This is Your Brain on Algorithms: Thinking the Movement of the Mind with Deleuze

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Abstract

After a consideration of technological metaphors for the mind/brain – specifically computer-related metaphors that came of age with the Turing machine and the development of cybernetics – I argue that first-order cybernetics dramatically changed the metaphors by which we think the brain/mind, although they remained embedded in humanist dualisms. Second-order cybernetics, on the other hand, gave to us the idea of the brain as an autopoietic system that can account for both autonomy and emergence. Of special importance in second-order cybernetics is the injunction against flows of information across self-referential system boundaries, emphasizing two aspects: *operational closure* and *operational recursion*. It is particularly these two concepts that interest me in thinking about what happens when algorithmic reason and the human brain start to function as a single autopoietic system. That is, I ask questions about the isomorphism between digital and biological systems. My argument is that the computer is no longer merely a metaphor for the brain because the brain *is* the computer. In other words, a real cybernetic movement in thought has occurred, similar to the real movement in the image brought about by cinema, as Deleuze argues in his two *Cinema* books. In closing, I argue that operational closure can be understood both in terms of what the neuroscientists Mark Solms and Karl Friston call 'Markov blankets' and in terms of Deleuze's theory of the logic of sensation, and that this can help us grapple with what algorithmic reason is doing to thought.

This is your brain on information: First-order cybernetics and information metaphors of the brain/mind

If you are of a certain age, you are likely to have some memories of the "This is your brain on drugs" commercials. Especially memorable is the eggy-brain advertisement. In the ad — available on YouTube (Kalamut 2010) — a serious looking man takes an egg out of a carton. Looking at the camera he says: "This is your brain". Maintaining the solemnity, he points to a pan on a stove. "This is drugs", he says. If you have seen the ad, you know what is about to follow. If you have not, I am sure by now you can guess what is going to happen next. Yes, cracking the egg into the pan, the man exclaims: "This is your brain on drugs". Your brain, apparently, is an egg ready to be had for breakfast.
Yum!?

Of course I get the intended metaphor: drugs crack your brain. But I also get that the intended metaphor was not a particularly successful one. Besides being wildly inaccurate, it hardly prevented drug use. If anything, it became the stuff of comedy. You might, being of this particular age, also remember the related Bill Hicks skit. (If not, you may want to Google it.) The point I am driving at is that metaphors related to the brain and/or mind have taken various forms throughout history, some more successful than others, as eggy-brain demonstrates. To be sure, the egg was used specifically to depict broken/attenuated cognition, whereas people more readily resort to technological metaphors for thinking about the brain/mind *in general*, and these metaphors tend to reflect the highest technological achievements of any given time. Moreover, these "mechanical metaphors" often become "*models* of the mind" (Marshall 1977: 476). Thus, the brain has been equated with water clocks, store houses, water systems such as hydraulic pumps, clock mechanisms, mechanical ducks, steam engines (notably by Freud), electricity, telephone switching networks, telegraphs and holographic storage devices, though perhaps none of these have stood the test of time quite like computer-related metaphors which came of age with the Turing machine and the development of cybernetics (Leibniz's *calculus ratiocinator* stands out as a forerunner of these ideas). "Henceforth, humans were to be seen primarily as information-processing entities who are essentially similar to intelligent machines" (Hayles 1999: 7).

What is known as first-order cybernetics — so called for its focus on *observed* systems (Wiener 1948) rather than *observing* systems (von Foerster 1973) — emerged in the late 1940s "as a technoscience of communication and control, drawing from mathematical physics, neurophysiology, information technology, and symbolic logic" (Clarke & Hansen 2009: 2). Interdisciplinary in nature and historically contemporaneous with the spread of linguistic structuralism, the development of cybernetics was aided by ten conferences, colloquially known as the Macy conferences, that took place between 1943 and 1954. The conferences — which were chaired by Warren McCulloch and attended by scholars such as Heinz von Foerster, Lawrence Kubie, Lawrence Frank, Heinrich Klüver, Margaret Mead and Gregory Bateson — focused on "connecting biological and computational systems by way of information theory and communications technology" (Clarke & Hansen 2009: 2). What distinguishes cybernetics from other theories and fields dealing in information, communication and control, however, is "its emphasis on control and communication not only in engineered, artificial systems, but also in evolved, natural systems such as organisms and societies, which set their own goals, rather than being controlled by their creators" (Heylighen & Joslyn 2001: 2). In fact, the focus on the goal-directedness of systems is perhaps one of the more important innovations of cybernetics as it speaks to the main objective of *any* system, namely the resistance of entropy. To give a fuller definition:

> Cybernetics is the science that studies the abstract principles of organization in complex systems. It is concerned not so much with what systems consist of, but how they function. Cybernetics focuses on how systems use information, models, and control actions to steer towards and maintain their goals, while counteracting various disturbances. (Heylighen & Joslyn 2001: 2)

To understand how systems use *information*, it is useful to define exactly what we mean by the concept. Together with Claude Shannon, Norbert Wiener defined information as that which is measurable and can "be studied on a statistical basis" (Wiener 1950: 2). That is, information measures order and pattern, as well as *entropy* or disorder and randomness, in a system (Wiener 1950: 2), though information and entropy should not be viewed as opposites nor as identical, even though some definitions give that impression.[1] What should rather be taken from these definitions is that there is a complex relationship between information and entropy because any system, at bottom, is aimed at counteracting entropy or maintaining homeostasis which, as we know from Simondon, does not imply a completely fixed and stable equilibrium, but a metastable one. Basically, homeostasis requires that "living organisms must occupy a limited range of physical states: their viable states, or valued or preferred states" — or what the neuroscientist, Karl Friston, calls their 'expected' states (Solms 2021: 154). If a system fails to restore homeostasis, the disequilibrium will likely lead to metabolic disorder which, in living systems, is expressed as disease or even death. Information, then, provides a way to statistically measure the amount of surprise for an event which, in the digital age, is translated into in bits. The fewer the bits of information "required to describe the actual location of each molecule", particle or unit in a system, the lower the entropy (Solms 2021: 156–157); the more bits of information required, the higher the entropy. In different terms, we can say that information is measured as constraint, where constraint is that which reduces uncertainty — so what is measured is the "difference between maximal and actual uncertainty" (Heylighen & Joslyn 2001: 7). Entropy, on the other hand, is measured as variability, meaning that at equilibrium a system will exhibit strict regulatory constraints and thus low entropy or well-defined expression patterns, whereas the opposite is true for systems exhibiting higher entropy expression patterns. Thus, entropy is the measure of unavailable energy that can be put to work in a system. Information theory is, then, "the starting point for a set of studies that have founded the notion of

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[1] Technically, Shannon defines information as "surprise, uncertainty and entropy", whereas Wiener describes it as "the measure of disorder", once again emphasizing the complex interrelatedness between order and disorder, as well as information and entropy. Yuk Hui argues that what these definitions share is "difference" (Hui 2011). This is why Gregory Bateson later defined information as "a difference which makes a difference" — so if there is no difference, there is no information (quoted in Hayles 1999: 51). This is also why we can say that information measures the *difference* between maximal and actual uncertainty. Drawing on this legacy, information becomes, in Simondon, "the differences and the possibility of difference which triggers and conditions the whole process of individuation" (Hui 2011).

negative entropy (or negentropy)", demonstrating that information "corresponds to the inverse of the processes of" entropy and that, "within the overall schema, information is not definable based on a single term, such as the source or the receiver, but it is definable based on the *relation* between the source and the receiver" (Simondon 2020b: 686–687, emphasis added). In philosophical terms we can describe this process, following Simondon, in terms of the individuation of a system — be that a physical, psychical or social system — which is aimed at the resolution of a metastable system. All systems are thus individuating systems, and systems that are in the midst of undergoing processes of individuation (Simondon 2020a: 7).

We will return to this idea later in the paper. What is important to understand for now, however, is that first-order cybernetics dramatically changed the metaphors by which we think the brain/mind. Moreover, the idea that minds, like computers, are models that process information has had far-reaching consequences, one being that "it can be implemented with vastly different kinds of physical equipment" (Solms 2021: 12). This view suggests that "the mind (construed as information processing) is a *function* rather than a structure" and this, in turn, implies that "the 'software' functions of the mind are implemented by the 'hardware' structures of the brain, but the same functions can be implemented equally well by other substrates, such as computers" (Solms 2021: 12). This metaphor of the brain/mind has had an enormous influence not only in academic circles, but also in popular culture, such as the cyberpunk genre. But, as can be surmised from much of the "technoid fantasies" of cyberpunk[2] and its offspring, first-order cybernetics remained "inscribed within classical scientific thought" and embedded in "humanist and idealist dualisms that describe the world in terms of an equivocal dialectics of matter and form [hylomorphism], of substance and pattern, in which the immaterial wrests agency away from the embodied" (Clarke & Hansen 2009: 4). This is, of course, the tension teased out by Katherine Hayles in *How We Became Posthuman* (1999). Her argument is that the new theory of information proposed at the Macy conferences, in combination with the information-processing model of neural functioning and computers that were capable of processing binary code and plausibly reproducing themselves, not only reinforced the mind-body dualism, but also resulted in the idea that the materiality of the brain, that is, the substrate from which the mind emerges, is incidental to its expression (1999: 2, 7). I imagine her in a commercial with binary code in the shape of a brain. The byline reads: *This is your brain on information.*

[2] Be this as it may, it should be remembered that the history and applications of cybernetics — as in literature — were always contested, with Bionic Men in the service of the State on one end of the continuum and replicants and hustlers hacking their way out of the "consensual hallucination" that is cyberspace on the other (Gibson 1984: 67).

Second-order cybernetics and autopoietic metaphors of the brain/mind

Second-order cybernetics — which should not be viewed as a discrete movement but as a continuation and augmentation of first-order cybernetics — was aimed at redefining homeostatic systems in such a way that the observer could be taken into account. In part, this was initiated when Heinz von Foerster published his groundbreaking work, *Observing Systems* (1981), although he had already begun describing the "recursive mechanisms in cognitive systems" in the 1970s, "thereby producing the initial formulations for a cybernetics of cybernetics (Clarke & Hansen 2009: 1). Of special importance in second-order cybernetics — which finds its maturation in the work of Humberto Maturana and Francisco Varela — is the injunction against "flows of *information* across the boundary demarcating an autopoietic or self-referential system from its environment" (Clarke & Hansen 2009: 9). Two aspects are emphasized here: *operational closure* and *operational recursion*. But to understand these two concepts, one has to grasp what is meant by *system.* We have already seen that any system is goal-directed and that its most important goal is the maintenance of homeostasis or metastable equilibrium; that is, the minimization of entropy, which a system achieves by measuring information as a probability distribution. In other words, a system responds to an energetic problematic by intervening "as an element of the problem" via individuation processes (Simondon 2020a: 9). But how are we to understand a system?

In *The Tree of Knowledge* (1998), Maturana and Varela lay the groundwork for understanding systems in terms of autopoietic organization. This involves two moves: defining *autopoiesis* and distinguishing between *organization* and *structure.* Autopoiesis, which consists of the Greek *auto-* (αὐτο-), meaning "self" — which Maturana and Varela take to mean autonomy — and *poiesis* (ποίησις), meaning "creation" or "production", denotes self-organization, organizational recursion (because the system is self-referential) and emergence. In order to maintain autopoietic organization, a system has to be operationally or organizationally closed to information from its associated milieus and the environment. That is, while a system is thermodynamically open, meaning it is open for the exchange of energy, it is operationally closed, which is to say it is closed to the exchange of information because its processes are self-referential or recursive. We find here the crucial difference between thermodynamic closure and cybernetic (or operational) closure. "Thermodynamically, a system is either open or closed to energic exchange with its environment; by contrast, autopoietic systems are both environmentally open to energic exchange and operationally closed to informatic transfer" (Clarke & Hansen 2009: 9). For Maturana and Varela, operational closure is what "*defines* the autonomous nature of the living being" (1998: 166, emphasis added). If a system is not operationally closed, its organization will not remain invariant, meaning it will cease to exist as it will not have any viable means to restore homeostasis. Recall that in order for a system to restore homeostasis it has to be capable of making reliable predictions about its state and generating effective actions that counteract entropy. If a system is open to information transfer, however, it will have to take into account the feedback it receives both internally and externally which would, inevitably, lead to confusion because the system would have to guess which information feed it should respond to — external or internal? In contrast, when a system is operationally closed, its feedback relations rely on itself, which allows it to measure deviations in its system and make the necessary adjustments. This boundary closure is another injunction raised by Hayles against cybernetics. In *My Mother Was a Computer* (2005), she argues that the notion of *entanglement*, as understood in the new materialisms, radically puts to question the idea of operational closure. In her words:

> A major implication of entanglement is that boundaries of all kinds have become permeable to the supposed other. Code permeates language and is permeated by it; electronic text permeates print; computational processes permeate biological organisms; intelligent machines permeate flesh. Rather than attempt to police these boundaries, we should strive to understand the materially specific ways in which flows across borders create complex dynamics of intermediation. At the same time, boundaries have not been rendered unimportant or nonexistent by the traffic across them. Biological organisms are not only computational processes; natural language is not code; and fleshly creatures are composed of embodiments that differ qualitatively from artificial life forms. Boundaries are both permeable and meaningful; humans are distinct from intelligent machines even while the two are becoming increasingly entwined. (Hayles 2005: 242)

While I am sympathetic to and respect Hayles's project, and that of the new materialisms more broadly, both of which are aimed at disrupting the "standard story of scientific realism" (Hayles 2005: 242) and dissolving mind/body dualisms, I tend to agree with Bruce Clarke and Mark Hansen that "these formulations [as they relate to operational closure] are simply too vague. It is not at all clear what exactly such 'permeation' might amount to, given the very different operational fusions being asserted" (2009: 9).[3] In their view, this move "glosses over the very differentiations from which systems are generated in the first place" and, in so doing, dismisses the "machinery of emergence before emergence even gets started" (Clarke & Hansen 2009: 9). It is my intention, in this paper, to convince you that operational closure *is* necessary for autopoietic systems (if not *all* systems) and that it can be understood both in terms of what Mark Solms and Karl Friston call 'Markov blankets' and in terms of Deleuze's theory of the logic of sensation. We will get to that. For now, be reminded that autopoietic systems must be opera-

[3] To be fair, since the publication of Clarke and Hansen's book in 2009, important work has been done on *sympoiesis* and *symbiogenesis* in the new materialisms and related fields, especially by scholars such as Donna Haraway, Anna Tsing and Scott Gilbert in their respective chapters in *Arts of Living on a Damaged Planet: Monsters of the Anthropocene* (Tsing et al. 2017) — though the point about operational closure does hold in my view, as will become clearer in the section on Markov blankets.

tionally closed to ensure operational recursion which is crucial for the restoration of metastable equilibrium. Put differently, operational closure is the property of autopoiesis that ensures that systems are self-organizing. But this does not entirely answer the question of what a system is.

To define a system, Maturana and Varela make a distinction between *organization* and *structure*. Organization, here, refers to "those relations that must exist among the components of a system for it to be a member of a specific class" (Maturana & Varela 1998: 47). In other words, organization refers to the *necessary* relations between components which combine to form a unity in general, for example a brain is defined according to the necessary relations between parts such as the cerebrum, the cerebellum, the brainstem, and so on. Structure, on the other hand, refers to "the components and relations that actually constitute a particular unity and make its organization real" (Maturana & Varela 1998: 47), for example, *your* brain can be distinguished from *mine*. An autopoietic system thus functions according to its specific organization and structure which it maintains through organizational closure but, although organizationally closed, a system does interact with its environment through *structural coupling*. "In these interactions, the structure of the environment only *triggers* structural changes in the autopoietic unities (it does not specify or direct them), and vice versa" (Maturana & Varela 1998: 75). And while it can trigger structural changes, it cannot trigger organizational changes, for reasons that I think are obvious. Structural coupling, then, is a way to account for emergence because it "adds to Varela's flexible and capacious conception of autonomy a global perspective that is not external to the operation of the organism"; that is, the integration of "the interactional domain" into "the multi-level, self-differentiated system of the organism" renders "the interactional domain a factor in the ongoing evolution of the internally differentiated system of the organism" (Hansen 2009: 129). What becomes clear here is that whereas first-order cybernetics gave to us a metaphor not only of the brain as a computer but, more specifically, of the mind as an information-processing model, second-order cybernetics gives to us the idea of the brain as an autopoietic system that can account for both autonomy and emergence.

Interlude: But what about affect?

Before looking at modulations of the computer metaphor vis-à-vis deep learning and algorithmic reason, I want to propose a somewhat altered definition of operational closure and add affect to the mix. Drawing on work by Mark Solms and Karl Friston, I want to suggest here that we think of operational closure in terms of a 'Markov blanket' — "a statistical concept" rather than a necessarily physical boundary — "which separates two sets of states from each other" so that the Markov blanket induces a partitioning between internal states and external ones, or system and not-system (Solms 2021: 164), "where the blanket itself consists of the states that separate the two" (Kirchhoff et al. 2018: 1). In other words, the Markov blanket contains *useful information* which, as we have seen, is important for a system to counteract entropy. Bear in mind that systems, such as organisms, "show a tendency to self-organize into a coherent whole despite them comprising a multiplicity of nested systems [and, accordingly, also a multiplicity of Markov blankets]. They also continuously work to preserve their individual unity, thus tending to "maintain a boundary that separates their internal states from their external milieu" (Kirchhoff et al. 2018: 1). Operational closure thus speaks directly to the partitioning rule of Markov blankets. "Casting operational closure in terms of the presence of a Markov blanket" also "gives the notion of operational closure a statistical formulation" which "allows us to explain what Varela called 'the intriguing paradox' of an autonomous identity: how a living system must both distinguish itself from its environment and, at the same time, maintain its energetic coupling to its environment to remain alive" (Kirchhoff et al. 2018: 6).

We have seen that it is necessary for a system to maintain operational closure to ensure operational recursion; that is, a system is closed to the exchange of information external to it so that its feedback relations rely on itself. This recursive feedback is what allows a system to measure deviations in its system and make the necessary adjustments to maintain metastable equilibrium without getting confused about which information is more useful, its own internal information or external information. In short, then, a Markov blanket is the boundary that instantiates operational closure and defines the boundary in a statistical sense. The existence of a Markov blanket means that "external states are conditionally independent of internal states, and vice versa, as internal and external states can only influence each other via sensory and active states" (Kirchhoff et al. 2018: 2). What this means in effect is that "external states can only be 'sensed' *vicariously* by the internal ones *as states of the blanket*", so even though external states can "influence the internal ones via the sensory states of the blanket" and internal states can "couple back to the external ones through" their active states "in a circular fashion" (Solms 2021: 164–165, emphasis added), external states cannot *directly* impact or alter either the operational closure or the operational recursion of a system. Of course, this also means that "biological systems like you and I are insulated from the world by our Markov blankets", meaning "we cannot compare our models directly with the way the world really is" and must, therefore, minimize surprisal by "measuring relative entropies — by quantifying the gap between the sensory states predicted by an action and the sensory states that actually flow from that action" via a kind of *sensing* (Solms 2021: 173). Perhaps the most important take-home message is that while the Markov blanket constitutes a boundary, it is a boundary that contains useful information which enables a system to minimize entropy, or what Friston calls 'free energy'[4] (analogous to thermodynamic quantity). That

[4] For a fuller description of free energy, see Aragorn Eloff's paper in this special issue. For the purposes of this paper, it is good enough for readers to understand this concept in terms of surprisal

is to say, free energy "is a bound on 'surprisal' (or negative model evidence) or more simply 'surprise'. The time average of surprise is entropy (a measure of uncertainty), so the minimization of free energy through time ensures that entropy is bounded" (Kirchhoff et al. 2018: 2). Put simply, for a system to minimize free energy or reduce metabolic expenditure, it has to minimize surprise by measuring information as a probability distribution because being able to predict what is about to happen is precisely how surprise — and thus free energy — is minimized.

Kirchhoff et al. explain that biological systems are able to "maintain low entropy distributions over their internal states (and their Markov blanket) despite living their lives in changing and uncertain circumstances" by engaging in *active inference* — an action dependent on perception which minimizes surprise about the causes of sensory states (2018: 3). Let's take the brain as an example. At each level of the brain's hierarchy we can find Markov blankets, or boundaries that are neither fixed nor stable but do instantiate a kind of operational closure. Because there is a Markov blanket, there is a boundary between the internal (system) and the external (not-system). This implies that the "brain must infer the most likely causes of its incoming signals without any direct access to the unknowable world beyond its blanket. All that the brain has to go on is the way that its own sensory states" flow and are modified (Solms 2021: 185). Perception, as Solms says, is thus really *apperception* because it "proceeds *from the inside outwards*" (Solms 2021: 185). The brain, accordingly, *infers* what is taking place external to it by measuring the regularities of internal signals which it uses to produce a probabilistic modal for predicting error or surprise. This generated model is then used to make active inferences which guide actions that are used, in turn, to "generate new sensory samples" so that the model can be further updated, "which it must do because models are imperfect things. This leads to new actions; and so on" (Solms 2021: 185). The implication of the process proceeding from the inside outwards is that the higher cortical levels of the brain have to actively infer or predict lower states, "all the way down to the changing states of our sensory receptors and physical actuators" (Anderson 2017: 5). Actions, from this point of view, can be seen as experiments, as Solms argues or, in Deleuzoguattarian vernacular, mappings rather than tracings. Recall that Deleuze and Guattari argue that a mapping "does not reproduce an unconscious closed in upon itself; it constructs the unconscious" (1987: 12). This would seem entirely compatible with Solms's view. Consciousness, as seen here, is "an experimentation in life", "an emission of particles-signs" that aids the *construction* of the body without organs (Deleuze & Guattari 1987: 134). But while emphasizing experimentation, Deleuze and Guattari also emphasize that there is a relationship between consistency, redundancy and experimentation. In fact, they frequently call attention to "injections of caution" as "a rule immanent to experimentation" because the construction of the BwO can be botched (Deleuze & Guattari 1987: 150). Even worse, it can destroy the circuits of desire, unbind the drives

minimization.

and short-circuit individuation and transindividuation processes. As they remind us: "It is nondesire as well as desire" (Deleuze & Guattari 1987: 149). Similarly, Solms argues that while action, and therefore experimentation or SEEKING[5], takes precedence over perception, "blind action is of little use"; one's model of the world must be carefully, if continuously, updated so that the acquired predictions — which become the conditions of experimentation — are "nuanced over time from incoming error signals" (Solms 2021: 187). But what impels action?

The answer, as you may have surmised, is *affect*. To summarize Solms's position briefly, he argues that affects are *always* conscious. Affects are thus differentiated from unconscious needs which the body can deal with autonomically through self-regulation. When you become aware of a feeling or affect, consciousness enters the equation. This is because affects are meant to convey to biological systems how well or badly things are going for them. In other words, feelings, or *felt* needs, are prioritized over unfelt ones and are themselves prioritized probabilistically. "This is done on a contextual basis. Priorities are determined by the relative strengths of your needs (the size of the error signals) in relation to the range of opportunities afforded by your current circumstances" (Solms 2021: 100). This is, interestingly, quite close to how Deleuze and Guattari view affect. According to them, affect is the nonhuman becoming-expressive of sensation (1994: 167, 169). Without its becoming-expressive, hence conscious, it would simply remain virtual. Once expressive, however, affects function as "an extended form of homeostasis which is a basic biological mechanism that arose naturally with self-organisation" (Solms 2021: 302–303). By hedonically valancing biological needs and, according to priority, triggering the actions needed to return a system to homeostasis, affect becomes "*the* fundamental vehicle" for the minimization of free energy, the "primary medium of volition" and the "fount of all mental life" (Solms 2021: 188). Affects, moreover, enable a system to mobilize the information it gets from its Markov blanket and, in so doing, minimize prediction error which in turn minimizes information flow, which again reduces metabolic expenditure; hence, entropy.[6] So what happens when affects are arrested or bypassed?

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5 Jaak Panksepp calls "the brain circuit responsible for 'the most energised exploratory and search behaviours an animal is capable of exhibiting'" the SEEKING system (Solms 2021: 28). For a more detailed analysis thereof, see Aragorn Eloff's article in this special issue.

6 This summary cannot possibly do justice to Mark Solms and Karl Friston's theory and I would urge readers to read Solms's *The Hidden Spring* (2021), as well as articles on the free energy principle by Karl Friston. It is also worth noting that although much needed critique of this theory is starting to appear, what I have used in this article holds for me.

This is your brain on algorithms: Algorithmic reason, deep learning and the movement of the mind

Artificial intelligence and deep learning are "having a moment", as Benjamin Bratton puts it (2015: 70), though dreams of creating intelligent machines — meaning machines that are at least as or more intelligent than humans — is centuries old. Recent approaches to creating intelligent machines differ vastly from research before 2010 which were aimed at representing human knowledge through the manipulation of symbols via explicit rules or logic. After 2010, "one family of AI methods — collectively called deep learning (or deep neural networks)" — became the dominant paradigm, so much so that artificial intelligence is often conflated with deep learning (Mitchell 2019: 8). To be clear, artificial intelligence (AI) "is a cross-disciplinary approach to understanding, modeling, and replicating intelligence and cognitive processes by invoking various computational, mathematical, logical, mechanical, and even biological principles and devices" (Frankish and Ramsey 2014: 1). Deep learning, a method inspired by neuroscience, is one approach among many in the field of machine learning to achieve this. Typically, a deep neural network (DNN) uses multiple or 'deep' layers of units, along with highly optimized algorithms and architectures. A breakthrough in DNN methods occurred with the advent of back-propagation which, as its name implies, "is a way to take an error observed at the output units" and "to 'propagate' the blame for that error backwards" so as to "assign proper blame to each of the weights in a network" (Mitchell 2019: 31). This allows a neural network to learn from error by determining how much to gradually modify the weights on connections in each layer in order to reduce the output error. The neural network is thus arguably using a form of reasoning, in this case, feedback and error correction; hence, the term *algorithmic reason*. Importantly, a DNN learns what *it* observes in a dataset, rather than what a human might. "If there are statistical associations in the training data, even if irrelevant to the task at hand, the machine will happily learn those instead of what you wanted to learn" (Mitchell 2019: 122). Characteristically, data consist of a mix of pattern and noise. When a network too rigidly learns patterns present in the training data, it results in poor performance when tested on new data. For example, you may want a model to learn how to distinguish between images showing a face and those that do not. Imagine that the original data set slants towards images with white male faces. What may occur when the model is tested on a new data set with more diverse faces is that it might incorrectly label women or people of colour. "Camera software for face detection is sometimes prone to missing faces with dark skin and to classifying Asian faces as 'blinking'", reflecting not only the biases in data but also in society at large (Mitchell 2019: 124). The model has, in other words, failed to *generalize* what it has learnt, whereas an effective model would neither over-extrapolate nor over-interpolate patterns from the training data set. In a word, the model is *overfitted* to white male faces.

In contemporary life, algorithms are deployed so widely that they could be said to be infrastructural, the implications of which are both geopolitical and philosophical (Bratton 2015: 69). "From the rationalization of labor and social relations to the financial sector, algorithms are grounding a new mode of thought and control" (Parisi 2015: 125). Driven by a money-information logic, the new cognitive-affective regime is one marked by what Deleuze recognized as continual modulation and adaptation, "a universal system of deformation" (1992: 5). But what guides this continual modulation and adaptation? Bernard Stiegler argues that it is *automation*. According to him, we are in the digital stage of grammatization, where grammatization refers to "the history of the exteriorization of memory in all its forms", including "nervous and cerebral memory" which pertains to the linguistic, auditory and visual; "bodily and muscular memory"; and "biogenetic memory" (Stiegler 2010: 71). To be sure, memory and knowledge are "originally exteriorized", meaning we have always exteriorized these, at least partially and mnemotechnically, for example via tools, artifacts and even rituals (Stiegler 2006). The reason for this is that exteriorized memory, or *hypomnesis*, frees functional memory or *anamnesis* from its total dependence on the human mind. This occurs according to certain logics and techniques, or *technē*, for example orthographic grammatization which extends oral technologies through writing, printing and painting. The point is that grammatization constitutes a "relationship between understanding, reason, imagination and intuition that comes to be transformed" (Stiegler 2019: 240). Like many of Stiegler's concepts, grammatization is a *pharmakon*, curative and poisonous at once. In its positive iteration, this exteriorization supports intergenerational and transgenerational memory which are needed for the construction of collective futural projection and action (Stiegler & Rogoff 2010). In its negative iteration, grammatization *disrupts* the production of what Stiegler calls "long circuits" — that which allows for *transindividuation* which, as the term implies, resides *between* the 'I' and the 'we' in a procedure of co-individuation, transforming both 'through one another' (Stiegler & Rogoff 2010). When, however, individuals interact with commercially deployed machine learning models in real time, they "grammatize their own behaviour" without maintaining long circuits (Stiegler 2018: 46). This kind of grammatization has been accelerated in societies of hyper-control due to the virtually continuous connection we have with mnemotechnological devices and the near-automatic 'dumping' of memory into these devices — cellphones being paradigmatic. These new hypomnesic systems have transformed hypomnesis into storage where externalized memory is kept without being used. All the while our data is being mined, alongside our attention and affective neurotransmitters and hormones, like dopamine, via mechanisms such as scrolling, clicking and liking. Consequently, thought has been transformed into unused memory and automated performativity. Scroll, scroll, scroll, like, scroll, heart, scroll, sad face, scroll, scroll, scroll, click, scroll, click, scroll…

According to Stiegler this has initiated a "*structural loss* of memory" a disruption of *all* forms of knowledge — and it is precisely this disruption that he conceives of as a *gener-*

alized proletarianization: the loss of work-knowledge (*savoir-faire*), life-knowledge (*savoir-vivre*) and conceptual knowledge (Stiegler 2006; 2019: 14). Instead, we have automated knowledge. This leads me to reconsider what exactly algorithmic reason is because, following this argument, I do not think it is reducible to computer thinking, nor even does it amount to a relation between computers and their associated milieus — *us.* Rather, algorithmic reason is constitutive of the melded human-machine brain which now functions as an autopoietic system. The computer is no longer a metaphor for the brain because the brain *is* the computer. A real cybernetic movement in thought has occurred, similar to the real movement in the image brought about by cinema, as Deleuze argues in his *Cinema* books (Deleuze 2007: 288). It's not just that cognition is controlled via a set of instructions, prescriptions, functions and feedbacks, it's that the fused human-machine brain, at the behest of the machinic part, has become "capable of generating its own conditions of reference" (Varela 2009: 66). Consequently, algorithmic reason *is* the movement of the mind because the computer and the brain *together* form *a single* closed system which functions according to circular processes of metabolic exchange. Stated differently, the algorithmic sensory loop "both expresses and is subordinated to the system's autonomy, to the maintenance of its autopoiesis" (Thompson 2009: 82) which, in this case, is driven by the capitalist-noetic nexus of the algorithmic condition. This shift is not merely technical, meaning a transition from analogue to digital, as Stiegler argues, but *organological* — a question of life and the living subject, where the biological has become technical, organized by the organic as much as the inorganic. The result of this is that the brain starts functioning like an overfitted network, an overly stratified BwO, which does not only mean that human brains over-extrapolate and over-interpolate patterns from the algorithmic systems they engage with, but also implies that there is no Markov blanket *between* the human mind and the computer network. The Markov blanket of the computer network *is* the Markov blanket of the brain. Essentially, algorithmic systems have hijacked human cognition, as well as their control mechanisms for error correction. So, when we *buffer*, we passively absorb or damp algorithmic perturbations, such as flashing advertisements. Similarly, *feedback* and *feedforward* require action to suppress or compensate for the effects of perturbations, but if what we are sensing is the state of a corrupted Markov blanket, our information-gathering processes also become corrupted, leading to diminished capacities to anticipate the effects of perturbations on our systems' main goal, namely surprise minimization and the counteraction of entropy. Moreover, living does not consist only of cognitive processes, but is made up also of affective ones which are themselves topological and noetic. Recall that emotive processes help us make sense of our world by "bringing signification and value into existence" which they achieve by hedonically valencing needs vis-à-vis "attraction and repulsion, approach or escape" (Thompson 2009: 82). When your affective states are hijacked by, for example, Twitter feeds, the mechanism by which felt needs are prioritized contextually becomes confused, leading to errors in probabilistic prioritization. Remember that affects are what enables a system to mobilize the information it gets from its Markov blanket which, in turn, allows a system to minimize prediction error and information flow, ultimately reducing metabolic expenditure and thus entropy. In this new autopoietic system, however, affects are confusedly dampened and highlighted according to capitalist-noetic recursivity, unbinding the drives through an automatization that reticulates noetic life and so induces a loss of reason, and reasons for living and dreaming. *This is your mind on algorithms.*

Dreaming: "Opening the Valves of Sensation"

In *The Neganthropocene* (2018), Stiegler argues that algorithmic governmentality and digital grammatization divert and short-circuit both individual and collective protentions, or the long circuits needed for the construction of collective futural projection and action "by outstripping and overtaking the noetic capacities of individuation, and doing so precisely insofar as the latter are protentional capacities" (2018: 46). This short-circuiting or disruption "of psychic and collective protentions, replaced by automatically generated protentions, impedes dreaming, wanting, reflecting and deciding, that is, the collective realization of dreams" (Stiegler 2018: 46). The destruction of sleep and dreaming so prevalent in contemporary society is, as reflected here, of great concern to Stiegler who understands dreaming as a negentropic activity because it creates — one might even say fabulates — new relations between retentions. This resonates with Solms's research on dreams where he found that "the 'wishful' SEEKING circuit lights up like a Christmas tree during dreaming sleep" (2021: 36). SEEKING, as he later argues, is in fact "our 'default' emotion. When we are not in the grip of one of the other ('task-related') affects, our consciousness tends towards this generalised sense of interest in the world" (Solms 2021: 108). Interestingly, the command neuromodulator for SEEKING is dopamine — which is of course extensively mined by algorithmic processes — but even more fascinating is that SEEKING is aroused during sleep "by demands made upon the mind for work, leading to problem-solving activities which must be guided by conscious feelings. Hence we dream" (Solms 2021: 108). Dreaming, accordingly, is one of the mechanisms for memory consolidation and reconsolidation — the latter of which is especially important for dealing with states of uncertainty and minimizing surprise. Dreams, Solms argues, are a form of problem-solving and are, as such, conscious activities (2021: 229). Remember that needs cannot all be felt at once and must be prioritized so that the actions generated can follow this prioritization. But actions are voluntary, "which means they are subject to here-and-now choices rather than pre-established algorithms" (Solms 2021: 303). This is what allows for the contextualization of felt needs and for choices to be made "on the basis of fluctuating precision-weighting" of "the incoming error signals that are rendered salient by prioritised needs" (Solms 2021: 304). The aim of this is, of course, to minimize uncertainty and maximize confidence through probabilistic prediction. This, precisely, is what reconsolidation is. When affect is arrested or bypassed, however, proactive engagement with surprise or uncertainty is negatively affected and the return to metastable equilibrium impeded. Here we can think not only of dreamlessness but of the sharp increase in mental illness and addiction induced by technological over-dependence, especially in younger generations, counting ADHD, depression, *hikikomori* or extreme social anxiety and isolation, and what has been termed 'snapchat dysmorphia' — "an obsession with perfect and perfectible appearance, exacerbated by tools on platforms like Snapchat and Instagram which provide filters for feature enhancement" (Gray 2022: 78). This is not to say that at least some of these conditions did not preexist; the point, rather, is that they are exacerbated to the extreme in the algorithmic condition we find ourselves in. Of specific importance here, though, is the loss of sleep, and specifically dreamless sleep, because it "leads to an overfitted brain that can still memorize and learn but fails to generalize appropriately" (Hoel 2021: 1). Dreaming, in short, helps us improve generalization and, in so doing, regenerate our noetic capacities of individuation, which is to say our protentional capacities, which include futural projection and action; that is, surprisal minimization. So the question is: *How do we dream again?*

The artist, Francis Bacon, provides a clue in describing his wish for the images he produces to open up "the valves of sensation" (Angelucci 2014: 407). We may think of this as a "program of intensification" in partnership with a "procedure of rupturing" (Deleuze 2004: xiii). In his work on Bacon, Deleuze describes Bacon's breaking with both figurative (representative) and abstract art as the *figural* — a discovery of rhythm, and specifically *distributed* rhythm (Deleuze 2004: xv). This distributed rhythm — which Deleuze and Guattari describe in *A Thousand Plateaus* as a "generalized chromaticism" or the placing of "elements of any nature in continuous variation" from which "new distinctions" can emerge (Deleuze & Guattari 1987: 97) — can be thought of as a characteristic of the logic of sensation. It appears as a set of *asignifying traits* — vital forces that extend, in Bacon's case, "beyond the edges of the painting" (Deleuze 2004: 1) but which, more generally, can be thought to extend beyond a specific moment. These *sensations*, whether chaotic, terrestrial or cosmic, "are no longer the problem of the place, but rather of the event" (Deleuze 2004: 15). Because it is related to the event, sensation, or affect, should be seen as interrelated to *force* and the *outside.* "Force", writes Deleuze, "is closely related to sensation: for a sensation to exist, a force must be exerted on a body, on a point of the wave" (2004: 56). But, Deleuze goes on to argue, "if force is the condition of sensation, it is nonetheless not the force that is sensed, since the sensation 'gives' something completely different from the forces that condition it" (2004: 56). This something different from the forces that condition it signals a relation exterior to its terms, a relation to the Outside. In other words, for affect or sensation to become expressive, it has to undergo a violence which forces us out of complacency by bringing us in relation to the

Outside so that we can become sensitive to signs or, in a different tenor, to the states of our Markov blankets. This becoming-sensitive is not representative because signs, for Deleuze, are that which escape representation even though they emerge from fields of representation. Thus, signs have a double aspect: they refer "to an *implicated* order of constitutive differences" (Deleuze 1994: 228, emphasis added; see also Zourabichvili 2012: 56–75) but can only be grasped as a problematic field once they have been *explicated* vis-à-vis sense which establishes communication between heterogeneous series. Once such communication is established, "events explode, phenomena flash, like thunder and lightning. Spatio-temporal dynamisms fill the system, expressing simultaneously the resonance of the coupled series and the amplitude of the forced movement which exceeds them" (Deleuze 1994: 118). But these "terrible movements" can only be sustained "under the conditions of a larval subject" (Deleuze 1994: 118), because a larval self is a self in metastable equilibrium, an individuating system amid process of individuation. As Simondon explains:

> In the living being there is an individuation by the individual and not merely an operation resulting from an individuation completed in a single stroke, as though it were a fabrication; the living being resolves problems, not just by adapting, i.e. by modifying its relation to the milieu (like a machine is capable of doing), but by modifying itself, by inventing new internal structures, and by completely introducing itself into the axiomatic of vital problems. (Simondon 2020a: 7)

A larval self is a passive self (synthesis), the support of the dynamisms of individuation (Deleuze 1994: 118). In effect, the larval self is "a pure spatio-temporal dynamism, with its necessary participation in the forced movement" (Deleuze 1994: 118). Think of an embryo, constituted of "vital movements, torsions and drifts" which it can easily sustain but which would tear an adult apart (Deleuze 1994: 118). This is why Deleuze says it is a "terrible movement" that only a larval self can sustain. The larval self, to put it differently, is *perplexed* because it is forced to pose a problem "as though the object of encounter, the sign, were the bearer of a problem — as though it were a problem" (Deleuze 1994: 140). This problematic — a tension or disparateness — is the primer for individuation, Stiegler's protentional capacities. Thus, in order to counter algorithmic reason as the movement of the mind augured by automation, we have to become larval selves so that we can become sensitive to signs and, thereby, capable of being affected. Sense is thus the counter-movement of the mind because it forces an encounter with signs, that is, with sensation or affect which engenders a becoming capable of being affected. For Deleuze and Guattari this idea is deeply connected not only to individual health, but also to politics and our capacities to collectively produce healthier forms of sociopolitical organization. In our current algorithmic societies, these capacities have been short-circuited, producing disaffected individuals through the unbinding of the drives and a concomitant withdrawal 'that generates disbelief, miscreance and discredit' — a feeling that life is not worth living (Stiegler 2019: 190). Becoming capable of being affected is the first step towards making reasonable that which initially was senseless. It is nothing short of a noetic act — an encounter with a sign that forces thought within thought. The logic of sensation, or the opening of the valves of sensation, is that which allows for the new to emerge, because it constitutes an *untimely* experimentation and is, therefore, not constrained by time in the sense of the present, the eternal or the historical. Rather, it is that which acts *counter to* and thus counter-actualizes our time for the benefit of a time yet-to-come, a people yet-to-come, but in the here and now (Deleuze 1997: 107).

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