An aerial photograph of a river valley. A wide, green river flows from the top left towards the bottom right. The surrounding mountains are covered in dense vegetation, appearing in shades of purple, pink, and yellow. The river's path is marked by a dark, winding line.

LIFE, RE-SCALED

**The Biological Imagination
in 21st-Century Literature
and Performance**

**EDITED BY LILIANE CAMPOS
AND PIERRE-LOUIS PATOINE**



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6. Neurocomics and Neuroimaging

David B.'s *Epileptic* and Matteo Farinella
and Hana Roš's *Neurocomic*¹

Jason Tougaw

Overtuning the age-old axiom that a picture is worth a thousand words, perhaps these PET images require millions of words to be understood!²

Joseph Dumit, *Picturing Personhood: Brain Scans and Biomedical Identity* (2004)

In his graphic memoir *Epileptic*, David B. portrays an impossible fantasy: that he might find a doctor who could 'transfer' his brother Jean-Christophe's epilepsy into him.³ He fantasizes that an exchange of brain matter might enable him to feel what it is like to be his brother. It is a fantasy of overcoming *the explanatory gap*, a term coined by philosopher Phillip Levine to describe a persistent obstacle to understanding consciousness from a neurobiological point of view: nobody can explain how immaterial experience—self, consciousness, cognition, memory,

1 This chapter is a revised version of the chapter 'Neurocomics and Neuroimaging', in Jason Tougaw, *The Elusive Brain: Literary Experiments in the Age of Neuroscience* (New Haven: Yale University Press, 2018), pp. 186–227, <https://doi.org/10.12987/9780300235609-012>.

2 Joseph Dumit, *Picturing Personhood: Brain Scans and Biomedical Identity* (Princeton: Princeton University Press, 2004), p. 24.

3 David B., *Epileptic* (New York: Pantheon, 2006); the original French title is *L'Ascension du Haut Mal*.

imagination, affect—emerges from brain physiology, from synaptic networks and brain regions, groups of neurons oscillating in and out of sync, stimulating each other with varying amplitudes of electricity, circulating chemicals that change each other's behaviour.⁴

Maintenant que je suis fort, j'imagine que je pourrais prendre sur moi la maladie de mon frère. Si un savant habile pouvait la transvaser dans mon crâne.



Fig. 1 David B., *L'Ascension du Haut Mal* (1999) © David B. and L'Association. All rights reserved. English translation: 'Armed with my newfound strength, I fantasize that I could take on my brother's disease if a resourceful scientist were to transfer it into my skull'.

'I fantasize', David B. writes, 'that I could take on my brother's disease if a resourceful scientist were to transfer it into my skull'.⁵ Throughout *Epileptic*, he struggles to empathize with Jean-Christophe. In his fantasy, brain science will rewrite his failure and undo the mutual alienation of two siblings. But no scientist is that resourceful. Readers don't need to see David B.'s imaginary scientist to know he is a quack (though versions of him *do* appear in other panels). The trappings of his steampunk lab undercut the fantasy with irony and despair. David B. draws Jean-Christophe's epilepsy as a serpent that slinks from panel to panel and page to page. In this particular panel, the serpent fuses with the characters' brain matter and the wires of retro machinery of a mad scientist's laboratory. In others, it slips out of the brain through scenes of family domesticity, medical clinics, and characters' dreams

4 Joseph Levine, 'Materialism and Qualia: The Explanatory Gap', *Pacific Philosophical Quarterly*, 64 (October 1983), 354–61, <https://doi.org/10.1111/j.1468-0114.1983.tb00207.x>.

5 B., *Epileptic*, p. 168.

and memories, to become a recurring image of epilepsy's reach beyond the brain. Epilepsy is a brain disorder, but it affects the whole of Jean-Christophe's body and life. He suffers physically and emotionally; his family is defined by the helplessness it makes them feel; his community ostracizes him. Neurology cannot eliminate Jean-Christophe's seizures, and the constellation of their effects is surely beyond the power of biomedicine. *Epileptic* reminds readers of a fact that is easy to overlook: the brain reaches through the whole body, through selfhood, touching identity, family, social life, and the physical environment.

Matteo Farinella and Hana Roš's *Neurocomic* (2014) offers a similar set of philosophical ideas about the relation between the brain and the self—in the form of a basic neuroscience lesson wrapped loosely in a fictional visual narrative.⁶ Farinella is an illustrator with a Ph.D. in neuroscience and Roš a research associate in neuroscience and pharmacology at the University College, London. Together they have created a hybrid text of literary neuroscience—a graphic neurology fairytale primer. *Neurocomic*'s quest narrative could not be more explicit, linking a search for self directly with the protagonist's journey through the human brain. A generic man finds himself trapped in a book read by a generic woman who attracts him. The characters are allegorical composites, unlike those in most brain narratives, which tend to represent individual, even idiosyncratic, experience. Like many works of contemporary literature, *Neurocomic* and *Epileptic* ask, in philosopher Catherine Malabou's words, *what should we do with our brain?*⁷ How might we understand its relation to identity? How should we live with it, study it, or write about it? Like so many twenty-first-century brain narratives, both texts conceive the physical brain as central to the stories they tell, the conflicts they plot, and the characters they portray; both genres engage brain research, translating neurobiological theories into literary experiments. Their creators experiment with narrative forms that may frame new views on the relationship between brain matter and the immaterial experiences that compose a self—what philosophers call phenomenology.

6 Matteo Farinella and Hana Roš, *Neurocomic* (London: Nobrow Press, 2014).

7 Catherine Malabou, *What Should We Do with Our Brain?*, trans. by Sebastian Rand (New York: Fordham University Press, 2008), p. 63.

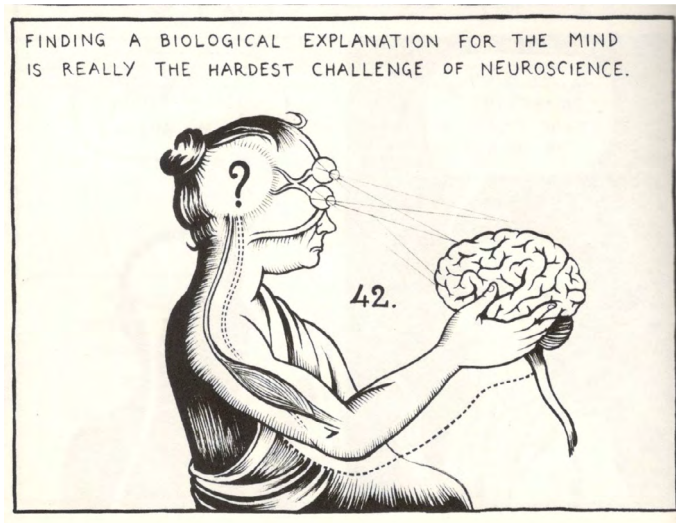


Fig. 2 Matteo Farinella and Hana Roš, *Neurocomic* (2014) © Matteo Farinella and Hana Roš. CC BY-NC-ND 4.0

Whereas *Neurocomic* creates characters whose brains become a vehicle for telling a story about the current state of neuroscientific knowledge, *Epileptic* portrays its characters' brains as part of an ensemble of images that define their search for what it means to suffer as a result of neurological conditions beyond their control. Like so many brain narratives, both books offer alternatives to 'you are your brain'/'you are not your brain' debates. The interplay of image and text in these graphic narratives becomes an analogue to the inexorably unraveling binary between physiology and subjectivity. That interplay offers constant reminders that we can see physiology—from the macro view of a whole brain to the micro views available through neuroimaging technologies—but we cannot see subjectivity. Nonetheless, an artist can represent it, just as developers and practitioners of brain scanning technologies hope they might be able to.

Neurocomic tells a representative story, not a particular one. Like Alice through her rabbit hole, the composite man falls through the book into what appears to be his own brain (or a composite one).

He meets a series of guides—famous figures from the history of neurology, including Santiago Ramón y Cajal, Charles Sherrington, and Eric Kandel—who lead him through the bewildering and often

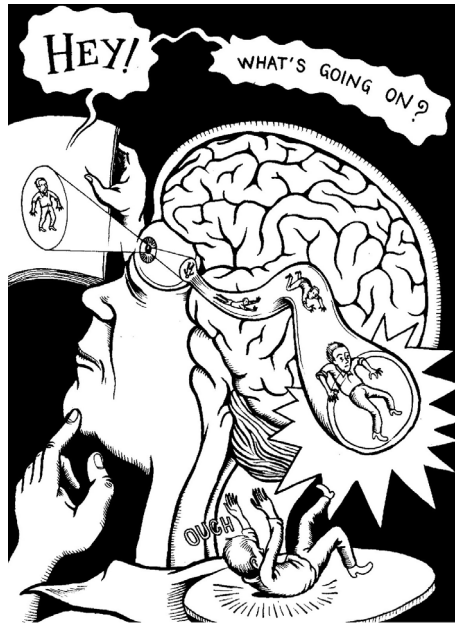


Fig. 3 Matteo Farinella and Hana Roš, *Neurocomic* (2014) © Matteo Farinella and Hana Roš. CC BY-NC-ND 4.0

terrifying ‘forest’ of his own brain and finally into the ‘castle of our consciousness’ (where he is reunited with the reading woman who initiated his ambivalent quest).⁸ But does the generic man find his *self* through the journey? Not quite. Instead he discovers he is an object of representation, twice over. He is a character in a book, made of pen strokes, panels, shapes, and words; and he is an animated being, made of bones, flesh, cells, electricity, and proteins whose continuous inter-relations would seem to create him—though, as in most literature inspired by neuroscience, it is not clear how his identity emerges from these inter-relations. The making of self through the tools of artistic representation become a substitute for the more elusive making of self through physiology. In many ways, *Neurocomic* would appear to tell a simple—and even simplistic—story about a series of great men who made great discoveries in the history of brain research. But its frame-tale structure complicates that story through its emphasis on representation. The frame embeds a history of neuroscience within the emerging

⁸ Farinella and Roš, *Neurocomic*, p. 113.

tradition of literary experiments that entangle neurological questions with aesthetic experiments.

Neurocomic's opening scenario and central conceit gives fictional form to a fantasy Michael Phelps, one of the key developers of the brain scanning technology positron emission tomography (PET), described in an interview with anthropologist Joseph Dumit:

Your body looks like it is a physical, anatomical substance, but inside there are all kinds of cells that are metabolizing things, or moving around and doing things, signaling to each other. We'd like to be able to watch this action. That is the objective. You know the activity is there, and you'd like to build a camera that can watch it. Well, one way to do that is first to say, "Well, if I was really little, I could go in there, move around, and watch those things. But since you cannot go in there, you can send a messenger. So you do that. So you take a molecule that will go and participate in that portion. [...] That is really what PET does. It reveals to us something that we know is going on in your body, but that we can't get to."⁹

With *Neurocomic*, Farinella and Roš fulfill Phelps' impossible wish, creating a protagonist who shrinks, to become 'really little', who can 'go in there, move around, and watch' the 'action' of his own brain. A human cannot shrink to enter a brain, but a character in a comic can. In that sense, the representational tools of a comic enable what is not possible in life—as might happen in a dream. When they give visual form to Phelps' fantasy scenario, Farinella and Roš emphasize a host of disparities between comics and brain scanning technologies—differences in aims, techniques, and cultural status. Their literary experiment involves play, irony, fantasy, and the breaking of boundaries, while scientific experiments involve observation, truth, and the boundaries of method. But Farinella and Roš's experiment also suggests some relations between literary and scientific experiment, which share the fundamental aims that motivate Phelps' fantasy: to get inside, to 'know something [...] we can't get to'. The impetus for these very different enterprises is rooted in personal suffering, the mysteries of physiology, and the making of knowledge. Finally—and perhaps most obvious, though little discussed—they both require human practitioners. A PET image and a frame of a graphic narrative are both designed by people whose judgments shape their results and their meanings. When

9 Dumit, *Picturing Personhood*, pp. 2–3.

Neurocomic's protagonist falls into the brain, readers see him tumbling into the explanatory gap.

The Tools of Comics

Literary criticism of graphic narratives has exploded with the genre's growing popularity and circulation in the last decade. Its most influential critics emphasize the possibilities for representing fluid identity and experience made possible by the distinctive features of the genre, starting with the interplay of text and image, but also including the creation of visual voice, frames that contain meaning, disrupted frames that loosen it, and the gutters between pages that guide and pace the reading experience. Rocco Versaci argues the interplay of text and image 'reminds us at every turn (or panel) that what we are experiencing is a representation'.¹⁰ In their introduction to an influential 2006 issue of *Modern Fiction Studies*, Hilary Chute and Marianne DeKoven argue that graphic narrative 'calls a reader's attention visually and spatially to the act, process, and duration of interpretation' because 'it refuses a problematic transparency, through an explicit awareness of its own surfaces'.¹¹ The hybrid form of graphic narrative enables modes of representation that bypass linear narrative. As Chute and DeKoven note, 'the form's fundamental syntactical operation is the representation of time as space on the page'. Following on this idea, they make several additional claims about the genre: 1) its hybridity is 'a challenge to the structure of binary classification', 2) it is a 'mass cultural art', drawing on high and low art indexes, 3) it is multigeneric, composed, often ingeniously, from widely different genres and subgenres, and 4) its visual and verbal elements 'do not merely synthesize' but can tug at or tussle with each other to create meaning of unruly referents that cannot be tamed by logical or linear structures.¹² For all of these reasons—and because of a lineage of comics as a subversive, subcultural art form—graphic narratives tend to offer alternative or non-mainstream takes on the subjects they represent. The explanatory gap of neuroscience and

10 Rocco Versaci, *This Book Contains Graphic Language: Comics as Literature* (New York: Bloomsbury Academic, 2007), p. 6.

11 Hilary Chute and Marianne DeKoven, 'Introduction: Graphic Narrative', *Modern Fiction Studies*, 52.4 (2006), 767–82 (p. 767), <https://doi.org/10.1353/mfs.2007.0002>.

12 *Ibid.*, p. 769.

the gutters of comics are a nice match in the pursuit of hypothetical knowledge about the physiology of selfhood.

In the theoretical neurosciences, the brain is routinely described as a representational organ. ‘You are your synapses’, writes Joseph LeDoux; the self is ‘a dynamic collection of integrated neural processes, centered on the representation of the living body’, writes Antonio Damasio.¹³ LeDoux and Damasio disagree about quite a lot, but they agree that the brain works by representing the self—and the world—via patterns of cellular and intracellular interaction. Of course, neither of these leading neuroscientists can be sure about how the feeling of selfhood emerges from these patterns of representation. LeDoux believes the key to consciousness lies in the physiology of the cerebral cortex and Damasio believes it lies in the evolutionarily older upper brain stem. They agree that either way it will involve the multiple interactions of both these brain areas, along with a host of others. While the debates continue and research advances, the field of consciousness studies proceeds largely through two modes of investigating brain-self-world relations: the thought experiment and the brain scan. Both modes—perhaps we can call them genres—tend to obscure their representational tools. This distinguishes them from other thought experiments, about echolocating bats, color scientists locked in colorless rooms, or zombies, which are like fairytales too, but are used to wage philosophical debates and ultimately the positions they represent outshine the outlandish hypothetical stories they tell. Brain scanning technologies like PET, SPECT, and fMRI represent brain activity through a complex process that involves the collection of data about the flow of chemicals, oxygen, or blood in the brain, the algorithmic representation of that data in visual forms, and the interpretation of the images by trained human experts. As scholars in many disciplines have noted, the result is an image that appears—to the non-expert—to speak for itself; that is, to represent neural activity directly.

I am arguing that neurocomics visualize a particularly vivid version of an idea implicit in most brain memoirs and neuronovels: we need to find more effective means of communicating about how knowledge

13 Joseph LeDoux, *Anxious: Using the Brain to Understand and Treat Fear and Anxiety*, 1st ed. (New York: Viking, 2015), p. 324; Damasio, Antonio, *Self Comes to Mind* (New York: Pantheon, 2010) p. 8.

regarding our brains is produced. We need rhetorical techniques that account for the epistemological gaps in research, the dynamic interplay of systems proposed by the theories (including physiological, environmental, and social ones) *and* the representational tools we use to develop those theories. We need rhetorical techniques with as much appeal as thought experiments and brain scans. Graphic narratives make meaning by inviting readers into the representational process—which seldom happens in the cultural circulation of neuroscientific knowledge.



Fig. 4 David B., *L'Ascension du Haut Mal* (1999) © David B. and L'Association. All rights reserved. English translation: 'They perform gaseous encephalograms on him. They shoot gas into his brain to inflate it so they can take photos in which they hope to find traces of a lesion or tumor. When my parents tell me about it, I visualize my brother in the clutches of mad scientists'.

Images of physical brains in graphic narratives are indirectly related to the images produced by neuroimaging technologies, in the sense that the cultural pervasiveness of such images—particularly those created through fMRI—are our era's most common form of the brain image. The comics I am discussing here do not duplicate or represent brain scans, favoring images that recall comic book traditions of exposed brains or brains with agency who become characters (usually villains). But both *Neurocomic* and *Epileptic* do gesture toward a relationship between neuroimaging and the visualization of brains in comics. In *Epileptic* (which Hilary Chute calls 'the most famous of graphic illness narratives'), Jean-Christophe undergoes gaseous encephalography, an outdated and little used technology that replaces cerebrospinal fluid with gases in order

to produce radiographic images.¹⁴ In David B.'s words, 'They shoot gas into his brain to inflate it so they can take photos in which they hope to find traces of a lesion or tumor. When my parents tell me about it, I visualize my brother in the clutches of mad scientists'. He is explicit here about the mediation of the image he presents for readers; it is based on third-hand knowledge. As Chute argues, *Epileptic* 'is a deeply stylized text, invested thoroughly in its own veracity but devoid of naturalism' which 'signals itself as an imaginative reconstruction of the past on every page'.¹⁵ The doctors explain the technology to his parents, they explain it to him, and he develops a terrifying fantasy about it, which he draws using stylistic features that appear throughout the memoir: the steampunk technology, the tiny doctors probing Jean-Christophe's outsized skull, the blank expression on his face, the snake-like tubes that recall the serpent of his epilepsy. If the doctors find a lesion or tumor, surgery might be able to help Jean-Christophe. But they don't. The brain scan becomes one more in a long series of attempts to find a solution to explain or eliminate Jean-Christophe's seizures, a string of epistemological failures. When David B. represents it, he is careful to cue readers to notice the mediation of the image he presents, mediation that reflects the epistemological failures of his family's quest to save his brother. The hope created by each possible cure or treatment—most of them based on false certainties—is destroying the family. As a writer and comics artist, he works in a medium that proliferates uncertainty. Even his identity is in question. David B. is a pseudonym. As a character in his memoir, the adult David B. and the child Pierre-Francois—his given name—are sometimes fused and sometimes distinct. If the memoir has a thesis, it is that he and his family need to find ways to live with such uncertainty.

By comparison, the stakes of *Neurocomic* are more academic, less personal, immediate, or visceral, but equally focused on foregrounding its representational resources—and those of the neuroscience it portrays. When Farinella and Roš explain the synapse, one of neuroscience's most basic concepts, they do it almost as a parody of conventional textbook illustrations.

14 Hillary Chute, 'Our Cancer Year; Janet and Me: An Illustrated Story of Love and Loss; Cancer Vixen: A True Story; Mom's Cancer; Blue Pills: A Positive Love Story; Epileptic; Black Hole (review)', *Literature and Medicine*, 26.2 (2008), 413–29 (p. 423), <https://doi.org/10.1353/lm.0.0005>.

15 Ibid., p. 423.

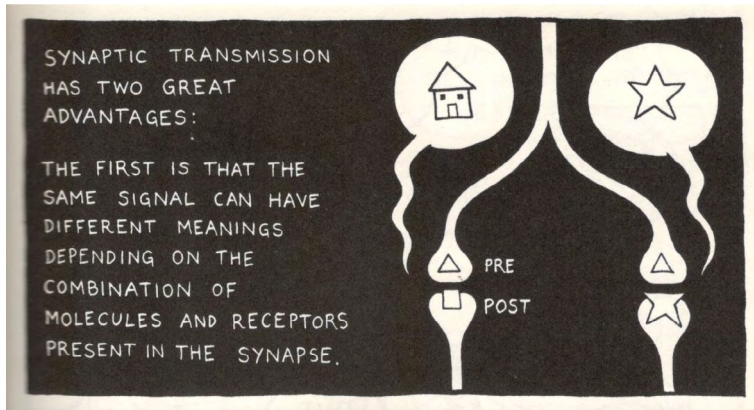


Fig. 5 Matteo Farinella and Hana Roš, *Neurocomic* (2014) © Matteo Farinella and Hana Roš. CC BY-NC-ND 4.0

Neurocomic does not make its meanings through text alone. Its meanings proliferate in their original, graphic context. They draw axons and dendrites like bones, the neurotransmitters as simple shapes (stars, squares, triangles), and the resulting signals in sperm-like thought bubbles. The representational resources of the comic—like Freud's dreams—almost demand the condensation of multiple meanings in a single image. A nerve cell is a bone, a neural signal a sperm cell. But such proliferation of meaning is not unique to comics or unheard of in neuroscience. The most conventional of textbooks describe a synapse as a gap or cleft, metaphorical language that involves similar condensation of meaning. Even the language Farinella and Roš use to explain the image closely resembles the language of textbooks: 'Synaptic transmission has two great advantages: The first is that the same signal can have different meanings depending on the combination of molecules and receptors present in the synapse'.¹⁶ Synapses make meanings—multiple and mutable ones. Their representational resources are designed to create flexibility, to make meaning in fluid and unpredictable ways. This is a routine observation in basic neuroscience, but not one whose implications receive much attention. Whereas a conventional textbook elides the condensation of meaning in both the process of synaptic transmission and its own representation of that process, *Neurocomic* emphasizes both: a synapse is a gap, or cleft, between two cells; its

¹⁶ Farinella and Roš, *Neurocomic*, p. 39.

meaning is composed of parts, like the triangle and square that make a house when you combine them; the generation of meaning is like the generation of life, figured like sperm cells; the process is embodied and mobile, an idea hinted at by the joint-like depiction of the pre- and post-synaptic neurons; its meanings become functional in the context of a brain's electrical oscillations, or brainwaves, hinted at by the wavy tales of those sperm-like thought bubbles.

Because it emphasizes the representational tools of the comic as genre, *Neurocomic* suggests that synaptic gaps—or clefts—are like the gutter in a comic book or the distance between neural correlates and *qualia*, the subjective, first-person, and ineffable qualities of perception. Gaps like these are central to controversies about the power of brain imaging to explain the human mind. Graphic brain narratives and neuroimaging could not be more different in terms of their goals or the technologies and strategies involved in their representations of the brain. But they are both technologies for creating images of the brain, and both types of image make claims about understanding relations between brain physiology and selfhood.

The Tools of Neuroimaging

Brain imaging techniques—including fMRI (functional magnetic resonance imaging), PET (positron emission tomography), and SPECT (signal photon emission computed tomography)—are often described as though they offer direct images of brains at work, rather than images of brains created through a complex process of measurement, statistical analysis, and computer-aided representations. As neurobiologist Susan M. Fitzpatrick explains,

the brain images displayed in scientific publications and in the popular media are not representations of changes in brain neuronal activity, or areas of 'activation', or the brain 'lighting up' or 'switching on'. Brain scans acquired with fMRI do not even graphically depict the magnitude of the BOLD [blood oxygen level dependent] signal. Rather, the images are computer-generated, color-coded 'maps' of statistically significant comparisons among data sets.¹⁷

17 S. M. Fitzpatrick, 'Functional Brain Imaging: Neuro-Turn or Wrong Turn?', in *The Neuroscientific Turn: Transdisciplinarity in the Age of the Brain*, ed. by Melissa M.

While scholars from multiple disciplines have made a clear-cut case that brain imaging does not provide direct access to brains, popular publications, neuro-self-help programs, and even published scientific papers promise—continuously and emphatically—that they do just that. As Dumit argues, the elision of technological complexity is bound up with assumptions about human behaviour and identity:

Brain-imaging technologies like PET offer researchers the potential to ask a question about almost any aspect of human nature, human behavior, or human kinds and design an experiment to look for the answer in the brain. Each piece of experimental design, data generation, and data analysis, however, necessarily builds in assumptions about human nature, about how the brain works, and how person and brain are related. No researcher denies this. In fact, they constantly discuss assumptions as obstacles to be overcome as trade-offs between specificity and generalization.¹⁸

That trade-off between specificity and generalization is both rhetorical and methodological. Too much specialization means a smaller audience, but it also leads to more circumscribed conclusions. The potential Dumit describes is exciting, and it makes perfect sense that researchers and practitioners are interested in making the most of it. As he observes, they are well aware of the complexities involved. If the general public is not aware, it is because so much of the rhetoric about brain imaging involves misleading translations of specific research designs for the sake of emphasizing the dramatic potential of the technology.

Concrete examples of the oversimplifications Fitzpatrick laments are plentiful, and they come in a variety of forms. Many of these are well-intended translations of medical jargon designed to provide readers with accessible shorthand, though it is difficult to dismiss the dramatic effects created by the shorthand. For example, in her biography of famous neurology patient H. M., Suzanne Corkin makes a dramatic claim: ‘Using MRI scans, we could look through Henry’s scalp and skull to see his brain’.¹⁹ In her biography, Corkin is aiming to create a feeling of intimacy with her subject. Looking through his scalp to see his brain, as

Littlefield and Jenell M. Johnson (Ann Arbor: University of Michigan Press, 2012), pp. 180–98 (p. 186), <https://doi.org/10.3998/mpub.4585194>.

18 Dumit, *Picturing Personhood*, p. 16.

19 Suzanne Corkin, *Permanent Present Tense: The Unforgettable Life of the Amnesiac Patient, H. M.* (New York: Basic Books, 2013), p. 80.

a character in a comic book might be able to, adds a physical dimension to that intimacy. In general, the apparent motives of such translations are more neutral, as with Cornell University's website advertising its MRI facilities:

Neuroscientist Valerie Reyna compares functional MRI—an imaging technique that allows researchers to see the brain in action—to the microscopes and telescopes that allow scientists to peer into cells and the cosmos to explore the mysteries of life. For the first time on Cornell's Ithaca campus, she and fellow researchers can observe how the brain fires when we think and react and compare how such activity differs among age groups and populations. Such work promises to bring into focus what was once out of sight—the hidden factors that drive human behavior.²⁰

Again, the writer eschews a detailed description of the technology's representational resources, describing instead a fantastical version that resembles a comic book scenario: researchers 'see the brain in action', revealing 'hidden factors that drive human behavior'. Those hidden factors—what we don't know about ourselves—appear fairly routinely in writing that makes promises about the powers of brain imaging technologies. In his book *Affective Neuroscience*, Jaak Panksepp offers a more accurate description that nonetheless is likely to be read in the tradition of rhetorical oversimplification: 'During the past decade, remarkable progress has been made in our ability to visualize what is going on inside the living human brain'.²¹ The word *visualize*—as opposed to *see*—presupposes an acknowledgement of the complex representational resources entailed in brain imaging. But it is a subtle presupposition, one readers accustomed to broader and more dramatic claims are likely to miss without more explicit rhetorical cues and detailed explanations of those resources.

In a case like Panksepp's description and Cornell's account of Reyna's research, the stakes and motives of this rhetoric are relatively benign, but when they migrate from the laboratory into other spheres, they can become more troubling. For example, Dan Ariely and Gregory S. Berns published a review article entitled 'Neuromarketing: The Hope

20 Karene Booker, 'A Window into the Brain', *Human Ecology*, 41.2 (Fall 2013), 5–7.

21 Jaak Panksepp, *Affective Neuroscience: The Foundations of Human and Animal Emotions* (New York: Oxford University Press, 1998), p. 90.

and Hype of the Neuroimaging Business' in *Nature's* 'Science and Society' section. As Dumit observes, the writers of these publications are usually well aware of the complexity their shorthand masks, but their shorthand has gained remarkable cultural purchase, obscuring rather the remarkable representational resources of the technologies they use to make images of the brain. In the abstract, they write, 'Although neuroimaging is unlikely to be cheaper than other tools in the near future, there is growing evidence that it may provide hidden information about the consumer experience'.²² The title of the article indicates an agnostic stance about the potential of neuromarketing. Indeed, the authors offer detailed consideration of both its ethical and methodological pitfalls. The ethical questions they cite include the violation of 'the privacy of thought', the exploitation of 'particular neurological traits' or 'biological weakness', and the unconscious or 'peripheral' manipulation of consumers. Methodological considerations include the fact that images of 'brain activation' are not meaningful unless they are correlated with 'another behavioural measurement', that large sample sizes are necessary, that measuring responses to complex stimulus (like an ad) is not possible with current technology, and the fact that motion and time affect behavioral responses correlated with images of brain activity.²³ These lists of ethical problems and methodological obstacles are daunting. To compound matters, the authors acknowledge how little research supports the efficacy of neuromarketing as well as the considerable cost of neuroimaging versus traditional market testing. Nonetheless, the authors conclude on what they describe as an optimistic note whose implications are troubling, to say the least. Neuromarketing, they suggest, might become cheaper than current marketing methods; it 'could provide hidden information about products'; and it might 'contribute to the interface between people and businesses and in doing so foster a more human-compatible design of the products around us'.²⁴ Between the abstract and conclusion, the 'hidden' information described moves from the human consumers to the products they might consume. While the authors don't make the connection explicit, the move is

22 Dan Ariely and Gregory S. Berns, 'Neuromarketing: The Hope and Hype of Neuroimaging in Business', *Nature Reviews Neuroscience*, 11.4 (April 2010), 284–92 (p. 284), <https://doi.org/10.1038/nrn2795>.

23 *Ibid.*, pp. 289–90.

24 *Ibid.*

dependent on an assumption that Antonio Damasio is right when he proposes that organisms and objects shape each other in the making of conscious experience.²⁵ Ariely and Berns envision a utopian future in which neuroimaging may benefit consumers by leading to the creation of products they don't realize they want, because consciousness masks their unconscious wishes. They dramatize a bizarrely Freudian capitalist fantasy that might make for a good storyline in a graphic narrative. As cultural analysis, it reveals more about the cultural neuromania involved in the circulation of ideas about brain imaging technology than it does about marketing or business.

While Ariely and Berns touch on many of the critiques of the hype around neuroimaging, they ultimately downplay them. Dumit's *Picturing Personhood* is an ethnographic study of experimental research using and cultural responses to PET scans; Fitzpatrick's 'Functional Brain Imaging: Neuro-Turn or Wrong Turn?' offers a detailed explanation of the methodologies involved in producing PET and BOLD fMRI scans, with an emphasis on 'what neuroimaging can and cannot reveal about the mind'. Hayles' 'Brain Imaging and the Epistemology of Vision: Daniel Suarez's *Daemon* and *Freedom*' offers a case study in the popular circulation of ideas in response to the ubiquity of neuroimaging. Johnson's "'How Do You Know Unless You Look': Brain Imaging, Biopower, and Popular Neuroscience' examines the representation of SPECT (single photon emission computed tomography) scans 'presented as visual evidence that is highly legible even to an untrained audience' in the neuro-self-help books by Daniel Amen. McCabe and Castel's 'Seeing Is Believing: The Effect of Brain Images on Scientific Reasoning' reports on empirical research documenting the 'persuasive power' of brain images among non-expert readers of fabricated news articles on various topics in cognitive psychology.²⁶

25 Antonio Damasio, *The Feeling of What Happens: Body and Emotion in the Making of Consciousness* (New York: Mariner Books, 2000).

26 Morana Alač and Edwin Hutchins, 'I See What You Are Saying: Action as Cognition in fMRI Brain Mapping Practice', *Journal of Cognition and Culture*, 4.3 ([n.d.]), 629–61 (p. 629), <https://doi.org/10.1163/1568537042484977>; Dumit, *Picturing Personhood*; Fitzpatrick, 'Functional Brain Imaging', p. 180; Katherine Hayles, 'Brain Imaging and the Epistemology of Vision: Daniel Suarez's *Daemon* and *Freedom*', *MFS Modern Fiction Studies*, 61.2 (2015), 320–34, <https://doi.org/10.1353/mfs.2015.0025>; Davi Johnson, "'How Do You Know Unless You Look?": Brain Imaging, Biopower, and Practical Neuroscience', *Journal of Medical*

The popular circulation of medical brain imaging tends to occlude its representational complexities. As Johnson observes, ‘The complex averaging procedures and statistical work that go into producing such images are lost in the neat, simple-looking images presented for the readers’ consumption and interpretation’.²⁷ In other words, the image of a brain scan is a fabrication of a complex process that requires enormous expertise both to create and to interpret, but the vivid and colorful results seem to present transparent meaning to non-experts—a fact exacerbated by a tendency in science journalism, popular neurological texts, and even textbooks to bypass the technical details involved in their production. The meaning of brain scans suggests serious implications, both medically and philosophically. As Dumit observes, ‘These brain images make claims on us because they portray *kinds* of brains. As people with obviously, one or another kind of brain, we are placed among the categories that the set of images offers. To which category do I belong? What brain type do I have? Or more nervously: Am I normal? Addressing such claims requires an ability to critically analyze how these brain images come to be taken as facts about the world’.²⁸ Brain scans portray serious knowledge whose representational complexities are often occluded. Ironically, graphic brain narratives tend to do just the opposite, offering playful alternatives that visualize the brain with a great deal of emphasis on their own representational strategies.

N. Katherine Hayles articulates something like a critical consensus when it comes to the lack of attention to the representational tools of brain scanning technologies in popular—and many specialized—accounts of its results,

The point is that interpretations of brain scans require careful consideration of the experimental design, knowledge of previous research linking behavior and regional brain activity, accuracy of the statistical analysis, and so forth. While the images themselves may appear seductively transparent, non-experts and even research professionals

Humanities, 29.3 (2008), 147–61 (p. 151), <https://doi.org/10.1007/s10912-008-9062-4>; David P. McCabe and Alan D. Castel, ‘Seeing Is Believing: The Effect of Brain Images on Judgments of Scientific Reasoning’, *Cognition*, 107.1 (2008), 343–52 (p. 343), <https://doi.org/10.1016/j.cognition.2007.07.017>.

²⁷ Johnson, ‘“How Do You Know Unless You Look?”’, p. 153.

²⁸ Dumit, *Picturing Personhood*, p. 5.

who have not read the original article should be very cautious about deciding what the images actually show.²⁹

By contrast, graphic narratives make their tools—ink strokes, interplay of words and images, frames, gutters—integral to the experience of reading them.

The authors of graphic novels render psychological experience in physical forms whose narratives are sutured with words. The juxtaposition of words and images reminds readers that representation is never transparent. Words and images translate or distort experience. When the narrative in question focuses on neurological experience, this emphasis on the representational resources of the artists becomes a vehicle for the elusiveness of the explanatory gap between physiology and subjectivity. That same explanatory gap is at play in neuroimaging, but too often it is bypassed when the meaning of brain scans appears—or is presented or received as—transparent. It is my contention that learning to read graphic brain narratives can be helpful in demystifying the representational qualities of neuroimaging, and that understanding the techniques and methods through which brain scans are created and interpreted can deepen a reader's understanding of graphic brain narratives.

A Person Surrounds This Brain

As a thought experiment, examine the image from *Neurocomic* on the facing page. Imagine the central figure isolated in negative space—minus the bird, sun, flower, and thistle or the sensory words that accompany them. You would see a human organism, with a schematic version of its brain and nervous system made visible (presumably through medical technologies). At best, the figure would appear clinical, at worst, monstrous; in either case, it would feel uncanny. The text at the top of the page is narration, offered by one of the protagonist's first guides, Santiago Ramón y Cajal, the 1906 Nobel Laureate famous for his detailed drawings of neurons emphasizing their treelike structure and proponent of the once controversial idea that brain matter is composed of distinct (rather than fused) cells we now call neurons. Ramón y Cajal

29 Hayles, 'Brain Imaging and the Epistemology of Vision', p. 322.

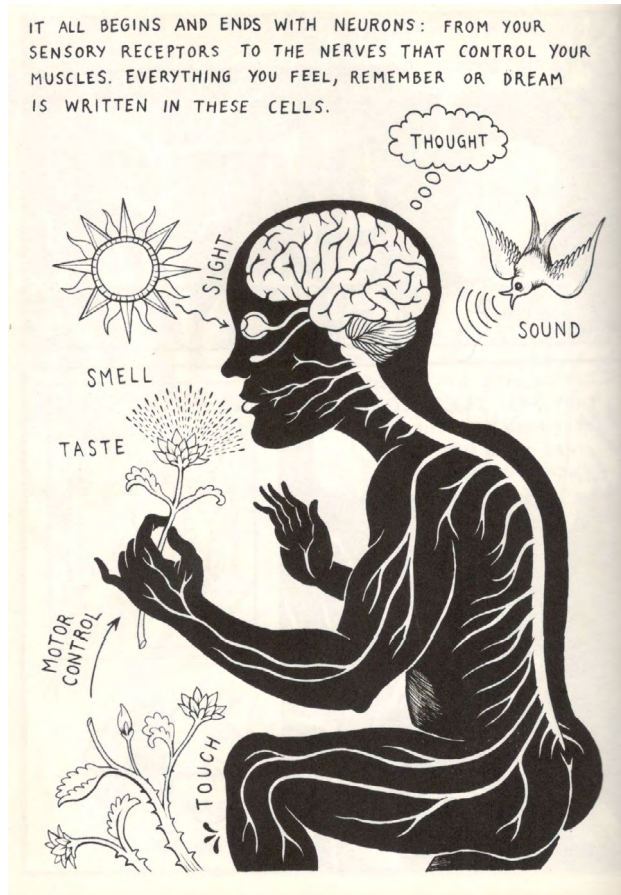


Fig. 6 Matteo Farinella and Hana Roš, *Neurocomic* (2014) © Matteo Farinella and Hana Roš. CC BY-NC-ND 4.0

explains to the tiny protagonist, 'It all begins and ends with neurons: From our sensory receptors to the nerves that control your muscles. Everything you remember, dream, or feel is written in those cells'.³⁰

Like all thought experiments, the exercise I just asked you to consider replaces real world complexity with a hypothetical scenario. The image on the page represents a human being in the fullness of experience—thinking, feeling, sensing. The image emphasizes the idea that this human is an organism, stripping away the barriers of flesh,

³⁰ Farinella and Roš, *Neurocomic*, p. 20.

bone, and hair to reveal the organs that enable life. Other elements in the image create a montage—a very different kind of representation—that seems to contradict Ramón y Cajal’s exposition. As Scott McCloud explains in *Understanding Comics*, a montage creates an image ‘where words are treated as integral parts of the picture’.³¹ Farinella and Roš create tension between text and image through what McCloud calls the ‘interdependent’ combination, ‘where words and pictures go hand in hand to convey an idea that neither could convey alone’.³² The image adds motion, context, and feeling to the text. Text and image create tension: the words *all* and *everything*—standing in here for the fullness of experience—are misleading. A thorny thistle provides the content of touch and gives it meaning that is only possible through interconnections with other senses, with feelings, with memories: *don’t touch this plant*. The same is true for the sight of the sun, the sound of a bird, or the smell of a flower. The montage of words and objects surrounding the figure gives visual form to the experience correlated with those neurons. The resulting meaning is akin to Damasio’s argument that the objects of perception are integral to the making of consciousness or feeling.

Of course, tensions between text and image are central to all graphic narratives. I argue that authors of neurocomics adapt these tensions for a particular purpose, making them stand-ins for unresolved debates about the relationship between neurology and experience. The contradictions and competing ideas that proliferate from the explanatory gap between physiology and feeling make room for stories. And comics, with their fluid mixing of fantasy and realism, are well suited to exploring the contradictions.

David B. creates images that emphasize the intimate proximity and distant epistemology of the brain’s relationship to the self and mind. In numerous images, David B. depicts Jean-Christophe’s brain as an object probed by doctors, healers, and philosophers—all struggling to explain connections between brain physiology and the feeling of selfhood. In the words of neuroscientist Jaak Panksepp, ‘All objective bodily measures [of ‘interior experiences’], from facial expressions to autonomic changes, are only vague approximations of the underlying

31 Scott McCloud, *Understanding Comics: The Invisible Art* (New York: William Morrow Paperbacks, 1994), p. 154.

32 *Ibid.*, p. 155.



Fig. 7 David B., *L'Ascension du Haut Mal* (1999) © David B. and L'Association. All rights reserved. English translation: 'The doctor who's treating him is stymied by my brother's epilepsy. He prescribes a new experimental therapy'.



Fig. 8 David B., *L'Ascension du Haut Mal* (1999) © David B. and L'Association. All rights reserved. English translation: 'In her mind, this sends us all back to square one. She has a vision of her son in the hospital with his head shaved. It is as if she is being pulled backwards. She reminds herself that Master N. is no longer there'.



Fig. 9 David B., *L'Ascension du Haut Mal* (1999) © David B. and L'Association.
All rights reserved. English translation: 'Unbeknownst to me, this flood of absurdities takes root in my brain. Images are born'.

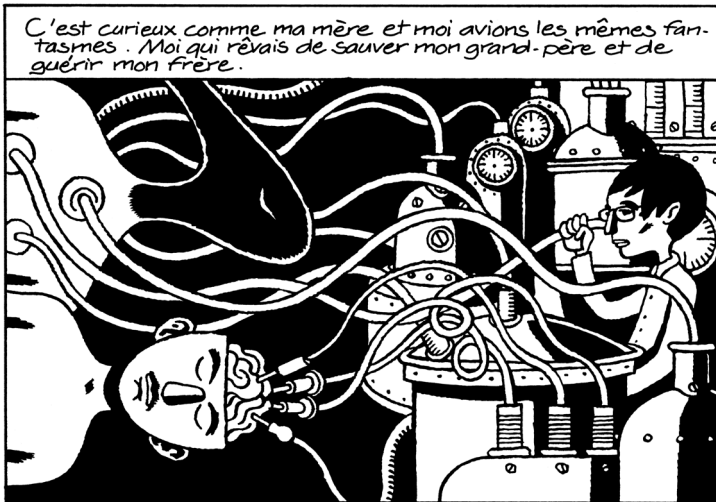


Fig. 10 David B., *L'Ascension du Haut Mal* (1999) © David B. and L'Association.
All rights reserved. English translation: 'It is odd how my mother and I had the same dreams. I'd been dreaming of saving my grandfather and my brother'.

neural dynamics—like ghostly tracks in the bubble chamber detectors in particle physics’.³³ In the words of cultural critic Ann Cvetkovich,

I tend to use affect in a generic sense, [...] as a category that encompasses affect, emotion, and feeling, and that includes impulses, desires, and feelings that get historically constructed in a range of ways. I also like to use *feeling* as a generic term that does some of the same work: namely the undifferentiated ‘stuff’ of feeling; spanning the distinctions between emotion and affect central to some theories; acknowledging the somatic or sensory nature of feelings as experiences that aren’t just cognitive concepts or constructions.³⁴

It is not surprising that the neuroscientist emphasizes the ‘underlying neural dynamics’ of affect and the cultural critic its historical construction. What they share—with each other and with the authors of neurocomics—is an emphasis on the elusive or ineffable quality of feelings, their subtle but immense range of expression, and the confusion they tend to create. In other words, they portray affect as a form of what McCloud calls one of graphic narrative’s specialties: the interplay of ‘the seen and the unseen’, or the felt and the unfelt.

With his visual depictions of brains, David B. exploits the comic form’s ability to mix fantastical and realist representation. Comics give form to the impossible. One key image from *Epileptic* visualizes David’s fantasy that a neuroscientist could meld his brain with his brother’s—one of dozens of images of physical brains David B. uses, ironically, to portray what cannot be seen or understood about his brother’s illness. A related image, in which two birdlike doctors climb ladders to peer into Jean-Christophe’s exposed brain, demonstrates his ironizing technique. The doctors’ semi-human form casts them as fantastical hybrid creatures, belonging more to the representational world of comics (or dreams) than to medicine. The ladders give physical form to the epistemological distance between them and a cure for Jean-Christophe. The exposed brain is a reminder that in comics, you can see just about anything. In life, seeing Jean-Christophe’s brain would require invasive techniques. David B. alternates images of brains with images of Jean-Christophe’s skull as it is being subjected to a variety of such invasive

33 Panksepp, *Affective Neuroscience*, p. 9.

34 Ann Cvetkovich, *Depression: A Public Feeling* (Durham: Duke University Press Books, 2012), p. 4, <https://doi.org/10.1215/9780822391852>.



Fig. 11 David B., *L'Ascension du Haut Mal* (1999) © David B. and L'Association.

All rights reserved. English translation: Middle Row, Left Panel: 'It'd be wonderful to let myself go'. Middle Panel: 'I could pretend to be an epileptic. I could imitate a seizure. I know how'. Right Panel: 'Anyway, I am an epileptic. These electrical discharges in my brain, like explosions, that's what they are! They are epileptic seizures!'



Fig. 12 David B., *L'Ascension du Haut Mal* (1999) © David B. and L'Association. All rights reserved. English translation Left Panel: 'I want to spill all the blood in my body'. Middle Panel: 'It would all come out at last. The anxiety, the fear, the justice, the rage'. Right Panel: 'Then I could sleep to my heart's content'.



Fig. 13 David B., *L'Ascension du Haut Mal* (1999) © David B. and L'Association. All rights reserved. English translation Left Panel: 'It is just another way of telling stories. You cannot help yourself'. Middle Panel: 'It is a way of conjuring unhappiness. It is magic'. Right Panel: 'I've read many stories that have helped me. I want to touch people with my books in return'.



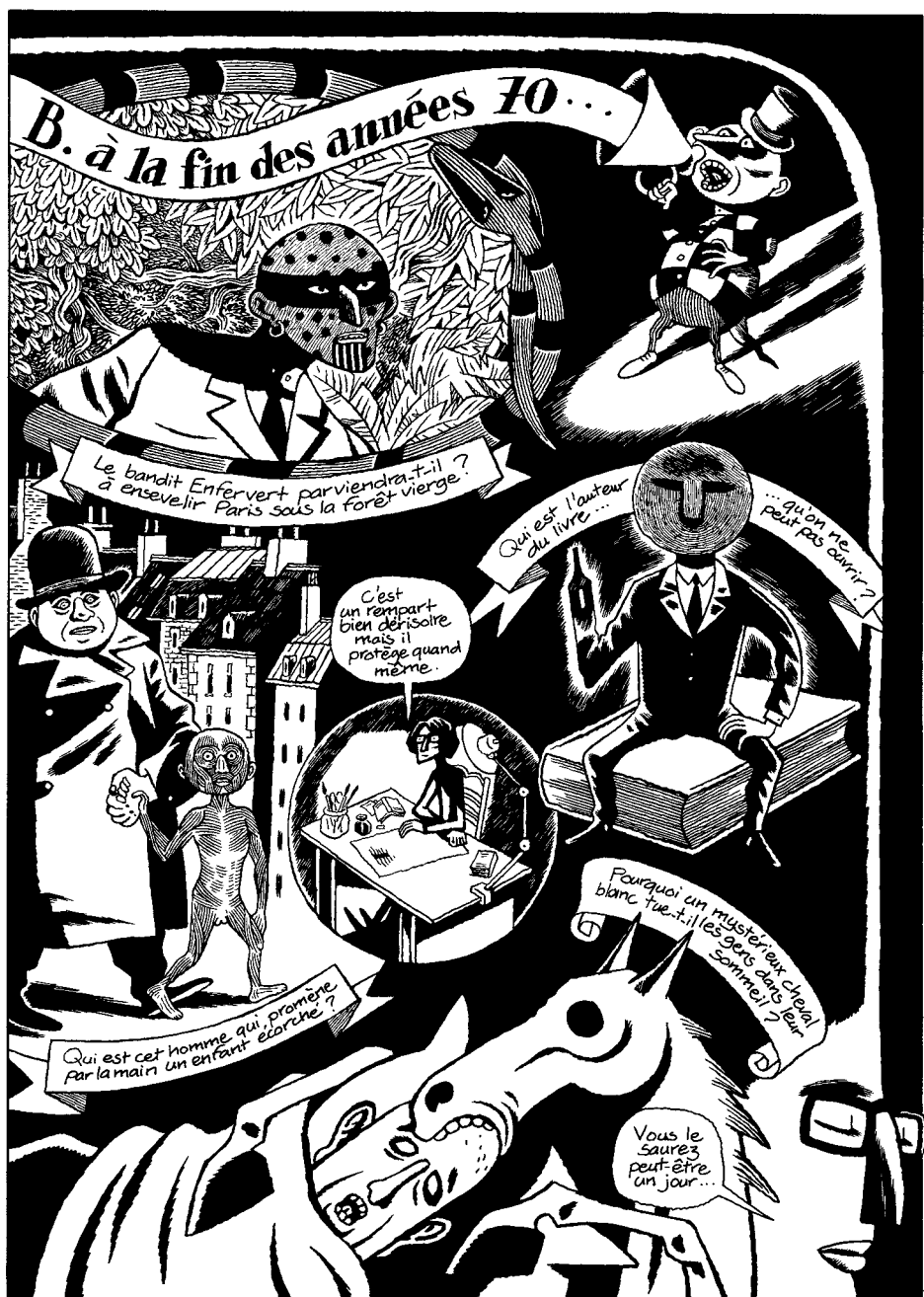


Fig. 14 David B., *L'Ascension du Haut Mal* (1999) © David B. and L'Association.
 All rights reserved. English translation: Banner: 'Come visit the inside of David B.'s head at the end of the 70s'.

techniques—generally figured as retro-futuristic canisters and tubes. In a typical example, Jean-Christophe's mother steadies herself atop her son's skull, while his doctors look on from a distance, poised on the head and tail of the serpent that represents his epilepsy throughout the book. Images like this collapse, condense, and distort time and space, a common technique in comics. The invasive technology belongs to a brutal history of medical experiments and to a future imagined by Jean-Christophe's doctors, one that involves the successful applications of their theoretical cures. The patient's skull, and therefore his brain, is outsized, larger than most of the other human bodies in the frame. Of course, this represents the size (or severity) of the problem, but it also represents that same epistemological distance between theoretical cures and successful applications.

A comic cannot claim to cure disease or resolve centuries of debate about the relation between brain and self. Instead, *Epileptic* offers an alternative to resolution: increasing attention to the author's identity as a writer and artist in neurological terms. David B. describes his writing as a series of 'electrical discharges' in his brain, 'like explosions' or 'tiny epileptic seizures'—through a series of frames that blur his identity with Jean-Christophe's. As the scene unfolds, he portrays a fantasy of severing his own head with macabre irony, likening himself visually to Hamlet holding Yorick's skull. He imagines he could bleed feelings: 'It would all come out at last: the anxiety, the fear, the justice, the rage'. But he revises the fantasy—and reattaches his head—within a few frames. 'Come on, admit it, you don't want to be sick [...] It is just another way of telling stories. [...] I've read many stories that have helped me. I want to touch people with my books in return'.³⁵ The fantasy is a personal response to the explanatory gap. Like so many theoretical accounts, it imagines that physiology and feeling are identical, and like these accounts, it undoes itself. But in this case, the undoing is an intentional bid to call attention to the tools of representation. In place of his morbid fantasy, David B. offers a revision on the fantasy of finding the immaterial in the material—that his art might *touch* other people, that the materials of his books will affect people physically via their immaterial responses to it.

35 B., *Epileptic*, pp. 289–90.

David B. emphasizes the materiality of reading, writing, and drawing throughout *Epileptic*. He uses facing pages to represent the complexity of his identity, or the person who surrounds his own brain (and his brother's). In a ribbon-like frame spanning the tops of both pages, he inscribes an invitation: 'Come visit the inside of David B.'s head at the end of the 70s'—words that flow backwards from a bullhorn held by a circuslike figure. This time, the inside of David B.'s head is not a brain, but a chaotic collection of fragments from stories he wrote and drew during the period. Stories that represent a decade's work, a lot of geographic wandering, and a rapidly evolving sense of identity collapse onto a single page—images from comics he has created and read, images of his brother's doctors condensed with images of the 'madmen' who populate both brothers' imaginations, and images of Jean-Christophe both healthy and sick. He represents himself directly, as writer and artist, in two bubbles, one on each page. He sits at a desk, with the tools of his medium: paper, pens, bright light. The speech bubble in the first image reads: 'There's a feverish, confused quality to these stories'. In the second: 'A pathetic bulwark, and yet it does shield me'.³⁶ Creating comics becomes a means of reconciling complex and apparently contradictory aspects of identity—and the flexible fluency of the form is key to ensuring that the reconciliation does not require tidy integration, that it can encompass the lumpiness of experience.

Neurocomic is a more explicitly pedagogical text than *Epileptic*, using the form of a graphic narrative to offer an accessible introduction to brain physiology and the history of neurology. But it is also a hybrid of fiction and nonfiction—and its fictional frame is by no means incidental. Farinella and Roš might have created a straightforward illustrated history of neurology, but instead they wrap it in a fictional fantasy about a shrinking man who wanders through a metaphorical forest, his own brain. Near the beginning of the story, a hypothetical human, brain exposed, examines the book page on which the protagonist is trapped. That hypothetical human is figured as the protagonist himself, in the role of reader, but also as the reader of this text. By analogy, the protagonist and reader are condensed into this hypothetical human. Near the end of the story, the woman courted by the protagonist explains: 'Our existence relies on the brain of the reader, which is able to see motion and hear

36 B., *Epileptic*, pp. 278–79.



Fig. 15 Matteo Farinella and Hana Roš, *Neurocomic* (2014) © Matteo Farinella and Hana Roš. CC BY-NC-ND 4.0

sounds [...] on a flat sheet of paper'.³⁷ This text begins on a panel featuring an unidentified character—'the reader' who is somewhat oddly, but perhaps tellingly, referred to in the second panel through the pronoun 'which'—holding a copy of *Understanding Comics*. It is a meta moment that multiplies. Readers are asked to imagine their own brains imagining these characters' brains—and to generalize the lesson to all readers, all brains. The result is a kind of recasting of the message attributed to Ramón y Cajal near the book's beginning. The 'it' in 'it all begins and ends with neurons' becomes the reader, trapped in an

³⁷ Farinella and Roš, *Neurocomic*, p. 132.

epistemological loop. This hypothetical reader can only learn about its brain by using that brain, and it cannot quite know if its flesh and blood are real or products of its own ability to 'see motion and hear sounds on a flat sheet of paper'. In other words, human brains make reality, and consciousness of that reality is subjective by definition. Meaning, as a result, is always contingent, and in the case of graphic narrative, that contingency flows from the continuous interplay of text and image. Like these characters, a neural pattern is a representation of the world—one composed of neurotransmitters and electricity, whose meanings are further shaped by variables like location, the rhythms of brain waves, and the support of glial cells. Any psychology textbook will tell you that a perception is a construction—or a functional distortion—of the objects it represents.

In that sense, graphic narratives are corollaries to academic critiques of the oversimplification of brain scanning technologies. As Fitzpatrick writes, 'brain-imaging scans are highly technical and difficult to interpret without expert knowledge of the subjects participating in the studies, the tasks performed, the techniques used to acquire the data, and the complicated statistical tools used to analyze the data and create the images'.³⁸ I am not suggesting that brain scanning technologies and graphic narratives are equivalent. This is decidedly not the case. Meta-representational techniques are integral to the representational tools of graphic narratives, part of the reading experience. The dissection and digital reconsolidation of brains, the measurement of their electrical patterns, or the imaging of their blood flow are powerful tools for gaining knowledge of their functions. The expert knowledge necessary to make and interpret the images created through brain scanning technologies involves a great deal of meta-representation, but their cultural circulation mostly obscures this fact. Clinicians, subjects, laboratories, machines, and algorithms disappear behind appealing images.

Despite obvious and vast differences, these technologies share one significant quality with neurocomics. They are representations of brains, built not found. Simply put: the images produced by brain scans will continue to circulate as 'neurojunk' unless the people doing the circulating—including journalists, marketers, clinicians, researchers, and artists—find the rhetorical means to situate them in the representational

38 Fitzpatrick, 'Functional Brain Imaging', p. 194.

frameworks that make them meaningful. The sentiment in the epigraph to this chapter, from Joseph Dumit's *Picturing Personhood*, extends from the PET images he examines to brain scanning technologies in general: 'Overturning the age-old axiom that a picture is worth a thousand words, perhaps these PET images require millions of words to be understood'. Experts in neuroscience are attuned to the complexity of the materials they use to make images of brains—and to the fact that these images don't so much represent personhood as an incomplete and highly mediated set of pictures of physiology. Nonetheless, they often translate the complexities of the technology into rhetoric that makes the images in question appear to be transparent images of brains. Jaak Panksepp's description of these images as visualizations is an example of a more accurate description, but it doesn't go far enough, elaborating on the work involved in creating these visualizations.

By definition, expert knowledge belongs to specialists, but the stakes of neuroimaging belong to anybody with a brain—and that is as good a reason as I can imagine to work hard to develop a set of explanatory and rhetorical techniques that can describe the meaning of brain scans to a larger public. But neurocomics, like so many literary responses to neuroscience, demonstrate an imbalanced relationship among the arts and sciences. The writers of brain memoirs and neuronovels—including the graphic varieties of both—are highly conscious of the personal, social, and philosophical stakes of representing and circulating expert knowledge. Individual experts in the neurosciences share the awareness, but collectively, as a set of disciplines, they aren't designed to respond to concepts or tools emerging from the arts and humanities. Literary writers and critics make a vocation of working with the intricacies of representations of all varieties of human experience and knowledge. Graphic narratives demonstrate one of literature's many contributions to contemporary understandings of the brain: their emphasis on meta-representation. To imagine collective, multidisciplinary collaboration among scientists and humanists interested in the meaning of brain images—or the relationship between brain and self more generally—remains an exercise in speculative fiction. Nonetheless, graphic brain narratives offer an implicit, but concrete, suggestion to those involved in the circulation of brain scanning images. Simply to include the word *representation* in descriptions of these images would help to clarify their

meanings—in no small part because the word would require some follow-up explanation, in accessible prose, of what is entailed in the representation of a brain—and, ideally, the person surrounding that brain.

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