyes'. 'We may', Stroud stated, 'need only very tiny little reflectors which somehow or other can become a stimulus pattern which is available for this particular mode of operation of our very ordinary thinking, seeing, and hearing machinery. This particular pattern of reflectors is what I see as it were with my internal eyes just as what I see when I look at a store window, is a pattern on the retinal mosaic' (Pias 2003, 121). Mental processes are equated here with processing data, and pattern-seeking, but it is internal 'eyes' from within the psychic apparatus that allow a self-reflexive apparatus for deferring decisions and agency. Mind emerges from multiple time systems operating between the real-time present of reception and circulating data, and memory in time, a cyclical 'refreshing' as in a television screen system, where change, and differentiation – between the organism and the environment, between networks – becomes possible through the delay and reorganization of circuits from within the organism. The problems of computational representation, the initial problems that were faced in mathematically and logically representing intelligence, were reorganized away from a language of conscious and unconscious, discrete and infinite, reason and psychosis, to the new terms of vacillating temporalities between immediacy and reflexivity.

Bateson, also an attendant at the aforementioned conferences and one of the founders of family therapy and addiction treatment programs, offered one of the more compelling models and practices for rethinking mind in his use of a model of the 'double bind' to explain psychic suffering, addiction, and other maladjusted and compulsive behaviors. In a conference in 1969, at the National Institute of Health, he offered an example to demonstrate his ideas of both psychology and treatment. He discussed a research project conducted with porpoises trained at Navy research facilities to perform tricks and other trained acts in return for fish. One day, he recounted, one of the porpoises was introduced to a new regimen. Her trainers deprived her of food if she repeated the same trick. Starved if she repeated the same act, but also if she did not perform, the porpoise was caught in a double bind. This experiment was repeated with numerous porpoises, usually culminating in extreme aggression, and a descent into what from an anthropomorphic perspective might be labeled disaffection, confusion, anti-social and violent behavior. Bateson with his usual lack of reservation was ready to label these dolphins as suffering a paranoid form of schizophrenia. The anthropologist was at pains, however, to remind his audience that these psychotic animals were acting rationally. In fact, they were doing exactly what their training as animals in a navy laboratory would lead them to do. Their problem was that they had two conflicting signals. The poor animals, having no perspective on their situation as laboratory experiments, were naturally breaking apart, fissuring their personalities (and Bateson thought they had them) in efforts to be both rebellious and compliant, but above all to act as they had been taught. Bateson argued this was the standard condition for humans in contemporary societies.

Having established the mechanisms that led to a decentered and multiple subject, Bateson commenced to articulate the dangers and possibilities of this condition. He recalled how, between the fourteenth and fifteenth time of demonstration, one of the porpoises 'appeared much excited', and for her final performance gave an 'elaborate' display, including multiple pieces of behavior of which four were 'entirely new – never before observed in this species of animal' (Bateson 2000, 278). These were not solely genetically endowed abilities, then, but were learned, the result of an experiment in time. This process in which the subject, whether a patient or a dolphin, uses the memories of other interactions and other situations to transform their actions within the immediate scenario was represented as the site of innovation. The dolphin's ego (insofar as we decide she has one) was sufficiently weakened to develop new attachments to objects in its environment through the memories of its past and of other types of encounters. This re-wired network of relations was what was held to lead to emergence through the re-contextualization of the situation within which the confused and conflicted animal found itself.

Bateson ended in triumph, having now successfully made the psyche inter-subjective and simultaneously amenable to technical appropriation via family therapy (Bateson 2000, 278). The productivity of a schizoid situation rested for Bateson on the discovery made by both communication theory and physics that different times could not communicate directly to one another. Only temporal differences resist circulation from within the definition of communication that was being put forward here. Bateson applied this understanding liberally to animals. In cybernetic models the ability of an entity to differentiate itself from its environment and make autonomous choices is contingent on its ability to engage simultaneously in dangerous spatial proximities with other entities and its ability to achieve distance from them in time.

At stake in the negotiation over the nature of networks and the time-scale of analysis was nothing less than how to encounter difference – whether between individuals, value in markets, or between vast states during the cold war. A question that perhaps started in psychoanalytic concerns over psychosis found technical realization in cybernetics. For cyberneticians the problem of analogue or digital, otherwise understood as the limits between discrete logic and infinity, the separation between the calculable and the incalculable, the representable and the non-representable, and the differences between subjects and objects, was transformed into a reconfiguration of memory and storage; a transformation that continues to inform our multiplying fantasies of real-time analytics, while massive data storage infrastructures are erected to insure the permanence, and recyclability, of data.

While the time of neural nets and communication theories is always pre-emptive, the shadow archive haunting the speculative network is one of an endless data repository whose arrangement and visualization might return imagination and agency to subjects. These wavering interactions – between the networked individual and the fetish of data – preoccupy us in the present, speaking through our contemporary concerns with data mining, search engines, and connectivity. The relationship between rationality and control drives the ongoing penetration and application of media technologies as the result of an imperative to seek consciousness through better visualization and collective intelligence through the collaboration of many logical, but hardly reasonable, agents. Architecturally these dual desires incarnate themselves in a proliferation of interfaces and a fetish for visualization and interactivity, merged with an obsession to amass and store data in huge systems of data centers and server farms. What had first been articulated as a problem of memory and time has now become a compulsion for analytics.

Theorizing the nervous network

I opened this essay arguing that cybernetics and its affiliated communication and human sciences aspired to the elimination of difference in the name of rationality, a dream of self-organizing systems and autopoietic intelligences produced from the minute actions of small, stupid, logic gates, a dream of a world of networks without limit, focused eternally on an indefinite, and extendable, future state.

Earlier in this essay, I also invoked Bateson's concerns about self-referential violence. What Bateson articulated was the worry that in the real-time obsession to entangle life with calculative logics, learning, and by extension thought, would itself be automated in such a way as lead to violent harm and, perhaps, the destruction of the world.

This condition only becomes inevitable, however, if we ourselves descend into the logic of immediate and real-time analytics. We must avoid this conclusion and this condition. Like Bateson's porpoise, torn between reactionary return and self-referentiality, we are forced to ask about the other possibilities that still lie inside our machines and our histories. The cycles of the porpoise re-enact the telling of cybernetic history where ideas of control and rationality are often over-determined in their negative valence, and the inevitability of the past to determine the future is regularly assumed. Perhaps the hope is in the very machinery that was imagined into being through the cybernetic circuits – systems that can both recognize and disavow their history, for which memory and archiving remain at tense and productively incommensurable distances, incarnated in a drive to accelerate the speed of speculation while intensifying the infrastructure for data gathering and storage; all supported by a nervous rationality that is constantly multiplying from within.

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Notes

1. The history of the pathology of schizophrenia is both long and constantly changing. The disease was first formally identified as dementia praecox in the 1890's, the term "schizophrenia" and the aforementioned symptoms were formalized by Eugene Bleuler in 1908 to describe a "split" or cognitive dissonance between personality, thinking, memory and perception. The definition of the disease continued to evolve, at the time McCulloch was writing there was no Diagnostic or Statistical Manual, and his definitions adhered to those of earlier in the 20th century. McCulloch himself was critical of the term, and often thought it was too often used to catalogue too many psychiatric pathologies, particularly psychotic ones. Like other practitioners at the time he classified schizophrenia into multiple subtypes, of which only one—paranoid—was prone to violence and to the regular imagination of threat and enemies to the self (Bleuler 1950).
2. The logic used in the article was taken from Rudolf Carnap, with whom Pitts had worked.
3. The pair had derived their assumptions about how neurons work on what, by that time, was the dominantly accepted neural doctrine in neuro-physiology. Using the research of Spanish pathologist, Ramón y Cajal, who first suggested in the 1890s that the neuron was the anatomical and functional unit of the nervous system and was largely responsible for the adoption of the neuronal doctrine as the basis of modern neuro-science, and the work of Ramón y Cajal's student, Lorento de Nó, on action potentials and synaptic delays between neurons and reverberating circuits, McCulloch and Pitts had the neurological armory to begin thinking neurons as logic gates (Ramón y Cajal 1999; McCulloch and Pitts [1943] 1988, 52).
4. See for example interviews on treatment of soldiers coming from World War II done in Britain where McCulloch steadfastly spoke against narrative therapy, and proactively promoted drug treatment to rewire circuits in the brain (BBC 1953; McCulloch 1954).
5. Gregory Bateson, Letter to Norbert Wiener, 22 September 1952 (The Papers of Norbert Wiener, MC22, Box Number: 10, Folder 155 p.2 Institute Archives and Special Collections, Massachusetts Institute of Technology, Cambridge, MA, USA).

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