Narrators of Neuromyth

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Abstract. Sociologists of science claim there is a 'neurobiologization of society' going on. Advances in neuroscience would pose challenges to various societal domains and neurobiological reductionism could even threaten the humanistic legacy. On the other hand, new neurobiological insights may yield potential benefits for human health and education. Novel fields of study and business arise like neuroeducation and neuromarketing that try to 'link' neuroscience and society. A sociology of neuroscience starts to form, now that a growing number of scholars is analyzing these 'neurocultural' discourses. In parallel, many neuroscientists worry about how their research findings transform in the public domain, urging for clearer communication and reflective practice. This paper tries to complement the toolkit of critical neuroscience while redefining the so-called 'neuromyth' concept. Here, I attempt to reach a broader conceptualization departing from the conviction that the myth goes deeper than mere misapprehension in society.

Keywords. Neurobiologization, transdisciplinarity, human brain project, science and literature, Vladimir Nabokov.

Introduction

Fast expansion of the neurosciences fuels an ongoing hype. The past decade has witnessed a mushrooming of 'new' disciplines trying to apply neuroscientific insights to societal domains. Such emerging fields of interdisciplinary study are invading the classroom ('neuroeducation'), the courthouse ('neurolaw'), the art gallery ('neuroesthetics'), the stock exchange ('neuroeconomics'), the advertising agency ('neuromarketing') and even churches ('neurotheology'). Bookstores fill up with popular science books on 'our' brain. People actually buy and read them. Such border territory resembles a Carrollian Treacle Well, from which one can draw all things that start with 'neuro' and purportedly have curative effects.[1]

A 'sociology of neuroscience' starts to form, with many scholars studying such phenomena.[2] Sociologists try to frame these phenomena by theorizing about a 'neurobiologization of society' and by analyzing 'neurocultural' discourses. One particularly interesting initiative in this regard is the project of 'critical neuroscience' (Choudhury et al. 2009), which is characterized by its proponents as a 'reflexive scientific practice' that should be practiced 'both within and outside' of neuroscience. Hence, exemplary for much critical science nowadays, it does not solely treat scientific prac-

[1] Cf. the dialogue between Alice and the Dormouse in *Alice's Adventures in Wonderland*. A curative well near Oxford was actually known by that name.

[2] 'Sociology of neuroscience' denotes the field that studies what neuroscientists do, how they think and how results of neuroscience research affect society. Note the difference with 'neurosociology' and 'social neuroscience' that revolve around neurobiological contributions to social phenomena (and that we now since the seventies and eighties of the 20th century).

tice as object of study, but advocates and at the same time rests on the idea of scientists as critical practitioners: "The critique we propose thus necessitates *reflexive* turn: neuroscientists need to critically examine scientific practices and institutions, as well as the wider social contexts within which they work." What's more, this not only begs from neuroscientists such a critically reflective attitude but even demands actual redesign of neuroscientific research based on outcomes of critical neuroscience studies.

Choudhury et al. (2009) put forward 7 core activities for their project: (1) historical, (2) technical and (3) ethnographic analysis of neuroscientific practice, (4) study of 'public engagement', (5) study of economic influences, (6) study of socio-political contexts and last but not least (7) the application of insights generated by these forms of critique to actual research practice. Notwithstanding that I am on the same page with these authors regarding the need for such a reflexive turn, I feel that these activities, as a set, will not suffice. The problem is with the final, most important activity.

Given that activity 1 to 6 are embedded in the humanities and translation of the insights yielded to natural science contexts will be far from easy, the intended application will not 'just happen' by adding on a demand for reflection to existing studies of science. Even a willingness to partake in critical neuroscience will not solve this problem entirely because incompatible world views behind theoretical frameworks of natural and social sciences may stand in its way. What critical neuroscience needs is an 8th core activity aimed at investigating the modes of thinking and the juxtaposition of different ways of knowledge production involved in its array of contributing disciplines. Such an 8th activity may be suitably termed 'comparative epistemology'.[3] Below, I will further elaborate on this methodology.

To explore the putative benefits of 'comparative epistemology' as an addition [4] to critical neuroscience's toolkit I want to conduct a case study on the Human Brain Project (HBP), the one-billion-Euro endeavor to build a human brain *in silico*. To be sure, this will not be an in depth investigation of the HBP but a form of neurocultural discourse analysis of statements in the public and scientific domain made by Henry Markram, director of HBP at the EPFL in Lausanne, and those of some of his colleagues and competitors. It will be limited to a number of papers by his hand (Markram 2006, 2011, 2012, 2013; Markram et al. 2011) and to the longitudinal documentary project, *Bluebrain*.[5]

Choudhury et al. (2009) employ a 'Fleckian' approach[6] to study the development of scientific ideas while travelling through society. In a similar fashion they try to reconstruct explanatory narratives for the transformation of neuroscientific facts over

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[3] This particular term I borrow from Hub Zwart's *Understanding Nature: Case Studies in Comparative Epistemology* (2008) in which he juxtaposes scientific and literary sources of knowledge illustrating how nature can be understood in different ways.

[4] The critical neuroscience project is in fact very philosophical. The inaugural paper's bibliography abounds with references to philosophical canonical works like Foucault's *Madness and Civilization*, Lorraine Daston and Peter Galison's *Objectivity*, and Joseph Rouse's *Engaging Science: How To Understand its Practices Philosophically*. However, the philosophical side to the project remains implicit, whereas here I will try to argue that it must be an explicit and autonomous part of its core activities.

[5] *Bluebrain*, a ten-year documentary project by Noah Hutton (bluebrainfilm.com) about the HBP was named after the Blue Brain Project (BBP), Markram's first brain project (2005-2013). Filming originally started in 2009. Every year between 2010 and 2020, a new chapter is released on the web. The Human Brain Project runs from 2013-2023. This documentary series basically pivots around the Markram 2009 quote during a TED talk in which he makes his much debated "ten years promise' ("It is not impossible to build a human brain and we can do it in ten years").

[6] See Ludwig Fleck's *Genesis and Development of a Scientific Fact* (1935).

time. Doing so, they may 'identify discrepancies between what the science directly demonstrates and what the representations of science tell us'. Here, I will embrace this idea of 'narration' but shun the upfront dichotomy between what science may directly demonstrate and misconceptions thereof. Instead I will argue that scientist and layman together are bound in a 'narrative of neuromyth' or could in fact themselves be narrators of neuromyth. The conception of a neuromyth that I will develop here resembles an 'origin story'[7] in the sense that it involves a claim to present some ultimate truth about human nature. Within the natural sciences it can take many shapes, like the 'gene for x' determinist shape that is easy to recognize. It is stereotypically linked to a positivist attitude towards science, a position Giere (2006) would refer to as 'objectivist realism', which he considers to be close to the 'common sense realism' position of many lay people. This is interesting for it gives a clue why certain types of knowledge production are easier accepted than others. My neuromyth concept also points a finger at the big risk for the critical neuroscience enterprise described above. After all, if you do not agree on to what extent the world can be objectively known or is socially constructed, it could be hard to realize successful cross-fertilization between disciplines.

The term 'neuromyth' is already used in neuroeducational contexts, where they denote misconceptions about neuroscientific results that have lead to unwarranted decisions in educational practice. The emergent domain of "mind, brain and education" (MBE) was established to fight such neuromyths and to fight those people whom MBE scholars refer to as 'the middle men of the brain based industry' (Goswami 2004; Fisher 2009). A noble cause for sure, but one cannot help but wonder whether it is these middlemen that created the myths. When I partook in a *Learning and the Brain* conference in Boston in 2012 and observed the interaction between scientists and teachers, the level of meaningful interchange seemed lower than I had hoped and hypothesized it would be. Instead, I witnessed a gap between the scientists on the stage and the teachers in the audience. In fact, teachers seemed to be more engaged in critical reflection on their own profession than scientists were. Yet, they regarded scientists with awe or they told me how they did not feel comfortable enough or given the opportunity to ask critical questions. What were sold were popular neuroscience books. Those books debunked myths, but reading them I felt like deeper myths should have been addressed.

MBE authors portray neuroscientists as disinterested, rigorous professionals that will not be tempted to produce sweeping statements even if their restraint causes frustration among the eager teacher community. In their view there is no cause for reflection, but for a new kind of professional, a 'neuroeducator' that can bridge the gap between neuroscience and educational practice. The educational neuromyth concept suggests that neuroscience may have the definitive answers, now or in the future, but that results should not be misinterpreted. According to my neuromyth concept this implication is itself neuromythical. Perhaps, in neuroeducational literature it is best to simply use the term misconception henceforward.

I have given a tripartite structure to the body of this essay. First, as said above, fragments of HBP discourse will be analyzed. This first section focuses on the interplay between science and society, and the dynamics of promises and expectations by which this interplay is characterized. In the second section I will contrast the scientific way of

[7] I deliberately choose this pendant of the *pourquoi* story, because these have this element of a 'just so story' where for no apparent reason one stops asking why something is so, once a proximate explanation is given, which is not unlike much life science research that mistakes mechanism for ultimate explanation.

knowing with a literary counterpart, by presenting a second protagonist, one more émigré based on the shores of Lake Geneva[8] who has otherwise nothing in common with the HBP director, Vladimir Nabokov. He is one of the prime examples of people with a successful professional life in both the arts and natural sciences and who has commented on the relationship frequently in interviews. Nabokov also provides a well-known example of how different modes of inquiry, associated with the arts or the sciences, may come together in a single mind. This may help counterbalance all the material that seems to support the incommensurability of both worlds. More in particular, Nabokov's descriptive method, his obsessive drive for observation as a natural historian make him an interesting figure for comparison with Markram and natural science as a whole in an era without hypothesis driven research as a standard. While cherry picking from Markram's and Nabokov's interviews I will try to relate what both men expressed about science—be it on 'blue brains' or blue butterflies[9]—to the narrative of neuromyths. It is this second section that functions as the epistemic core of this paper.

Nabokov was also an excellent commentator on the "Two Cultures" debate, first framed by C. P. Snow in 1959. This at times overheated debate will figure in the background of the third section, where the communication of concepts between different disciplines is discussed. What is at stake here is whether the program for progress outlined by critical neuroscience, strengthened by epistemic comparison and keenly aware of neuromyths, will build better bridges than before.

1. Milestone Mysteries

> "We don't have to see the brain as a mystery black box, these things can be understood."
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> —HENRY MARKRAM, *Bluebrain* film project[10]

It is the year 2014. We are halfway through the ten years that Markram predicted that it would take him and his group to build the human brain (TED talk 2009): "It is not impossible to build a human brain and we can do it in ten years."[11] What we might call the 'Frankenstein syndrome' could well have been the strongest influence on the image of scientists over the last century—the half-mad scientist tinkering with life itself, driven by a quest for knowledge and fame, detached from society, unhampered by ethical considerations. So, if it was this vein Henry Markram, director of the HBP, was trying to tap into during this talk, he surely managed to do so. In a BBC World Service interview he added: "If we build it correctly it should speak and have an intelligence and behave very much as a human does" (Fildes 2009).

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8 He and his wife Véra lived for more than fifteen years in the Montreux Palace Hotel in Montreux, which is located on Lake Geneva a couple of miles east of Lausanne. The shores of Lake Geneva are also famously known as the place where Mary Shelley had the 'waking dream' that expanded into her first novel *Frankenstein*.

9 Nabokov's specialization within lepidoptery was on the natural history of *Polyommatini* or 'blues'.

10 The *Bluebrain* documentary series will be abbreviated here as BBF, with the attached number indicating which year of the ten-year span. The reference for this Markram quote, then, is: BBF-1 around 7.10; the HBP website states it thus: "Understanding the human brain is one of the greatest challenges facing 21st century science. If we can rise to the challenge, we can gain profound insights into what makes us human, develop new treatments for brain disease and build revolutionary new computing technologies. Today, for the first time, modern ICT has brought these goals within sight."

11 Back then it was still the Blue Brain Project (2005-2013). Now that the HBP runs, again, for ten years (2013-2023) perhaps Markram has 'bought' another four years, but in fact on the basis of this promise we should be having an eye on 2019 for this remarkable promise.

This ten-year period is a very interesting time period. Given current rapid technological changes anything can happen in ten years, yet it is not too far away to trigger a sense of urgency.[12] When you want to describe how neuromyths come into being you may very well check out these places where scientists' promises don't live up or exceed public expectations. For what are they, these promises? How come scheduled milestones are still taken seriously when so often they are not reached in time or at all? What do the tales tell that sell science? Obama's announcement speech for the BRAIN[13] initiative, the American answer to the HBP, had one particular sentence that says a lot: "We still haven't unlocked the mysteries of three pound of matter that sits between our ears." Apparently, mysteries are bound to matter. Such mysteries may be 'unlocked'. And what does 'still' mean here? Have we tried so hard? Should we have unlocked them already?

Markram's words are far from mysterious in this regard. He is a one-liner machine, marking every interview with his ten-year milestone: "I want to see this built, in ten years, as I said. It's going to be built. I think it will be a very important step for science. I think we will understand the brain before we finish building it."[14] As the last quotation illustrates, when it comes to the relationship between the model and the understanding of the brain, these one-liners do not suffice. So, to be precise, this is not 'just' about building a supercomputer that can do amazing things, this is not about building a robot, this is about a full understanding of the brain: "I'm in to this thing to understand the brain. Not for my grandchildren to understand the brain. That's it. In my lifetime and as soon as possible."[15] How we should see such a full understanding remains obscure, it will have to do with the somewhat paradoxical relationship between what the model tells the scientist and vice versa. The next section will delve deeper into this.

Yet, to be sure, what one would really appreciate as understanding, namely a full understanding of all the thoughts and behavior of a single human being does indeed seem to belong to the scope of the HBP: "Eventually you will be able to build, I think, very individual models. *Your brain*. We'll be able to have it that you start with a template and take everything about you into account and then the template morphs into a personalized brain. And it's in principle possible in ten years."[16]

Other neuroscientists' responses are central to the third year episode of the Blue Brain documentary project. Their comments pivot around the same issues: milestones and mysteries. For instance computational neuroscientist Haim Sompolinsky acknowledges there is a new dawn in neuroscience: "The metaphor of exploring, we are beyond it, I think. Exploring the nervous system as an uncharted territory for the last 50 years. The new era of neuroscience is that we are going to map." In a way this 'new dawn' matches the shift from hypothesis-driven research to big data science.

Nevertheless, he shares his doubts about the HBP: "Grand projects? Yes. But grand projects have to be realistic." Even one of the HBP project managers shows signs of disbelief: "Is the brain capable of understanding itself? I think the answer is no."

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12 Cf. Ray Kurzweil's prediction for the Singularity in 2045, which still feels somewhat abstract. Also Kurzweil predicts that the human brain will be reverse-engineered 'by the mid-2020s' (Kurzweil 2005).

13 Acronym for "Brain Research through Advancing Innovative Neurotechnologies."

14 BBF-1 around 14.40.

15 BBF-1 around 10.50.

16 BBF-1 around 13.00. Markram also sketches a sort of evolutionary timeline from rodent to cat to primate to human: "We will finish rodent brain, both mouse and rat, in the next two or three years." It is up for discussion whether these goals have been attained last year.

And he goes on to recognize: "The BBP is a controversial project definitely, and it is very polarizing." Henry Markram explains this is how the scientific community operates, but that it may just need some time: "Everything changes… science, society. At the root of the problem is that we are dealing with a cultural change. What is the minimum I could measure about the brain to reconstruct it. That is the challenge of neuroscience. Very much against tradition. Naturally, I need a bulletproof vest, this is not easily accepted."[17] On the basis of these quotations it remains difficult to grasp what the 'roadmap' is. Do they want to to measure and describe as much as possible, to 'draw the entire map' so to speak, or are they satisfied with developing some minimal notion where reconstruction equals understanding.

Sebastian Seung, a Princeton computational neuroscientist,[18] claims that as long as we have not mapped the 'flight map' of the brain, that is, all the connections between neurons, or 'the connectome', the HBP will be quite useless. In his interview he says that the HBP is far from clear when it comes to deliverables: "Any kind of long term goal requires milestones, to show that the project is going somewhere, that is, I think, completely missing." [19] What he thinks is a genuine milestone we must guess after, but the fact that he refers to the Turing test[20] gives us a clue; it should be about concrete situations that can go either way. We need falsifiable statements, apparently.

Columbia University's Rafael Yuste tries to reconcile: "We are all foot soldiers for mankind, this is much bigger than any of us" and "it is not that I'm trying to be diplomatic. People are viewing this as a zero sum game. I view this as a positive sum game. Forget about the public, how about mankind, the progress of science?"[21] He does have a 'dream experiment' Seung may appreciate, that is to have the circuit they are working on play the piano, 'just like a musician plays the piano'. If that latter part is to be taken seriously we are heading towards a different direction than the direction that was taken in the Deep Blue versus Garry Kasparov chess contests in 1996 and 1997. There, it was about a clear outcome, either win or lose, man or machine, but it was not about a machine that should operate 'just like' a human being. It was about a clash between brute force computation power against… well, we do not know precisely. If the HBP can build a 'real' human brain, can it also personalize it by loading 'everything about Vladimir Nabokov' into the model and have it write a Nabokovian novel, or something that could make a Nabokov scholar believe it is? We will never have the computer power to produce a Borgesian Babylonic library (that is, infinite) and pull that novel from its digital shelves, but once we can make the model create something that resembles language, how far away are we still. What would be the 'quantum leaps' of human nature that cannot be mimicked?

"I suppose it is understandable that some people are afraid of such a model,"[22] Markram says, going in to the issue of communication to the public. His senior science writer divides the responses over two categories, on the one hand the people who say it can't be done because "there is a mysterious life spirit there", on the other hand people who object because they consider it dangerous ("You are trying to build a golem, or

17 BBF-3 around 14.30.
18 He is the son of the philosopher T.K. Seung.
19 BBF-3 around 16.00.
20 What Seung refers to here is a concrete test that would seem to count as proof of principle, in this case Turing's test which would accredit machines with intelligence when a human being cannot discriminate between the machine's answers and those of another human being. Whether the answers are correct does not matter, as long as they resemble those of a human (but cf. Searle's Chinese room).
21 BBF-3 17.14 and further.
22 BBF-2 around 11.20.

Frankenstein").[23] Obviously, the EU has funded the HBP for a reason and the potential health benefits that could result from the research are part of that. Markram frequently mentions brain diseases like depression and Alzheimer's, and claims in five to ten years we will live ten years more (a bold prediction resembling the 'Methuselarity' described by Aubrey de Grey and Paul Hynek[24]) and the health burden will progress fast in this domain if we keep doing the things the way like before. Here, it is interesting to refer to an idea in Fernando Vidal's paper on 'brainhood' (2009), in which he links the hype about neuroscience to 'a certain view of the human being' that has ascended 'throughout industrialized and highly medicalized societies'. Apparently, the conception that 'we are nothing but brains' coevolved with the acceptance of pharmaceutical intervention targeted at that particular organ.

In his *Science* interview, Markram mixes grand vistas with sobering statements: "What is difficult to get across to the public is that the end result of what we build is going to be far more boring[25] than they would hope. It's going to be like a massive telescope or an MRI machine sitting in a hospital." Then again, even the sober statement may be turned into a big promise: "It's going to be a new diagnostic tool that sits in a hospital. You will be able to run a simulation before a doctor gives you some medicine. The ultimate facility for personalized medicine." The promissory allure of neuroscientific research in the light of medical progress obviously contributes to the expectations of the public. Markram knows how to sell science, but does not differ much from other neuroscientists in this regard. Current systems of science publishing and funding demand this, and it is standard practice for neuroscientists to start the introduction section of fundamental research papers with a paragraph giving some disease statistics.

Interestingly, the documentary project also captures Markram's moments of self-reflection ("I'm learning it the hard way. I mean, in the beginning you have to say things in a general way.")[26] Such moments make one wonder to what extent the documentary film is actually an intervention.

Christof Koch of the Allen Institute brings up that a lot depends on our definition of understanding (and that, realistically, we do not even understand the brain of the roundworm *Caenorhabditis elegans*).[27] Then he expands that realistic position to the claim of some philosophers like Colin McGinn (1999) who argue that we will never understand the brain. When it comes to choosing between understanding in ten years or never, he tactfully answers: "I think we are somewhere in the middle."

With these puzzling milestone statements in mind I turn to Nabokov who will figure more prominently in the next two sections, as a spokesman for the bliss of both the sciences and the arts. Alvin Toffler once asked Nabokov about science's privileged position in demystifying mysteries: "You have also written that poetry represents 'the mysteries of the irrational perceived through rational words.' But many feel that the 'irrational' has little place in an age when the exact knowledge of science has begun to plumb the most profound mysteries of existence. Do you agree?" Nabokov's answer was as clear as Markram's forecasting: "This appearance is very deceptive. It is a

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23 Interesting how, according to this common mistake, Frankenstein the scientist and his monster have somehow merged into one.

24 Concept akin to Singularity referring to the turning moment in history when biotechnological progress in anti-aging starts to yield an exponential increase in life expectancy. Markram's predicted rate of life expectancy increase is about four times higher than current projections of the WHO and UN.

25 BBF-3 6.10 "The reason why I am putting a bit more effort [in this project] than in normal press… There is a lot of misconception about what this project is, their idea of what a model is."

26 BBF-4: around 16.00.

27 BBF-4 8.10.

journalistic illusion. In point of fact, the greater one's science, the deeper the sense of mystery. Moreover, I don't believe that any science today has pierced any mystery. We, as newspaper readers, are inclined to call 'science' the cleverness of an electrician or a psychiatrist's mumbo jumbo. This, at best, is applied science, and one of the characteristics of applied science is that yesterday's neutron or today's truth dies tomorrow. But even in a better sense of 'science'—as the study of visible and palpable nature, or the poetry of pure mathematics and pure philosophy—the situation remains as hopeless as ever. We shall never know the origin of life, or the meaning of life, or the nature of space and time, or the nature of nature, or the nature of thought" (Nabokov 1990, 44).

The HBP milestones are milestones for solving mysteries. However, what makes the HBP milestones mysterious is not so much that they undergo time shifts depending on project progress and subsidization, but that it remains unclear what is meant by the very words they contain, like 'understanding' and 'reconstructing'. As to conclude this first section I want to point to this motif of mystery and suggest that these milestone stories of demystification could themselves be neuromyths since they fulfill a desire for origins as ultimate explanation. The panacea for 'cerebral subjects' (Vidal 2009, Pickersgill et al. 2011) is a medicine against uncertainty. In the end it all leads back to ourselves, and our fears. In Nabokov's famous existentialist story 'Terror', the author gives us an epistemological conceptualization of such fears: "You see, we find comfort in telling ourselves that the world could not exist without us, that it exists only inasmuch as we ourselves exist, inasmuch as we can represent it to ourselves. Death, infinite space, galaxies, all this is frightening, exactly because it transcends the limits of our perception" (Nabokov 1997, 176). The same holds true for the universe beneath our skull.

2. Microscope and Telescope

> "To know that no one before you has seen an organ you are examining, to trace relationships that have occurred to no one before, to immerse yourself in the wondrous crystalline world of the microscope, where silence reigns, circumscribed by its own horizon, a blindingly white arena—all this is so exciting that I cannot describe it."
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> —VLADIMIR NABOKOV, 1945 letter to his sister Elena[28]

Who is afraid of the microscopic? Not Vladimir Nabokov, giant of modern fiction and professional lepidopterist at the same time. He craved for that standalone otherworld and the accumulation of hours staring into that 'white arena' blinded him, literally, to some extent.[29] Craving for what? For an indescribable excitement brought by detailed, meticulous study of minute butterfly parts. The fact that his excitement was indescribable to him does not imply, obviously, that he didn't *know* what it was related to. In fact, his description has the aura of adventure, of wandering through a land of wonder,

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[28] See *Nabokov's Butterflies: Unpublished and Uncollected Writings* (2000), edited and annotated by Brian Boyd and Robert Michael Pyle, 387.

[29] In a television interview with Kurt Hoffmann (Bayerischer Rundfunk, October 1971), he said: "These studies required the constant use of a microscope, and since I devoted up to six hours daily to this kind of research my eyesight was impaired forever; but on the other hand, the years at the Harvard Museum remain the most delightful and thrilling in all my adult life" (see Nabokov 1990, 190). And in a 1975 interview: "Since my years at the Museum of Comparative Zoology in Harvard, I have not touched a microscope, knowing that if I did I would drown again in its blind well" (see Clarke 1975, 67-69).

of pristine nature: "To know that no one before you has seen an organ you are examining, to trace relationships that have occurred to no one before, to immerse yourself ..." We witness a glimpse of a romantic self-portrait, of the scientist as a direct heir to the great explorers and naturalists that once conquered *Terra Incognita* and discovered new species: Nabokov, the treasure hunter, with his butterfly net in the Swiss Alps or microscope in a Harvard laboratory.

Reading through his interviews, it occurred to me that this invariable motif of 'treasure hunting' is about a hunt for novelty—not for Truths. The lepidopterist-writer, shunned the metaphysical 'Grand Stories', the literary and scientific 'Big Ideas'. His epistemology is experiential, his stance toward the real world one of careful, blissful observation and description. In a 1962 interview he states it thus: "Reality is a very subjective affair. I can only define it as a kind of gradual accumulation of information; and as specialization. . . . [B]ut you never get near enough because reality is an infinite succession of steps, levels of perception, false bottoms, and hence unquenchable, unattainable" (Nabokov 1990, 10-11). In that same interview, when asked for the connection in being both a professional lepidopterist and novelist, he states: "I think that in a work of art there is a kind of merging between the two things, between the precision of poetry and the excitement of pure science" (Nabokov 1990, 10).

This intriguing chiasm, the unanticipated pairing of characteristics and disciplines, should not be interpreted as mere word play but as a sincere description of his vision and feelings. A few years later he goes even further by placing this poetical precision not in the work of art but *inside* science: "The tactile delights of precise delineation, the silent paradise of the camera lucida, and the precision of poetry in taxonomic description represent the artistic side of the thrill which accumulation of new knowledge, absolutely useless to the layman, gives its first begetter" (Nabokov 1990, 78-79).

Markram delves into the microscopic domains just like Nabokov did, but there is a crucial difference according to his own words: "Reductionists must keep digging. I'm digging, I'm a reductionist. I dig. But it's not enough just to dig, you have got to put it together." In the second part (year 2) of the *Bluebrain* documentary film project, he describes in almost mystical words how that goes about, this putting together of pieces: "We can see deeper into the brain and when we see deeper we see rules."[30] He goes on to introduce the 'telescope' as a metaphor for the model they are working on: "The magic of that is that theory and experiment were originally the way of discovery, or knowledge discovery. The telescope improves with better rules. I believe it is going to become a very important knowledge discovery tool. It will catalyze in itself discovery."[31] The paradoxical nature of a model's representation of reality lies beyond the line where it starts telling us things we didn't anticipate. This is where the rules come in and the model's autocatalyzation. Models are fed with rules and they spit out new ones. A process that is simultaneously 'magical' and mathematical. Moreover, the aptly chosen metaphor of the telescope, with its connotations of objective visual observation, makes it seem like we are dealing with observable truths. The two pillars of science, mathematical logic and observation come together in what the telescope metaphor suggest and actually represents.

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30 BBF-2 around 08.20.

31 In his 2011 *Science* interview, Markram also uses this metaphor and mirrors the universe and the brain: "It's like building a giant telescope to peer into deep space, only that we'll be able to look deep into the brain and ask questions that are impossible experimentally and theoretically" (Markram 2011, 748-749). What exactly is meant by theoretically impossible questions remains unclear.

Now what is this model, exactly, given that Markram thinks they will understand the brain before they finish building it (*vide supra*)? Giere in his paper on how models are used to represent reality contends that "it is not the model that is doing the representing [aspects of the world]; it is the scientist using the model who is doing the representing" (Giere 2004, 447).

The scientific practice of representing the world is "fundamentally pragmatic" according to Giere (2004). Therefore he is interested in the activity of representing, and scientists as intentional agents, with roughly the form "S uses X to represent W for purposes P". An HBP example of that would be "Markram/HBP uses Telescope to represent Human Brain for Understanding and Treating Disease". This would make perfect sense when subsequently the contexts of disease treatment are clearly defined and there is a strong rationale tying this conceptualization to the activities of representing. Yet, I have trouble reconstructing the HBP in this form, because not only do we lack the wider conceptualization of the disease problem, but particularly because the model is put forward as an actual representation of entire human nature.

Markram started out as a microscope man. I remember when I attended a conference talk by Henry Markram in 2001—having just started my PhD in neuroscience—there was some consternation about his take-home message. Did he really say they were going to map each and every neuron of the cortex? The way I was trained was to always 'look for' general mechanisms (that were supposed to 'underlie' a phenomenon) and think about the physiological relevance of the data you managed to collect at the electrophysiological level. Here, someone was advocating a revolutionary turn towards massive description. But what use could Markram's 'stamp collection' have for the scientific community? I recall how conversations over coffee after his talk were loaded with an odd blend of envy and ridicule. I myself had trouble seeing where his project would be heading towards, all the more when in my own research getting a grip on the myriad regulatory pathways within even one single neuron already seemed like staring into a bottomless abyss.[32] Did his focus on description change during the early years of the BBP, or was there always a deterministic core to this description that reflected the vision of fully understanding the brain by sheer computer power?

Now that I think back, I realize that his style of scientific thinking resembled that of a natural historian, but the difference with Nabokov's style is the dominance of the theoretical matrix that pre-structures the wondrous empirical phenomena. A comparative epistemology may expose subtle or less subtle differences between different modes of inquiry, or rest on a Foucauldian notion of dominant ways of thinking per time period manifest across disciplines, it will always have to deal with what is going on inside a single scholar's mind versus what is happening in society at large. An alternative view on science history, one that doesn't carry along the Bachelardian focus on rupture as so many others the last 50 years, is that of STM scholar Pickstone (1993, 2001), who asserts that indeed history has witnessed shifts of scientific thinking, but

[32] Koksma et al. (2003) show that neurosteroid sensitivity of $GABA_A$-receptors depends not only of subunit composition but also on phosphorylation state, adding another layer of regulation with endless possibilities. A pentameric structure like a $GABA_A$-receptor with only a limited set of subunits can be constructed in more ways than one has predicted there are elementary particles in the universe. Regardless of how useful neuronal modeling may be, 'exhaustive modeling' of only a single neuron seemed impossible to me, let alone of an entire brain. In the account of Giere (2004) on models, they serve the purposes of the scientist, they are part of a practice and should depend on the problem one faces. He gives the example of modeling the water flowing through pipes would not be modeled adequately at the molecular level. Likewise, Markram et al. (2011) are unsure about the level of biological detail the HBP would finally need.

that certain progress is made and the different 'ways of knowing' can be traced in extant thinkers as layers. I find this an attractive concept, since it allows for comparison and communication between different modes of inquiry across disciplines because of the capacities of the human mind, more than the somewhat mystical workings of a *Zeitgeist*.

Now, on the one hand Markram's telescope stands for a new way of knowing: "What we are developing is a new foundation, a new instrument—a telescope—that will allow one to look deep into the brain, offering a more systematical approach to any disease." On the other hand, the telescope is an actual instrument that Markram envisions to sit in a hospital and scientists may reserve time on it to conduct experiments.[33] "It's an infrastructure to be able to build and simulate the human brain, objectively classify brain diseases and build radically new computing devices" (Markram 2011, 748).

Regardless of all the attention his BBP/HBP has had so far, his most cited paper is still by far his 1997 *Science* paper (Markram et al. 1997) with Nobel Prize winner Bert Sakmann on synaptic plasticity and backpropagating action potentials ('dendritic APs').[34] Although it is early to tell, this may indicate that 'the neuroscientific community' takes his early work more serious than his current ambitions. Unsurprisingly, the very first reference in this paper is to the work of Donald Hebb (1949). This psychologist hypothesized that when neurons are simultaneously active their synaptic contact may be strengthened (often paraphrased as 'fire together, wire together'). Hebbian theory has a canonical status in neuroscience and learning theory. The interesting thing about these Hebbian Rules (also known as Hebb's postulate) is that they hint at what sort of thing it is that Markram thinks about when he makes mention of these rules that see deep into our brains. Hebb's postulate foreshadowed a lot of research on synaptic plasticity among which that of Markram himself.

When it comes to biological rules, what the HBP currently seems to lack is a developmental and evolutionary point of view. Humans evolved and human evolution like all evolution followed a contingent, historic, one time trajectory, a trajectory which was perhaps driven by myriad selective pressures, but that was neither programmed in any consistent sense nor resulted in a program as a product. Markram, and many others like him, do talk about humans as 'being brains' for which there exists a blueprint in the genome. Systems biology has been on the rise since that other colossal human project, the Human Genome Project (HGP) success, dissolved into public disillusionment about the lack of progress made in medicine now that the human genome was fully sequenced. Agreed, the complexity is enormous. We do not have to run away from it, but we may approach it in many different ways. The lesson learned could be that no full reduction is possible within the biological sciences, but studying phenomena at different levels still has the advantage that outcomes at one level may render constraints for interpreting outcomes at another level. In the end, for an understanding that

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[33] Markram 2012, 52. See also BBF-2 around 5.00: "Then we are going to invite scientists, including scientists who don't agree with us, to come and do experiments with our telescope."

[34] Google Scholar in April 2014 finds 2311 citations for this *Science* paper versus 669 for his 2006 *Nature Reviews Neuroscience* paper on the Blue Brain Project (Markram 2006). To be absolutely sure, mentioning this citation difference does not in any way illustrate my personal opinion about Markram's brain projects. That this paper uses the HBP to illustrate and develop the neuromyth concept does not mean its author believes the HBP to be without merit. In fact, I would not even feel qualified to comment on whether the EU's investment will be money worth spent. At the very least, it will strongly enhance collaboration between neuroscientific research groups, which mostly turns out to be a good thing.

goes beyond the proximate level of mechanisms, we need to study the developmental and evolutionary trajectories.

Both Nabokov and Markram rely heavily on empirical experience, even though Nabokov does discriminate between the senses: "even with the best of visions one must touch things to be quite sure of 'reality'" (Nabokov 1990, 79).[35] Interestingly enough, for a taxonomist, Nabokov does not exhibit much of a belief in the order of things. He prefers the delightful detail over the general principles and rules. This goes for both science and literature. The "literature of ideas" he referred to as topical trash.[36] Developmental systems biology, unlike systems biology in general, truly functions as a scaffold for pluralism in the life sciences. Such realism, like Dupré's promiscuous realism, does not make a caricature out of scientific practice, but stays away from the positivist, determinist, essentialist preconditions that still characterize the neuroscientific community (see Dupré 1995). It is those preconditions that set in motion and constantly feed the narrative of neuromyth, apart from any considerations on how science and society interact.

Nabokov beautifully blends the evolutionary and developmental when in comes to the human mind by describing how he and his wife discovered (*sic*) the wondrous physical existence of their baby and describes the color of their newborn's eyes:

> that swimming, sloping, elusive something about the dark-bluish tint of the iris which seemed still to retain the shadows it had absorbed of ancient, fabulous forests where there were more birds than tigers and more fruit than thorns, and where, in some dappled depth, man's mind had been born; and above all, an infant's first journey into the next dimension, the newly established nexus between eye and reachable object, which the career boys in biometrics or in the rat-maze racket think they can explain. (Nabokov 1988, 228)

3. The Art of Translation

To what extent does a presupposed neurobiologization of society represent something new? Haven't we seen this kind of debate of the respective roles of the natural sciences, the arts and the humanities many times before? From time to time this debate gets overheated and armies march to the battlefield called Human Nature. Underneath this is the fear of many for being portrayed as a brain instead of a human with a brain. Vidal uses the term 'cerebral subject' for this reduced-to-its-brain human, a subject "specified by the property of 'brainhood', i.e. the property or quality of being, rather than simply having, a brain (Vidal 2009; see also Pickersgill et al. 2009).

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[35] The paleontologist and essayist Stephen Jay Gould discussed Nabokov's lepidoptery in his essay 'No Science Without Fancy, No Art Without Facts: The Lepidoptery of Vladimir Nabokov' (reprinted in Gould 2002, 29-53). Gould notes that Nabokov was occasionally a scientific 'stick-in-the-mud'. For example, Nabokov never accepted that genetics or the counting of chromosomes could be a valid way to distinguish species of insects, and relied on the traditional (for lepidopterists) microscopic comparison of their genitalia. Interestingly, recent studies on butterfly migration back up Nabokov's ideas about evolutionary paths of certain species. At least, being stuck in the mud he didn't become a genetic determinist.

[36] Interviewer: "What is your reaction to the mixed feelings vented by one critic in a review which characterized you as having a fine and original mind, but 'not much trace of a generalizing intellect', and as 'the typical artist who distrusts ideas?'" Nabokov: "In much the same solemn spirit, certain crusty lepidopterists have criticized my works on the classification of butterflies, accusing me of being more interested in the subspecies and the subgenus than in the genus and the family. This kind of attitude is a matter of mental temperament, I suppose. The middlebrow or the upper Philistine cannot get rid of the furtive feeling that a book, to be great, must deal in great ideas" (Nabokov 1990, 41).

The complicated reality of this debate is that most of the time there actually is something at stake, even though sometimes it resembles a self-perpetuating academic exercise. There is a lot of talk about gaps and bridges, and certain naturalists famous among the general public, such as Stephen Jay Gould and E. O. Wilson, have undertaken sincere attempts to bring both parties closer together. The effect of scholarly work in this arena could also be, ironically, a dichotomizing one. Even C. P. Snow reconsidered original statements about his "Two Cultures" residing on either flank of the "rift" between scientists and literary intellectuals, but his idea of a third culture did not help to break down discursive fences (Snow 1963).

The idiosyncratic, dual professional life of Nabokov shows there does not have to be a gap at the concrete level of the individual. His own views corroborate that line of reasoning, given his answer in the *Wisconsin Studies in Contemporary Literature* interview to a question asking to position himself in the "Two Cultures" debate: "I might have compared myself to a Colossus of Rhodes bestriding the gulf between the thermodynamics of Snow and the Laurentomania of Leavis, had that gulf not been a mere dimple of a ditch that a small frog could straddle. The terms 'physics' and 'egghead' as used nowadays evoke in me the dreary image of applied science, the knack of an electrician tinkering with bombs and other gadgets. One of those 'Two Cultures' is really nothing but utilitarian technology; the other is B-grade novels, ideological fiction, popular art. Who cares if there exists a gap between such 'physics' and such 'humanities'? Those Eggheads are terrible Philistines. A real good head is not oval but round" (Nabokov 1990, 78).

Gaps may be defined at the institutional level, they may be abstract or quite material, but in the end it matters what studying these gaps yield. If it is so that scientific progress may actually kill knowledge, if it would be so that neuroscientists lack the attitude and knowledge to engage in reflexive practice, if it would be a correct observation that philosophy has become too much of an isolated domain of thinking, and scientific education leads to early specialization, such projects like critical neuroscience have a lot to fight for. What is needed is studies that reach the level where it becomes clear what different professionals mean when they use certain words, including the working definition for concepts, conscious or not (see, for example, Margolis and Laurence 2014).

But then again, other trends seem to be going on, as there is so much transdisciplinary work going on between scientific disciplines and between theory and practice that it is hard to forecast where we are heading. Nabokov appreciated, in that same interview, the role of language when it comes to crossing boundaries: "I certainly welcome the free interchange of terminology between any branch of science and any raceme of art. There is no science without fancy, and no art without facts. Aphoristicism is a symptom of arteriosclerosis."

Yet, we need people that master the art of translation, since the quest for a *lingua franca* relies too much on old notions of unity and order. Such translation skills are hard to come by because we still struggle with the aftermaths of the 'Science Wars' and the mirrored positions of 'social construction of science' versus 'scientific construction of society' are still held. Ideal translators of poetry, according to Nabokov—who was brought up speaking three languages at home—not only master both languages perfectly, but are also great poets themselves. We do not need more mythwatchers to join the horde of 'middle men', what we do need is reflective practitioners on either side that have reframing capacities and use them while enjoying the putative benefits of boundary crossing. What makes the critical neuroscience program strong is precisely

that it begs for a new type of scientist, a reflective practitioner.[37] This calls for many things, particularly from an educational point of view, but to my mind it should not call into action a bridge specialist at the cost of critical reflection on either side of the river.

One cannot engage in comparative epistemology entirely without metaphysical positioning. Then again, this doesn't mean every scientist should also be trained as a philosopher. Yet, there are interesting philosophers like Giere who search for a metaphysical position that "mediates between the objectivism of most scientists, or the realism of many philosophers of science, and the constructivism found largely among historians and sociologists of science" (Giere 2006). Why not add such authors to the discourse that critical neuroscience intends to build?

Conclusion

The success of the critical neuroscience project and other such projects depends on the ability of scientists' ability to reflect critically on their own discipline's practice and principles and appreciate them as a human product, which means it is also produced by historical and social factors. Moreover, they should engage in comparative epistemology. This does not include a conviction that all theories have equal epistemic value, or suchlike relativist notions, but it does include a comprehension of science as an inherently disunited array of conceptualizing the world. Acknowledging the disunity of science may open us up to the therapeutic effects of comparative epistemology. This therapy, then, would allow for progress in such critical science enterprises that involve the scientists themselves.

More than 150 years after Charles Darwin's seminal work on evolution, the anti-essentialist philosophy that forms its theoretic core is starting to finally gain ground in the life sciences. Medical textbooks for the first time include sections on evolutionary medicine, genomics in the post-HGP era is embracing developmental biology, and notions of health and self get more context-based given the lack of biological standards for calibration. We may once more embrace the legacy of Ernst Mayr and Niko Tinbergen, who added the evolutionary and developmental to the mechanic as inextricable levels of understanding needed for meaningful biological explanation. The evolutionary element comprises both evolutionary drivers that may relate to the putative use of a trait, but also the view of evolution as a complex of contingent, historical trajectories. To explain biologically, in this fashion, means opening up to ever more questions. It comprises an inherent protection against neuromyths.

A disordered world that may be ordered only according to the purposes of the one who orders does not have to be antirealist. The fact that kinds may be indiscernible from one another does not in itself endanger the reality of 'things in the world'. What we are left with are the stories that we want to tell because they have a purpose, because they serve a cause. Our narratives would not be centered upon a quest for origin, but accounts that recognize the idiosyncrasies of life and people, accounts that would matter, given the current situation. The normative turn in science is imminent and this is a good thing. With all the great work involved in the HBP wouldn't it be better if the scientists would have made clear exactly what it is about patient's lives that they want to improve, from a patient's perspective, that is? In this way Giere's 'purposeful representing' would be both a conscious epistemological and conscientious ethical activity.

[37] Cf. Schön (1983) and Schön and Rein (1995).

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