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Nerves of data: the neurological turn in/against networked media

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Over the last year or so, a loose idea, albeit one with ‘hard’ evidence, has been gathering speed – ‘the neurological turn’ in humanities and social science discourses, particularly in analyses of screen and new media technologies and reception. The neurological turn refers mainly to the resorting to neuroscience by non-neuroscientific scholars, journalists and commentators for evidence of the ways in which, variously, the internet, gaming, screens in general, databases and all manner of informatics devices are changing the ‘wiring’ in our brains. Probably the best known of these turns toward neuroscience has been Nicholas Carr, whose 2008 article for the *Atlantic* magazine, ‘Is Google Making Us Stupid? What the Internet is doing to our brains’[1] was so widely discussed in both print media and the blogosphere that it garnered its own Wikipedia entry.[2.] Observing that his own reading habits seemed to be changing as a result of constant skimming and hyperlinking in the online context, Carr, in spite of making his name as a blogger/journalist, bemoans the loss of meditative, deep thought about the world, ‘Once I was a scuba diver in the sea of words. Now I zip along the surface like a guy on a Jet Ski.’[3] Although Carr here does not offer any neuroscientific evidence of his niggling fears about his drifting synapses, he does refer to another author who could be said to sit amid these spectra of ‘neuro’ turns, Maryanne Wolf. A developmental psychologist, Wolf had, a year earlier, published another tome that worried about our failing capacities to think and read with any depth in an age of surface-oriented media.[4] Carr later went on to develop his argument in his most recent book, *The Shallows* armed with a swathe of neuroscientific ‘evidence’ demonstrating the internet’s neuroanatomical impact.[5] Furnishing images of the brain taken *in vivo* while subjects surfed the net, functional Magnetic Resonance Imaging (fMRI) studies, conducted by psychiatrists who are likewise convinced of the impact of contemporary technologies on our ‘wiring’ seem to offer incontrovertible truth of a rapid rewiring.[6]

This ‘turn’ toward neuroscience has struck those in the humanities of a certain generation, and with at least some vested interest in ‘literature’ and scholarship, the hardest. Although not in quite the same vein, Katherine Hayles has also lined up to fret about the potential loss of deep thought and reading.[7] And along somewhat different lines, Bernard Stiegler sees a new formation of biopower – psychopower – emerging, whose pharmacological and neural marketing technics work at the level of the neuronal capture of an entire younger generation’s attentional capacities.[8] This is a rather amorphous crowd, admittedly, yet murmurs and observation of this growing shift toward neuroscience to bolster evidence for the damning decline in literary and cognitive standards are registering across contemporary media analysis. Geert Lovink, for example, has recently named this ‘a neurological turn in internet criticism’, and he points out that this is also taking place in a German-speaking context.[9] It climbs on the bandwagon, he argues, of a current obsession throughout the media with mind and consciousness, especially evidenced by all and any reporting of neuroscience and its penetrating imaging of our insides, from locating the brain’s centre for happiness using fMRIs to the role of mirror neurons in all and any example of human cognition. Indeed, at the end of 2011, a group of actual neuroscientists, science and technology scholars and philosophers will hold a workshop in Berlin to discuss ‘the neurological turn’, a phenomenon they see encroaching into a variety of social and cultural spheres and blowing out of proportion claims made in the name of neuroscience.[10]

Like Lovink, I share a concern with the ways in which analysis of contemporary media is resorting to neuroscience, drawing especially on the indexical power of its images to prove that our minds are ‘devolving’ in some shape or form. But I think that such amassing of images and studies in internet and media analysis requires closer attention. We should not turn away form neuroscience altogether and engage only in more obviously social and political critiques of internet, gaming or screen media trends. If the ‘neurological turn’ in and against networked media is a nebulous forking pathway, stretching its tendrils across a range of heterogeneous neurosciences, neuroscientists, networked media entities and media theorists, it is nonetheless materially embedded in the techniques and visuals of functional magnetic resonance imaging. Functional Magnetic Resonance Imaging (fMRI), with all its promises and claims to be an *in vivo* lens; a real time mind movie; the soundtrack to the brain’s activities. As thinkers in areas other than science, we need a greater understanding of what constitutes the materialities of the neuroscientific image and how such materialities engage with the ubiquity of ‘real time’ media imaging vectors, for example.

But I will also argue here that the neurological turn against, in particular, networked media comprises part of a ‘neural’ continuum in which the technics of contemporary media are more and more imbricated. This continuum stakes out a more generalized uptake of the neural as a means for extending a kind of symbiosis between new forms of software, computational architecture and soft ‘thought’. As it turns out, the recent push toward developing a general and global ‘artificial intelligence’ to accompany and ultimately overtake online search by networked corporations such as Google, also turns toward the neural. As George Dyson revealed as far back as 2005 after visiting Google HQ in Mountain View, the corporation had already begun its quest to capture the world’s data in order to build a form of distributed artificial intelligence: “We are not scanning all those books to be read by people,” explained one of my hosts after my talk. “We are scanning them to be read by an AI.”[11] This may seem a long way from fears about the internet rewiring the brain. Yet, I want to suggest, it occupies part of a broad neural spectrum that pervades networked media research and development. A neural spectrum in which, at one end, it is asserted that our media rot our brains; and, at the other, a more subtle insertion, in which networked media interstitially territorialise circuits of thought and action. Google’s shift from search to AI, pre-empted in 2005 and announced more formally by Eric Schmidt Google’s CEO in 2010, stakes a claim over a new space for soft thought.[12]

Google is not alone in using a branch of AI – specifically machine learning – to extract pattern from data; Amazon’s recommendation system for purchasing has set the pace already for data mining customers’ purchasing habits. But in using a number of machine learning operations, particularly in developing its new Prediction API, which I discuss later in this article, Google occupies an increasingly large slice of this neural spectrum. It expressly ties the development of such software to its desire to become the information architecture which functions *before* we consciously think, search, act. This, I will suggest later, is not so much the space of cognition but rather the territory of the pre-cognitive: that grey area of the ‘just before’ of consciousness and intentionality, where networked corporations increasingly want to insinuate themselves. All those ‘ we recommend’ emails, those ‘like’ icons and those privacy settings we forget to activate are harbingers of a ‘neuro-perceptual’ soft apparatus that will soon claim to know what we want to think, where we want to go, what we want to purchase before we do. As it turns out, then, the neurological turn against contemporary media may have little impact on the same media’s overall predilections for an increasing bandwidth on the neural spectrum.

I will begin by looking at two different examples and deployments of fMRIs. In his recent book, *The Shallows*, Nicholas Carr refers to and uses a 2007 study as evidence of – as the book’s subtitle stridently asserts – ‘what the Internet is doing to our brains’ (2010a: 120-126).[13] The fMRIs come from a neuro-sociological study by psychiatrist Gary Small who exposed both ‘naive’ and ‘savvy’ participants to online ‘hypermedia’. In these studies, Small’s resulting fMRIs function as visual indicators of structural neuro-anatomical change; before and after the brain makeover shots that document the fundamental fact that something has occurred to alter the neuro-anatomical structure of the brain. The second example is a ‘generic’ fMRI image, not from a study but rather ‘a sample’ used to persuade people of the efficacy of a commercially available ‘neuro’ product. The image is a series, a sequence of changing areas of the brain ‘lit’ up as a result of an fMRI being run on a subject. It sits on the homepage of the *No Lie MRI* company, which hosts a suite of test centres across the US catering increasingly to the legal profession·The image sequence appears on the bottom of the ‘Product Overview’ page of No Lie MRI’s website at URL: http://noliemri.com/products/Overview.htm fMRIs are geared toward capturing the neural response involved in intentionally telling a lie when a participant is asked a series of questions. The subject’s *in vivo* neural responses are then measured to see if there is a level of excitation of neurons in areas of the brain associated with anticipation and intention, suggesting the subject is lying. Here the fMRI operates as a visual index of process – the brain caught in the act of anticipation, of something to come.

As a record of process, of something that is in the middle, and about to be, the fMRI is indicative of a changing brain as it mobilises the subject in order to *not* speak the truth. Importantly, the indexical claim made by such an image rests on three important functions attributed to neuro-imaging, and especially imaging processes such as fMRI. The first is that neuro-imaging infallibly accesses brain processes and maps these processes in a manner similar to photography and cartography.[14] That is, it provides direct vision or correspondence to an area, which, due to scale, lack of accessibility or technical deficiencies, the naked eye cannot see unaided. As Dumit has argued, neuro-imaging has come to assume the evidential status of older visual technical modes of imaging.[15] The second is that neuro-images claim to capture the neural correlates of mental processes, especially in studies such as those conducted by Small on the 'browsing' brain or by claiming that an intention to lie correlates with certain areas of neural excitation. As a result, in locating anatomical change or activity in the brain, as is the case with Positron Emission Tomography (PET) or fMRI, inferences are then made to states of mental and emotional life.[16] The third, resting on both previous claims, is that as an imaging technique such as fMRI accesses the invisible neurobiological cornices of our behavior, it does so in real time. It furnishes us with *motion capture* of something we are not visibly, intentionally or actually capable of accessing, yet is said to be taking place within us. It is this third claim, tethered as it is to a contemporary media reality of the *moving* technical image of real time events, that gives fMRI its newly emerging status as pre-indexical, pre-empting action, like being about to tell a lie, before it has even happened. The claim made by a company such as *No Lie fMRI* that an fMRI visualises anticipation, indicates the ways in which the neurological image also comes to occupy similar space as Google's predictive software research and development along the continuum of a broadening cultural 'neuralism'. But as we shall also see, fMRIs are not visual images in the same way that even the digital photograph, is a visual image. As its name states, the fMRI is a *functional* image; that is, it dynamically images cerebral blood activity as a function of time. When we simply compare a before and after image, as Carr's reference to Small's study reproduces, we freeze frame the functional and durational aspects of the imaging and focus instead on what comparisons the two images seem to morphologically proffer.[17] If we want to deploy fMRIs in a nontherapeutic and cultural context, we must be savvier with our relation to the more dynamic and plastic character of complex, computational visual artefacts.

Soft nerves, hard data

Both uses of fMRIs as visual techniques and technologies raise a number of political and conceptual issues about the status and deployment of the neurological as material artefact, which I will return to later. But for the moment I want to note how the expanding, diffuse mobilisation of techniques such as fMRI, signals an increasing *turn toward* the neural as a means of thinking, acting in, negotiating and shaping the contours of contemporary media and culture. Thought, focus, attention – especially of the so-called 'iGeneration' of 18-24 year-olds – and the synapses themselves have increasingly been characterised as deteriorating, being in a state of crisis or under attack, targeted by economies, techniques and cultures of fragmenting and accelerating media. Computational culture's revving up/dumbing down tendencies effect a significant shift, according to Carr, away from depth and substance toward the flatlands of surface insignificance, 'the shallows':

…our online habits continue to reverberate in the workings of our brain cells even when we're not at a computer. We're exercising the neural circuits devoted to skimming and multitasking while ignoring those used for reading and thinking deeply[18]

For those at the alarmist end of the turn to the neurological in media analysis, the software and hardware of media technologies are literally turning our 'wetware' to mush, transforming our nerves of steel to nerves of data.

I am not as interested here in rehearsing these quite different positions about the effect of contemporary media upon the matter and capacities of our brain, as I am in following the vectors of the turn itself. Although such writers view the neurological ills and benefits of contemporary media differently, they nonetheless wholeheartedly *turn toward* neuroscience as the substrate from which to garner evidence for their claims about media effects. The most strident of these claims – particularly by Carr, Greenfield and earlier Wolf as to the actual 're-wiring' of the brain's structure by exposure to the computer screen and net – also signal *a turn away* from contemporary media technologies and culture. Both Stiegler and Hayles' arguments are more nuanced. Nonetheless they conjoin with Carr and Greenfield inasmuch as the vector they follow deploys neuroscience evidentially yet simultaneously deploys nebulous 'entities' such as 'the mind', 'attention' 'generations' 'youth' and 'the internet'. But it is precisely the unproblematic unity and homogeneity of such entities that is questioned by a number of contemporary neuroscientists: Vilanyur Ramachandran's behavioural neurology or Steven Rose's neurobiology, for example. It pays to pay attention to the kind of neuroscience being evoked by the neurological turn against networked media.

The other turn that I want to chart in tandem with the above is the turn in networked media itself toward systems, tools and processes of what I will call 'neuro-perception'. This includes, for example, the development and implementation of Google's Prediction API tool (part of its self-conscious switch in systems development from 'search' to artificial intelligence), which is in effect a marriage of cloud computing with predictive AI. This is part of networked entities and corporations' growth and use of data mining systems that learn from and model data in order to predict future directions. In fact, this turn has been taking place for some time. During the 1990s, when we were, on the one hand, experiencing an explosion in the life sciences and artificial life, artificial intelligence research was nevertheless ticking along. But as John Johnston has suggested, AI priorities largely shifted away from the construction of human-machine intelligence and the goal of creating an artificially intelligent 'mind', and over to 'practical' applications for industry and for the military.[19] A raft of 'smart applications' were tried and tested such as electronic fraud detection, voice and face recognition and data mining systems.

This, too, signals a neural turn but a qualitatively different one from the idea that networks and media are rotting our brains. Rather this R&D is imbricated in generating and deploying a distributed, networked architecture and infrastructure that still owes a debt to mid-twentieth century cybernetic insights. In particular, to Warren McCulloch and Walter Pitts conception of the movement of the brain's electrochemical impulses through neural circuits as a form of biological computation.[20] Importantly, McCulloch and Pitts drew a formal analogy between the activity of neurons acting in neurophysiological networks in order to receive and transmit electrical signals and the 'activity' of logical propositions and their networks of relations:

The "all or none" law of nervous activity is sufficient to insure that the activity of any neuron may be represented as a proposition. Physiological relations existing among nervous activities correspond, of course, to relations among the propositions; and the utility of the representation depends upon the identity of these relations with those of the logic of propositions.

In fact, McCulloch and Pitts shed less light on the brain's activities and more on a mode of thinking computationally beyond simple input-output models of information processing. Their paper gave impetus to the modeling of *artificial* rather than biological neural networks and initiated research into questions of modeling learning and adaptation in AI. What this analogy between physical and artificial neurons facilitated was a kind of backwards and forwards mapping that has also entwined and harnessed computational models of thinking to the activity of (idealised) neural correlates: '…they simplified and idealized the known properties of networks of neurons so that certain propositional inferences could be mapped onto neural events and vice versa.'[21]> Perhaps in spite of the fact that McCulloch and Pitts were aware that the 'neural' they were referring to had been largely abstracted from its biology, the far reaching implications of their analogy has meant that computational neural modeling is underpinned by some association to a neurophysiological base.

As Johnston has argued, this enmeshing of the neurobiological with the computational has continued to provide an AI research direction that is different from the concentration upon language, general intelligence and symbolic processing.[22] In a range of contemporary AI contexts that deal with large datasets, it is generally acknowledged that various models and manipulations of artificial neural networks provide the best paradigms and applications for machine learning applications that involve pattern recognition.[23] A deficiency of McCulloch and Pitts' early neural networks was that the artificial networks modeled were simply too small to compute at either a satisfactory machine-based rate or compare with the operations of the billions of biological neurons that support the generation of actual neural patterning across their networks.[24] In fact, neural networks as they now feature in AI have become largely non-biological and increasingly concerned and interlinked with branches of statistics and data analysis. This branch of AI's orientation toward machine learning now finds itself at home in information networks such as the internet and in databases. In part this is due to the fact that large enough datasets and, especially with the development of shared online platforms, enough instances of distributed parallel processing networked nodes can 'collectively' combine to create a kind of vast quasi-AI. Or at least this seems to be the dream of networked corporations such as Google, as we can glean from another infamous Eric Schmidt-'ism':

> In five years, Google will have built "the product I've always wanted to build–we call it 'serendipity,'" he said, adding that it will "tell me what I should be typing."[25]

From one angle it appears that deployment of machine learning techniques across, especially online industries, signals that biological neurality may have fled the scene of such models. Yet Google's search aspirations rest precisely upon a *reterritorialisation* of mind/intelligence in which a raft of machine learning techniques from data mining through to dataset training reclaim the non-cognitive dimensions of brain and thought for the technics of artificial neural networks.

The neural has definitively re-entered the fray when aspects of machine learning come to be applied, as they are with Google's Prediction API, to anticipating or pre-empting the domain of pre-cognitive thought-action relationships such as 'the serendipitous' or 'anticipation/prediction'. I want to suggest, then, that networked media really are re-turning to the neural in their exploration of techniques for machine learning. What they hope to territorialise via creating an AI that can, for example, 'read' large datasets, is a kind of intelligence that exists interstitially in the nebulous spaces before conscious (human) thought clearly emerges.

This vector of distributed and networked intelligence is at work in the current research and development of networked corporations such as Google as it transforms search mechanisms into a much further reaching ever-present, predictive form of AI. As Eric Schmidt has more recently claimed:

> "We're still happy to be in search, believe me. But one idea is that more and more searches are done on your behalf without you needing to type.I actually think most people don't want Google to answer their questions, …They want Google to tell them what they should be doing next."[26]

In the case of its *Prediction API*, Google releases its data mining/prediction tool to users on the basis that their data gets stored on Google servers.[27] Effectively, what occurs is that data becomes *less* distributed and more concentrated within the proprietorial grasp and confines of particular networked corporations. That stored data also becomes the testing field for a tool enabled with machine learning capacities that is likewise Google's property. This has major implications for networked cultures and for its political economies. The *Prediction API* turns out to be a way of initiating a new pathway for, or at least changing, the usual user-developer assemblage in computational culture. Rather than simply providing content (from user) for an application (by developer), the machine learning architecture of the *Prediction API*, is driven by a recursive adaptation of the data/content by and into the development of the application itself. There are of course precedents here across all kinds of software development communities – gaming and open-source code for example. But machine learning changes the game plan – it *automates* the development process making it in some fundamental ways non-participatory.

What crucially differentiates this neural vector from the one that concerns Carr, Greenfield and others, is that here we are dealing with dispersed, pervasive and entangled interconnectivities. The relative unities of deep 'thought', focused 'attention', mind and brain as structure, 'the young brain', the old brain, the younger generation, the older generation (and so on) posited by the 'anti-networkers' such as Carr et. al., give way to vectors and relationalities such as artificial neurons, data-neural architectures, pattern and, increasingly, prediction that precedes reflective or intentional thought but captures areas of the attentional spectrum. Or to put it more bluntly: while we stumble around as clueless co-habitants of radically distributed, embedded, networked ecologies, Nicholas Carr is mainly worried about what is going on inside his head.

But there's more than a turn here and more at stake than a difference in neurological model and application. There's a staggering leap. How did we travel from pattern to prediction? How is it that for a networked media corporation like Google, search is morphing into a form of AI that anticipates your next move? And what implications does this assemblage of 'machine-us' intelligence, riding the slippery slope of the predictive, have for the molecularity of thought and perception and, equally, for its molar socio-technical conjunctions? With much insight, William Gibson captures this amorphous state of play and the profound affective ambivalence that such entanglements generate:

> …it [Google] makes everything in the world accessible to everyone, and everyone accessible to the world. But we see everyone looking in, and blame Google. Google is not ours. Which feels confusing, because we are its unpaid content-providers, in one way or another. We generate product for Google, our every search a minuscule contribution. *Google is made of us, a sort of coral reef of human minds and their products.*[28]

What Gibson probes is the relational architecture of 'Google-us' meshes – a brain-machine-information-perception architecture. Or, if you like, a microprocessual assemblage relaying and resonating through a socio-technical ensemble. A coral reef, in which the allopoietic generation of information incrementally folds back into an autopoietic habitat that already 'knows' what we want to see, hear and do. Google is made of/by us – the product of our connective, informatic cognition. As we contribute content, we make a 'Google-us' earth. But we also discard the integrity of our 'selves' 'minds' 'actions', as molecules of our exoskeleton are divested and become not ours. Importantly, alongside the amorphousness of such entanglements, Gibson points to? Underlines? the ambivalence we likewise experience when confronted with Google's move to an AI that *predicts* what we want to do next. We have previously imagined artificially intelligent *entities* – benign or malevolent *agents* – he asserts. But we hadn't culturally configured an AI so distributed and diffuse yet so modulating of both cognition and perception. We perhaps hadn't dreamt of *neuro-perception* as the emerging vector guiding networked corporations.

From neuro-turns to neuropolitics.

This is where the neurological turns *in* and *against* networked media bifurcate. How and where neurological architectures and processes are situated and deployed – 'in the brain' or relationally and transversally across brains and media – differs in the critiques by Carr et. al, on the one hand, and the R&D direction of Google's neuro-perceptual territorialisations, on the other. Both the neurological turn *against* networked media and the neuro-perceptual turn *toward* prediction use neuroscience and artefacts such as fMRIs and yet they remain worlds apart. The critique of networked media based upon a conception of damage done to thought, attention and youth by Carr and Greenfield radically misconstrues and misconceives the neuropolitics of contemporary networked media. Geert Lovink has raised concerns about the turn toward neuroscience in net criticism precisely because, as he laconically puts it, this plays right back into an Anglo-American media obsession with reporting the 'science of the brain'.[29] Where in this, he asks, is the economic and political analysis of Google and of the colonization of content, real time and labour?

Although concurring with these comments, I nonetheless think we need simultaneously to be asking specific questions about the *neural* micro-politics at play here and to try to figure out their conjunctions and relays with molar dimensions. Bernard Stiegler's critique of contemporary media, to be fair, does take aim at psychopower and its 'noopolitics'. He argues that the consumer or market-related and driven elements of contemporary biopower – including such phenomena as neural marketing and the pharmacological economies and subjectivations of ADD and ADHD – operate at the level of 'attention capture'.[30] But how does attention get captured? What are the technics of this capture? What indeed might a more networked or ecological understanding of and approach to media and to the media artefacts of neuroscience bring to understanding the capturing, sequestering and inflecting of attention? I think Bill Connolly's nomenclature of 'neuropoltics' is more useful than Stiegler's noopolitics because it gets at the transversal and dynamic meshwork of neurological, affective, perceptual, cognitive *and* socio-technical components at stake in thinking through what thought might be in relation to contemporary culture and politics:

> …the inventive and compositional dimensions of thinking are essential to freedom of the self and to cultivation of generosity in ethics and politics. Thinking participates in that uncertain process by which new possibilities are ushered into being.[31.William Connolly, *Neuropolitics: Thinking Culture Spee*d (Minneapolis: University of Minnesota Press, 2002), 1.]

Soft imaging the brain

Let's return to the two different fMRIs that I mentioned at the beginning of this essay. In Gary Small's study, which both Carr and Small use as evidence of the internet's ability to 'rewire' the plastic and malleable circuitry of the brain, we see the before and after snapshots. To begin with, the brain of the naïve user is relatively unwired for hypermedia. Fast forward 5 hours per day x 5 days of web surfing and this naïve brain's 'wiring' lights up differently – incontrovertible evidence that neuro-anatomical change has taken place due to networked media engagement! In a voice poised between wonder and terror at the incredible swiftness of such 'reprogramming on the fly', Carr remarks, 'The human brain is almost infinitely malleable'.[31] Yet as with all before and after shots, change itself can only be inferred. What is captured, then, is *the fact that* change has happened, indexed to the implication that what we are seemingly looking at here is that fact rendered as neuro-anatomical structure.

No Lie MRI's description of its product online tempts us with the attempt to capture the detection of a lie as it happens, by providing a kind of stop-frame animation version of the fMRI. Although, on the one hand, this could be viewed as an extension of the before and after technique, in combination with what the fMRI proposes to capture and its deployment of what it calls 'Differential activation during the telling of a lie', what is going on here is different from the Small study. Here we are in the midst of capturing *process;* the mode of attention being captured is infinitesimally more fleeting and faster than the decision to click on a weblink. *No LIE MRI* lays claim to imaging/capturing the brain during the unfolding of intentionality; that is, its promises rest upon the delivery of real time image processing. It seeks to capture the movement and change that takes place as the nonconscious neural intention to *not* tell the truth neurally initiates. It stakes this claim on the idea that what the fMRI captures is the micro-process of neurological change itself.

But what does an fMRI actually visualize? Nothing quite as simple or complex as wiring and firing or intentionality. To begin with, and as I mentioned earlier, an fMRI is not specifically an 'image-based' image. In fact, in order to become image, what is required in the fMRI is the conversion of a non-image space of data. Like MRIs, fMRIs measure a combination of signals from all over the object (often the brain) being imaged. The signals captured are composed of a series of sine waves, with individual frequencies and amplitudes. These frequencies and amplitudes are computed using a process called the Fourier transform, which converts signal from the time domain into the frequency domain. Magnetic field gradients are captured by the scanning process, and their frequencies and their rate of change is then related to the position where the signal is picked up by the scanner. The frequencies are then separated out and their amplitudes are plotted as an image. Frequently a number of manipulations in the Fourier transform space that allow for smoothing of the final image data, elimination of noise via, for example, high pass filters and so forth, take place before the 'image' of an fMRI is generated. What is being scanned and what is done to the signal captured computationally is in quite a fundamental way non-imagistic and closer, if anything, to a soft processing of audio signal. This should come as no surprise given that the image we eventually get is an image of rate of change as a function of *time*. As Joseph Dumit has shown in the realm of PET imaging, functional brain imaging at its constitutive level should not be confused with morphological images of the brain, *even* though such images appear to generate an images of the brain's morphology.[32]

Once we actually move to the area of the image, we need to further remember *what* it means to image a process of cerebral change. The areas of 'colour' we often see are converted from grayscale in the original imaging (after the Fourier transform space has been transformed into image data) and these map a 'capture' of hemodynamic response. We see the surplus of oxyhemoglobin (oxygenated blood) remaining in the veins, measured as a ratio of the increase to decrease of cerebral blood flows. Active neurons require both glucose and oxygen in order to fire and an fMRI traces the movement of blood transporting glucose and oxygen through the vascular system necessary for firing. But as is usual in the area of neurological imaging, *what* is being imaged is up for question. Are we seeing the trace of the activity of neurons themselves, for example, or are we seeing the trace of activity caused by neurotransmitters, which likewise require cerebral blood flow? An fMRI cannot distinguish these substantially – it is a mapping of oxygenated blood flow; that is, of *processes*. Furthermore, although the spatial resolution of the fMRI is remarkable, its temporal resolution is relatively poor with an estimated 4–5 second period needed for image capture during which changes in blood flow may have occurred at least twice over.

These remain areas of neuroscientific dispute. But we can be sure that what we are *not* seeing in those colour patches is a neuron, a wire, a circuit, a network or a restructure of structure *itself*. We are looking at a mathematically inflected (ratio of increase to decrease), re-coloured, afterimage selected out of dynamic processuality. Interestingly, the more the fMRI becomes visual (and especially when it statically becomes 'an' image or even two comparable images), the *less* indexical it can be said to be, given that its initial data comprises signal generated by waves. As 'an' imaging of the brain, then, we need to understand the final startling 'images' that locate emotions, states and changes as sets of cross-processed signal. What is important in this cross-processing is that *relations between data variables* such as frequency, amplitude and position are maintained.

If we were to deploy a Peircean semiotics here we could say that the fMRI is less indexical and more iconic. But in this instance the fMRI comprises a special case of the icon: the diagram. For Peirce, the icon was itself subsumed under the second category of his trichotomous classification of signs, in which signs were to be ordered by the ways they denoted their objects.[34.

Charles Sanders Peirce, 1932 and 1933. *Collected Papers*, Charles Hartshorne and Paul Weiss (eds.), vols 1–8, (Harvard: Harvard University Press), 243–63.] Icons are a kind of sign, which share the qualities of their objects, such as resemblance. Diagrams are 'in the main' a kind of icon that resembles not the object itself but the relations necessary for generating an object: '…since a diagram, though it will ordinarily have Symboloide Features, as well as features approaching the nature of Indices, is nevertheless in the main an Icon of the forms of relations in the constitution of its Object,…'[33] The Peircean diagram, while iconic, is not strictly speaking indexical. Its mimetic properties are not caused by the object to which it refers.[34] Peirce overlays image and object diagrammatically; the consistency of their resemblances lie not with cause but rather in the event of their overlay, or we might say, their *cross-processing*.

Paolo Virno has suggested that Pierce was attempting to deterritorialise the diagram's mimeticism from signification per se, making it instead into a condition for the possibility of semiosis.[35] We see in Peirce this discovery of the diagram as a method for moving reasoning away from embodying meaning or functioning as description, model or illustration, toward the diagrammatic as an event that generates novelty, 'A *diagram* is an *icon* or schematic image embodying the meaning of a general predicate; and from the observation of this *icon* we are supposed to construct a new general predicate.'[36] This also shifts the diagram away from representation toward generation. Although this is not the place to conduct a sustained argument about the qualities of soft imaging, we could speculate as to whether any fundamentally nonvisually generated computational image – that is, imaging that is computed (rather than say imagistically scanned) as a function of mathematical transforms – is always nonrepresentational and comprised not of information but rather *relations*.

Moreover, what an fMRI indicates is that we are in the middle of something. The image is not simply a tracing of action but a forwarding: this one image refers to its others both captured and (in the 4-5 second gap) not captured and tells us something else will be about to have come. And this is vitally important, because if the fMRI indicates that the brain can change because of its exposure to media or because it is about to lie, then it indicates nothing more than that the brain is always changing, always in process – something to which rewiring and lying are likewise prone. In a non-therapeutic context, the visual status of the fMRI is more diagrammatic, less cartographic. And here I mean also to invoke Deleuze and Guattari's sense that what the diagram expresses are the virtualities of imaging; the potential unfoldings that an image will have – not all of which will in actuality unfold. For them, this places the diagram in the realm of a material, yet mathematical modality of assembling intensive aesthetic elements:

> A diagram has neither substance nor form, neither content nor expression… A matter-content having only degrees of intensity, resistance, conductivity, heating, stretching, speed, or tardiness; and a function-expression having only "tensors", as in a system of mathematical, or musical, writing.[37]

Instead we might try to conceive the imaging in fMRIs differently along these diagrammatic axes, transversally drawing out the virtualities of neural processes: the brain looks like it is moving toward *this* but may also be moving toward *that*; there's a burst of activity here but then nanoseconds later there's another burst elsewhere. In contrast to when the fMRI is presented as a single image of brain change traces activity that's occurred, as a tracing of process it can also sketch a virtual future, moving us forward indeterminately to what will be unfolding multifariously somewhere else.

There's a lot we aren't seeing, that we miss. And so we have to insert, conjecture, and 'back fill'. But the fMRI corralled into 'demonstrating' structural change – as with Nicholas Carr's deployment of Small's studies of structural change in web surfers' brains – loses its virtualities. It loses the potential to express the brain changing again in response to….well, less exposure to the web, exposure to noise in the street, and so on. Losing a relation to its virtualities means it also loses its relations to the materialities that neuroscience now ascribes to brains: plasticity and dynamism. It also loses the dynamic temporal schematization of thought-action-perception that a genealogy of thinking about brain-mind has provided us. In *No Lie MRI*'s techniques and *modus operandi* for the fMRI, the indeterminacy of a dynamic, distributed brain-mind is sacrificed as such images fix neural process and feed into a neuro-perceptual politics similar to that of networked media corporations such as Google. Here the fluidity of the spectrum comprising attentional capacities is whittled down into bounded territories, captured into definitive and linear flows such as anticipation-intention and prediction-action. What both *No Lie MRI* and Google are seeking is to insert themselves at a molecular level into the temporal intervals between what we sense and what we know, harnessing attention to prediction so that we inhabit an environment where 'they' feel what we are going to know before we feel or know it. An insertion into the middle of something happening – the readiness potential of the now – in order to fold in and effectively close out an openness to futurity.

What we need, then, is a way to perceive these images dynamically as filaments of the complexity of neuro-affective-perceptual-cognition as it comes *technically* to light. This requires ecological vision. Or, put another way, the capacity to comprehend brain images as machinic assemblages, to deploy Felix Guattari's concept:

> The different components are swept up and shaped by a sort of dynamism. Such a functional ensemble will hereafter be described as a machinic assemblage. The term assemblage does not imply any notion of bond, passage or anastomosis between its components. It is an assemblage of possible fields, of virtual as much as constituted elements…[38]

As dynamic, *as* diagrammatic, *as* machinic, the fMRI casts light and shadows upon, as much as it is constitutive of, the turns – no, twists and involutions – of the current neuropolitics of networked media. A different approach to the micro-processes and politics of neuro-imaging can eke out a different relation to neural artefacts and to the materialities of brains. What is at stake is a shift away from the cartographic toward the diagrammatic and toward a different 'vision' of the relations between brains, thought and (soft) technics.

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