



King's Research Portal

DOI:

[10.1177/1357034X15623363](https://doi.org/10.1177/1357034X15623363)

Document Version

Peer reviewed version

[Link to publication record in King's Research Portal](#)

Citation for published version (APA):

Rose, N. S. (2016). Reading the Human Brain: How the Mind Became Legible. DOI: 10.1177/1357034X15623363

Citing this paper

Please note that where the full-text provided on King's Research Portal is the Author Accepted Manuscript or Post-Print version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version for pagination, volume/issue, and date of publication details. And where the final published version is provided on the Research Portal, if citing you are again advised to check the publisher's website for any subsequent corrections.

General rights

Copyright and moral rights for the publications made accessible in the Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the Research Portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the Research Portal

Take down policy

If you believe that this document breaches copyright please contact librarypure@kcl.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

The Mind Transparent? Reading the human brain.

Nikolas Rose

September 2015

Accepted for publication in *Body and Society*

Address for correspondence

Nikolas Rose

Professor of Sociology

Head of Department of Social Science, Health and Medicine

King's College London, D.4, East Wing, King's Building, London WC2R 2LS, UK

Email: nikolas.rose@kcl.ac.uk

Abstract

The human body was made legible long ago. But what of the human mind? Is it possible to 'read' the mind, for one human being to know what another is thinking or feeling, their beliefs and intentions. And if I can read your mind, how about others – could our authorities, in the criminal justice system or the security services? Some developments in contemporary neuroscience suggest the answer to this question is 'yes'. While philosophers continue to debate the mind-brain problem, a range of novel technologies of brain imaging have been used to argue that specific mental states, and even specific thoughts, can be identified by characteristic patterns of brain activation; this has led some to propose their use in practices ranging from lie detection and security screening to the assessment of brain activity in persons in persistent vegetative states. This paper reviews the history of these developments, sketches their scientific and technical bases, considers some of the epistemological and ontological mutations involved, explores the ecological niches where they have found a hospitable environment, and considers some implications of this materialization of the readable, knowable, transparent mind.

Keywords

Mind reading, neural lie detection, brain imaging, P300 wave, thought identification, theory of mind

"Le cerveau c'est l'écran"

Gilles Deleuze ¹

Do you know what I am thinking? Do I know what you are thinking? Could I ever really know what's in your mind - your thoughts, your intentions, the images playing in that internal cinema? And if *I* could know this, what about others – what about those who govern us, our authorities? Could *they* go beyond knowing our intentions prospectively from our statements or retrospectively from our actions, to predicting our actions from some kind of prior knowledge of our thoughts? And could that prior knowledge arise, not from the exterior comportment of our body or the expressions on our face, or from psychological investigations probing our state of mind, but from the brain itself? Is it, could it ever be possible to 'read' thoughts in the human brain?² Might we, as some believe, be "sleepwalking into a *Minority Report* society" where 'brain reading' is deployed to identify potentially dangerous individuals – pre-criminals - within those practices of prediction, prevention, preclusion and pre-emption that have become so salient in our current security states.³

In the US, the Department of Homeland Security is already piloting a programme known as FAST - the Future Attribute Screening Programme – to identify individuals who harbour terrorist intentions.⁴ A report in the journal *Nature* – accompanied by the almost obligatory reference to the film *Minority Report* - was entitled "Terrorist 'pre-crime' detector field tested in the United States" (Weinberger, 2011). FAST does not, in fact, seek to read brains, but focuses upon physiological indicators assessed at a distance - measures of such functions as heart rates and the steadiness of the gaze - to try to predict intentions. This has not stopped some from dreaming of a time when more direct technologies would be deployed to identify 'malintent' – technologies that do not rely on measuring surrogate proxies of intent in the body, but go straight to the brain.

In 2007, there was a flurry of publicity about some experiments by John-Dylan Haynes and his group where fMRI scanning appeared to enable the researchers to identify the intentions of their subjects before they acted (Haynes, Sakai et al., 2007). The headline in the Guardian in February of that year read “The brain scan that can read people’s intentions” and Haynes commented “Using the scanner, we could look around the brain for this information and read out something that from the outside there’s no way you could possibly tell is in there. It’s like shining a torch around, looking for writing on a wall.”⁵ And in July 2014, a BBC website publicized the work of Jack Gallant and his group under the headline “I built a brain decoder”: “What are you looking at? Scientist Jack Gallant can find out by decoding your thoughts.”⁶

What has happened here to those age old distinctions between brain and mind that have so troubled our philosophers?⁷ Of course, humans have always had their methods to discern the beliefs, feelings and intentions of others. Their readings of the eyes, faces, voices, gestures, comportment of others – usually through methods that are not conscious or calculated - appears to underpin sympathy, empathy, compassion, love, as well as suspicion, and fear and no doubt much else. These abilities have been the stuff of lives and of stories of lives for millennia. The facility of most humans to read the minds of others to detect deception and guilt is utilised in practices of investigation and systems of criminal justice, and taken for granted in crime thrillers and novels of betrayal in everyday life, in love and marriage, in espionage and war. Over the last twenty years, developments in the brain sciences – in the field known as ‘social cognition’ - have sought to uncover the neural mechanisms that underpin – or ‘subserve’ as they often say – such ascriptions of contents to other minds.⁸ Arguments that there are evolved brain regions that are specialised for reading the intentions and emotions of others, and indeed ‘feeling their pain’, are moving out of the laboratory, not only into the psychiatric clinic – explaining disorders such as autism in terms of anomalies in the mind reading capacities of those diagnosed⁹ – but also – hesitantly

and often controversially - into forensic psychiatry, notably in debates about the neural basis of 'psychopathy'.¹⁰

But while social neuroscientists have sought to establish the neurobiological basis for the human *capacity* to read intentions, beliefs or emotions in the minds of others, and to characterise the pathologies that result from brain damage or other anomalies in such capacities, they have usually stopped short of suggesting that another – your conspecific, your spouse, your boss, your government – can 'read' your brain to access the *specific content* of your thoughts or of your memories, the precise details of your beliefs, the nature of your intentions, the exact form of your desires.¹¹ As far as memories are concerned, every student of neuroscience knows of Karl Lashley's search for the location of the elusive 'engram' in rodents (Lashley, 1950), and Wilder Penfield's experiences with his epileptic patients who seemed to recall some memories when certain locations on their cortex were electrically stimulated during operations to ablate their focal lesions (Penfield, 1952). The existence of identifiable cerebral locations of such memory traces – even in rats let alone in humans - has long remained contested. Recently, however, a number of neuroscientists have claimed that they are able to use neurotechnologies to identify not just memories, but also specific thoughts, beliefs and intentions in the brain itself. Although most of the researchers resist the application of the term, popular reports have been quick to dub these endeavours 'mind reading'.¹²

These attempts to identify thoughts and memories in the brain itself are directed towards practical applications in diverse areas: security and crime control, the development of prostheses for military personnel injured in battle, and clinical sites where patients are unable to express their thoughts and intentions in normal ways.¹³ They are clearly 'dual use' technologies, that is to say they can be utilised for civilian and therapeutic purposes, as well as in military and security practices, in surveillance, warfighting and even mind-control. However, over and beyond these specific

deployments, and the familiar ethical conundrums that they generate, I want to suggest that this new capacity to 'read' mental events in the tissues of the brain, may have consequences for our very understanding of what we are as humans – that is to say, it is, potentially, an event in historical ontology. Philosophers, psychologists and philosophically minded neuroscientists have long debated issues of dualism and materialism, and that debate will undoubtedly continue. Critical scholars from science and technology studies and elsewhere have pointed to the fact that much contemporary neuroscience attributes capacities to the brain on the basis of experimental findings in highly artificial laboratory contexts (e.g. Cohn, 2008; Cohn, 2008), without addressing the reality that brains are constitutively embodied, saturated by and dependent upon their constant transactions with inputs from without. They have argued, correctly in my view, that bodies are in and of the world with all that this implies,¹⁴ and that 'thought' is impossible to understand without recognising its dependence on a complex transpersonal milieu of language, meaning and culture.¹⁵ Sociologists of 'expectations' have pointed to the characteristic overclaiming that accompanies many new technological developments, and rightly argued that many such developments fail in translation from the purified domain of the lab to the messy and complex external world (e.g. Hopkins, Martin et al., 2007). But despite the many unresolved quandaries that haunt those debates, and the many criticisms that can be, and have been, levelled against them, this new 'materialist' ontology of thought is taking shape, not through a philosophical resolution of the age old dilemmas, but through developments in technology. Notwithstanding the explanatory gap – the daunting gulf that exists between a knowledge of molecular events in the neurons of the brain and an explanation of how the mental events that are 'subserved' arise – and despite all the critiques - these technologies embody and enact the premise that the brain is the place where mental events are located and that there must, therefore, be material traces of such mental events in the brain itself. And if those traces exist, it must be possible - both

in principle and now it seems in practice - to make them legible. My aim in this paper is description and not critique: it is to characterize these ways of thinking and to consider the mutation in our understandings of the human to which they are contributing.

Seeing the mind

These days, phrenology, the attempt to read human characteristics by measuring the contours of the skull, ascribing different mental faculties to specific areas and measuring them by assessing the enlargements or indentations in each, is usually ridiculed as a pseudoscience. In the form popularized by Spurzheim and Combe, it probably deserves this fate. But as proposed by Franz Joseph Gall, it entailed two theses with lasting impact on the sciences of mind and brain (Gall, 1810). First, that the brain was the seat of the mind. Second that the brain was organized in such a way that different mental functions were located in specific areas. These theses were heretical: despite Gall's famous Spinozist attempt to reconcile his views with those of the Catholic Church – as in his famous phrase “God and the brain. Nothing but God and the brain” (Rieber, 2006) – his teachings were banned in his native Austria because of their materialism and he was forced to flee to Paris. But the thesis of localisation remained foundational for later brain researchers (Hagner, 1997; Hagner, 2001; Hagner and Borck, 2001). Nineteenth century neurologists – Broca, Wernicke, Fleschig and many more - dissected the brains of those who had suffered brain injuries, criminals and the mad in the attempt to find in the dead brain the cerebral roots of their mental pathologies in life. They tried, with some success, to correlate disorders of speech, thought, memory or conduct shown in life with lesions in the post-mortem brain, but were less successful when they sought the corporeal signs of insanity in the tissues – in the shape or size of the brain, the configuration of its parts and folds, or the presence of lesions in the nerve fibres or the white or grey matter.¹⁶ Broca, like Gall, was a materialist, a founder member of the Society for Mutual Autopsy which examined the brains of the wise and virtuous in the

attempt to identify the cerebral underpinnings of their greatness. Jennifer Michael Hecht's account of this work makes clear the risky materialism espoused by these figures who are sometimes mocked as naïve or malign (Hecht, 1997; Hecht, 2003).¹⁷

But the *living* brain, protected by the opaque skull, remained invisible – it could be imagined but it could not be seen. In the early years of the twentieth century, a number of clinicians attempted to render the living brain amenable to visualization by X-Rays (cf. Kevles, 1997). The first attempts – by Walter Dandy and then by Egas Moniz - worked by injection of air, or dye, into the ventricles of the brain, or the blood vessels within it – a painful process but one that could reveal gross abnormalities, lesions or tumours and so had a limited but important clinical role (Dandy, 1918; Moniz, 1933).¹⁸ But from that point on, a series of techniques were developed that seemed to be able to render visible the living brain in action. The first measures of brain activity that could be made 'non-invasively' without piercing the skull were electrical. The idea that there were electrical currents in the brain was given technological form in the 1920s by Hans Berger with his invention of electroencephalography: his claim in 1929 that one could identify characteristic rhythms, waves and spikes of this current by the use of electrodes placed on the exterior of the skull was initially met with indifference if not scepticism (Haas, 2003).¹⁹ However, developed by others notably Edgar Adrian, it seemed to enable researchers to correlate the pathologies of living subjects with patterns of activity in different regions of the brain – although the EEG was used as a diagnostic tool and made no claims to read specific mental states let alone thoughts - at least initially (Adrian and Matthews, 1934; Haas, 2003). The EEG was followed by a range of other analogous methods that sought to reveal the activities of the living brain in real time, to make mental activity legible by placing sensors of one sort or another on the exterior of the skull. The most recent of these is NIRS – near infrared spectroscopy – involves the subject donning a kind of 'helmet' with multiple sensors that use infra-red light than can penetrate the intact skull. These are used to measure changes in blood oxygenation in

the brain which is thought to correlate with brain activation. Although the main uses of NIRS were initially medical, it is now being used to study vision, language and many other 'functional' properties of the brain such as vision, hearing, and the performance of cognitive tasks (Villringer and Chance, 1997). To quote the title of a review of this technology, NIRS enables one to go 'Beyond the Visible' by imaging the human brain with light (Obrig and Villringer, 2003). As early as 2006, Scott Bunce and his colleagues at Drexel University, supported by funds from the US Defence Advanced Research Projects Agency (DARPA) Augmented Cognition Program, the Office of Naval Research (ONR) and Homeland Security, pointed out its many practical advantages over other methods of brain imaging, because it enabled the subjects to move about, and to carry out tasks in a relatively normal environment. More relevant for present purposes, Bunce suggested that because of these advantages, NIRS had significant potential in the detection of deception and other investigations that needed to be done in clinical offices or environments other than laboratories (Bunce, Izzetoglu et al., 2006).²⁰ I will return to these neurotechnologies of lie detection later.

The idea underpinning NIRS - that levels of blood oxygenation indicate brain activity because active brain regions and circuits require increased oxygenation - was, of course, the basis of the most prominent technology claiming to measure brain activity, functional magnetic resonance imaging or fMRI. Positron Emission Technology (PET) was the first apparatus that seemed to do for the brain what X-Rays had done for the body - to let the mind walk among the tissues themselves as an early enthusiast had exclaimed about X-Rays (Kevles, 1997: 2; for the history of PET, see Nutt, 2002). However it is a difficult method to use as it involves the preparation and injection of short-lived radiolabelled molecules in a medical cyclotron close to the site of the imaging lab. The uptake of those labelled molecules in different brain regions is measured using a scanner that imaged multiple sections through the brain and compiled them together using versions of the algorithms that had previously been developed for

CT (computerised axial tomography) structural imaging of tissues (Dumit, 2003).²¹ But despite these logistical difficulties, and the recognition of the great technical achievements that were entailed in PET, a more fundamental shift was less interrogated. The invention of PET enabled visualization to slip almost imperceptibly from one epistemology and ontology to another – it seemed almost as if the characteristics of the gaze were unaltered when it moved from imaging brain *structure* to imaging brain *function*. In both cases what was rendered visible by the ‘engines of visualization’ (Maynard, 2000) were simulations, but simulations of function embodied very different technical and neurobiological assumptions than those of structure. In the case of function, those neurobiological premises included a thesis about localization – that it was both possible and important to identify specific regions or loci in the brain that ‘subserved’ particular mental functions or states – and a thesis about measurement – that these loci might be identified by measuring the amount of activity within them when an individual undertook a task, by means of a proxy.²² These two assumptions, along with many others, underpinned the development and interpretation of fMRI. This used the principle of magnetic resonance imaging, a superb technical achievement involving pioneering work of many inventors and researchers – to image a proxy measure of function – changes in blood oxygenation (Raichle, 2009). It did not require any direct invasions into the body by dyes or tracers, but worked on the principle that oxygenated blood had different magnetic properties than non-oxygenated blood, and that when an individual placed his or her brain in a scanner, this was able to identify those regions – actually those voxels in a three dimensional space within which the brain was situated – where blood oxygenation changed during a task – whether that be identifying a pattern on a screen or merely simulating a mental state.

The first papers using this technology were published in 1980 – thirty years later they were running at around 10,000 per year.²³ Interpreting the results from the use of this BOLD technique,²⁴ as it was called, raised a multitude of technical, epistemological and

ontological questions (Logothetis, 2008). Not just those multitude of assumptions 'black boxed' in the incredibly sophisticated computer packages that turned data from voxels in a three dimensional space into simulated images that had a compelling realism. Not just those concerning the thesis of localisation: 'blobology' – as some have derisively termed it²⁵ - seems to ignore the complex circuitry of the human brain and the fact that any mental function entails, and depends upon, activity in multiple regions and circuits of the human brain and its integral connections with inputs from the wider nervous system.²⁶ Not just those concerning the measurement techniques, which involve 'subtracting out' all activity in the 'resting brain' – that is to say ignoring anything except measurable changes in blood oxygenation while the individual in the scanner carries out the instructions of the researcher (Raichle and Snyder, 2007; Callard and Margulies, 2011). But also those of scale: Logothetis estimates that a typical voxel size in fMRI "contains 5.5 million neurons, between 2.2×10^{10} and 5.5×10^{10} synapses, 22km of dendrites and 220km of axons" (Logothetis, 2008: 875) leaving to one side all the other complications that will shape the blood oxygen level variations within this cube of brain tissue, notably the balance in every single neuron between excitation and inhibition. But it is not only that this technology is imaging heterogeneous neural activity, to say the least, it is also because we actually have almost no idea of the appropriate scale to image mental function – at the cellular level, at the level of specific circuits, at the level of the whole brain, at the level of the whole nervous system....²⁷ And, of course, the technology itself, inescapably dependent on what can be done in a scanner, imposes very severe constraints on recognizing that in everyday life, mental activity occurs in persons, in bodies, spaces and interactions that we have come to call, for shorthand – social.

But nonetheless, it became widely accepted that here, at last, was a technique to render the activities of the working mind visible in the living brain.²⁸ And it was on the basis of that claim that brain imaging in general, and fMRI in particular, moved out of the

laboratory in which it was born, and out of the psychiatric and neurological clinic where it found its initial habitat, and started to occupy all the ecological niches that psychology had already colonised – which is to say, all those places where human conduct seemed to be shaped by the activity of the human mind. And while psychology’s proxies for mind reading – its projective tests, its scales, its interviews and inductions from laboratory experiments – were so often criticised and even parodied for their claims to *really* know what their subjects were thinking, the proxies used by the brain imagers, and the elaborate statistical and other transformations entailed in rendering those compelling simulations – those pictures of mental activity in the brain – largely slipped unnoticed into the background. An objective and materialist technology for ‘reading the mind’ now seemed to be possible.

Deception: what is a lie?

Perhaps the first to claim to be able to identify specific thoughts or memories in the brain were those who believed they could identify the neural signatures of deception – to detect the liar and the lie.²⁹ Lawrence Farwell’s ‘brain fingerprinting’ technique measures a particular pattern of electrical brain activity – the P300 wave – and Farwell argues that this responds differently when a suspected liar is exposed to images or words, depending on their prior knowledge – for example. when a suspect in a crime is shown an image of the crime scene or the weapon, the patterns of brain activity will differ according to whether that information is ‘stored’ in their brain.³⁰ While in Farwell’s technology, as in the search for the engram, the brain is construed as a kind of storage device for memories, two other commercial companies in the US - No Lie MRI and Cephos Corporation - base their technologies on fMRI, and seek the neural signature of the way in which – in their view - the brain actively manages the process of deception. For example, No Lie MRI Inc. “provides unbiased methods for the detection of deception and other information stored in the brain.... The technology used by No Lie

MRI represents the first and only direct measure of truth verification and lie detection in human history!... No Lie MRI uses techniques that: Bypass conscious cognitive processing.... Measure the activity of the central nervous system (brain and spinal cord) rather than the peripheral nervous system (as polygraph testing does)."³¹

These claims to be able to identify specific patterns of brain activity when an individual is lying have been much criticized on both technical and legal grounds (Simpson, 2008; Brown and Murphy, 2009; Rissman, Greely et al., 2010; Shen and Jones, 2011).³² Despite the endeavours of entrepreneurial neuroscientists, the courts and legal system seem able to recognise the multiple problems in extrapolating from laboratory based studies - where individuals are instructed to lie or tell the truth - to real life situations where the very fact of being accused of a crime generates unknown patterns of brain activity, and where those who are genuinely guilty are likely to employ multiple techniques to disguise their deception. But, as with the polygraph,³³ there is a potential market for these devices outside the agonistic and rule governed domain of the courtroom, in industry, in the military, in the investigative process itself, and it is here that the purveyors of neural lie detection are seeking a more credulous – or less scrupulous - market for their wares.

It appears that this is how the infamous Brain Electrical Oscillations Signature (BEOS) test is being used in India.³⁴ There was much publicity when the BEOS test - a 'guilty knowledge' test developed by an Indian neuroscientist Champadi Raman Mukundan which operates on the same principle as Farwell's P300 method - was used in 2008 to convict Aditi Sharma for murder – giving her husband sweets laced with poison - on the basis of her "neuro-experiential knowledge": it was claimed that characteristic brain patterns showing such knowledge were elicited during an EEG examination when she heard statements concerning the act of poisoning. It was not her words that were used to convict her – she remained silent – but the evidence of the brain itself. There was

rather less publicity when she was released on bail pending appeal, after the National Institute of Mental Health and Neuro Sciences (NIMHANS) declared that brain scan evidence did not meet appropriate criteria of scientificity and could not be used in court. In 2010, in a ruling also considering the admissibility of evidence from the polygraph and from narcolepsy, the Indian Supreme Court ruled – largely on the grounds of the rights not to self-incriminate - that no individual can be forcibly compelled to take a lie detector test, whether a traditional polygraph or a neural lie detector – and that evidence from such tests was inadmissible in Indian courts.³⁵ But according to Angela Saini, the BEOS test is still widely used in India, not in the courtroom but in the investigative process, where it apparently has induced numerous suspects to make confessions.³⁶

No Lie MRI now also imagines its potential customers outside the courtroom: security firms, insurance companies, banks and financial service corporations, concerned about deception by employees, but currently forbidden (in the US) from using the polygraph on their employees.³⁷ Similarly, they ask, why should it not be used by governments concerned about corruption, by individuals concerned to discover if their partners or potential dates are telling the truth – indeed anywhere where deception is a problem, fraud is a possibility, or confidence is to be maintained, neural lie detection can play its part. In the US in particular, the security apparatus provides one potentially hospitable ecological niche. Thus Larry Farwell is keen to suggest the crucial role of brain fingerprinting in identifying potential terrorists, detecting whether they have a memory of a particular training camp, code word, bomb making procedure or whatever.³⁸ As Melissa Littlefield has shown, much of the original impetus for funding of research into brain based lie detection came from the CIA and related agencies: as she argues, the terrorist attacks on the US in September 2001 created “a niche of heightened anxiety” amenable to the rhetoric of brain based lie detection (Littlefield, 2009: 383).

The thesis that is beginning to acquire plausibility is that while deceitful words are cheap and easy, and bodies can be trained to deceive, the brain cannot lie.³⁹ But from the lab to the real world is a rather longer and more difficult journey than the inventors suggest – for in the real world, innocent individuals being tested are awash with confusing and competing affects, the potentially guilty are alert to the need for countermeasures, and, at least as far as the law is concerned, each defendant must to be judged as an individual rather than on the basis of probabilities (although this last proviso does not apply to those detained at borders on the basis of algorithms of riskiness).⁴⁰ And what is a lie – for if a mistaken belief, genuinely held, is a lie, who among us is not a liar. We should not be surprised to find an emergent neuroethical discourse on the nature and limits of neural privacy (Wolpe, Foster et al., 2005; Langleben and Moriarty, 2013; Farah, Hutchinson et al., 2014). Yet despite the aspirations of the spooks, the rhetoric of the entrepreneurs, and the worries of the ethicists, we remain a very long way from the science fiction scenarios of brain scanners at the borders to screen those passing through for lying about their intentions to commit terrorist acts.⁴¹

Intention

Despite the abiding interest of the defence and military establishment especially in the US (Tennison and Moreno, 2012), neural lie detection remains, in the main, the questionable aspiration of enthusiastic and often somewhat marginal entrepreneurs. But the desire to read the contents of the mind in the brain itself remains unquenched in the heartland of neurobiological research, even though most prefer terms such as ‘brain reading’ or ‘thought identification’ to demarcate their scientific research from popular mythology. I have already referred to the media reports of the research by John-Dylan Haynes at the Max Planck Institute for Human Cognitive Brain Sciences in Leipzig which, in the words of Ian Sample, the respected science correspondent of the Guardian

newspaper, broke “controversial new ground in scientist’s ability to probe people’s minds and eavesdrop on their thoughts, and raises serious ethical issues over how brain-reading technology may be used in the future.”⁴² Using the scanner, said Professor Haynes, enables us to look around the brain for information “It’s like shining a torch around, looking for writing on a wall”. Scary indeed, scary enough to provoke Professor Haynes to speculate about the implications when the criminal justice system uses the technique to identify pre-criminals, and to lead various neuroscientists and neuroethicists to reach for their pens to express their anxieties about the potential implications.

Of course, we should not be surprised to find that the experiment was rather less dramatic than this report suggests. Eight volunteers who met certain criteria (handedness, vision) were asked by the researchers in a laboratory to decide whether they would add or subtract two numbers that they would later be shown on a screen (Haynes, Sakai et al., 2007). Both before they were shown the numbers, and during their completion of the task, they were scanned with fMRI, which focussed on activity in the medial prefrontal cortex. There was a time delay of between 2.7 and 10.8 seconds between the time when they were instructed to form their intention and the time when they were presented with the material to carry out the task; in around two thirds of the cases, the researchers were able to predict from the brain signature in the scan whether the individual would add or subtract the numbers. Hence, the paper concluded, it was possible to ‘decode intentions’ from patterns of activity in the medial prefrontal cortex. While this particular paper gained the publicity, it drew on a longer trajectory of previous research; Haynes, working with others including Geraint Rees,⁴³ had published a number of papers suggesting that it was possible to decode mental states from brain activity in humans, and that this in principle would make ‘brain reading’ possible (Haynes and Rees, 2006; Haynes, Sakai et al., 2007). And in a series of subsequent experiments on ‘volition’, Haynes - who was to become Director of Berlin Center for

Advanced Neuroimaging (BCAN) - and others have attempted to study the non-conscious neural determinants of free decisions, arguing that fMRI studies can identify distinct patterns of activity in the brain during the period of anticipation, before an individual is aware of having made a decision (Kahnt, Heinzle et al., 2010; Tusche, Bode et al., 2010; Haynes, 2011; Haynes, 2015).⁴⁴ When Haynes gave a talk at the World Science Festival in 2009, it was tagged “It sounds like you are talking about mind-reading”.⁴⁵

In a related line of research, a number of investigators have suggested that ‘though identification’ in the human brain is possible because the brain develops specialised neurons to react to specific images. Thus, for instance, Christoph Koch, Itzhak Fried and their colleagues have argued that specific neurons encode very particular memories:

“We have previously shown that neurons in the human medial temporal lobe (MTL) fire selectively to images of faces, animals, objects or scenes ... Here we report on a remarkable subset of [medial temporal lobe] neurons that are selectively activated by strikingly different pictures of given individuals, landmarks or objects and in some cases even by letter strings with their names. These results suggest an invariant, sparse and explicit code, which might be important in the transformation of complex visual percepts into long-term and more abstract memories.” (Quiroga, Reddy et al., 2005: 1102).

Most strikingly, for the researchers, was a neuron that selectively fired when the individual was exposed to a picture of an actress. Making use of intracranial electrodes implanted in the brains of eight patients undergoing surgery for epilepsy, they found that a single neuron in the right anterior hippocampus was activated by pictures of Halle Berry, drawings of Halle Berry, images of Halle Berry dressed as Catwoman and by the letter string ‘Halle Berry’. In another subject, a single neuron in the left posterior hippocampus was activated exclusively by different views of the actress Jenifer Aniston

which perhaps explains why The National Geographical Magazine's feature article on 'Secrets of the Brain' in its April 2014 issue was prefaced by a photomontage of dozens of pictures of Jennifer Aniston.⁴⁶

Other researchers also argued that it was possible to use brain scanning technology to identify specific thoughts – in this case, not by activating a neuron that encoded a specific visual memory, but by mapping the neurons that fire during a current thought of a particular object. In 2004, Tom Mitchell and Marcel Just and their colleagues at Carnegie Mellon University published a paper in which machine learning techniques were used on fMRI images, not averaging them over a period, as is normal, but seeking to detect a “transient cognitive state” by “automatically decod[ing] the subject’s cognitive state at a single time instant or interval.” This paper focussed on vision, and detailed three “case studies in which we have successfully trained classifiers to distinguish cognitive states such as (1) whether the human subject is looking at a picture or a sentence, (2) whether the subject is reading an ambiguous or non-ambiguous sentence, and (3) whether the word the subject is viewing is a word describing food, people, buildings, etc.” (Mitchell, Hutchinson et al., 2004: 145). In 2009, their work moved beyond vision to focus on what they came to call “thought identification;” this work was featured in a CBS documentary fronted by Leslie Stahl entitled “Tech that reads your mind” which claimed that the goal of Just and Mitchell was to see if they could identify exactly what happens in the brain when people think specific thoughts:

They did an experiment where they asked subjects to think about 10 objects--5 of them tools like screwdriver and hammer, and 5 of them dwellings, like igloo and castle. They then recorded and analyzed the activity in the subjects' brains for each. "The computer found the place in the brain where that person was thinking 'screwdriver'? [Stahl asked] “Screwdriver isn't one place in the brain. It's many places in the brain. When you think of a screwdriver, you think about how you hold

it, how you twist it, what it looks like, what you use it for," Just explained....When we think "screwdriver" or "igloo" for example, Just says neurons start firing at varying levels of intensity in different areas throughout the brain. "And we found that we could identify which object they were thinking about from their brain activation patterns," he said. "We're identifying the thought that's occurring. It's...incredible, just incredible," he added."⁴⁷

The neuroethicists were on hand to speculate about the implications for the US criminal justice system – for example, given that no one can be forced to testify against themselves, would brain images fall foul of the Fifth Amendment? And apparently “Back at Carnegie Mellon, Just and Mitchell have already uncovered the signatures in our brains for kindness, hypocrisy, and love.”⁴⁸ In the same programme, John-Dylan Haynes commented on the capacity of brain imaging to see if an individual recognized an image of a face or place that they had seen before – maybe an Al Qaeda training camp – he had not been contacted by the US security agencies, he said, but he had been contacted by the Germans.

In another much publicized experiment, the team of Shinji Nishimoto and Jack Gallant at Berkeley claimed to be able to reconstruct movies using only the results from brain imaging using a modified version of the BOLD response (Nishimoto, Vu et al., 2011). The website Unwitting Victim, which shows some of the reconstructed images, drew parallels between this research and the storyline of movies such as *Brainstorm* and *The Cell*, where researchers were able to access experiences, dreams and memories – and points out that “In Harry Potter ... memories and thoughts were treated as tangible objects that can be extracted from the mind and viewed by others or even stored for future perusal.”⁴⁹ Despite the publicity that I referred to at the start of this paper – “I build a brain decoder” - the more widespread use of this technology to extract such details from the brain itself may be some way off – the procedure used by Nishimoto and

Gallant required volunteers to remain still in a brain scanner for many hours at a time.⁵⁰ But the point remains: technology here appears to have demonstrated that not just thoughts, memories and intentions, but also the images that populate our internal world – are not fleeting and transient impressions in an ephemeral mental domain, but are materially embedded in the brain itself.

Can they read your mind?

“Mind-boggling! Science creates computer that can decode your thoughts and put them into words” screamed a headline in the *Daily Mail* on the first of February 2012: “Scientists believe they have found a way to read our minds, using a computer program that can decode brain activity in our brains and put it into words.”⁵¹ But the website of the UK’s NHS Choices took a more sanguine view.⁵² With the strapline “Mind reading remains in the realm of fantasy” it gave a clear account of the work of scientists in Robert Knight’s lab at Berkeley who took advantage of the opening of the skull for some 15 subjects undergoing brain surgery to attach electrodes to the lateral temporal cortex (Pasley, David et al., 2012). The researchers used the signals from that area to try to reconstruct words that the subjects heard. Although the findings showed that the reconstructions were of very poor quality, and recognizable only by computer models and not by human listeners, the research was reported by the normally sober Daily Telegraph as “Mind-reading Device Could Become Reality”. Much of the excitement of the newspapers rested not on the capacities of such technologies to invade neural privacy, however, but on their role in the more traditional niche of the clinic: the hope that they may allow the ‘reading’ of the minds of those with ‘locked in syndrome’, or for those with spinal cord injuries to control computers or machinery with their thoughts.⁵³

Work on ‘neural prostheses’ has already begun to show these possibilities. A series of papers from Andrew Schwartz and his colleagues have charted their development of brain-controlled interfaces “devices that capture brain transmissions involved in a

subject's intention to act, with the potential to restore communication and movement to those who are immobilized." (Schwartz, Cui et al., 2006: 205). Using a cerebral implant that records action potentials from populations of individual neurons in motor cortical areas, initially with monkeys, and most recently with humans, signals are transmitted that enable the subject to move a prosthetic limb with thought alone. In 2012, they reported in *The Lancet* the success of an operation to use a neural implant for Jan Scheuermann, 52-year-old woman with longstanding quadriplegia, who was able to manoeuvre a mind-controlled, human-like robot arm in seven dimensions to perform complex motions of everyday life – she was able to move the arm, turn the wrist, close the hand for the first time in nine years – although, of course, it was not part of her physical body (Collinger, Wodlinger et al., 2013).⁵⁴

In related, somewhat controversial research undertaken by Miguel Nicolelis at his lab at Duke University Medical School – and in the International Institute of Neuroscience of Natal which he founded North-eastern Brazil – monkeys with multi-electrode cortical implants connected wirelessly to robots or computer-generated images have learned to control the movements of these robots or avatars, sometimes situated in far distant labs, by their brain activity alone (Nicolelis and Chapin, 2002), and rats with their brains 'wired together' have been able to transmit "behaviorally meaningful sensorimotor information" from brain to brain (Pais-Vieira, Lebedev et al., 2013).⁵⁵ In fact, Nicolelis is harshly critical of the reductionism and localisation-ism of many of the brain researchers whose work I have discussed in this paper, arguing against those who believe that they can reconstruct brain processes from a focus on the properties of individual neurons, that the belief that brain functions are localised is fundamentally misleading, and that memories, thoughts and representations of the world do not inhere in single neurons, as in the Halle Berry example, but are created by populations of neurons constantly in flux, constantly creating and recreating internal neuronal models of the world (Nicolelis, 2011). Nonetheless, in the words of the titles of some of his

papers, Nicolelis is 'reconstructing the engram' and 'seeking the neural code' (Nicolelis, Ghazanfar et al., 1997; Nicolelis and Ribeiro, 2006). Readers will not be surprised to learn that the research of both Schwarz and Nicolelis was part funded by the Defence Advanced Research Projects Agency,⁵⁶ which recently announced its ElectRX program, a \$78.9 million project, part of President Obama's BRAIN initiative, to develop a cerebral implant that can track and respond to brain signals in real time with the aim of both reading, and modulating, neural activity.⁵⁷ For while both body and brain may be rendered 'readable', in the materialist ontology of the person that is taking shape, the brain has the advantage over the body in being both a potentially legible surface of thoughts and intentions, and the potentially modulatable locus of those thoughts and intentions. In that respect, at least for those whose objective is control - whether that be for security or therapy - legibility in itself is only a first step: reading out the messages from the brain leads to the hope that one might read back messages into the brain to modulate those thoughts and intentions themselves.

Conclusions

So will 'they' soon be able to read our minds? Are we sleepwalking into a Minority Report society? Must we defend neural privacy, and worry about our security agencies not merely reading our texts and emails, but accessing our thoughts themselves, seeing the neural traces of every little lie, every perverse desire, every evil or antisocial intention? It is certainly premature to conclude that these neurotechnologies have rendered the mind transparent through their access to traces in the brain; these endeavours are currently largely confined to the enclosed and artificial sites of the laboratory. It is too early to tell whether the efforts of the enthusiasts and entrepreneurs, in alliance with the hopes of our military and law enforcement agencies, will succeed in taking these technologies out of the lab into practices for the surveillance of dangerous individuals, let alone in using brain modulation directly for the

government of conduct.⁵⁸ Both utopian and dystopian speculations are based on extrapolations from limited experiments in very artificial situations which bear little relevance to how beliefs, intentions, desires and the like are manifested, experienced, communicated and regulated in the everyday world. Claims about mind reading in the popular media undoubtedly entail familiar mishmashes of technology, software, epistemology, ontology, expectations, ethics and politics. And when the speculations of neuroethicists, the exaggerations of neuroscientists, the imaginations of science fiction, and the aspirations of our military researchers coincide, a heady mix of unreality usually results. Practical applications of these brain reading technologies are most likely merely to add to the multiple other low tech – and perhaps less fascinating - tools that are already used for these purposes for children, asylum seekers, job seekers, benefit seekers and many others. Perhaps the most interesting questions are less technical than political - not ‘can we read the mind’, but why, in particular practices, do some want to read some minds, and why do some dream that new neurotechnologies will make this possible.⁵⁹

Nonetheless, despite all our doubts and our necessary scepticism we may be seeing signs here that a new ontology is gradually emerging out of the shadows. Even if they remain confined to laboratory conditions, there is a challenging materialism embodied and enacted in the capacity of novel neurotechnologies to access the contents of the human mind, whether these be to evaluate the presence of particular mental states or capacities, the existence of durable memory traces, or even the fleeting existence of specific thoughts and intentions. Must we suppose a mental realm that is different in substance or extension from the brain? While Wittgensteinian philosophers object that such neuroscience attributes to brains things that can only properly be attributed to persons (Bennett and Hacker, 2003), can we consider the possibility that these neural processes do not merely ‘subserve’ mental states but are, instead, the real material locus

of such mental states, feelings and intentions? Could it be that it is indeed the brain that thinks, feels and intends?

Perhaps this is what Gilles Deleuze was hinting at in that enigmatic phrase “the brain is the screen” which I used as the epigraph to this paper. One might argue that the most durable philosophies of the human have always had a very close relation to contemporary medical and scientific practices.⁶⁰ Speaking of the relationship between philosophy and cinema in an interview published in 1998, Deleuze says

“One goes quite naturally from philosophy to cinema, but also from cinema to philosophy. Their unity is the brain. The brain is the screen. I don't believe linguistics or psychoanalysis are of great help for the cinema. On the other hand, there is the biology of the brain, molecular biology. Thought is molecular, there are molecular speeds which make up the slow beings that we are. Michaux's saying: ‘Man is a slow being, who is only made possible by fantastic speeds.’ The circuits and links of the brain do not pre-exist the stimuli, granules or corpuscles which trace them” (Deleuze and McMuhan, 1998: 48-49).

And elsewhere, referring directly to the claim “Man thinks, not the brain”, Deleuze argues the reverse: “It is the brain that thinks and not man – the latter being only a cerebral crystallization. We will speak of the brain as Cézanne spoke of the landscape: man absent from, but completely within the brain” (Deleuze and Guattari, 1994: 210).⁶¹ Despite the mundane interests of those who fund much of the work I have discussed in this paper, despite the overclaiming endemic in the popular media, and despite the potent mixture of potentially hopeful clinical applications and potentially undesirable socio-political deployments within these findings, something more profound may be happening in these endeavours to read thoughts in the molecular biology of the brain. And if we are witnessing the glimmering of a mutation in ontology, it will undoubtedly

have implications for our philosophies and for our ethics, for the ways we are governed by others and for the ways we understand and govern ourselves.

Acknowledgements

Thanks to Joelle Abi-Rached, Des Fitzgerald, Gavin Smith and Martin French for very helpful comments, not all of which have been able to take account of in this version.

Thanks also to the generous comments from those who have heard earlier versions of this paper in the Anthropology Department of the University of Auckland, in the Sociology Department of the Australian National University, and at the Aarhus University in Denmark. Of course, all errors of fact and interpretation are mine. This paper draws on research for the Human Brain Project that has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 604102.

Biographical Note

Nikolas Rose is Professor of Sociology and Head of the Department of Social Science, Health and Medicine at King's College London. His latest book, written with Joelle Abi-Rached, is *Neuro: the new brain sciences and the management of the mind*, Princeton, 2013.

NOTES

Except where otherwise stated in the notes, all web links were last accessed, and active, on 1.09.2015

-
- ¹ Deleuze's phrase "the brain is the screen" is discussed helpfully in an interview with Melissa McMuhan published in 1998 (Deleuze and McMuhan, 1998). I return to this phrase in the conclusion.
 - ² In this paper I will not address the large and growing literature in the social sciences about brain imaging, in areas such as neuroeconomics, neuromarketing and so forth, some of which is explored in N. Rose and J. Abi-Rached, *Neuro: The New Brain Sciences and the Management of the Mind*, Princeton University Press, 2013. Here I focus on the use of neurotechnologies with the aim of identifying thoughts, beliefs and intentions directly in the brain, the link between these technologies and actual or potential strategies of surveillance and control, and the potential emergence of a 'materialist' ontology.
 - ³ The 2002 film, *Minority Report* is often used by those who worry about the spread of surveillance technologies. In the film, three youth with special precognitive abilities are kept sedated and linked to a computer that reads their neural patterns. Law enforcement agents use the projections of this cyborg assemblage to foresee criminal acts before they occur, and to arrest and charge individuals with so-called 'precrimes'. The phrase "sleepwalking into a Minority Report society" was used by some of the commentator when the research of John-Dylan Haynes, discussed below, was reported in the popular media.
 - ⁴ The PowerPoint slides from a 2007 presentation of FAST by the Department of Homeland Security can be accessed at <https://publicintelligence.net/dhs-future->

[attribute-screening-technology-mobile-module-fast-m2-overview/](#) They helpfully show the imagined set-up in which an individual walks through an enclosure equipped with sensors that remotely read a range of physiological indicators and calibrate them against norms, so that law enforcement personnel can apprehend those who register high on markers of malintent. Initially named 'Project Hostile Intent' (http://www.dhs.gov/xlibrary/assets/privacy/privacy_pia_st_phi.pdf), the official description of the project, dating from 2008, can be found here:

http://www.dhs.gov/xlibrary/assets/privacy/privacy_pia_st_fast.pdf. It has been subject to various investigations concerning 'privacy risks' and Freedom of Information requests by the US Electronic Privacy Information Center:

<https://epic.org/foia/dhs/fast/>

⁵ <http://www.theguardian.com/science/2007/feb/09/neuroscience.ethicscience>

⁶ <http://www.bbc.com/future/story/20140717-i-can-read-your-mind>

⁷ For a relentless rehearsal of the position that contemporary neuroscience attributes to brains things that can only properly be attributed to persons, see the work of Bennett and Hacker (Bennett and Hacker, 2003). I shall return to this question at the end of the paper.

⁸ The initial hypothesis about 'theory of mind' in primates was put forward by Premack and Woodruff (Premack and Woodruff, 1978). Evolutionary psychologists such as Nicholas Humphreys speculated that the large brain size of humans and some other primates was related to the computational capacities necessary for social relations in large groups, and argument later developed by Robin Dunbar (Humphrey, 1976; Dunbar, 1993; Dunbar, 1998). Leslie Brothers coined the phrase 'social brain' in her classic paper of 1990, which made the argument that there were specific brain regions for 'social cognition' in humans and some other primates (Brothers, 1990). These and other arguments laid the basis of what John Cacioppo christened 'social neuroscience' (for a useful history, see Cacioppo, Berntson et al., 2011). Later, and

contested, arguments concerning ‘mirror neurons’ suggested that what was at stake was not a ‘theory’ of mind, but rather that when one individual observes the actions or emotional expressions of another, a small number of neurons are activated in the brain of the watcher in the very circuits that are activated in the individual who is observed (Gallese and Goldman, 1998; Rizzolatti and Craighero, 2004; Iacoboni, Molnar-Szakacs et al., 2005). Enthusiasts for mirror neurons argued that this capacity for imitation was fundamental to the evolution of human societies (Ramachandran, 1995) though others doubted their very existence (Borg, 2007; Hickok, 2009; Lingnau, Gesierich et al., 2009). Some researchers have claimed to resolve this dispute by direct recording of excitation from single cells in human medial frontal and temporal cortices while patients executed or observed hand grasping actions and facial emotional expressions (Mukamel, Ekstrom et al., 2010: 750). With or without mirror neurons, the existence of brain regions specialised for social cognition is now widely accepted, as is the belief that this ‘social brain’ circuitry can be located in certain brain regions or pathways (Adolphs, 2007; Frith, 2007; Frith, 2007).

- ⁹ Most famously in the thesis that children diagnosed with autism lack ‘theory of mind’ (Baron-Cohen, Leslie et al., 1985; Ramachandran and Oberman, 2006). The ‘mind-blindness’ thesis (Baron-Cohen, 1997) remains controversial, and Baron-Cohen himself has sought to supplement it with additional, and even more controversial, theses on the role of emotions, sex differences and hormones.
- ¹⁰ There is a growing research programme based on the hypothesis that ‘psychopathy’ – a highly contested category in itself – is characterised by deficits in social cognition, such that psychopaths lack empathy, and do not ‘feel the pain’ of others (Decety, Skelly et al., 2013; Decety, Skelly et al., 2014). From the turn of the century, psychopathy rapidly became the topic of dozens of research studies using fMRI (Moll, de Oliveira-Souza et al., 2002; Adolphs, 2003; Raine, Lencz et al., 2003; Raine, Ishikawa et al., 2004; Moll, Zahn et al., 2005; Yang, Raine et al., 2005; Blair, 2007;

Weber, Habel et al., 2008; Gregory, Simmons et al., 2012). An intensive and well funded research programme is under way to find the neural signatures that would predict adult psychopathy - the neural signatures of that inability to feel empathy that led to callous and unemotional behaviour in children, and worse in adults (Viding, Blair et al., 2005; Hodgins, Viding et al., 2008; Viding, Jones et al., 2008; Viding, Jones et al., 2008; Viding, Hanscombe et al., 2010; Carré, Hyde et al., 2013). The aim is to identify those lacking the evolved capacity for normal moral reason *before* their violent or criminal behaviour becomes apparent, is preventive intervention, which most often takes the form of training those individuals and their parents in ways of managing and channelling their wayward impulses in acceptable directions for the good of each and the good of all.

¹¹ Although, as both Joelle Abi-Rached and Des Fitzgerald pointed out to me, the algorithms used for data mining, whether by Amazon, Google or by the US National Security Agency, do already to something like this, although not by accessing your thoughts themselves, only via the traces of your desires that you leave on the web.

¹² I cite some examples later in this paper, but the description this work as 'mind-reading' is not confined to the popular media, see, for example, the reports by Kerri Smith in *Nature* (Smith, 2008; Smith, 2013).

¹³ One could refer to these as 'ecological niches', in the way the term is used by Ian Hacking, in his book *Mad Travellers* (Hacking, 1998) to describe the ways in which certain accounts of human pathology can first find, and then lose, their conditions for flourishing.

¹⁴ This is an argument made most powerfully by Francisco Varela (Varela, Thompson et al., 1993)

¹⁵ Arguments about 'the extended mind', most compellingly made by Andy Clark and David Chalmers, are well known (Clark and Chalmers, 1998; Clark, 2008). Many of these points were also made in an uncharacteristically humanist intervention by

Georges Canguilhem entitled 'The Brain and Thought' , given as a lecture at the Sorbonne organized by the *Mouvement universel pour la responsabilité scientifique* (MURS) in December 1980, and first published in the journal *Prospective et Santé* 14, Summer 1980, pp. 81-98 and republished as the foreword to the proceedings of a conference (Actes du colloque 6-8 December 1990), *Georges Canguilhem: Philosophe, historien des sciences*, (Canguilhem, 1993: 11-33). It is now in English translation (Canguilhem, 2008).

¹⁶ This, of course, was the method used by the famous explorers of brain function in the nineteenth century in their practices of localization – Broca, Wernicke, Fleschig and many more. And there were some twentieth century exceptions, notably the work of Wilder Penfield, whose reactivation of memories - referred to earlier in this paper - occurred while he 'mapped' the cortex by stimulating areas that had been exposed during surgery to ablate the foci of severe and intractable epilepsy.

¹⁷ Of course, this work also led to the search for the brain bases of mental capacities, arguments about differences in brain size between men and women, and the brain bases of a hierarchy of the races. The enthusiasm for such crainiology was short lived, not least because the brain data often failed to correlate with popular beliefs about the links between social worth and brain size. Once more, details and further references are given in Rose and Abi-Rached, 2013.

¹⁸ Egas Moniz, of course, went on to develop the procedure known as lobotomy or leucotomy; he and others used it to intervene in the living brains of many afflicted individuals in the tragic endeavour to ameliorate the symptoms of mental disorder.

¹⁹ While some suggest that his work on the EEG was terminated and he was retired because of opposition to the Nazis: more recently, historians have suggested that he was, in fact, a member of the SS, and participated in the "Court for Genetic Health" that ordered sterilizations: the Wikipedia entry is actually a good guide to this dispute: http://en.wikipedia.org/wiki/Hans_Berger , last accessed 1.9.15.

²⁰ “In comparison to fMRI, with fNIRs participants can sit upright and work on a computer ... watch television or movies, and even walk on a treadmill... These attributes also allow fNIRs to be used with children and with patient populations that may find confinement to an fMRI magnet overwhelming or painful. A number of sensor applications exist, depending on their use, including caps, tension straps, and medical-grade adhesive applications. fNIR is quiet and comfortable and is therefore amenable to sensitive protocols such as the induction of positive moods... Portable systems exist that operate from a laptop computer and a control box approximately 2 in × 6 in × 8 in. Finally, fNIRs is relatively inexpensive, with available systems ranging between US\$25,000–\$300,000” (Bunce, Izzetoglu et al., 2006: 57).

²¹ To stress the obvious, computerized tomography images *structure*, that is to say tissues, while PET claims to image *function*, by means of a process where changes in the ‘activity’ of certain tissues is indicated by their active take up of molecules labeled with radioactive tracer.

²² Many contemporary neuroimagers would argue that they have left these assumptions behind – that they now seek to understand neural circuits and not merely to identify brain locales, and that they are developing measures that are less dependent on blood oxygenation as a proxy (Lichtman and Denk, 2011). However one only has to scan recent papers that use fMRI in claims about the neural bases of human mental life to see the persistence of these two assumptions.

²³ We discuss these in detail in Rose and Abi-Rached, 2013.

²⁴ BOLD is an acronym for Blood Oxygenation Level Dependent.

²⁵ Not all use this term in a derisory way: <https://theconversation.com/adventures-in-blobology-20-years-of-fmri-brain-scanning-4095> last accessed 1.9.15.

²⁶ Over the last five years, many have sought to go beyond blobology to ‘connectomics’ and have used fMRI in an attempt to chart functional circuits activated in particular tasks – for a good discussion see Biswal, Mennes et al., 2010.

²⁷ Thus, for example, while there is a significant movement of researchers committed to molecular level neuroimaging – for example those associated with the work of Henry Wagner (Wagner, Burns et al., 1983; Wagner, 2006; Wagner, 2009), it is by no means clear that the molecular gaze is the most appropriate to image mental functions.

²⁸ Most of the researchers themselves tried to be more cautious, for example speaking of ‘neural correlates’ of mental activity while an individual conducted specific tasks. However many were less cautious when making public statements, and popular interpreters were even less circumspect, see for example the work of Rita Carter which was written in collaboration with eminent neuroscientists (Carter, Aldridge et al., 2009; Carter and Frith, 2010). And even when reporting the caution of the researchers, headlines tell a different story, for one recent example of many, see <http://www.livescience.com/37267-how-to-see-inside-the-mind.html> last accessed 1.9.15.

²⁹ For an excellent collection of papers on these issues, see the collection edited by Melissa Littlefield (Littlefield, 2011). I have already mentioned the earlier suggestions that NIRS could be used in this way, and there is a significant programme of research on this, notably by researchers in a number of Asian countries (e.g. Ding, Gao et al., 2013; Trinh, 2013; Ding, Sai et al., 2014) with some now suggesting that the technology is ready for real- life uses. At least one patent application has been lodged in the US for a method using NIRS to detect a ‘suicide terrorist’: “This method can be advantageously employed at various security check sites, such as airports, train stations, or any other sites susceptible of terrorist attacks (Wu, 2013) .

³⁰ <http://www.larryfarwell.com/index.html> last consulted 1.9.15. Farwell holds several patents on his technology dating back to 1994: Method and apparatus for multifaceted electroencephalographic response analysis (MERA). U.S. Patent #5,363,858 (1994); Method and apparatus for truth detection. U.S. Patent #5,406,956 (1995); Method for electroencephalographic information detection. U.S. Patent

#5,467,777 (1995); Apparatus for a classification guilty knowledge test and integrated system for detection of deception and information. U.K. Patent # GB2421329 (1997).

³¹ <http://www.noliemri.com/> last consulted 1.9.15. There are some reasons to believe that this organization looms rather larger in the imagination of ethicists than is warranted by its actual commercial or juridical presence.

³² For some legal debate on the robustness of the claims made by CEPHOS, see <https://stanfordlawyer.law.stanford.edu/2010/06/fmri-lie-detection-fails-its-first-hearing-on-reliability/> and, for the 2012 decision by the US Sixth Circuit, see <http://www.ca6.uscourts.gov/opinions.pdf/12a0312p-06.pdf>

³³ There are many studies of the history and sociology of the polygraph, see for example Cole, 2009; Lynch, Cole et al., 2010.

³⁴ <http://www.wired.co.uk/magazine/archive/2009/06/features/guilty> last accessed 1.9.15.

³⁵ The judgment (Selvi & Ors vs State Of Karnataka & Anr on 5 May, 2010 concerned a group of criminal appeals against convictions using these technologies. In fact the test in question here was the so called BEAP test - 'Brain Electrical Activation Profile Test' - but the ruling referred to all such tests:

<http://indiankanoon.org/doc/338008/> - thanks to Kriti Kapila for directing me to this ruling.

³⁶ <http://www.wired.co.uk/magazine/archive/2009/06/features/guilty> last accessed 1.9.15.

³⁷ <http://www.noliemri.com/customers/Overview.htm> last accessed 1.9.15.

³⁸ Farwell continues to collaborate with the FBI in his research, most recently co-authoring a study with FBI employees on the accuracy of his P-300 and P-300 MERMER (Memory and Encoding Related Multifaceted Electroencephalographic Response) technologies in detecting the presence or absence of particular

information in the subjects brain (Farwell, Richardson et al., 2013). This paper is one of a series of papers now being published based on research conducted with “the CIA, the FBI, the U.S. Navy, and elsewhere” now that security concerns have apparently been resolved.

³⁹ See the video made to mark him being chose as one of Time Magazine’s Time 100 (in 2012): the 100 innovators who may be the Picassos or Einstein’s of the 21st Century:

<https://www.youtube.com/watch?v=Qwme8wiUTu8>

⁴⁰ I am referring here to US-VISIT –which links biometrics to data mining from multiple databases – and the collection and mining of Passenger Name Record (PNR)information supplied on incoming passengers.

⁴¹ Though see the patent application noted above that proposes that NIRS can be used for exactly this purpose.

⁴² <http://www.theguardian.com/science/2007/feb/09/neuroscience.ethicsofscience> last accessed 1.9.15.

⁴³ At the same time as the Haynes paper was causing such a stir, Geraint Rees of University College London was involved in an exhibition at the Science Museum in London entitled ‘Neurobotics: The Future of Thinking’ and is pictured on the website for the exhibition under the heading “The Mind Reader”. While the web link at <http://www.sciencemuseum.org.uk/antenna/neurobotics/private/121.asp> is no longer active, the text read “How would you feel if someone could read your innermost thoughts? Geraint Rees of UCL says he can. By using brain-imaging technology he’s beginning to decode thought and explore the difference between the conscious and unconscious mind. But how far will it go? And shouldn’t your thoughts remain your personal business?”: I was directed to this exhibition by the website Global Research: <http://www.globalresearch.ca/intrusive-brain-reading-surveillance-technology-hacking-the-mind/7606> last accessed 1.9.15.

-
- ⁴⁴ These studies of volition all extend, but do not question, the rather bizarre but highly influential experiments of Benjamin Libet (Libet, Gleason et al., 1983; Libet, 1985; Libet, Freeman et al., 1999; Libet, 2004): these are discussed in detail in Rose and Abi-Rached, 2013.
- ⁴⁵ http://worldsciencefestival.com/videos/it_sounds_like_youre_talking_about_mind_reading last accessed 1.9.15.
- ⁴⁶ Koch explained this finding in a talk at the World Science Festival http://worldsciencefestival.com/videos/the_jennifer_aniston_brain_cell; see also <http://www.newscientist.com/article/dn7567-why-your-brain-has-a-jennifer-aniston-cell.html> - last accessed 1.9.15. In a recent article in *National Geographical Magazine*, the discovery of the Jenifer Aniston neuron was used as a hook on which to hang the exposition of the new science of the brain: <http://ngm.nationalgeographic.com/2014/02/brain/img/08-aniston-composite-670.jpg> last accessed 1.9.15.
- ⁴⁷ Quoted from the transcript of the programme which can be found at http://news.cnet.com/8301-11386_3-10131643-76.html last consulted 1.9.15.
- ⁴⁸ http://news.cnet.com/8301-11386_3-10131643-76.html last consulted 1.9.15. For more recent work by Mitchell and Just, using their technique to explore the presence or absence of 'self-representations' in those diagnose with autism, see Just, Cherkassky et al., 2014.
- ⁴⁹ <http://www.unwittingvictim.com/BrainMovieImage.html> last consulted 1.9.15. B
- ⁵⁰ See also <http://www.sciencedaily.com/releases/2011/09/110922121407.htm> last consulted 1.9.15. For a recent discussion which generalizes from these experiments, see Huth, Nishimoto et al., 2012.
- ⁵¹ <http://www.dailymail.co.uk/sciencetech/article-2094671/Mind-boggling-Science-creates-decode-thoughts-words.html> last consulted 1.9.15.

⁵² <http://www.nhs.uk/news/2012/02February/Pages/mind-reading-telepathy-inner-voice.aspx> last consulted 1.9.15.

⁵³ In 2010, much publicity was given to a study from Adrian Owen and his group at Western University in Canada, seeming to demonstrate the possibility of using such techniques to identify willful thought processes in patients in persistent vegetative states (Monti, Vanhaudenhuyse et al., 2010). The potential of these 'brain-computer interfaces is discussed in detail in a recent report from the Nuffield Council on Bioethics (Nuffield Council on Bioethics, 2013).

⁵⁴ For other experiments along the same lines, see Wang, Collinger et al., 2013. and for a more general discussion on progress in this area, see Schwartz, 2013.

⁵⁵ The experiment with the rats was intended to be a step towards making an organic computer. It was reported in *Nature* in 2013:
<http://www.nature.com/news/intercontinental-mind-meld-unites-two-rats-1.12522>:
Nicolelis is quoted as saying ““It’s not telepathy. It’s not the Borg,” he says. “But we created a new central nervous system made of two brains.”

⁵⁶ For the work that is funded in the Nicolelis lab, see
<http://www.bbc.com/future/story/20130311-ten-military-mind-experiments>

⁵⁷ Reported in a number of sources in October 2013, e.g.
<http://www.cnet.com/uk/news/darpa-developing-implant-to-monitor-brain-in-real-time/> ; <http://www.forbes.com/sites/stevenkotler/2014/09/02/neuro-modulation-2-0-new-developments-in-brain-implants-super-soldiers-and-the-treatment-of-chronic-disease/> .

⁵⁸ Few would suggest that we are on the verge of Jose Delgado’s ‘Psychocivilized Society’ but it is relevant to point out that his ‘stimoceivers’ – which could both remotely monitor the electrical activity of the brain, and remotely stimulate specific areas of the brain - aimed to do just this, although with much cruder technology (Delgado, Mark et al., 1968; Delgado, 1969). Delgado’s research was, also funded by the US

military. In the future, given that polygraphs are already used in a variety of ways in monitoring sex offenders, one might imagine these technologies being developed to control those convicted of sexual offences against children: for example, perhaps a condition of release from confinement under licence might be the use of a neural implant to monitor and modulate undesirable thoughts or intentions

⁵⁹ Thanks to Des Fitzgerald for making this point to me in more or less these exact terms.

⁶⁰ Consider, for two simple examples, Descartes' medical studies and his concerns with using medical knowledge to ensure his own health, brilliantly discussed by Steven Shapin (Shapin, 2000) or the fascination of the sensationalist philosophers such as Condillac with medical innovations in which sight was restored to people who had been blind (I discuss these in Chapter One of Rose, 1985). Of course, as Shapin points out, the relation of many philosophers to the medicine of their times has often been very critical, although such attempts to reconstruct medical thought and practice on a 'sound philosophical basis' have seldom been successful - as Shapin puts it the "do not make for edifying reading: they look more like testaments to human folly than to the power of reason" (ibid.: 134). Perhaps there is a lesson here for some of our contemporary philosophical critics of neuroscience.

⁶¹ This quote is from the exceptionally dense conclusion to this book, which is entitled "From Chaos to the Brain".

References

- Adolphs, R. (2003). 'Cognitive Neuroscience of Human Social Behaviour.' *Nature Reviews Neuroscience* **4**(3): 165-178.
- Adolphs, R. (2007). 'The Social Brain: Insights from Cognitive Neuroscience.' *Progress in Natural Science* **17**: 99-105.
- Adrian, E. D. and B. H. C. Matthews (1934). 'The Berger Rhythm: Potential Changes from the Occipital Lobes in Man.' *Brain* **57**(4): 355-385.
- Baron-Cohen, S. (1997). *Mindblindness: An Essay on Autism and Theory of Mind*, New York: MIT press.
- Baron-Cohen, S., A. M. Leslie, et al. (1985). 'Does the Autistic Child Have a Theory of Mind?' *Cognition* **21**(1): 37-46.
- Bennett, M. R. and P. M. S. Hacker (2003). *Philosophical Foundations of Neuroscience*. Malden, MA ; Oxford, Blackwell Pub.
- Biswal, B. B., M. Mennes, et al. (2010). 'Toward Discovery Science of Human Brain Function.' *Proceedings of the National Academy of Sciences* **107**(10): 4734-4739.
- Blair, R. (2007). 'The Amygdala and Ventromedial Prefrontal Cortex in Morality and Psychopathy.' *Trends in Cognitive Sciences* **11**(9): 387-392.
- Borg, E. (2007). 'If Mirror Neurons Are the Answer, What Was the Question?' *Journal of Consciousness Studies* **14**(8): 5-19.
- Brothers, L. (1990). 'The Social Brain: A Project for Integrating Primate Behavior and Neurophysiology in a New Domain.' *Concepts in Neuroscience* **1**: 27-61.
- Brown, T. and E. Murphy (2009). 'Through a Scanner Darkly: Functional Neuroimaging as Evidence of a Criminal Defendant's Past Mental States.' *Stanford Law Review* **62**: 1119.
- Bunce, S. C., M. Izzetoglu, et al. (2006). 'Functional near-Infrared Spectroscopy.' *Engineering in Medicine and Biology Magazine, IEEE* **25**(4): 54-62.

- Cacioppo, J. T., G. G. Berntson, et al. (2011). A Brief History of Social Neuroscience. In A. Kruglanski and W. Stroebe. *Handbook of the History of Social Psychology*. New York: Psychology Press.
- Callard, F. and D. S. Margulies (2011). 'The Subject at Rest: Novel Conceptualizations of Self and Brain from Cognitive Neuroscience's Study of the 'Resting State'' *Subjectivity* **4**(3): 227-257.
- Canguilhem, G. (1993). *Georges Canguilhem: Philosophe, Historien Des Sciences*. Paris: Albin Michel.
- Canguilhem, G. (2008). 'The Brain and Thought.' *Radical Philosophy* **148**: 7-18.
- Carré, J. M., L. W. Hyde, et al. (2013). 'The Neural Signatures of Distinct Psychopathic Traits.' *Social Neuroscience* **8**(2): 122-135.
- Carter, R., S. Aldridge, et al. (2009). *The Human Brain Book*. London; New York, N.Y.: DK Publishing.
- Carter, R. and C. D. Frith (2010). *Mapping the Mind*. Berkeley, University of California Press.
- Clark, A. (2008). *Supersizing the Mind: Embodiment, Action, and Cognitive Extension: Embodiment, Action, and Cognitive Extension*. Oxford: Oxford University Press.
- Clark, A. and D. Chalmers (1998). 'The Extended Mind.' *analysis*: 7-19.
- Cohn, S. (2008). 'Making Objective Facts from Intimate Relations: The Case of Neuroscience and Its Entanglements with Volunteers.' *History of the Human Sciences* **21**(4): 86.
- Cohn, S. (2008). 'Petty Cash and the Neuroscientific Mapping of Pleasure.' *Biosocieties* **3**(02): 151-163.
- Cole, S. A. (2009). *Suspect Identities: A History of Fingerprinting and Criminal Identification*. Boston: Harvard University Press.
- Collinger, J. L., B. Wodlinger, et al. (2013). 'High-Performance Neuroprosthetic Control by an Individual with Tetraplegia.' *The Lancet* **381**(9866): 557-564.

- Dandy, W. E. (1918). 'Ventriculography Following the Injection of Air into the Cerebral Ventricles.' *Annals of Surgery* **68**(1): 5.
- Decety, J., L. Skelly, et al. (2014). 'Neural Processing of Dynamic Emotional Facial Expressions in Psychopaths.' *Social Neuroscience* **9**(1): 36-49.
- Decety, J., L. R. Skelly, et al. (2013). 'Brain Response to Empathy-Eliciting Scenarios Involving Pain in Incarcerated Individuals with Psychopathy.' *JAMA Psychiatry* **70**(6): 638-645.
- Deleuze, G. and F. Guattari (1994). *What Is Philosophy?* London: Verso.
- Deleuze, G. and M. McMuhan (1998). 'The Brain Is the Screen: Interview with Gilles Deleuze on 'the Time-Image'.' *Discourse* **20**(3): 47-55.
- Delgado, J. M., V. Mark, et al. (1968). 'Intracerebral Radio Stimulation and Recording in Completely Free Patients.' *The Journal of Nervous and Mental Disease* **147**(4): 329-340.
- Delgado, J. M. R. (1969). *Physical Control of the Mind: Toward a Psychocivilized Society*, New York, London: Harper and Row.
- Ding, X. P., X. Gao, et al. (2013). 'Neural Correlates of Spontaneous Deception: A Functional near-Infrared Spectroscopy (Fnirs) Study.' *Neuropsychologia* **51**(4): 704-712.
- Ding, X. P., L. Sai, et al. (2014). 'Neural Correlates of Second-Order Verbal Deception: A Functional near-Infrared Spectroscopy (Fnirs) Study.' *NeuroImage* **87**: 505-514.
- Dumit, J. (2003). *Picturing Personhood: Brain Scans and Biomedical Identity*. Princeton NJ: Princeton University Press.
- Dunbar, R. I. M. (1993). 'Coevolution of Neocortical Size, Group Size and Language in Humans.' *Behavioral and Brain Sciences* **16**(4): 681-693.
- Dunbar, R. I. M. (1998). 'The Social Brain Hypothesis.' *Evolutionary Anthropology* **6**(5): 178-190.

- Farah, M. J., J. B. Hutchinson, et al. (2014). 'Functional Mri-Based Lie Detection: Scientific and Societal Challenges.' *Nature Reviews Neuroscience* **15**(2): 123-131.
- Farwell, L. A., D. C. Richardson, et al. (2013). 'Brain Fingerprinting Field Studies Comparing P300-Mermer and P300 Brainwave Responses in the Detection of Concealed Information.' *Cognitive Neurodynamics* **7**(4): 263-299.
- Frith, C. D. (2007). *Making up the Mind : How the Brain Creates Our Mental World*. Oxford: Blackwell.
- Frith, C. D. (2007). 'The Social Brain?' *Philosophical Transactions Of The Royal Society B-Biological Sciences* **362**(1480): 671-678.
- Gall, F. J. (1810). *Anatomie Et Physiologie Du Système Nerveux En Gènèral, Et Du Cerveau En Particulier; Avec Des Observations Sur La Possibilit De Reconnoitre Plusieurs Dispositions Intellectuelles Et Morales De L'homme Et Des Animaux, Par La Configuration De Leurs Têtes, Etc*. Paris: F. Schoell.
- Gallese, V. and A. Goldman (1998). 'Mirror Neurons and the Simulation Theory of Mind-Reading.' *Trends in Cognitive Sciences* **2**(12): 493-501.
- Gregory, S., A. Simmons, et al. (2012). 'The Antisocial Brain: Psychopathy Matters: A Structural Mri Investigation of Antisocial Male Violent Offenders.' *Archives of General Psychiatry* **69**(9): 962-972.
- Haas, L. (2003). 'Hans Berger (1873–1941), Richard Caton (1842–1926), and Electroencephalography.' *Journal of Neurology, Neurosurgery & Psychiatry* **74**(1): 9-9.
- Hacking, I. (1998). *Mad Travelers : Reflections on the Reality of Transient Mental Illnesses*. Charlottesville ; London: University Press of Virginia.
- Hagner, M. (1997). *Homo Cerebralis : Der Wandel Vom Seelenorgan Zum Gehirn*. Berlin: Berlin Verlag.
- Hagner, M. (2001). 'Cultivating the Cortex in German Neuroanatomy.' *Science In Context* **14**(4): 541-563.

- Hagner, M. and C. Borck (2001). 'Mindful Practices: On the Neurosciences in the Twentieth Century.' *Science In Context* **14**(4): 507-510.
- Haynes, J.-D. (2015). 'A Primer on Pattern-Based Approaches to Fmri: Principles, Pitfalls, and Perspectives.' *Neuron* **87**(2): 257-270.
- Haynes, J.-D. and G. Rees (2006). 'Decoding Mental States from Brain Activity in Humans.' *Nature Reviews Neuroscience* **7**(7): 523-534.
- Haynes, J.-D., K. Sakai, et al. (2007). 'Reading Hidden Intentions in the Human Brain.' *Current Biology* **17**(4): 323-328.
- Haynes, J. D. (2011). 'Decoding and Predicting Intentions.' *Annals of the New York Academy of Sciences* **1224**(1): 9-21.
- Hecht, J. M. (1997). 'French Scientific Materialism and the Liturgy of Death: The Invention of a Secular Version of Catholic Last Rites (1876-1914).' *French Historical Studies* **20**(4): 703-735.
- Hecht, J. M. (2003). *The End of the Soul : Scientific Modernity, Atheism, and Anthropology in France*. New York ; Chichester: Columbia University Press.
- Hickok, G. (2009). 'Eight Problems for the Mirror Neuron Theory of Action Understanding in Monkeys and Humans.' *Journal of Cognitive Neuroscience* **21**(7): 1229-1243.
- Hodgins, S., E. Viding, et al. (2008). 'The Neurobiology of Violence: Implications for Prevention and Treatment (Special Issue).' *Philosophical Transactions of the Royal Society B* **363**: 1503.
- Hopkins, M. M., P. A. Martin, et al. (2007). 'The Myth of the Biotech Revolution: An Assessment of Technological, Clinical and Organisational Change.' *Research Policy* **36**(4): 566-589.
- Humphrey, N. K. (1976). 'The Social Function of Intellect,' pp. 303- 317 in P. Bateson and R. A. Hinde (eds.) *Growing Points in Ethology*. Cambridge: Cambridge University Press

- Huth, A. G., S. Nishimoto, et al. (2012). 'A Continuous Semantic Space Describes the Representation of Thousands of Object and Action Categories across the Human Brain.' *Neuron* **76**(6): 1210-1224.
- Iacoboni, M., I. Molnar-Szakacs, et al. (2005). 'Grasping the Intentions of Others with One's Own Mirror Neuron System.' *PLoS Biology* **3**(3): e79.
- Just, M. A., V. L. Cherkassky, et al. (2014). 'Identifying Autism from Neural Representations of Social Interactions: Neurocognitive Markers of Autism.' *PloS One* **9**(12): e113879.
- Kahnt, T., J. Heinzle, et al. (2010). 'The Neural Code of Reward Anticipation in Human Orbitofrontal Cortex.' *Proceedings of the National Academy of Sciences* **107**(13): 6010-6015.
- Kevles, B. (1997). *Naked to the Bone : Medical Imaging in the Twentieth Century*. New Brunswick, N.J.: Rutgers University Press.
- Langleben, D. D. and J. C. Moriarty (2013). 'Using Brain Imaging for Lie Detection: Where Science, Law, and Policy Collide.' *Psychology, Public Policy, and Law* **19**(2): 222-234.
- Lashley, K. S. (1950). In Search of the Engram. In J. F. Danielli and R. M. Brown. *Physiological Mechanisms in Animal Behaviour*. New York: Academic Press: 454-482.
- Libet, B. (1993). 'Unconscious Cerebral Initiative and the Role of Conscious Will in Voluntary Action.' *Behavioral and Brain Sciences* **8**(4): 529-566.
- Libet, B. (2004). *Mind Time: The Temporal Factor in Consciousness*. Boston: Harvard University Press.
- Libet, B., A. Freeman, et al. (eds.) (1999). *The Volitional Brain : Towards a Neuroscience of Free Will*. Thorverton: Imprint Academic.

- Libet, B., C. A. Gleason, et al. (1983). 'Time of Conscious Intention to Act in Relation to Onset of Cerebral Activity (Readiness-Potential): The Unconscious Initiation of a Freely Voluntary Act.' *Brain* **106**(3): 623.
- Lichtman, J. W. and W. Denk (2011). 'The Big and the Small: Challenges of Imaging the Brain's Circuits.' *Science* **334**(6056): 618-623.
- Lingnau, A., B. Gesierich, et al. (2009). 'Asymmetric Fmri Adaptation Reveals No Evidence for Mirror Neurons in Humans.' *Proceedings of the National Academy of Sciences* **106**(24): 9925.
- Littlefield, M. (2009). 'Constructing the Organ of Deceit the Rhetoric of Fmri and Brain Fingerprinting in Post-9/11 America.' *Science, Technology & Human Values* **34**(3): 365-392.
- Littlefield, M. M. (2011). *The Lying Brain : Lie Detection in Science and Science Fiction*. Ann Arbor, Mich.: University of Michigan Press.
- Logothetis, N. K. (2008). 'What We Can Do and What We Cannot Do with fMRI.' *Nature* **453**(7197): 869-878.
- Lynch, M., S. A. Cole, et al. (2010). *Truth Machine: The Contentious History of DNA Fingerprinting*. Chicago: University of Chicago Press.
- Maynard, P. (2000). *The Engine of Visualization: Thinking through Photography*. New York: Cornell University Press.
- Mitchell, T., R. Hutchinson, et al. (2004). 'Learning to Decode Cognitive States from Brain Images.' *Machine Learning* **57**(1-2): 145-175.
- Moll, J., R. de Oliveira-Souza, et al. (2002). 'The Neural Correlates of Moral Sensitivity: A Functional Magnetic Resonance Imaging Investigation of Basic and Moral Emotions.' *The Journal of Neuroscience* **22**(7): 2730-2736.
- Moll, J., R. Zahn, et al. (2005). 'The Neural Basis of Human Moral Cognition.' *Nature Reviews Neuroscience* **6**(10): 799-809.

- Moniz, E. (1933). 'Cerebral Angiography: Its Application in Clinical Practice and Physiology.' *The Lancet* **222**(5751): 1144-1147.
- Monti, M. M., A. Vanhaudenhuyse, et al. (2010). 'Willful Modulation of Brain Activity in Disorders of Consciousness.' *New England Journal of Medicine* **362**(7): 579-589.
- Mukamel, R., A. D. Ekstrom, et al. (2010). 'Single-Neuron Responses in Humans During Execution and Observation of Actions.' *Current Biology* **20**(8): 750-756.
- Nicolelis, M. (2011). *Beyond Boundaries*. New York: Holt.
- Nicolelis, M. A. and J. K. Chapin (2002). 'Controlling Robots with the Mind.' *Scientific American* **287**(4): 46-55.
- Nicolelis, M. A., A. A. Ghazanfar, et al. (1997). 'Reconstructing the Engram: Simultaneous, Multisite, Many Single Neuron Recordings.' *Neuron* **18**(4): 529-537.
- Nicolelis, M. A. and S. Ribeiro (2006). 'Seeking the Neural Code.' *Scientific American* **295**(6): 70-77.
- Nishimoto, S., A. T. Vu, et al. (2011). 'Reconstructing Visual Experiences from Brain Activity Evoked by Natural Movies.' *Current Biology : CB* **21**(19): 1641-1646.
- Nuffield Council on Bioethics (2013). *Novel Neurotechnologies: Intervening in the Brain*. . London, Nuffield Council on Bioethics.
- Nutt, R. (2002). 'The History of Positron Emission Tomography.' *Molecular Imaging & Biology* **4**(1): 11-26.
- Obrig, H. and A. Villringer (2003). 'Beyond the Visible—Imaging the Human Brain with Light.' *Journal of Cerebral Blood Flow & Metabolism* **23**(1): 1-18.
- Pais-Vieira, M., M. Lebedev, et al. (2013). 'A Brain-to-Brain Interface for Real-Time Sharing of Sensorimotor Information.' *Scientific Reports* **3**: 1319
- Pasley, B. N., S. V. David, et al. (2012). 'Reconstructing Speech from Human Auditory Cortex.' *PLoS biology* **10**(1): e1001251.
- Penfield, W. (1952). 'Memory Mechanisms.' *AMA Archives of Neurology & Psychiatry* **67**(2): 178-198.

- Premack, D. and G. Woodruff (1978). 'Does the Chimpanzee Have a Theory of Mind?' *Behavioral and Brain Sciences* **1**(4): 515-526.
- Quiroga, R. Q., L. Reddy, et al. (2005). 'Invariant Visual Representation by Single Neurons in the Human Brain.' *Nature* **435**(7045): 1102-1107.
- Raichle, M. E. (2009). 'A Brief History of Human Brain Mapping.' *Trends in Neurosciences* **32**(2): 118-126.
- Raichle, M. E. and A. Z. Snyder (2007). 'A Default Mode of Brain Function: A Brief History of an Evolving Idea.' *Neuroimage* **37**(4): 1083-1090.
- Raine, A., S. S. Ishikawa, et al. (2004). 'Hippocampal Structural Asymmetry in Unsuccessful Psychopaths.' *Biological Psychiatry* **55**(2): 185-191.
- Raine, A., T. Lencz, et al. (2003). 'Corpus Callosum Abnormalities in Psychopathic Antisocial Individuals.' *Archives of General Psychiatry* **60**(11): 1134.
- Ramachandran, V. S. (1995). 'Mirror Neurons and Imitation as the Driving Force Behind 'the Great Leap Forward' in Human Evolution.' *EDGE: The third culture*. Available at <https://edge.org/conversation/mirror-neurons-and-imitation-learning-as-the-driving-force-behind-the-great-leap-forward-in-human-evolution>.
- Ramachandran, V. S. and L. M. Oberman (2006). 'Broken Mirrors: A Theory of Autism.' *Scientific American* **295**(5): 62-69.
- Rieber, R. W. (2006). 'Nothing but God and the Brain' pp 31-41 in R. W. Reiber (ed.) *The Bifurcation of the Self: The History and Theory of Dissociation and Its Disorders*. New York: Springer.
- Rissman, J., H. T. Greely, et al. (2010). 'Detecting Individual Memories through the Neural Decoding of Memory States and Past Experience.' *Proceedings of the National Academy of Sciences* **107**(21): 9849-9854.
- Rizzolatti, G. and L. Craighero (2004). 'The Mirror-Neuron System.' *Annual Review of Neuroscience* **27**: 169-192.

- Rose, N. (1985). *The Psychological Complex: Psychology, Politics and Society in England, 1869-1939*. London; Boston: Routledge & Kegan Paul (also available at <http://nikolasrose.com/index.php/books/>)
- Rose, N. and J. M. Abi-Rached (2013). *Neuro: The New Brain Sciences and the Management of the Mind*. Princeton, N.J. ; Woodstock: Princeton University Press.
- Schwartz, A. B. (2013). Progress toward a High-Performance Neural Prosthetic, pp .14-15 in *Brain-Computer Interface (BCI), 2013 International Winter Workshop*, doi: 10.1109/IWW-BCI.2013.6506612
- Schwartz, A. B., X. T. Cui, et al. (2006). 'Brain-Controlled Interfaces: Movement Restoration with Neural Prosthetics.' *Neuron* **52**(1): 205-220.
- Shapin, S. (2000). 'Descartes the Doctor: Rationalism and Its Therapies.' *The British Journal for the History of Science* **33**(02): 131-154.
- Shen, F. and O. Jones (2011). 'Brain Scans as Evidence: Truths, Proofs, Lies, and Lessons.' *Mercer Law Review* **62**: 861.
- Simpson, J. R. (2008). 'Functional MRI Lie Detection: Too Good to Be True?' *Journal of the American Academy of Psychiatry and the Law Online* **36**(4): 491-498.
- Smith, K. (2008). 'Mind-Reading with a Brain Scan.' *Nature News* , 5 March 2008, doi:10.1038/news.2008.650.
- Smith, K. (2013). 'Reading Minds.' *Nature* **502**(24 October 2013): 428-430.
- Tennison, M. N. and J. D. Moreno (2012). 'Neuroscience, Ethics, and National Security: The State of the Art.' *PLoS Biology* **10**(3): e1001289.
- Trinh, N. N. P. (2013). *Analysis of the State of Physiology of Untruth in Prefrontal Cortex Measured by Functional near-Infrared Spectroscopy (F-Nirs)*, International University HCMC:Vietnam.
- Tusche, A., S. Bode, et al. (2010). 'Neural Responses to Unattended Products Predict Later Consumer Choices.' *The Journal of Neuroscience* **30**(23): 8024-8031.

- Varela, F. J., E. Thompson, et al. (1993). *The Embodied Mind : Cognitive Science and Human Experience*. Cambridge, Mass.: MIT Press.
- Viding, E., R. J. Blair, et al. (2005). 'Evidence for Substantial Genetic Risk for Psychopathy in 7-Year-Olds.' *Journal of Child Psychology and Psychiatry* **46**(6): 592-597.
- Viding, E., K. B. Hanscombe, et al. (2010). 'In Search of Genes Associated with Risk for Psychopathic Tendencies in Children: A Two-Stage Genome - Wide Association Study of Pooled DNA.' *Journal of Child Psychology and Psychiatry* **51**(7): 780-788.
- Viding, E., A. P. Jones, et al. (2008). 'Heritability of Antisocial Behaviour at 9: Do Callous-Unemotional Traits Matter?' *Developmental Science* **11**(1): 17-22.
- Viding, E., A. P. Jones, et al. (2008). 'Heritability of Antisocial Behaviour at 9: Do Callous - Unemotional Traits Matter?' *Developmental Science* **11**(1): 17-22.
- Villringer, A. and B. Chance (1997). 'Non-Invasive Optical Spectroscopy and Imaging of Human Brain Function.' *Trends in Neurosciences* **20**(10): 435-442.
- Wagner, H. N. (2006). 'From Molecular Imaging to Molecular Medicine.' *Journal of Nuclear Medicine* **47**(8): 13N.
- Wagner, H. N. (2009). *Brain Imaging : The Chemistry of Mental Activity*. New York ; London: Springer.
- Wagner, H. N., H. D. Burns, et al. (1983). 'Imaging Dopamine-Receptors in the Human-Brain by Positron Tomography.' *Science* **221**(4617): 1264-1266.
- Wang, W., J. L. Collinger, et al. (2013). 'An Electrocorticographic Brain Interface in an Individual with Tetraplegia.' *PloS One* **8**(2): e55344.
- Weber, S., U. Habel, et al. (2008). 'Structural Brain Abnormalities in Psychopaths—a Review.' *Behavioral Sciences and the Law* **26**(1): 7-28.
- Weinberger, S. (2011). 'Terrorist 'Pre-Crime' detector Field Tested in United States. Screening System Aims to Pinpoint Passengers with Malicious Intentions,' *Nature News* 27 May 2011, doi:10.1038/news.2011.323

Wolpe, P. R., K. R. Foster, et al. (2005). 'Emerging Neurotechnologies for Lie-Detection: Promises and Perils.' *The American Journal of Bioethics* **5**(2): 39-49.

Wu, M.-T. (2013). Method of Detecting a Suicide Terrorist, US Patent 20,130,041,263.
United States Patent Application 20130041263.

Yang, Y., A. Raine, et al. (2005). 'Volume Reduction in Prefrontal Gray Matter in Unsuccessful Criminal Psychopaths.' *Biological Psychiatry* **57**(10): 1103-1108.