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Brainmedia

One hundred years of performing live brains, 1920–2020

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Introduction

Prelude: Live brain demonstrations in 1934 and 2014

On 12 May 1934, members of the British Physiological Society gathered in a large Cambridge University lecture hall to witness the first UK demonstration of a technology measuring the electrical activity of the human brain. To prove that the brain displayed varying patterns of electrical nerve activity and that this could be measured from the scalp, neurophysiologists Bryan Matthews and Edgar Adrian used a new technical set-up that included an amplifier and an oscillograph, all visible on stage.¹ During the demonstration, Matthews would measure Adrian's brain activity, recorded by a pen zigzagging on a moving piece of paper. Simultaneously, the audience of invited scientists could see a magnified projected image of the moving arm of the ink-writer on a large projection screen above the stage.² This direct projection allowed spectators to see the recorded activity change when Adrian closed his eyes or solved a math problem. One scientist who attended wrote in a later account how "those who were privileged to be present will never forget [...] the dramatic effect of the first demonstration of the Berger [now called EEG] rhythm [...] I suppose that, to anyone present at that demonstration, it offered a first glimpse of great new possibilities [...] Adrian and Matthews's demonstration [...] will be recognized as an event of epoch-making importance!"³

On 1 November 2014, the city of Amsterdam was unusually brimming with brains. As part of a celebration of the "European Year of the Brain," visitors of the Amsterdam Museum Night could, for example, witness a dissection of a brain in the university library, walk into a giant brain at the NEMO Science Center, and measure their brain activity at the former anatomical theatre (De Waag). For the latter event, titled *Brain Waves*, volunteers had signed up through an open call on Facebook, agreeing to participate in an experiment in which their brain activity would be measured on stage and directly shown to an audience. Three participants at a time were fitted with EEG headsets and asked to take a seat in the middle of the circular room. Scientists dressed in white lab coats encouraged the subjects to stay focused while being confronted with a range of

¹ Theories and techniques involved in this demonstration are explained in: E. D. Adrian and B. H. C. Matthews, "The Berger Rhythm: Potential Changes from the Occipital Lobes in Man," *Brain* 57 (1934).

² This demonstration took place on May 12, 1934, with the help of an epidiascope (a type of image projector). See Adrian's account in Edgar Douglas Adrian, "The Discovery of Berger," in *Handbook of Electroencephalography and Clinical Neurophysiology*, ed. Antoine Rémond (Amsterdam: Elsevier, 1971). Adrian cannot recall whether flicker lights were used on stage to produce distinct alpha waves. For another account of the demonstration, see W. Grey Walter, "Thought and Brain: A Cambridge Experiment," *The Spectator Archive*, 4 October 1934.

³ Henry Dale (source and year unspecified) cited in David Millett, "Wiring the Brain: From the Excitable Cortex to the Eeg, 1870-1940" (Dissertation, University of Chicago, 2001), 346.

stimuli, such as a burlesque dancer, loud electronic music, and a brain teaser. Colorful visualizations of the participants' corresponding brain activities were projected on three large screens lining the walls of the space. An adjacent explanatory legend helped visitors to interpret and compare the differing brainwave states on view. An unexpectedly overwhelming number of people lined up to participate in *Brain Waves*, perhaps because, as one participant exclaimed: "It just seemed so cool to see my own brain activity in real-time!"⁴

Studying performances of live brains: an introduction

Adrian and Matthew's 1934 demonstration and the 2014 *Brain Waves* event are examples of spectacular appearances of the active brain outside the scientific laboratory. Both demonstrations are instances of the deliberate ways scientists and science educators perform a direct view of the living brain, invoking a sense of seeing the brain "in action," of perceiving it live, as it were. This "live brain" is at the center of this study. It interests me as a practice, idea, myth and imaginary.

My scholarly work in this thesis analyzes original historical material with a transdisciplinary scope. First, I synthesize scholarship in the history of science and media studies, introducing analytical concepts to better understand emerging practices of imagining, conceptualizing, and performing the brain in action. To that end, my analysis uses three key concepts – *brainmedia*, *performing knowledges*, and *forms of liveness* – which I will introduce in this chapter. Secondly, based on my research of many not previously accessed historical documents (focused on the USA and Europe), I present five case studies of live brains from the 1920s until today. Introducing these five case studies, I first locate the emergence of the live brain in the early decades of the twentieth century, embedding it in a broader historical context with special attention to Michel Foucault's writings on the correlative constitution of the neurological gaze.

My thesis traces one hundred years of performing live brains (characterized by shifting forms of "liveness") through five case studies: Chapter 2 tackles the creation of illuminated brain models around 1930; Chapter 3 covers staged recordings of brainwaves from the 1930s to the 1940s; Chapter 4 focuses on live brains *on* television and conceptions of brains *as* television in the 1940s and 1950s; Chapter 5 addresses real-time EEG feedback circuits around 1970; and Chapter 6 "brain-to-brain" art-science installation works between 2013-2019. To analyze these five case studies, I examine practices and imaginaries that shaped and enacted the idea of perceiving the live

⁴ "Brainwaves During Museum Night," Waag Society, <https://waag.org/en/blog/brainwaves-during-museum-night>.

brain. Particularly, I inquire into the way new approaches to technical and broadcast media and new ideas of mediation undergirded different imaginaries of seeing the brain in action.

Describing the emergence of a new conception of the living brain in the twentieth century, my argument is that it was specific *assemblages of* brains and media – brainmedia – that allowed for the formation of what I call the live brain. My main question is how conceptions of the “brain at work” were practically produced and negotiated in specific historical situations. Asking what is required to create a live brain, I am interested in the enmeshments of screens, nerve preparations, experimental subjects, and computer displays, but also rhetorical tropes, science on television, or art-science installations that together imagine and conceive the brain in action. I particularly inquire into the role of media and mediation in such assemblages, asking how various media (including both technical and broadcast media) *and* changing historical ideas of mediation shaped the conception and examination of the active brain. Throughout, I show how new conceptions of media and mediation allow the human brain to be *thought differently* – as a brain in action – and opened new ways to perform and enact this live brain.

Turning back to this chapter’s precludes from two very disparate moments in time prompts a series of questions: What was needed to produce a live brain in 1934 and in 2014? What repertoires of scientific performance could demonstrate the brain in action in a scientific lecture hall in Cambridge and on a platform for “public science” in Amsterdam? How were audience members prompted to understand this performance and how do their accounts reflect historical understandings of mediation, as well as previous experiences and instances of seeing the living brain and body at work? How were brainmedia assembled across a projector apparatus, a screen, but also in newspaper accounts (in 1934) and online (in 2014)? Which expertise and what kinds of dramatization did these knowledge performances invoke? What type of live brain was enacted and what type of interventions into our lives did this live brain allow?

A critical history of brain science, or: Is the medium the message?

By introducing the concept of brainmedia to approach the past and the present of seeing the brain at work, I aim to nuance two key strands in critical-humanities scholarship of the brain sciences. The first is the dominant narrative in the historiography of the brain and mind sciences in the twentieth century that attributes a special historical status to the rise of functional imaging in the 1990s, viewing their emergence as a watershed moment in the history of the brain at work, creating a live brain that was persuasively transparent and heralded powerful popular acclaim for the neurosciences. With this thesis, I present alternative histories of the functioning, living brain – inside and outside the laboratory – before and after the 1990s, thus opening up different lineages

and historical perspectives. Secondly, critical literature about the rise of a new neuro-centered culture since the 1990s, tends to depict this culture as one in which the scientific and the popular are rather rigidly demarcated. I, however, claim that there is no such clear demarcation, rather a back and forth between different realms of knowledge production.

It is by now commonplace to start an analytical account of the brain and mind sciences with the so-called “Decade of the Brain” in the 1990s, which is said to mark the start of the omnipresence of the brain and the brain sciences in cultural discourses (omnipresent, that is, understood from the viewpoint of affluent Western societies, where the majority of brain studies are conducted and circulated).⁵ This historical flagpole then gives way to a characterization of the present as a “brain culture” or “neuroculture”: a present in which the brain makes striking appearances in popular media, in which brains are increasingly equated with the “self,” and in which the brain sciences are attributed a remarkable explanatory power for complex phenomena ranging from adolescent behavior and gender differences to consumption, criminality, and depression.⁶ Already during the 1990s and in the early 2000s a number of cultural and sociological studies critiqued this hegemonic status of the neuro-disciplines. Their ascent is often located in the emergence of functional brain imaging in the 1990s (PET and fMRI), which produced beautiful, colorful images of brains “lighting up” with varying mental behaviors, leading to speculation about, and promises of, mapping cognitive functions that ran far ahead of theoretical understandings and scientific proof.⁷

Numerous scholars have remarked on the seductive allure of these new images of the brain in action and critiqued image-oriented brain research (pejoratively called “blobology”).⁸ Perhaps, some authors have argued, it is because these imaging methods mesh morphological and functional

⁵ About the “Decade of the Brain” initiative and other neuroscience awareness initiatives see Dolores Modic and Maryann P. Feldman, “Mapping the Human Brain: Comparing the Us and Eu Grand Challenges,” *Science and Public Policy* 44, no. 3 (2017).

⁶ “Brain culture” in Davi Johnson Thornton, *Brain Culture. Neuroscience and Popular Media* (New Brunswick (NJ) and London: Rutgers University Press, 2011). “Neuroculture” in G. Frazzetto and S. Anker, “Neuroculture,” *Nature Reviews Neuroscience* 10, no. 11 (2009). Francisco Ortega and Fernando Vidal, eds., *Neurocultures: Glimpses into an Expanding Universe* (Frankfurt am Main/New York: Peter Lang, 2011). For a summary of the scholarly backlash against the neuro-turn, see Melissa M. Littlefield, “‘A Mind Plague on Both Your Houses’: Imagining the Impact of the Neuro-Turn on the Neurosciences,” in *The Human Sciences after the Decade of the Brain*, ed. Jon Leefmann and Elisabeth Hildt (London: Academic Press, 2017).

⁷ Anne Beaulieu, “Images Are Not the (Only) Truth: Brain Mapping, Visual Knowledge, and Iconoclasm,” *Science, Technology & Human Values* 27, no. 1 (2002); Adina L. Roskies, “Neuroimaging and Inferential Distance: The Perils of Pictures,” in *Foundational Issues in Human Brain Mapping*, ed. Stephen José Hanson and Martin Bunzl (MIT Press, 2010); Letitia Meynell, “The Politics of Pictured Reality: Locating the Object from Nowhere in Fmri,” in *Neurofeminism: Issues at the Intersection of Feminist Theory and Cognitive Science*, ed. Robyn Bluhm, Anne Jaap Jacobson, and Heidi Lene Maibom (London: Palgrave Macmillan, 2012).

⁸ “Seductive allure” in D. S. Weisberg et al., “The Seductive Allure of Neuroscience Explanations,” *Journal of Cognitive Neuroscience* 20, no. 3 (2008). “Blobology” in Cordelia Fine, *Delusions of Gender: How Our Minds, Society, and Neurosexism Create Difference* (New York: W.W. Norton, 2011), 153.

data that they make it seem, in historian Michael Hagner's words, as if one "observes the mind at work just as one observes the blushing or the mimicry of a face [...] Neuroimaging, then, is a kind of physiognomy turned inward."⁹ Around 2000, a number of ethnographers examining new PET, MRI, and fMRI practices analyzed the theories and assumptions that are built into visualizations of active brains and demonstrated that these imaging practices' claims to truth depend heavily on the technologies created to construct them.¹⁰ In 1996, Hagner argued that functional brain images had caused a shift in conceptualizing the brain when the abstract information-processing model of cognitive science ("the brain as computer") was replaced by visual images of brain activation that offered a remarkable concreteness.¹¹ These images seemed to show the mind at work, thus visually strengthening the idea that cognitive functions could be decisively mapped and hence that these cognitive functions ("brain states") were real.¹² Because these images buttressed the idea that the living, working brain had become transparent, various *longue-durée* narratives frame the advent of functional imaging in the 1990s as a decisive turning point in the cultural history of the brain sciences.

For some cultural historians, notably Cornelius Borck and Roger Smith, the Decade of the Brain and the advent of functional imaging not only suggest a critical juncture, but also seem to present an *endpoint* with regards to the history of cultural imaginaries of the brain at work. In this account, the 1990s birth of the colorfully imaged brain constitutes the conclusion of a long history of models of, and metaphors for, the brain's mechanisms, replacing it "with the immediacy of an artificially real brain image," as Cornelius Borck has argued, now "the brain has become the medium and the message."¹³ Similarly, historian Roger Smith argues that these imaging practices constitute a major turning point in the history of psychology and psychophysiology: "It is tempting to think that in brain science, Marshall McLuhan was right: the medium is the message – the technology of representation determines the content of knowledge."¹⁴

⁹ Michael Hagner, "The Mind at Work: The Visual Representation of Cerebral Processes," in *The Body Within: Art, Medicine and Visualization*, ed. Renée van de Vall and Robert Zwijnenberg (Leiden: Brill, 2009), 87.

¹⁰ Anne Beaulieu, "The Space inside the Skull : Digital Representations, Brain Mapping and Cognitive Neuroscience in the Decade of the Brain" (Dissertation, University of Amsterdam, 2000); Joseph Dumit, *Picturing Personhood: Brain Scans and Biomedical Identity* (Princeton [NJ]: Princeton University Press, 2004); Andreas Roepstorff, "Brains in Scanners: An Umwelt of Cognitive Neuroscience," *Semiotica* 134, no. 1/4 (2001); "Transforming Subjects into Objectivity. An Ethnography of Knowledge in a Brain Imaging Laboratory," *FOLK, Journal of the Danish Ethnographic Society* 44 (2002).

¹¹ Michael Hagner, "Der Geist Bei Der Arbeit. Überlegungen Zur Visuellen Repräsentation Cerebraler Prozesse," in *Anatomien Medizinischen Wissens: Medizin- Macht- Moleküle*, ed. Cornelius Borck and Susan M. DiGiacomo (Frankfurt am Main: Fischer-Taschenbuch-Verlag, 1996).

¹² Ibid.

¹³ Cornelius Borck, "Toys Are Us. Models and Metaphors in Brain Research," in *Critical Neuroscience: A Handbook of the Social and Cultural Contexts of Neuroscience*, ed. Suparna Choudhury and Jan Slaby (Oxford, UK: Wiley-Blackwell, 2011), 129.

¹⁴ Roger Smith, *Between Mind and Nature: A History of Psychology* (London: Reaktion Books, 2013), 259.

Neither Borck nor Smith would adhere to a strong version of the claim that there are no more metaphors in the brain sciences. They simply mean to underline a quantitative shift in the brain sciences, a change in the relation of technology (medium) vis-à-vis theorization (message). Their endpoint narrative should thus perhaps be understood as a rhetorical argument that in fact aims to argue the opposite: that the promise of functional imaging of the 1990s was nothing new. Earlier histories of functional imaging (such as Borck's work on the history of EEG and Smith's work on the history of the mind-brain problem) show that such promises of transparent brains and the possibility to trace mental states through physiological measurements have much longer and varied histories. Well-known in this respect are Gerd Gigerenzer's observations on a shift from theory to instruments (what he calls a "tools-to-theory heuristics") that took place in the domain of cognitive psychology, where he claims that the empirical method of inferential statistics (emerging with the ubiquity of computers in psychological and psychophysiological laboratories in the 1960s) positioned "the mind as an intuitive statistician."¹⁵ Yet even though the move from theories to tools has a long history, there seems to be something qualitatively different about image-making in the 1990s. As Hagner has argued, while the old questions pertaining to the relationship between mind, experience, and brain formulated in the nineteenth century essentially remain the same, brain science is now more than ever determined by "newly enabled views and grasps by new technology."¹⁶ Something happened in the wake of the Decade of the Brain that allowed these images to gain great power.

This attribution of an exceptional position, i.e. the particularly persuasive power of the 1990s' blinking brain, is problematic, as it is made possible by associating this persuasion to a new, ever-expanding popular realm for neuroscience, a so-called neuroculture. Yet this focus on a pervasive neuroculture has the problematic tendency to suggest a division between imaging practices in the laboratory and the circulation of the "active brain" outside the laboratory. When scholars describe visual and public manifestations of neuroculture (most often in popular-science journals or newspapers), they invoke a general public of laypeople who are easily fascinated by the beautiful and authoritative appearance of brain images, and in turn just as easily convinced by the claims the images are asked to support. Brain images, with their seductive reality effects and promise of objectivity, can cause the "apparent materialization," as Maurizio Meloni puts it, of particular emotions, affects, and behaviors at the level of observed processes in the brain and they seem to do so especially in popular media and public discourse.¹⁷ Functional brain images are, as

¹⁵ Gerd Gigerenzer, "From Tools to Theories: A Heuristic of Discovery in Cognitive Psychology," *Psychological Review* 98, no. 2 (1991): 255.

¹⁶ Michael Hagner, *Der Geist Bei Der Arbeit: Historische Untersuchungen Zur Hirnforschung* (Göttingen: Wallstein, 2006), 36.

¹⁷ Dumit, *Picturing Personhood*, 112.

Joseph Dumit puts it, “expert images” that exert “undue persuasiveness” over non-experts because of their “apparent legibility.”¹⁸

Laypeople’s perception of the spectacular-looking functional-brain images and performances (such as the *Brain Waves* example) is hence positioned as an important driver of the promissory culture of neuroscience. When an overly credulous public is exposed to expert or appropriated brain images, it is all too eager to adopt neurocentral views of phenomena such as love, voting preferences, or criminal behavior. According to critical neuroscience scholar Jan Slaby, this cultural support is due to a “hunger” for self-objectification, or, more generally, “people’s natural affinity for reductionistic explanations of cognitive phenomena,” as David McCabe and Alan Castel claim in a much-cited article on the interpretation of brain images.¹⁹ Similarly, Matthew Crawford, talking about “the limits of Neurotalk,” refers to brain imaging as “that fast-acting solvent of critical faculties,” and Steven Poole writes about the “rise of popular Neurobollocks,” including brain images that “like religious icons, inspire uncritical devotion.”²⁰ Some scholars emphasize these processes of deceitful seduction are not the work of neuroscientists, but of popular science writers. There is a distinction, as Jan MacVarish and colleagues claim, between proper neuroscience and “neuroscientism,” i.e. a difference “between legitimate findings emerging from [...] research on neurological functioning and the activities of those who appropriate the authority of scientific objectivity to pursue moral, political or commercial agendas in the public sphere.”²¹

My analysis reveals that by creating stark bifurcations between “legitimate” science and those who “appropriate” science in the public sphere these critical narratives foreclose a deeper understanding of the circulation between these two realms, as well as the ways in which certain scientific practices of conceptualizing and mediating research afford particular appropriations over

¹⁸ “Objective Brains, Prejudicial Images,” *Science in Context* 12, no. 1 (1999): 175. While Joseph Dumit admits that scientists are equally complicit in “neurorealism” by their presentation of brain scans, he is especially attentive to ways in which brain images “overflow” their status as “expert images” when they enter arenas beyond the laboratory, such as popular-science magazines, doctor’s waiting rooms, Hollywood movies, discourses of mental illness, or courtrooms. Ibid.

¹⁹ Jan Slaby, “Steps Towards a Critical Neuroscience,” *Phenomenology and the Cognitive Sciences* 9, no. 3 (2010): 398; David P. McCabe and Alan D. Castel, “Seeing Is Believing: The Effect of Brain Images on Judgments of Scientific Reasoning,” *Cognition* 107, no. 1 (2008): 344. Consumers of brain culture, in this line of thinking, are characterized by a “particular willingness, a specific kind of satisfaction gained in construing oneself as powerless, a-rational, subject to uncontrollable external or internal forces that ultimately determine one’s fate.” Jan Slaby and Shaun Gallagher, “Critical Neuroscience and Socially Extended Minds,” *Theory, Culture & Society* 32, no. 1 (2015): 46.

²⁰ Matthew B. Crawford, “The Limits of Neurotalk,” *The New Atlantis* 19 (2008): 65; S. Poole, “Your Brain on Pseudoscience: The Rise of Popular Neurobollocks,” *New Statesman*, September 06 2012. par. 18. Both cited in Martha J. Farah, “Brain Images, Babies, and Bathwater: Critiquing Critiques of Functional Neuroimaging,” *Hastings Center Report* 44, no. s2 (2014).

²¹ Jan MacVarish, Ellie Lee, and Pam Lowe, “Understanding the Rise of ‘Neuroparenting,’” in *We Need to Talk About Family: Essays on Neoliberalism, the Family and Popular Culture*, ed. Roberta Garrett, Tracey Jensen, and Angie Voela (Newcastle: Cambridge Scholars Publishing, 2016), 100.

others. Here, I challenge the seemingly straightforward dichotomy between “genuine” and “appropriated” science, i.e. between the sincere intentions of brain scientists and the wrongful, spectacularizing, grandiose claims of brain-science communicators. I also do not presume the public to have any reductionist affinity, but instead I aim to historicize how notions of the popular and the public, as well as notions of (legitimate) science popularization and science expertise, are invoked in different situations. Going beyond both neuro-enthusiasm and neuro-skepticism, I investigate the way live brains are performed in the interplay between scientists, science communicators, and spectators. If, within this interplay in brain science, “the medium is the message,” I ask, what *was* the medium?

From metaphors to brainmedia: Theoretical concepts of media-historical research

The central concept of this thesis is “brainmedia,” a term I coined to denote the material-discursive assemblages that produce and demonstrate the live brain. “Brain” in brainmedia stands for the cerebral organs as they have been (and are) shaped and enacted by the historically variable concepts and practices used to examine them. “Media” refers to three different kinds of media: the technological apparatuses neuroscientists use in laboratories; an environment understood as a medium that affected modern brains; and the new broadcast- and other forms of recording- and presentational media that brain scientists used to communicate and think about their research of the ‘brain in action’. Throughout my case studies, I show how brains are constituted, through brainmedia, as “live brains.”

With my conceptualization of brainmedia, I build on – but also depart from – what could be called a history of metaphors of the brain. By analyzing brainmedia as assemblages I can relate to these metaphors and analogies in a different way – dive deeper, so to say, into the tropes’ tissue. I do so by moving beyond an exclusively linguistic or discursively oriented approach to metaphor. This is not to dismiss the long and important tradition in the study of cerebral metaphors and analogies (about a battle of nerve cells or human nerves as an internet network, for example).²² There is a vast and important body of work that describes and uncovers the effects of the figurative

²² “Battle of nerve cells” in Stephan Besser, “From the Neuron to the World and Back: The Poetics of the Neuromolecular Gaze in Bart Koubaa’s ‘Het Gebied Van Nevski’ and James Cameron’s ‘Avatar,’” *Journal of Dutch Literature* 4, no. 2 (2013). Superseding an analysis of the meaning effects of specific tropes and metaphors of the brain, Stephan Besser provides an analysis of the way tropes can be used to create “systems of analogy” that allow for varying linkages between biological and social concepts. For a critical view on the brain as network metaphor versus a view of the brain as today’s (actual) complicated material internet network, see Philip Hauéis and Jan Slaby, “Connectomes as Constitutiveley Epistemic Objects: Critical Perspectives on Modeling in Current Neuroanatomy,” *Progress in Brain Research* 233 (2017).

language employed to describe processes of nerve activity, thinking, memory, and emotion.²³ As historian Douwe Draaisma noted, the domain of mental processes is particularly abundant with metaphor, because “the literal description of mental processes seems to be fundamentally excluded [...] the problem with much figurative usage in psychology is that no literal alternative is available.”²⁴ The brain provokes trope-heavy language because it performs complex and important functions, yet it does not straightforwardly reveal the internal mechanisms at work in its intriguing grey matter.

Metaphors are a central conceptual device in knowledge production; as Laura Otis puts it: “metaphors do not ‘express’ scientists’ ideas; they *are* the ideas.”²⁵ Indeed, brain-research discourse is rife with metaphors and tropes, especially analogies between brains and technology, including, since the nineteenth century, what we may call media technology (phonograph, telegraph, telephone, internet). A sole focus on the discursive translations and rhetorical figurations between technological media and biological entities, however, cannot do justice to the imploded and recursive qualities of their technoscientific entanglement. The history of tropes for the brain, the nervous system, and the neurological subject reveals a material-discursive fabric in which we can never untangle the neural and its “other” – whether, technology, tissue, or text.²⁶ Synaptic gaps, cerebral hemispheres, neural networks, nervous transmissions, and brainwaves are always already built by analogy, always already part of infinitely recursive loops – what Laura Otis has helpfully called “metaphorical circuits.”²⁷ The danger of a study of machine-organism metaphors is that it takes up a too “easy-going metaphoric,” as Jussi Parikka notes, placing phenomena “on an explanatory grid that has already stabilized the relations of nodes.”²⁸ On the contrary, as I emphasize with this thesis, technology does not “mediate” biology in the sense of a metaphorical model “translating” bodies through representation. Instead, media modulate the world through what Pasi Väliäho calls “transposition” – bodies and technologies form new assemblages in which nothing was ever “natural” or “other.”²⁹

²³ Juliana Goschler, “Metaphors in Cognitive and Neurosciences: Which Impact Have Metaphors on Scientific Theories and Models?,” *Metaphorik.de* 12 (2007), <http://www.metaphorik.de/12/goschler.pdf>; Borck, “Toys Are Us. Models and Metaphors in Brain Research.”

²⁴ Douwe Draaisma, *Metaphors of Memory: A History of Ideas About the Mind* (Cambridge: Cambridge University Press, 2000), 11. Draaisma observes a shift to mechanical analogies for the mind starting in the seventeenth century and a second shift in the nineteenth century to new technologies of recording (photography, phonograph, cinematography).

²⁵ Laura Otis, *Networking: Communicating with Bodies and Machines in the Nineteenth Century* (Ann Arbor: University of Michigan Press, 2001), 48. cited N. Katherine Hayles, *Unthought: The Power of the Cognitive Nonconscious* (Chicago & London: University of Chicago Press, 2017), 120.

²⁶ Laura Otis’ work on the historical relation between metaphors of networks and the study of nerve cells points to the limits of a simple metaphorical analysis, showing how similar metaphorical referents (networks, for example) could be used to make differing arguments. Laura Otis, “The Metaphoric Circuit: Organic and Technological Communication in the Nineteenth Century,” *Journal of the History of Ideas* 63, no. 1 (2002): 107.

²⁷ *Ibid.*

²⁸ Jussi Parikka, *Insect Media: An Archaeology of Animals and Technology* (Minneapolis: University of Minnesota Press, 2010).

²⁹ Pasi Väliäho, “Bodies Outside In: On Cinematic Organ Projection,” *Parallax* 14, no. 2 (2008): 17.

It is with this transposed perspective in mind that I coin the term brainmedia. I conceptualize brainmedia as organic/technical/media/cultural assemblages, i.e. as the material-discursive assemblages that configure the ‘live brain.’ I mean for the term “material-discursive” to resonate with Donna Haraway’s study of technoscience. Haraway speaks of the “collapse of metaphor and materiality” to advocate a study of science not as “a question of ideology but of modes of practice among humans and nonhumans that configure the world materially and semiotically – in terms of some objects and boundaries and not others.”³⁰ Her perspective makes it possible to describe the “naturecultures” that we both inhabit and are part of, worlds in which materiality and semiotics cannot be separated but have to be “imploded” (considered as ever more densely knotted) to use Haraway’s vocabulary.³¹ My focus on the imploded, the material-discursive, aims to bridge what James Bono has described as the false rift between studying the materialities of scientific practice (the assumed focus of science studies) and the discursive analysis of science (the assumed focus of the cultural or literary analysis of science).³²

The 100 years of brainmedia that I present in this thesis – an era in which media have often been understood as ever more intimately present – warrants a new specification of Haraway’s naturecultures. New forms of media are not only always enmeshed in the material world themselves, but are particularly potent forces in enmeshing other entities we may have previously viewed as separate bodies, machines, or things.³³ Hence, we need articulations of material-discursive assemblages, of naturecultures, that pay special attention to the position of media and mediation in these entanglements, invoking what Rosi Braidotti has called “medianaturecultures.”³⁴ In the past decade, media-studies scholars have coined various hybrid notions with different inflections to approach such an analytical project: “medianatures” (Jussi Parikka), “biomedia” (Eugene Thacker), “mediabodies” (Marie-Louise Angerer), or the “biomediated body” (Patricia

³⁰ Donna Jeanne Haraway, *Modest-Witness@Second-Millennium. Femaleman-Meets-Oncomouse: Feminism and Technoscience* (New York & London: Routledge, 1997), 97. Haraway uses the term “material-semiotic” to speak of sites where metaphors and materialities collapse, which she variably calls “material-semiotic apparatuses,” “articulations,” “fields,” “worlds,” or “webs”. Ibid.

³¹ Ibid., 97. ‘Naturecultures’ in *The Companion Species Manifesto: Dogs, People, and Significant Otherness*, vol. 1 (Chicago: Prickly Paradigm Press, 2003), 12.

³² Formulating a material-discursive approach, James Bono has proposed the terms “metaphorics of science,” which insists on the embodied, performative and material dimensions of metaphor, what he calls “embodied metaphors-in-action”, “material metaphors” or “performative metaphors”; they are “part of the material world and *instruments* for our knowing and manipulating it.” James J Bono, “Why Metaphor? Toward a Metaphorics of Scientific Practice,” in *Science Studies. Probing the Dynamics of Scientific Knowledge*, ed. Sabine Maasen and Matthias Winterhager (Bielefeld: Transcript Verlag, 2003), 226; “Making Knowledge: History, Literature, and the Poetics of Science,” *Isis* 101, no. 3 (2010).

³³ Richard Grusin, “Radical Mediation,” *Critical Inquiry* 42, no. 1 (2015): 146; Sarah Kember, “Doing Technoscience as (‘New’) Media,” in *Media and Cultural Theory*, ed. James Curran and David Morley (London & New York: Routledge, 2007).

³⁴ Rosi Braidotti, “The Critical Posthumanities; or, Is Medianatures to Naturecultures as Zoe Is to Bios?,” *Cultural Politics* 12, no. 3 (2016).

Clough).³⁵ Recently, N. Katherine Hayles has offered the term “cognitive assemblages” to describe the particular assembling that happens between humans and new technologies (what she dubs technical cognizers), such as novel types of sensors that exteriorize some of the micro-temporal processes happening below human consciousness.³⁶ Working in resonance with these articulations of medianaturecultures, I offer my conception of brainmedia as a viable means to analyze the proliferation of the live brain.

For me, studying historical assemblages of brainmedia means both studying how brains, nerves, minds, and selves are articulated as interwoven with our (media-)technological environment, and examining how notions of mediation and technological media have changed how the brain could be thought. As part of brainmedia, the brain is always already a medianatureculture, always already entangled with media technologies, social practices, and metaphors; and media denote the historically variable processes of mediation, conceptions of mediating, and technical media through which knowledge about the active brain emerges.

By analyzing brainmedia as assemblages, I also enact these brainmedia. Describing, theorizing, negotiating and criticizing assemblages in this thesis brings those assemblages into being, makes them emerge more clearly. This is what John Law has described as the performance of writing, “telling stories about the world also helps to perform that world [...] what is being performed is thereby rendered more obdurate, more solid, more real than it might otherwise have been.”³⁷

A media-historical approach to the media enmeshed with brain science

Writing about one hundred years of brainmedia, from the 1920s until 2020, I methodologically align myself with a heterogeneous body of historical media studies that comprise both media-archaeological and media-genealogical approaches. I sidestep ongoing debates about Foucauldian concepts here, as neither approach refers to rigidly circumscribed methodologies, but both circumscribe a set of concerns and analytical emphasis in investigating the historical development of media apparatuses and practices, and media’s relation to power/knowledge formations.³⁸ I use

³⁵ Jussi Parikka, “New Materialism as Media Theory: Medianatures and Dirty Matter,” *Communication and Critical/Cultural Studies* 9, no. 1 (2012); Eugene Thacker, *Biomedea* (Minneapolis: University of Minnesota Press, 2004); Marie-Luise Angerer, “Medienkörper: Zur Materialität Des Medialen Und Der Medialität Der Körper,” in *Kultur — Medien — Macht: Cultural Studies Und Medienanalyse*, ed. Andreas Hepp and Rainer Winter (Wiesbaden: VS Verlag für Sozialwissenschaften/Springer, 1997); N. Katherine Hayles, “Unfinished Work: From Cyborg to Cognisphere,” *Theory, Culture & Society* 23, no. 7-8 (2006).

³⁶ *Unthought*.

³⁷ John Law, *Aircraft Stories: Decentering the Object in Technoscience* (Durham: Duke University Press, 2002), 6.

³⁸ See the discussion on media archeology and media genealogy in Erkki Huhtamo and Jussi Parikka, “Introduction: An Archaeology of Media Archaeology,” in *Media Archaeology: Approaches, Applications, and Implications*, ed. Erkki Huhtamo and Jussi Parikka (Berkeley and Los Angeles: University of California Press, 2011).

the term “media-historical analysis” to emphasize this combined approach, though at times I refer to (media) genealogy to signal an interest in a “history of the (neurocultural) present,” redrawing the development of the relation between brains and media in the twentieth century.

A media-historical analysis is sensitive to media as an emergent part of the fabric of knowledge formation. This means that a combined archaeological and genealogical study of researching the active brain is also always a study of the formation of the (brain)media that constitute this active brain. Recently, we can see media-sensitive approaches being taken up by historians of science. Philip Sarasin, for example, has rallied for attention to media in the history of knowledge (*Wissensgeschichte*), emphasizing the constitutive role of media: “knowledge is shaped by the logic of the media because it always has to be formatted” [;] “media function as filters that select, emphasize and repress knowledge, change it and connect it with other elements of knowledge.”³⁹

Yet, a more radical media-historical approach takes media’s “formatting” role in knowledge production and cultural formation a step further. Media, in the media-historical sense that I propose here, are as much constitutive *of* culture as they are constituted *by* culture; media have world-making capabilities. This also means that what counts as a medium is itself always in flux. Media are not fixed but always in a state of “becoming media,” as Joseph Vogl has emphasized, transforming “apparatuses, codes, symbolic systems, forms of knowledge, specific practices, and aesthetic experiences” into media.⁴⁰

I believe that when media are studied in their emergence, it is imperative to investigate the “grey zones” in their development when new forms of mediation have not yet been delineated as a medium. This is why I also study the imaginary media and media imaginaries related to brainmedia: the longed-for machines and fantastic ways to access the active brain, as well as the imaginaries of mediation that surpass conventional spatio-temporal boundaries of outer world and inner brain, living and dead, visible and invisible.⁴¹ In chapter three, for example I analyze a fictional brain wave reader that can supposedly communicate with the dead, while chapter six features a contemporary media installation that invokes the possibility of getting feedback on “brain-to-brain synchronization.” I discuss such grey zones, media imaginaries, and imaginary media as they relate

³⁹ Philipp Sarasin, “Was Ist Wissensgeschichte?,” *Internationales Archiv für Sozialgeschichte der deutschen Literatur (IASL)* 36, no. 1 (2011): 168.

⁴⁰ Joseph Vogl, “Becoming-Media: Galileo’s Telescope,” *Grey Room* 29 (2007): 16.

⁴¹ On “imaginary media” and “media imaginaries” see Jussi Parikka, “Imaginary Media: Mapping Weird Objects,” in *What Is Media Archaeology*, ed. Jussi Parikka (Cambridge, UK: Polity, 2012); Simone Natale and Gabriele Balbi, “Media and the Imaginary in History: The Role of the Fantastic in Different Stages of Media Change,” *Media History* 20, no. 2 (2014); Eric Kluitenberg, “On the Archeology of Imaginary Media,” in *Media Archaeology: Approaches, Applications, and Implications*, ed. Erkki Huhtamo and Jussi Parikka (Berkeley and Los Angeles: University of California Press, 2011).

to brain research not to trace the origins of particular (brain)media assemblages, but rather to emphasize contingencies and describe their rise and demise.⁴²

My media-historical analysis examines how media, as Alexander Monea and Jeremy Packer put it, “allowed certain problems to come to light, be investigated, and chosen for elimination and how media aided in the various solutions that have been enacted.”⁴³ For me, studying phenomena media-historically means positioning media assemblages within their historical discourse and examining the practices and thoughts that enable media to come into being and in turn also influence this field of possibilities. In my case studies of brainmedia, a genealogy of live brains requires studying specific media assemblages and remaining attentive to media as a constitutive part of knowledge formation and to shifts from one discursive formation to another. My media-historical analysis thus uncovers the required conditions for legitimate statements about the active brain and brain activity. Different at different points in time, such articulations of active brains were fueled by – and at the same time opened up – the possibility for (normative) categorization and governmentality through (discourses about) brain science. Note, for example, that an EEG exhibition in 1937 (discussed in Chapter 2) was part of a broader, government-steered, normative public discourse that also included personality and intelligence testing and an emphasis on biometrics. Or note that new devices developed to show spatio-temporal brain activity in the 1950s (discussed in Chapter 3) fortified a project to develop categorizations of personalities and mental (ab)normalities. Conditions of knowledge (the subject of archaeology) are always conjoined with networks of power that provoke knowledge formation (the subject of genealogy). Significantly then, my analysis of configurations of knowledge about the live brain shows how much brains (as minds, selves, and subjects) are articulated as part of the fabric of a modern media landscape. This placement of the subject within media opens the subject with a live brain up – makes it conducive – to new networks of knowledge/power. It is with an eye to studying the networks of knowledge/power informing contemporary assemblages of the live brain in the twenty-first century that I present historical accounts of brainmedia.

⁴² On the concern for the non-teleological, nonlinear, and contingent in media-historical studies, see Jussi Parikka, ed. *What Is Media Archaeology?* (Cambridge, UK: Polity, 2012); Timothy Druckery, “Foreword,” in *Deep Time of the Media: Toward an Archaeology of Hearing and Seeing by Technical Means*, ed. Siegfried Zielinski (Cambridge (MA): MIT Press, 2006).

⁴³ Alexander Monea and Jeremy Packer, “Media Genealogy: Technological and Historical Engagements of Power — Introduction,” *International Journal of Communication* 10 (2016): 3154.

Understanding scientific practices and communications through “performing knowledges”

Next to the concept of brainmedia, a second important analytical dimension is my consideration of scientific practices as *performing knowledges*. I approach knowledge production about live brains as taking place across different spheres, both inside and beyond the academic laboratory. The concept of performing knowledges allows me to attend to many actors and sites where live brains are produced, and move away from the dichotomy between “genuine” (serious, academic, institutional) brain science versus “popular” views about the brain and the implications of brain science. I thus adhere to a more inclusive, and recursive conception of science as it is performed, mediated, and configured within and beyond the inner circles of the science establishment.

In the past decades, historians of science, scholars in science studies, and historians of knowledge have proposed less dichotomous conceptual frameworks to understand scientific practices, for example James Secord’s notion of “knowledge in transit” and the idea of “circulating knowledge” (as developed by a number of authors).⁴⁴ To study circulating knowledge means acknowledging the fact that the nature and status of knowledge change during moments of transition, and zooming in on the particularity of such changes and mutations instead of forging easy distinctions between “genuine” science and popular-, para-, or pseudo-science, or between the history of science and the history of science popularization.⁴⁵ The popular must itself be historicized as a changing category, as part of the transformation of public knowledge.⁴⁶

To study circulating knowledge as being performed means moving away from a diffusionist model of science popularization – the idea that authentic science is only dramatized, staged, or performed when it is mediated to lay audiences – and also steering clear of the notion of a “legitimate” sphere of science that becomes mitigated or diluted through circulation.⁴⁷ Instead, following the example of scholars in cultural studies of scientific knowledge, it is important to understand this distinction between the scientific and the popular as a dichotomy that is itself

⁴⁴James A Secord, “Knowledge in Transit,” *Isis* 95, no. 4 (2004). On ‘circulation’, see Lynn K. Nyhart, “Historiography of the History of Science,” in *A Companion to the History of Science*, ed. Bernard Lightman (Chichester: John Wiley & Sons Ltd, 2016), 12-6; Johan Östling et al., “The History of Knowledge and the Circulation of Knowledge. An Introduction,” in *Circulation of Knowledge. Explorations in the History of Knowledge*, ed. Johan Östling, et al. (Lund: Nordic Academic Press, 2018).

⁴⁵Bernadette Bensaude-Vincent, “A Historical Perspective on Science and Its “Others”,” *Isis* 100, no. 2 (2009); Jonathan R Topham, “Rethinking the History of Science Popularization/Popular Science,” in *Popularizing Science and Technology in the European Periphery, 1800–2000*, ed. Agustí Nieto-Galan, Enrique Perdiguero, and Faidra Papanelopoulou (Farnham: Ashgate Publishing, 2009).

⁴⁶Andreas W. Daum, “Varieties of Popular Science and the Transformations of Public Knowledge: Some Historical Reflections,” *Isis* 100, no. 2 (2009): 320.

⁴⁷Roger Cooter and Stephen Pumfrey, “Separate Spheres and Public Places: Reflections on the History of Science Popularization and Science in Popular Culture,” *History of Science* 32, no. 3 (1994): 249; Stephen Hilgartner, “The Dominant View of Popularization: Conceptual Problems, Political Uses,” *Social Studies of Science* 20, no. 3 (1990).

continuously enacted.⁴⁸ At every stage, it takes effort and rhetoric to separate the supposedly scientific from the popular, and this boundary work deserves particular investigation.⁴⁹

My study of brainmedia examines *how* knowledge about the brain circulates across scenes, scenarios, and spheres of knowledge production, thus also uncovering the materiality and mediality of circulating knowledges. Examining live brains as assembled across different sites (lectures, public demonstrations, magazine articles) allows me to examine the emergence of new knowledges shaped by new stages, spaces, and repertoires for performing these knowledges. I borrow the term from Mary Dupree and Sean Franzel, who, in their edited volume *Performing Knowledge, 1750-1850*, highlight “the specific physicality, materiality and temporality of the performance situation,” as well as the emergence of new types of knowledge performers and audiences.⁵⁰

In this thesis, I use “performativity,” “performing,” and “performances” for two main reasons: to flag the potential performativity of presenting knowledge and to highlight the potential dramatic structure of performances of knowledge. First, studying brainmedia as heterogeneous assemblages requires analyzing their reality-producing (performative) dimension – that is, their ability to enact (to call into being, to bring forth, to hail) that which it has set out to disclose. Media, as used in performances of knowledge, have special performative or reality-producing qualities, what media theorist Sybille Kramer has called *das in-Szene-setzende Wahrnehmbarmachen*: meaning that media also create and stage the things they make perceptible.⁵¹ Media thus “phenomenalize,” in Kramer’s words, enacting what they mediate while they mediate, and this means that “which they embody is not a more or less stabile entity, but only exists in the fluid and processual presence of media action.”⁵²

Aside from performativity, I speak of “performing” brainmedia because that makes it clear that knowledge production (about the live brain) is a practice carried out for an (actual or imagined) public that reconfigures, by rhetorical and material means, what has been performed; it transforms knowledge. In this sense, these performances are related to (theatrical) plays or acts that have a persuasive objective – making something look truthful, beautiful or cool, for example. These intersecting meanings of performativity and performance/ing resonate with the work of key

⁴⁸ Joseph Rouse, “What Are Cultural Studies of Scientific Knowledge?,” *Configurations* 1, no. 1 (1993): 13.

⁴⁹ Thomas Gieryn, “Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists,” *American Sociological Review* 48, no. 6 (1983).

⁵⁰ Mary Helen Dupree and Sean B. Franzel, “Introduction: Performing Knowledge, 1750–1850,” in *Performing Knowledge, 1750-1850*, ed. Mary Helen Dupree and Sean B. Franzel (Berlin & Boston: Walter de Gruyter GmbH & Co KG, 2015), 9.

⁵¹ Sybille Krämer, “Was Hat “Performativität” Und “Medialität” Miteinander Zu Tun?: Plädoyer Für Eine in Der “Aisthetisierung” Gründende Konzeption Des Performativen. Zu Einführung in Diesen Band,” in *Performativität Und Medialität*, ed. Sybille Krämer (München: Fink, 2004), 25.

⁵² Ibid.

historians and philosophers of science. Well-known in this respect are Donna Haraway, Bruno Latour, Andrew Pickering, and Karen Barad, who analyze (with different emphases and vocabularies) the performativity of reality-producing agents assembled in lab experiments and other scientific practices.⁵³ Alternatively, scholars such as Stephen Hilgartner, José van Dijck, and Peter Weingart have focused on “staging” and “dramatization” within and beyond scientific laboratories, for example “science on stage” in popular news media, science exhibitions, or policy debates.⁵⁴ Performativity and performance intermingle in these studies, as scholars use concepts such as “choreography of truth,” “experimental scenography,” “theatre of proof,” “demonstration assemblage,” “material performativity,” or “scenarios of knowledge” for analytical approaches that point to reality-producing actions and agents at the basis of material-discursive assemblages, with special attention to staging, both in the lab and in the public sphere.⁵⁵

Studying the performing of scientific knowledge implies that science is rarely only about persuading an audience of a finding’s truthfulness, of the scientists’ trustworthiness, or of the authority of the instrumental set-up and the scientific locale. Performances of scientific knowledge are never merely about “making real,” they always interface with other important aspects such as the interpellation of particular types of audiences and the specific ways in which science could be sensed, felt, and appreciated. Historian Henning Schmidgen gives the example of late nineteenth-century physiologists who were eager to connect their recording devices to projection machines that would allow the collective experience of seeing their immediate inscriptions.⁵⁶ Scientific practices were thus significantly influenced by this goal of making public, as Jimena Canales notes: “the history of these technologies thus intersects with the larger history of spectacle, from the classroom to the movie theater.”⁵⁷ Scientists produce their performances of knowledge as part of,

⁵³ Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society*, Revised ed. (Cambridge, Mass.: Harvard University Press, 1988); Haraway, *Modest-Witness@Second-Millennium.Femaleman—Meets—Oncomouse*, Andrew Pickering, *The Mangle of Practice: Time, Agency, and Science* (Chicago: University of Chicago Press, 1995); Karen Barad, “Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter,” *Signs* 28, no. 3 (2003).

⁵⁴ Stephen Hilgartner, *Science on Stage: Expert Advice as Public Drama* (Stanford (CA): Stanford University Press, 2000); José van Dijck, *Imagination: Popular Images of Genetics* (Basingstoke, London: Macmillan, 1998); Peter Weingart, *Die Wissenschaft Der Öffentlichkeit: Essays Zum Verhältnis Von Wissenschaft, Medien Und Öffentlichkeit* (Weilerswist: Velbrück, 2005).

⁵⁵ “Choreography of truth,” in Iwan Rhys Morus, “Placing Performance,” *Isis* 101, no. 4 (2010): 777. “Experimental scenography” in Bruno Latour, “From Fabrication to Reality. Pasteur and His Lactic Acid Ferment,” in *Pandora’s Hope: Essays on the Reality of Science Studies*, ed. Bruno Latour (Cambridge, MA: Harvard University Press, 1999). “Theatre of proof,” in *The Pasteurization of France* (Cambridge, MA: Harvard University Press, 1993), 86. “Demonstration assemblage,” in Henning Schmidgen, “Pictures, Preparations, and Living Processes: The Production of Immediate Visual Perception (Anschauung) in Late-19th-Century Physiology,” *Journal of the History of Biology* 37, no. 3 (2004): 481. “Material performativity,” in Pickering, *The Mangle of Practice*, 16. “Scenarios of knowledge” in Victoria Tkaczyk, “The Making of Acoustics around 1800, or How to Do Science with Words,” in *Performing Knowledge, 1750-1850*, ed. Mary Helen Dupree and Sean B. Franzel (Berlin & Boston: Walter de Gruyter GmbH & Co KG, 2015), 36.

⁵⁶ Henning Schmidgen, “1900—the Spectatorium: On Biology’s Audiovisual Archive,” *Grey Room* 43 (2011).

⁵⁷ Jimena Canales, “Recording Devices,” in *A Companion to the History of Science*, ed. Bernard Lightman (Chichester: John Wiley & Sons, 2016), 509.

and with an eye to, broader structures and functioning of visibility. Hence, it is important to investigate the affective dimensions of performing knowledges – the fears, hopes, and desires they enact – as well as the forms of storytelling, imaging, and imagining by which they are produced.⁵⁸ As Ian Morus says, “looking at performances should also get us thinking about science in terms of doing rather than writing, aesthetic pleasure rather than hard reason.”⁵⁹

For me, analyzing the emergence of the active brain as a live brain means to move from a confined analysis of scientific images to an analysis of performing knowledges that, in their circulation, entail a variety of processes of articulation, conceptualization, visualization, and demonstration. With this thesis I expand the analytical frame by looking at complex mediations in which brain models, metaphors, or installations are performed, that is, conceptualized, developed, demonstrated, and exhibited in public, across the boundaries of established scientific discourses and science.

Different Forms of Liveness: Watching the brain at work

Why is it so cool to see our own brain activity in real-time? to repeat the question of a participant of the *Brain Waves* installation (mentioned in the prelude above) at Amsterdam’s Anatomical Theatre. How can we understand such a fascination with the view of the living brain? In the brainmedia case studies in this thesis, I analyze these as varying instances of “live” brains. My conception of liveness is as a category of spatio-temporal operativity that is differently configured in different media-historical constellations. “Liveness” is not solely a technical, nor a primarily experiential term, but denotes a more dynamic concept covering different configurations of directness, nearness, here-ness, aliveness, liveliness, and now-ness. These different configurations of liveness are what I call the specific *forms of liveness* that matter in my histories of brainmedia.

According to one of its meanings in the Oxford English Dictionary, the adjective “live” denotes a performance or event that is “heard or watched at the time of its occurrence [...] not pre-recorded.”⁶⁰ Yet by speaking of different forms of liveness in relation to brain research I expand that notion (usually more narrowly associated with the realm of radio or television) to cast a specific media-analytical perspective on brainmedia in the twentieth century. In my case studies of live brains, I study the forms of liveness enacted and assembled in brainmedia up close. Examining situations in which scientific measurements of the living brain are performed and presented in

⁵⁸ Maureen McNeil et al., “Conceptualizing Imaginaries of Science, Technology and Society,” in *The Handbook of Science and Technology Studies*, ed. Ulrike Felt, et al. (Cambridge, Mass.: MIT Press, 2016), 457.

⁵⁹ Morus, “Placing Performance.”

⁶⁰ Oxford English Dictionary, “*Live, Adj. 1, N., and Adv.*” (Oxford University Press).

different ways, I note that they are never only about invoking immediacy, instantaneity, or transparency, as they are also always paired with other associated notions – tied to forms of liveness – such as authority, attraction, aliveness, liveliness, or intimacy. In fact, by studying various historical brainmedia with special attention to their forms of liveness, I present an alternative to the dominant scholarly focus on the apparent immediacy and transparency of situations in which the active brain is performed (the interpretations of which are often rhetorically assigned to a naïve spectator who imagines a direct window into the brain).

Various scholars have described the puzzling nature of scientific mediation practices (making visible the invisible) by speaking of the “paradox of transparency” (Cornelius Borck), “myth of total transparency” (Jose van Dijck), and “a ‘dream’ of media-free immediacy” (Florian Sprenger), on the one hand positing the fact of mediation, the mediated nature of processes of scientific transcription, and on the other hand the attribution, on a discursive or experiential level, of direct access to these newly visualized entities, hence erasing any mediation processes.⁶¹ Though it is important to describe the tension between these two poles – a rhetorical opposition that has spurred important media-theoretical investigations – the notion of the paradox also sets up a too general a rift, one that cannot fully describe what happens in particular historical performances of knowledge. In contrast, my aim is to historicize attributions of (spatial) nearness and (temporal) speed in histories of performing the “live brain.” My case studies demonstrate that performances of live brains are never merely about producing an immediate view inside the living brain; they are never only about producing a supposed encounter with nature. Media may conjure sensations of intimacy, liveliness, or aliveness that cannot be equated with just a desire for transparency: to become live means that mediation can become both transparent and present.

By emphasizing liveness over immediacy, I do not mean to dismiss the importance of examining the ideal of immediacy or transparency in studying the human brain. The rhetoric of transparency is a structuring narrative in the twentieth-century ambition to access the living brain. Indeed, in this thesis, this rhetoric is omnipresent in varying historical imaginaries of direct entry into the brain at work; my chapters present historical desires to make the skull translucent, imaginations of direct access to the interior world, and the wish to view the activities of the living brain as they happen. Yet I am not tracing the twentieth-century discourse of increasing cerebral translucency, nor am I merely exposing the perils and pitfalls of the myth of the transparent brain

⁶¹ “Paradox of transparency” in Cornelius Borck, “Die Unhintergebarkeit Des Bildschirms,” in *Mit Dem Auge Denken: Strategien Der Sichtbarmachung in Wissenschaftlichen Und Virtuellen Welten*, ed. Bettina Heintz, Arnold O. Benz, and Jörg Huber (Zürich: Ed. Voldemeer, 2001), 388. “[I]deal of transparency” in José van Dijck, *The Transparent Body: A Cultural Analysis of Medical Imaging* (Seattle, WA.: University of Washington Press, 2005), 15. ‘[D]ream’ of media-free immediacy” in Florian Sprenger, *Medien Des Immediaten: Elektrizität, Telegraphie, McLuhan* (Berlin: Kadmos, 2012), 5. Sprenger in fact discusses the problem of this analytical frame, and calls for a historicization of narratives of immediacy.

at various moments in history. Instead, I demonstrate how historically situated conceptions media and mediation are imbricated in the formation of the live brain.

My attention to varying forms of liveness contributes to scholarship in historical epistemology. The work of Lorraine Daston and Peter Galison has already enabled us to look at the way different historical time periods engender different “objectivities,” connected to what they call shifting “epistemic virtues,” i.e. the changing ways in which scientists are supposed to behave in order to be regarded as good scientific practitioners (being restrained, creative, or trustworthy, for example). My analysis of performances of knowledges is especially attentive to the epistemic virtues attributed to (emerging) media, and I show how aesthetic, artistic, and performance-oriented modes of knowledge production arise in varying “virtuous” relations envisioned between scientists and the technical and broadcast media they use.

In developing the notion of *forms of liveness*, I argue that we can extend the term “live” from its narrow association with a presumed origin in 1934 (the liveness of radio) to function as a broader investigative concept that sensitizes the historian to discern the situated fabric of different temporal-spatial configurations and sensations that depends on existing technologies, affective positions, and situated knowledges. In relation to brainmedia, “liveness” is a particularly rich analytical concept, enabling us to see that producing spatio-temporal configurations of active brains – determining what counts as alive, direct, objective, engaging, aesthetic, automatic, or comprehensible, for example – is always contingent and relational: in different historical situations, experiential, technical, and rhetorical elements are intricately and variably intertwined. The pre-recorded may be experienced as current, something brought from far away may be sensed as (co-)present. If, as Philip Auslander states, media “make claims on us” about liveness, the question is how such a claim can emerge: liveness depends on the situated interpretation of mediation practices and technologies.⁶²

Understood in this way, liveness is generated by more than technical advances in relay speed. This is not to downplay the importance of liveness’ technological dimension, which is foregrounded in the scholarship of media-theorist Wolfgang Ernst, who speaks of the media-specific, “proper” temporal dimensions (*Eigenzeit*) of technological media, what he calls their specific temporalities and tempo-realities, “tempor(e)alities” in short.⁶³ Ernst’s study of

⁶² Philip Auslander, “Digital Liveness: A Historico-Philosophical Perspective,” *PAJ: A Journal of Performance and Art* 34, no. 3 (2012): 8. Paddy Scannell has also pointed to this situated performativity of live events (their “event-character”); they enact liveness but can only “work” as live in appropriate situations. Paddy Scannell, *Television and the Meaning of Live: An Enquiry into the Human Situation* (Cambridge and Malden: Polity Press, 2014), 105.

⁶³ Also important is Ernst’s observation that different media-induced tempor(e)alities (such as “real-time”) do not progress linearly alongside the development of different media technologies, but can be intermingled and connected in different time periods and within technological ensembles.

“chronopoetics” highlights the technological processes and micro-temporal configurations by which “technical objects embody complex temporalities,” for example, the calculated windows of delay time in what is called “real-time.”⁶⁴ Employing Ernst’s approach to a study of brainmedia, we can start to see that when a nerve network is compared to a display device (in Chapter 2), or when a cathode-ray oscillograph is used to both visualize groups of active nerves and provide visual stimuli (Chapter 4), this means that particular technical temporal configurations (embodying specific chronopoetics) were assembled and enacted to show the brain in action. While Ernst provides significant insights into tempor(e)alities as a technically oriented media archaeologist, my emphasis in this thesis is on broader assemblages, on discourses on liveness, and on technological devices involved in performing the living, working brain. For me, studying brainmedia assemblages that perform the live brain means studying not only the forms of liveness embodied by technical objects, but analyzing the way “technical and living beings” assembled together in brainmedia are always “instantiating and embodying complex temporalities,” to speak in N. Katherine Hayles’ terms.⁶⁵

Hence, the argument substantiated in my five case studies is that liveness emerges through socially configured, phenomenally experienced, and technologically mediated assemblages of (spatial) co-presence and (temporal) simultaneity, or varying instantiations thereof. What I call forms of liveness are produced by different (configurations of) *technologies* that produce specific spatio-temporalities (direct, live, real-time); by particular cultural *discourses* tied to mediation; and by the invocation and interpellation of particular *sensations*, i.e. an “experience” of liveness for audience members. What is more, forms of liveness are also part of what I call the *politics* of liveness. This means studying the institutional structures creating particular claims to liveness through relations of center and periphery, current or past, dominant or subservient.⁶⁶

⁶⁴ Wolfgang Ernst, *Chronopoetics: The Temporal Being and Operativity of Technological Media* (London & New York: Rowman & Littlefield, 2016). citing N. Katherine Hayles, “Komplexe Zeitstrukturen Lebendiger Und Technischer Wesen,” in *Die Technologische Bedingung. Beiträge Zur Beschreibung Der Technischen Welt*, ed. Erich Hörl (Frankfurt am Main: Suhrkamp, 2011), 217. As Lisa Gitelman has pointed out, Ernst hardly attends to the importance of sociohistorical context for the emergence of new media technologies. Lisa Gitelman, *Always Already New: Media, History, and the Data of Culture* (Cambridge (MA): MIT Press, 2006), 10.

⁶⁵ N. Katherine Hayles, *How We Think: Digital Media and Contemporary Technogenesis* (Chicago: University of Chicago Press, 2012), 106.

⁶⁶ As Nick Couldry has argued in this context, “Liveness is not a descriptive term, but a category, depends on “place within a wider system or structured pattern of values, which work to reproduce our belief in, and assent to, something wider than the description carried by the term itself,” Nick Couldry, “Liveness, “Reality,” and the Mediated Habitus from Television to the Mobile Phone,” *The Communication Review* 7, no. 4 (2004): 354.

Critical histories and the neuro-enchanted present

Historians have a role to play in critically evaluating the current hegemonic position of the neurosciences. This was one of many suggestions in the inaugural proposal of an initiative called “Critical Neuroscience,” launched in Berlin in 2008, which urgently called for critical analyses of the brain sciences because it viewed neuroscience as a domain that often presents itself as apolitical despite its increasing complicity in normative and economic agendas of, for example, self-optimization and economic productivity.⁶⁷ Critical neuroscientists have issued an important caution against a problematic neurocentrism in today’s culture: we should be wary of such neurocentrism because it does not do justice to the embodied, enculturated, enactive, and affective dimension of human behavior, and because it may feed into what has been called “neuro-governmentality,” brain science that prescribes how people live their lives, builds norms and politics into brain facts, and makes the social look natural.⁶⁸

While the Critical Neuroscience initiative no longer exists as a physical or institutional research group, its agenda is still important, not least because of its call for the need for critical histories of the neurocultural present. A number of historians of brain and mind sciences have employed this longer perspective to study histories of, for example, the double brain, the elite brain, ideas of brain localization, phrenology, and emotion research, asking us with these studies to reconsider the inevitability of current neuroscience, i.e. “not to take today’s solutions as the final answers.”⁶⁹ One important observation from these historical accounts concerns the heterogeneity of the brain and mind sciences. The term “neuroscience,” for example, only emerged in the 1960s and circumscribes a very heterogenous conglomerate of practices.⁷⁰ Framing historical narratives

⁶⁷ See Suparna Choudhury and Jan Slaby, “Introduction,” in *Critical Neuroscience: A Handbook of the Social and Cultural Contexts of Neuroscience*, ed. Suparna Choudhury and Jan Slaby (Oxford, UK: Wiley-Blackwell, 2011). For a recap, see Des Fitzgerald et al., “What’s So Critical About Critical Neuroscience? Rethinking Experiment, Enacting Critique,” *Frontiers in Human Neuroscience* 8 (2014). Cornelius Borck, “Auf Der Suche Nach Der Verlorenen Kultur: Vom Neuroimaging Über Critical Neuroscience Zu Cultural Neuroscience – Und Zurück Zur Kritik,” *Berichte zur Wissenschaftsgeschichte* 41, no. 3 (2018).

⁶⁸ Maurizio Meloni, “Philosophical Implications of Neuroscience: The Space for a Critique,” *Subjectivity* 4, no. 3 (2011). On ‘neuro-governmentality’ see particularly Nikolas Rose and Joelle Abi-Rached, “Governing through the Brain: Neuropolitics, Neuroscience and Subjectivity,” *The Cambridge Journal of Anthropology* 32, no. 1 (2014).

⁶⁹ Choudhury and Slaby, “Introduction,” 15. A number of important cultural and conceptual ‘histories of the brain’ have been published in the last two decades, tracing histories of ideas in the brain and mind sciences and examining the social, economic, political and cultural situatedness of brain facts and cerebral models. Just a few examples: Anne Harrington, *Medicine, Mind, and the Double Brain: A Study in Nineteenth-Century Thought* (Princeton: Princeton University Press, 1987); Cornelius Borck, *Hirnströme: Eine Kulturgeschichte Der Elektroenzephalographie* (Göttingen: Wallstein Verlag, 2005); Michael Hagner, *Geniale Gehirne: Zur Geschichte Der Elitegehirnforschung* (Göttingen: Wallstein Verlag, 2004); Roger Smith, *Inhibition: History and Meaning in the Sciences of Mind and Brain* (Los Angeles: University of California Press, 1992); Katja M. Guenther, *Localization and Its Discontents: A Genealogy of Psychoanalysis and the Neuro Disciplines* (Chicago: University of Chicago Press, 2015); Laura Salisbury and Andrew Shail, eds., *Neurology and Modernity: A Cultural History of Nervous Systems, 1800-1950* (London: Palgrave Macmillan, 2010).

⁷⁰ Max Stadler argues that since the 1990s, a new history of the neurosciences emerged with a “culturalist orientation” that is guilty of grafting the history of neuroscience onto a history of the brain and re-imagining the history of the

as histories of the brain, the mind, or the neurosciences may give the false impression that these have been constant, dominant, or meaningful objects of (scientific) research. In fact, the history of mind and brain sciences is, as Stephen Clark and Delia Gavrus emphasized, “a patchwork of loosely held together fragments,” which means that any *longue-durée* account should avoid conjuring a false epistemological coherence of the many disciplines involved in the study of brains, minds, selves, bodies, psyches, mental pathologies, psychologies, behaviors, nerves, and humans.⁷¹

Writing big histories of the brain is risky, as by conjuring historical narratives that “lead up” to the omnipresence of the brain today, historians may help to fortify the brain sciences’ current hegemonic position.⁷² Max Stadler thus argues that we need to “defamiliarize” ourselves from our neuroscientific past.⁷³ Other historians of brain and mind sciences have also emphasized the importance of unsettling established historical narratives by writing “different” and “marginal” histories.⁷⁴ Yet, what a marginal history of the mind and brain is always needs to be historicized in relation to established narratives about the past, as Stephen Casper and Delia Gavrus note.⁷⁵ With this thesis, I aim to contribute to this by moving between histories of brain science in laboratories and scientific writing and histories of public performances of brain, and between cultural histories of the brain in relation to histories of media and mediation.

Still, writing big histories of the brain might be too risky. Historian Roger Cooter is convinced that historians will inevitably be co-opted by what he calls the “neuro-turn.”⁷⁶ By writing *longue-durée* histories that trace the formation of neurocentrism and neurobiologization, such histories may help to naturalize and sustain these tendencies, and thus turn into technologies of power for, instead of critical reflections on, the new regime of truth. Pessimistic, Cooter writes: “we stand largely on the inside of the turn’s enchantment, capable of offering some criticisms but not much by way of historical critique of the sort that entails both looking beyond the object of

brain through the lens of “modern neuroscience.” He also argues we should not overemphasize the brain as a unit of analysis in histories prior to the 1950s; less spectacular histories of research on nerves and muscles, often in animal models, were ubiquitous. Max Stadler, “The Neuromance of Cerebral History,” in *Critical Neuroscience*, ed. Suparna Choudhury and Jan Slaby (Hoboken [NJ]: Wiley-Blackwell, 2011).

⁷¹ In parallel, Roger Smith remarks there is no comprehensive history of the mind-body debate for the twentieth century; it is an unavoidably patchy narrative – psychologists, physiologists, and philosophers used different idioms and often did not speak to the same problems. Roger Smith, “Representations of Mind: C. S. Sherrington and Scientific Opinion, C.1930–1950,” *Science in Context* 14, no. 4 (2001): 537.

⁷² Roger Cooter, “Neural Veils and the Will to Historical Critique: Why Historians of Science Need to Take the Neuro-Turn Seriously,” *Isis* 105, no. 1 (2014).

⁷³ Max Stadler, “Circuits, Algae and Whipped Cream: The Biophysics of Nerve, Ca. 1930,” in *The History of the Brain and Mind Sciences: Technique, Technology, Therapy*, ed. Stephen T. Casper and Delia Gavrus (Rochester: University of Rochester Press, 2017).

⁷⁴ “Marginal” histories in Stephen T. Casper and Delia Gavrus, “Introduction. Technique, Technology, and Therapy in the Brain and Mind Sciences,” *ibid.* “Different” histories in Mattia Della Rocca and Claudio Pogliano, “Different Histories from 20th Century Neuroscience,” *Nuncius* 32, no. 2 (2017).

⁷⁵ Casper and Gavrus, “Introduction. Technique, Technology, and Therapy in the Brain and Mind Sciences.”

⁷⁶ Cooter, “Neural Veils and the Will to Historical Critique,” 146.

inquiry itself to the conditions of possibility for it and standing back to reflect on our own position as historians in relation to it.”⁷⁷ I am more optimistic about the potential of tracing some of the historical conditions of neurosciences’ lofty position today. My work emerges from “inside the neuro-turn’s enchantment,” and it is from this vantage point in a fully media-enchanted world that I see the importance of studying the historical emergence of the notion of the living brain as the live brain.

I believe that the public history of the brain and the brain sciences in the twentieth century has not received enough attention. With respect to the nineteenth century, there are ample studies of the presence and practice of mind and brain science beyond scientific circles (think of the study of phrenology, nervousness, and neurasthenia), yet there is considerably less research on the way knowledge of the brain was circulated between laboratories and lay audiences since the beginning of the twentieth century.⁷⁸ Additionally, by focusing on the imbrication of media in various historical case studies, I also contribute to an understanding of the way scientific techniques and practices do not emerge instantly, but always need to be negotiated and performed in specific historical contexts.

Summarizing the three conceptual tools introduced in this chapter, I analyze a genealogy of brainmedia in five case studies through the frame of *brainmedia as assemblages*, approached as a practice of *performing knowledges* that generate new *forms of liveness* in conceptualizing and imagining the active brain. Brainmedia configure different forms of liveness, that is, as assemblages they conjure varying spatio-temporalities and spatio-tempo-realities. Brainmedia assemble new technical configurations as well as novel experiences of the direct-ness, nearness, here-ness, presence, aliveness, togetherness, and now-ness of perceiving the brain in action – the live brain.

⁷⁷ Ibid.

⁷⁸ For a good overview of nineteenth century neuroscience in relation to popular audiences, see Stephen T. Casper, “History and Neuroscience: An Integrative Legacy,” *ibid.* For the early twentieth century, Roger Smith is one of the few sources that note how popular literature on the brain offered “empowerment through materialist representations of mind, for example, by linking personality and the energies of the brain.” Smith, “Representations of Mind,” 514. Borck also remarks on the scarcity of research on the relation between publicity and science in the twentieth century. Cornelius Borck, *Brainwaves: A Cultural History of Electroencephalography* (London & New York: Routledge, 2018), 120. ff. 116. An exception, in this respect, is Melissa M. Littlefield, *The Lying Brain: Lie Detection in Science and Science Fiction* (Ann Arbor: University of Michigan Press, 2011).