Brainmedia

One hundred years of performing live brains, 1920–2020

Lysen, F.C.

Publication date
2020

Document Version
Other version

License
Other

2. Displaying Dynamic Brains: Illuminated Brain Models and the Enchanted Loom, 1928–1938

> The brain is waking and with it the mind is returning. It is as if the Milky Way entered upon some cosmic dance. Swiftly the head-mass becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern though never an abiding one; a shifting harmony of subpatterns.1
> — Charles Scott Sherrington, *Gifford Lectures*, 1938.

The "enchanted loom" might be the most cited and used metaphor for the nervous system in the past century. It pictures the active brain as a magical tapestry, a sparkling, spectacular cerebral display. Coined by eminent neurophysiologist Charles Sherrington in 1938, the metaphor has become a rhetorical commonplace in twentieth and twenty-first-century neuroscience publications ever since. From discussions of computational networks (*Enchanted Looms: Conscious Networks in Brains and Computers*) to popularly oriented volumes on consciousness (*The Enchanted Loom: Mind in the Universe*), the glittering loom functions as a flexible icon that can be appropriated in different imaginaries of cerebral space.[2] Yet with the passing of time, the historical context from which it emerged has been largely forgotten. In fact, Sherrington's loom is part of a broader history of scientists and science communicators who attempted to conceptualize and picture active cerebral processes and dynamically localized brain functions from the late 1920s onwards. In the 1930s, I will show, the enchanted loom, as part of this historical context, was proposed as a scheme of the working brain that had a particular "engineering bent," as Sherrington put it.[3]

Sherrington's enchanted loom exemplifies the ebullient figurative language scientists employed (and still employ) to speak about the active mechanisms of the brain. I argue that the metaphor should be understood as having been particularly shaped by changing questions about the possibility of visualizing and localizing processes and dynamic functions in the brain, spurred by new model-making ideas and technologies, and by new spheres for performing knowledge in

[1] Charles Scott Sherrington, *Man on His Nature* (Cambridge: Cambridge University Press, 2009 [1940]), 225. (printed version of the *Gifford Lectures 1937-1938*). Chapter 2 is a revised and expanded version of Flora Lysen, "It Blinks, It Thinks? Luminous Brains and a Visual Culture of Electric Display, Circa 1930," *Nuncius* 32, no. 2 (2017).
[2] Rodney Cotterill, *Enchanted Looms: Conscious Networks in Brains and Computers* (Cambridge: Cambridge University Press, 2000). Robert Jastrow, *Enchanted Loom: The Mind in the Universe* (New York: Simon & Schuster Trade, 1981).
[3] Sherrington, *Man on His Nature*, 225. Sherrington's loom metaphor was often cited by, among other people, William Grey Walter in radio lectures and popular publications. See: W. Grey Walter, *The Living Brain* (New York: W. W. Norton & Company, 1963 [1953]); "Enchanted Loom," (Great Britain: BBC Radio, 1948).

the 1930s. Together, these developments allowed a new assemblage of imaginaries and practices to emerge: new brainmedia providing a novel conception of the active brain. Tracing such assemblages, I discern the rise of a "live brain" as an illuminated, engineered object that particularly befitted a modernizing urban environment.

This chapter focuses on two such assemblages that shape "live brains," which have not been studied before: the three-dimensional Luminous Brain model, which was an educational device developed in Vienna in 1931, and the "motograph brain," an analogy 1930s neurophysiologists used to picture a dynamic nervous system as a type of illuminated news ticker or message board. These two examples of blinking brainmedia linked illumination, technical media, broadcast media, and brain activity in new spheres to perform knowledges, i.e. new spaces where science could be communicated to a broader public. My analysis of these two shows a shift in the conceptualization of nervous activity towards what I call the "logic of instant display." I argue that new display technologies allowed this new form of liveness to emerge, enabling an image and imaginary of direct, yet technically mediated access to the brain's invisible, dynamic activities.

By analyzing the resonances of electro-technology in the communication and presentation of nerve research around 1930, I contribute to scholarly analyses of reverberations between technological media and conceptions of human brains, constituting new live brains. Existing scholarship has predominantly focused on two eras and topics: nineteenth-century analogies between telegraph technology and human nerves, and the period starting in the 1940s, which saw a conceptual amalgamation between the information processing of early computers (logical calculators) and the work of the nervous system.[4]

An important and cross-cutting observation from these histories is that machine-organism analogies can vary in their interpretation and signification, that is why they should always be studied up close. The network analogy (which compared telegraphs to the nervous system and neuronal webs to telegraph networks), for example, was used to make different

[4] Timothy Lenoir, "Helmholtz and the Materialities of Communication," *Osiris* 9 (1994); Christoph Hoffmann, "Helmholtz's Apparatuses. Telegraphy as Working Model of Nerve Physiology," *Philosophia Scientiæ* 7, no. 1 (2003); Iwan Rhys Morus, "'The Nervous System of Britain': Space, Time and the Electric Telegraph in the Victorian Age," *The British Journal for the History of Science* 33, no. 4 (2000); Rhodri Hayward, "'Our Friends Electric': Mechanical Models of Mind in Postwar Britain," in *Psychology in Britain: Historical Essays and Personal Reflections*, ed. G. C. Bunn, A. D. Lovie, and Graham Richards (Leicester: British Psychological Society, 2001); L. E. Kay, "From Logical Neurons to Poetic Embodiments of Mind: Warren S. Mcculloch's Project in Neuroscience," *Science in Context* 14, no. 4 (2001). Claus Pias, "Elektronenhirn Und Verbotene Zone. Zur Kybernetische Okonomie Des Digitalen," in *Analog, Digital: Opposition Oder Kontinuum? : Zur Theorie Und Geschichte Einer Unterscheidung*, ed. Jens Schröter and Alexander Böhnke (Bielefeld: Transcript, 2004).

arguments about nerves and telegraphs depending on local discourses.[5] Taking heed of this, this chapter adds to the understanding of the much less studied interwar period, when new conceptions of cerebral function and structure were established.[6] I trace attempts to find "dynamic" visual imaginaries for the idea of a dynamically active brain, and analyze how such practices and rhetoric helped negotiate new forms of technical mediation.

A number of cultural historians have described the pervasive influence of electrification around 1900. As Lauren Rabinovitz put it, it served as "a sensory synecdoche for the confluence of technology, excitement and modernity."[7] Important in this respect are Cornelius Borck's observations on that time, when he describes an interaction between electricity's material culture (through the electrification of everyday life), and its rhetorical and conceptual pervasiveness in cultural discourses, an electrical imaginary which "opened up a new space for imagined and explored electro-organic and electro-psychic interactions."[8] Electro-technology could thus advance, in Borck's words, as "a medium of ambivalences between the body and mind, the soul and society."[9]

In this chapter, I build on these broader observations, adding a new element of media-analytical specificity: active brains were conceptualized and represented through new ideas about, and devices for, electronic mediation developed in the interplay between scientists and science communicators. In describing such electro-technological reverberations, the brain indeed emerges "as a piece of electric technology" (as Borck put it) around 1930, but it did so, I argue, through new brainmedia assemblages that involved the development of new electronic displays. Thus, the active brain could become conceptualized as a particular type of live brain: a brain as display.[10]

[5] Otis, "The Metaphoric Circuit," 107. Florian Sprenger, for example, studied emerging telegraph technologies in the nineteenth century, and points to a discrepancy between grand narratives of the nineteenth-century preoccupation with instantaneity and speed, and local discussions by engineers about whether the telegraph offered immediate transmission. Sprenger, *Medien Des Immediaten*, 21-25.
[6] On the lack of historical research for the period of the 1930s, see: Justin Garson, "The Birth of Information in the Brain: Edgar Adrian and the Vacuum Tube," *Science in Context* 28, no. 1 (2015).
[7] Cornelius Borck, "Media, Technology and the Electric Unconsciousness in the 20th Century," in *L'ère Électrique - the Electric Age*, ed. Olivier Asselin, Silvestra Mariniello, and Andrea Oberhuber (Ottawa: University of Ottawa Press, 2011), 37; Lauren Rabinovitz, *Electric Dreamland: Amusement Parks, Movies, and American Modernity* (New York: Columbia University Press, 2012), 133. See also: Killen, *Berlin Electropolis*; David E. Nye, "Electricity and Electrification," in *The Oxford Companion to United States History*, ed. Paul Boyer (Oxford University Press, 2001); Killen, *Berlin Electropolis*; Christoph Asendorf, *Batteries of Life: On the History of Things and Their Perception in Modernity* (Berkeley and Los Angeles: University of California Press, 1993); Anson Rabinbach, *The Human Motor: Energy, Fatigue, and the Origins of Modernity* (New York: Basic Books, 1990).
[8] Cornelius Borck, "Electrifying the Brain in the 1920s: Electrical Technology as a Mediator in Brain Research," in *Electric Bodies: Episodes in the History of Medical Electricity*, ed. Paola Bertucci and Giuliano Pancaldi (Bologna: Università di Bologna, 2001), 263.
[9] *Brainwaves*, 77. Jeffrey Sconce offers the notion of a "logic of transmutable flow" to denote the intricate discursive and material assemblages of electricity, information, and consciousness that emerged in the early decades of the twentieth century. Jeffrey Sconce, *Haunted Media: Electronic Presence from Telegraphy to Television* (Durham (NC): Duke University Press, 2000), 8.
[10] Borck, "Electrifying the Brain in the 1920s: Electrical Technology as a Mediator in Brain Research," 263.

A feverish image of the brain gone mad: Electro-brains and a crisis of representation

> Broadway, with its exceptional illumination at night, looks like the delirium of brains gone mad. Flashing signs, powerful light signals, wandering letters, moving figures on the edge of the roof, tubes of color, floodlights, airplanes with flares augmented by voices from loudspeakers, the megaphone, knocking sounds from the window panes: this supplants and complements our perception of the present.[11]
>
> —Fritz Giese, *Psychotechnik*, 1928

Writing in 1928, the German psycho-technical researcher Fritz Giese compared the illuminated cityscapes of his day with the delirious imagination (*Fieberbild*) of a raving brain. An assault on the senses, a "screaming in color," he wrote, "this is the mentality of this world!" In the 1920s, modern cities sparked both delirious imaginations by the brain as well as feverish images of the brain. As Cornelius Borck has expounded, images of brains and illuminated cities intertwined; the electrification of everyday life spurred analogies of the body and the brain as "bioelectrical-media-technical hybrids" through which ideas of mental energies and electric currents were newly amalgamated.[12] Today, the best-known examples of 1920s hybrid brainmedia are perhaps the educational illustrations of Fritz Kahn, which integrated the functions of the brain in modern industrial worlds populated with telephone and radio networks, screening rooms, and railway stations, creating images of particularly "urban brains," as Borck has argued, within the space of the hectic, modern city [Figure 2.1].[13]

Kahn's work is exemplary of the way the mediated, electrified metropolis shaped a particular interpretative potential for thinking about the mechanisms of the brain, and the way that urban space was itself presented as a nervous system that served the transmission of electricity – completing the metaphorical circle.[14] Yet, looking at Kahn's images, this potential must be understood mainly on the level of visual hyperbole. His metropolitan brain analogies were attractive because they integrated the brain with attractive, ever-changing technologies.[15] The underlying idea was still a simple stimulus-response circuit, however, not a whole brain network of

[11] Fritz Giese, *Psychotechnik* (Breslau: Ferdinand Hirt, 1928), 105. I thank Max Stadler for pointing me to this passage. Translations from non-English languages are my own, unless otherwise noted.
[12] Cornelius Borck, "Urbane Gehirne. Zum Bildüberschuss Medientechnischer Hirnwelten Der 1920er Jahre," *Archiv fur Mediengeschichte* 2 (2002): 272.
[13] Ibid.
[14] Ibid., 261.
[15] This hyperbole is what Borck describes as the "pictorial excess" (*Bildüberschuss*) of media-technical brain worlds. Ibid., 264. On Kahn's approach to illustration, see Michael Sappol, *Body Modern: Fritz Kahn, Scientific Illustration, and the Homuncular Subject* (Minneapolis: University of Minnesota Press, 2017).

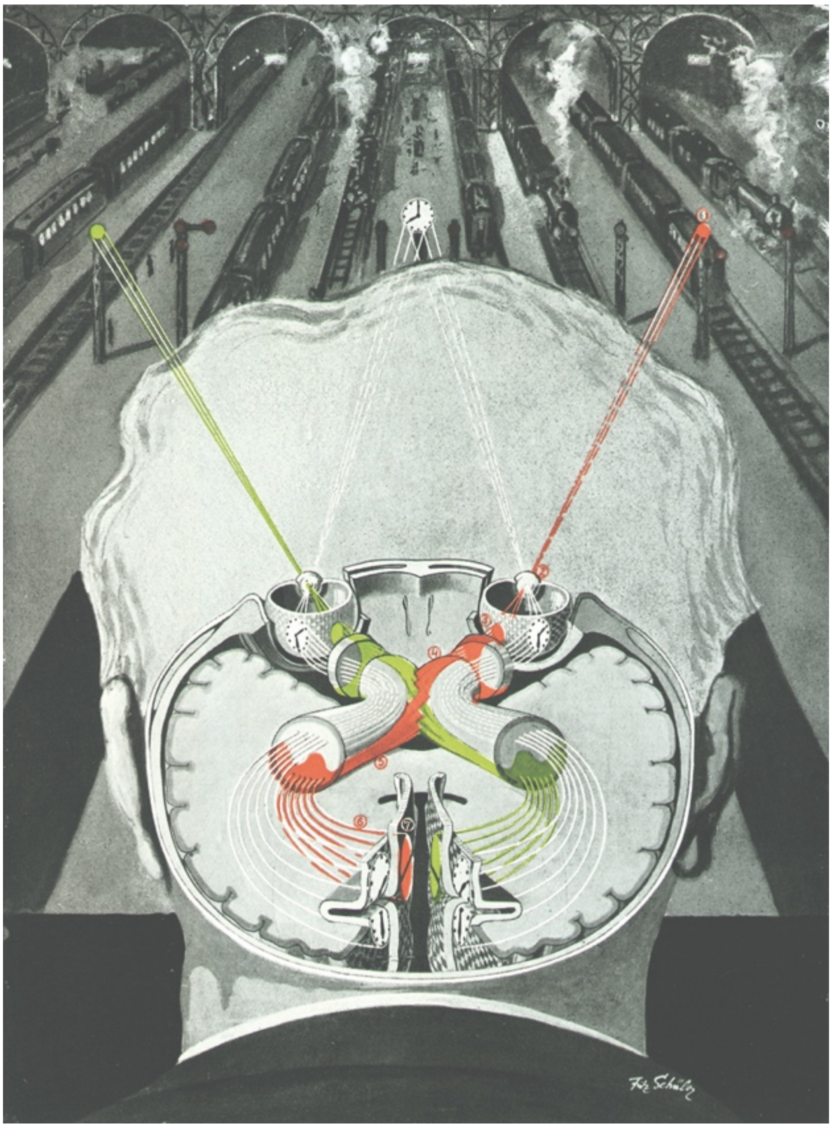

Figure 2.1 Fritz Kahn, Die Lichtwarhnehmung, 1929 (illustration)

innervation, but a focus on elementary, electro-technical systems of excitation – a view that had predominated the focus of nerve researchers until the mid-1920s.[16]

Kahn's transparent brains were part of an international public sphere of science education in the USA and Europe, communicated through new popular-science magazines, newspaper sections, radio broadcasts, and health exhibitions, supported by a new professional sphere of science-educational expertise and new forms of mediating science.[17] Cross-sections of heads and

[16] About the predominance of the 1920s stimulus-response model, see Katharina Schmidt-Brücken, *Hirnzirkel: Kreisende Prozesse in Computer Und Gehirn: Zur Neurokybernetischen Vorgeschichte Der Informatik* (Bieleveld: Transcript Verlag, 2014), 137.

[17] Arne Schirrmacher, "Introduction: Communicating Science: National Approaches in Twentieth-Century Europe," *Science in Context* 26, no. 3 (2013). Sybilla Nikolow, ed. *Erkenne Dich Selbst!: Strategien Der Sichtbarmachung Des Körpers Im*

transparent brains featured in popular articles and books about popular psychology, psycho-technics, and new scientific research into the brain, and often did so with a particular promissory ring. Writing about contemporary research into nerve cells for the popular *UHU* magazine in 1928, for example, Kahn predicted that it was only a "question of time and technological progress" before one could use an x-ray microscope to see through the skulls of living people and read their knowledge, memories, and experiences "directly and un-deceptively."[18]

Images of transparent brains connected to a rising materialism in 1920s popular science that imagined human nature and character as chiefly determined by hormones and the structure of the nervous system.[19] Yet, any rift between popular and professional science should not be overstated, there were no confidently materialist utterances of popular educators on the one hand, and hesitant statements of brain scientists regarding brain-mind or brain-behavior relations on the other: the situation was more ambiguous, with both promissory and ambivalent tones being struck across various spheres of knowledge regarding the potential cerebral basis of behavior and the mind.[20] As Roger Smith has expounded, the unfinished and "incoherent" state of knowledge about the nervous system was in itself a topic of particular consideration in the early decades of the twentieth century.[21]

This "incoherence" of new knowledge on the nervous system and how it could be interpreted and mediated became pressing in the 1920s. Neurologists from various countries noted that the scientific basis of functional localization (particular locations in the brain corresponding with particular human behaviors) was weak. Different brains showed functions at different positions, and the brain's functional localization could change over time. While some of these inconsistencies had already been voiced in the late nineteenth century, in the early decades of the twentieth century these problems became more pressing.[22] By then, it had become commonplace to dismiss nineteenth-century schemes of localization based on the correlative research of cerebral lesions in patients with aphasia, for example. In 1920, British neurologist Henry Head looked back at the late nineteenth-century desire to localize and map brain function, describing how "the rage

20. Jahrhundert (Köln: Böhlau, 2015). Bernadette Bensaude-Vincent, "In the Name of Science," in *Science in the Twentieth Century*, ed. John Krige and Dominique Pestre (Amsterdam: Harwood Academic Publishers, 1997).

18 Fritz Kahn, "Wie Arbeitet Das Gehirn?," *UHU* 11 (1928).

19 Peter J. Bowler, *Science for All: The Popularization of Science in Early Twentieth-Century Britain* (Chicago: University of Chicago Press, 2009), 50.

20 Roger Smith, "Physiology and Psychology, or Brain and Mind, in the Age of C. S. Sherrington," in *Psychology in Britain: Historical Essays and Personal Reflections*, ed. G. C. Bunn, A. D. Lovie, and G. D. Richards (Leicester, England: The British Psychological Society, 2001).

21 Ibid., 237.

22 John T. MacCurdy, "The General Nature of Association Processes within the Central Nervous System 1," *British Journal of Psychology. General Section* 22, no. 2 (1931); L. S. Jacyna, *Lost Words: Narratives of Language and the Brain, 1825-1926* (Princeton: Princeton University Press, 2009), 103-07. Harrington, *Medicine, Mind, and the Double Brain*, 260-68.

for diagrams became a veritable mania [.] Each author twisted the clinical facts to suit the lesions he had deduced from his pet schema."[23]

Instead, Head, but also scientists such as Kurt Goldstein in Germany and Karl Lashley in the US, suggested there were "dynamical aspects" to recuperating function after brain damage ("vicarious function"); the brain seemed able to adapt and re-organize in ways that could not be explained by rigid localization.[24] In this situation, the term 'dynamic', had a particularly flexible interpretative ring: it suggested interacting components and changing spatio-temporal relations of function. Already in the nineteenth century (as mentioned in chapter one), Charcot and associated researchers had used the adjective "*dynamique*" to suggest the existence of "dynamic lesions" in the brains of hysterical subjects that may or may not be registerable in the body's posture and gestures. By the 1920s, scientists in a number of European countries and in the USA, including Goldstein, Lashley, and Head, but also neuropathologist Constantin von Monakow and neurologist Pierre Marie (Charcot's former pupil and co-author of the female writer image mentioned in chapter one), were influenced by a "holistic" approach to science in which terms like "dynamic" – but also "plasticity" and "regeneration" – were part of a vocabulary that emphasized wholeness and positioned itself opposite the increasing influence of a mechanistic, fragmented modern life.[25]

This dynamic conception of the active brain suggested that the brain's structure and function were variably related – through what Lashley called "patterns" or a "field theory" of brain activity – yet the word dynamic did not precisely explain how this worked in practice.[26] While previous theories had proposed the close correspondence of structural and functional units and the specialization of brain areas or cells, now scientists argued that notions of cerebral organization and brain activity were in fact hardly understood. Accordingly, various scholars described the state of neurology research as being in severe crisis. Brain research, as one researcher put it, was like an unfinished building, "we have placed numerous blocks alongside each other, but the synthesis towards a complete, successful building is still missing."[27]

[23] Henry Head, "Aphasia: An Historical Review: The Hughlings Jackson Lecture for 1920," *Proceedings of the Royal Society of Medicine; Section of Neurology* 14 (1921): 396.

[24] "Dynamical aspects" in Karl Spencer Lashley, "Basic Neural Mechanisms in Behavior," *Psychological Review* 37, no. 1 (1930): 12. "Vicarious function" in K. S. Lashley, "Studies of Cerebral Function in Learning. Iv. Vicarious Function in Destruction of the Visual Areas," *American Journal of Psychology* 59, no. 1 (1922).

[25] About holism in relation to neurology in the interwar period, see Anne Harrington, "Metaphoric Connections: Holistic Science in the Shadow of the Third Reich," *Social Research* 62, no. 2 (1995); *Reenchanted Science: Holism in German Culture from Wilhelm II to Hitler* (Princeton University Press, 1999). L. S. Jacyna, "Questions of Identity: Science, Aesthetics, and Henry's Head," in *Greater Than the Parts : Holism in Biomedicine, 1920-1950*, ed. George Weisz and Christopher Lawrence (Oxford & New York: Oxford University Press, 1998).

[26] Nadine Weidman notes that Lashley was influenced by gestalt theorists such as Kurt Koffka and Wolfgang Kohler, but that his holism was of a particular kind, as he refrained from speaking of an "organism as a whole" or of vitalist concepts. Weidman, *Constructing Scientific Psychology*, 44.

[27] A. Jakob, "Die Lokalisation Im Grosshirn," *Klinische Wochenschrift* 10, no. 44 (1931): 2025. In the case of Weimar Germany, Anne Harrington describes this crisis atmosphere in neurology as part of a more general preoccupation with

A glow-in-the-dark brain from Vienna

The example of the Luminous Brain model (*das Leuchtende Gehirn*), built in Vienna in 1931, serves as a case study to examine how scientists and science educators tried to navigate their ambiguous situation: they both wanted to draw public attention to brain science and respond to an uncertain "dynamic" conception of how function was structured in the brain.[28] In terms of attention, the Luminous Brain was certainly successful: from the USA to Australia, newspapers described it as a "record achievement," "a monster globe" eight times the size of a real human skull, radiating "blue, green, crimson, purple, pink, and yellow lights, an orgy of sparkling colour."[29] [figure 2.2]

Designed by a team of three professionals – an engineer who worked for Vienna's Technical Museum, a neurologist, and a psychiatrist – it was patented as an educational device, "an improved type of anatomical model" with a switchboard that could illuminate various fluorescent tubes representing anatomical elements inside the brain.[30] [Figure 2.3] The Luminous Brain functioned in a context of popular-science education that was unique to Vienna, where science had become a prevalent topic for newspapers and radio, and where the effects and aims of science education were a topic of vivid discussion.[31] Mounted on wheels to make it transportable, the model toured various *Volkshochschulen*, voluntary associations that allowed the Viennese middle class to actively engage with science.[32] In these spaces, it served as a centerpiece for a variety of lectures on brain science by its two main creators, Edith Klemperer, psychiatrist at the Psychiatrischen und Nervenklinik of the University of Vienna and neurologist Robert Exner.

crisis in various disciplines, a general movement against mechanistic or machinic explanations and a turn to phenomenology. Anne Harrington, "Kurt Goldstein's Neurology of Healing and Wholeness: A Weimar Story," in *Greater Than the Parts: Holism in Biomedicine* (Oxford: Oxford University Press, 1998).

[28] To my knowledge, the Luminous Brain model is presently lost.

[29] "A Luminous Brain. Nerve Specialist's Invention," *The West Australian*, February 12 1937. "World's First Luminous Brain Model Made by Woman Doctor," *The Mail*, 31 July 1937.

[30] A line drawing in the international patent reveals its structure: iron wires formed a basic outline of the cerebrum, while inside various anatomical elements of the brain were represented by fluorescent tubes. Following color-conventions in medical textbooks, the model used individual colors to illuminate eleven different elements ranging from the olfactory bulb, motor nerve, and sensory nerve to the nucleus dentatus and corpus callosum. Edith Klemperer, "Anatomical Model," (1934). http://www.google.nl/patents/US1951422.

[31] Ulrike Felt, "Science and Its Public: Popularization of Science in Vienna 1900-1938," in *Quand La Science Se Fait Culture: La Culture Scientifique Dans Le Monde. Actes I*, ed. Bernard Schiele, Michel Amyot, and Claude Benoit (Sainte-Foy (Québec): Editions MultiMondes : Université du Québec à Montréal : Centre Jacques Cartier, 1994).

[32] Newspaper announcements prove the model was shown at various Volkshochschulen, including Gesellschaft der Ärtze, the Anatomisches Institut, the Österreichsiche Volkshochschule, Volksheim Ottakring, Leo-Vorein, the Österreichischen Klub, and the Technical Museum (one employee of the latter, engineer Joseph Nagler had been co-developer of the model). See also Klemperer's account in "Die Schöpferin Des Ersten Wiener Gläsernen Gehirnmodells," *Neues Österreich*, 6 February 1953.

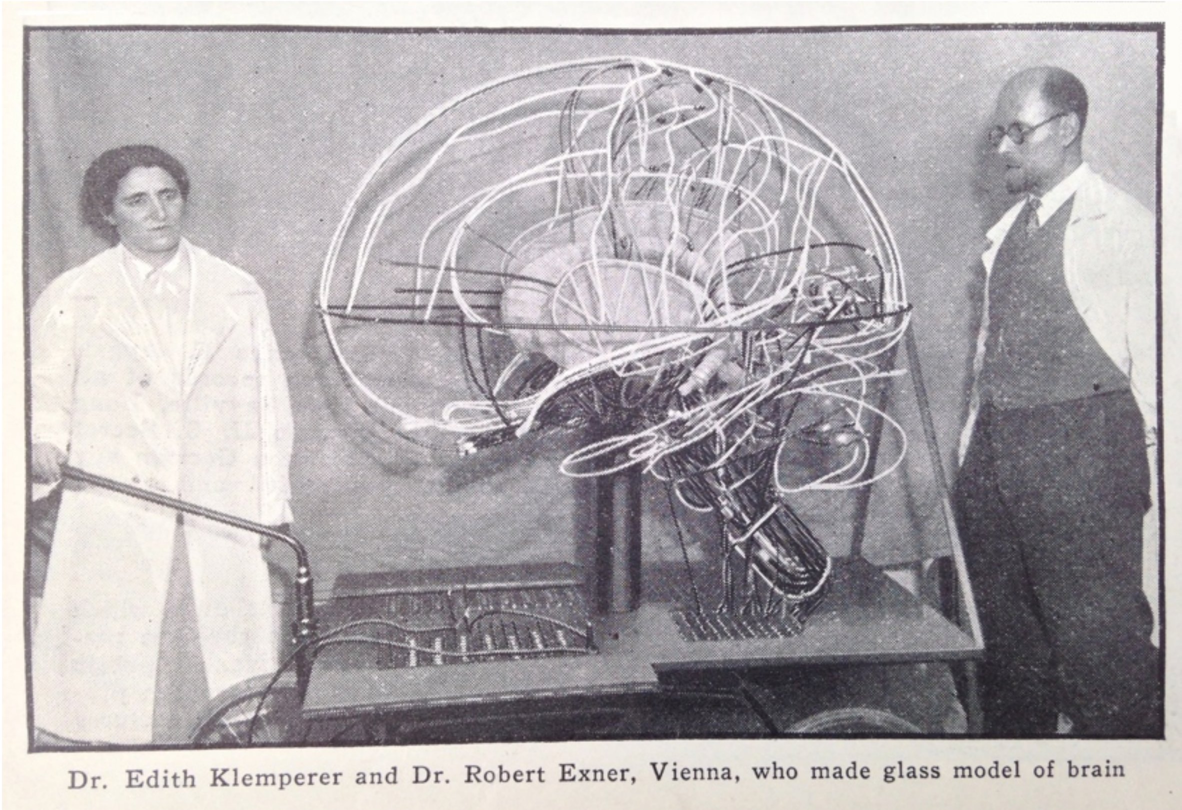

Figure 2.2 Dr. Edith Klemperer and dr. Robert Exner, Luminous Brain model from Vienna, c. 1931 (photograph)

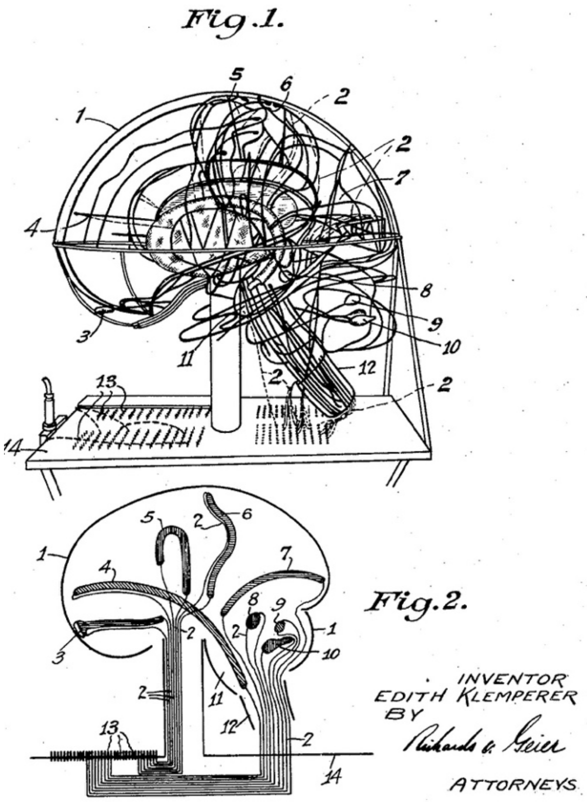

Figure 2.3 Edith Klemperer, Anatomical Model. 1931 (patent drawing)

Advocating the device in neurological and medical journals, Klemperer and Exner invoked new insights from perceptual psychology in describing the model as a great aid to students' "mental image" of the make-up of the brain; its three-dimensionality and illumination would help them gain clear and vivid knowledge.[33] The makers emphasized the model's ability to "impress" (it would be "unforgettably impressive" or *einprägsamer*, "more impressive"), thereby presenting it as both attractive and pedagogically effective, eye-catching and instructive.[34] As such, it could live up to the Viennese intellectual circles' discussions on psychotechnics, perceptual psychology, and effective visual education.[35] Through illuminated transparency, it evoked the multiple dimensions of what science-educational discourses had called *Anschaulichkeit*: a type of perceptibility that effected greater comprehension – "clarity" – through the vividness or liveliness of seeing a living example, a vivacity that would attract and impress viewers.[36]

By emphasizing perceptual instructiveness and the ingenuity of technical illumination, the model makers warded off potential criticism of the model's spectacular looks. In a later account, Exner would write that the "educational model was not meant be a Homunculus nor a fun-fair attraction, but an image that the student can take in and build up in their own brain."[37] In evoking this nexus of popular appeal – perception-scientific validity and educational value – the Luminous Brain, which one newspaper dubbed the "Glass Brain" – was akin to the better-known "Glass Man" model produced for the international traveling hygiene exhibitions by the Dresden Hygiene Museum in Germany, internationally hailed for its beautiful colored organs which could light up sequentially.[38] Sequenced illumination in educational displays especially also enabled animation, a type of stimulation that was conceived in relation to a newly envisioned urban spectator of scientific knowledge.

[33] Robert Exner, "Das Leuchtende Gehirnmodell," *Psychiatrisch-Neurologische Wochenschrift* 35 (1933). Edith Klemperer, "Demonstration: Das Gehirnmodell, Ein Plastischer Beleuchteter Unterrichtsbehelf Zur Darstellung Der Einzelnen Funktionen," *Zentralblatt fur die gesamte Neurologie und Psychiatrie* 61 (1932): 499. One of the first official appearances of the model was at the First International Neurological Congress in Bern, in 1931.

[34] "Unforgettable impression" (*unvergesslich einzuprägen*) in "Kurzkurs 'Das Leuchtende Gehirnmodell'," *Mitteilungen der Volkshochschule Wien Volksheim* 8, no. 2 (1935). "*einpragsamer*", in Exner, "Das Leuchtende Gehirnmodell."

[35] Exner was one of many Viennese scientists who combined his interests in psychology, physiology, and perception studies (predominantly color perception) with interests in effective science teaching and demonstration. On the development of Exner's ideas, see Deborah R. Coen, *Vienna in the Age of Uncertainty: Science, Liberalism, and Private Life* (Chicago: University of Chicago Press, 2008). Janet Ward mentions the presence of psychotechnics in Vienna through the advertising office started by Edward Bernays. Janet Ward, *Weimar Surfaces: Urban Visual Culture in 1920s Germany* (Berkeley: University of California Press, 2001), 101. n. 42

[36] On *Anschaulichkeit*, see Christian Stifter, "'Anschaulichkeit' Als Paradigma. Visuelle Erziehung in Der Fruhen Volksbildung, 1900-1938," *Spurensuche* 14, no. 1-4 (2003).

[37] Robert Exner, "Das Gehirnmodell," *Annalen des Naturhistorischen Museums in Wien* 59 (1953).

[38] "A Glass 'Brain' Aids Medical Students," *The Maitland Daily Mercury*, March 29 1932.

Animated brains for modern citizens

Around 1930, sequenced illumination was advocated as a way to combine attraction and scientific education, and especially to successfully integrate scientific visualizations within a specifically modern urban environment. Writing in a professional journal for artificial lighting, *Das Licht*, scholar Werner Lincke considered this new light-educational method (*Lichtlehrmethode*) not only a wonderful method to "enliven" (*beleben*) "dead pictures" or "dead statistics" (just like animation films did, he notes), but also a necessary technology in a new economy of public attention.[39] Inhabitants of the modern metropolis were constantly bombarded by illuminated advertisements; they were "estranged from the quiet tranquility necessary to appreciate numbers and words" and had learned "to seclude themselves from the obtrusive impressions from outside."[40] Because this modern city dweller no longer reacted to simple representations and words, exhibition makers had to employ moving, illuminated, and changing images not only to leave a more lasting impression, but also to exert a "greater incentive to take a look, even if the object in question has no initial interest for the exhibition visitor."[41] Vienna's glass brain belonged to this modern culture of attractive illumination. One newspaper suggested that the model's creators must have been influenced by a stroll on Vienna's Kärtnerstrasse, with its glorious advertising displays.[42]

Illuminated models were part of a new material culture of illuminated displays that included urban shop windows and facades, but also novel approaches to exhibition making and science-pedagogy that advocated "dynamic displays," a type of animation that could excite the over-stimulated urban citizen.[43] Things needed to move, twinkle, swirl, and make sound; a lively clarity was considered vital to attract and retain visitors' attention. Reasoning in this vein, exhibition makers argued that illumination controlled by buttons would be particularly attractive. When visitors themselves could choose to highlight parts of models or display cases, this would stimulate their natural "urge to play" (*Spieltrieb*).[44] At the celebrated 1930 Dresden Hygiene exhibition, push-button illumination served to enliven a diagram of the brain's functional nerve centers. [Figure 2.4] Pressing a button with a photograph of a mouth would light up the corresponding brain area for

[39] Werner Lincke, "Lehrmeister Licht," *Das Licht. Zeitschrift für praktische Leucht- und Beleuchtungs- Aufgaben* (1930): 127. I thank Max Stadler for reference to this source.
[40] Ibid. I thank Max Stadler for reference to this source.
[41] Ibid.
[42] "World's First Luminous Brain Model Made by Woman Doctor."
[43] On the development of international exhibition languages of 'dynamic displays,' see Karen A. Rader and Victoria E. M. Cain, *Life on Display: Revolutionizing U.S. Museums of Science and Natural History in the Twentieth Century* (Chicago: University of Chicago Press, 2014), 100; Erin McLeary and Elizabeth Toon, ""Here Man Learns About Himself"," *American Journal of Public Health* 102, no. 7 (2012).
[44] Lincke, "Lehrmeister Licht," 125.

speaking on a transparent brain diagram.[45] In another traveling exhibition, a giant three-dimensional brain model speckled with buttons allowed corresponding photographs to light up on an adjacent board.[46] However modern this light-educational method seemed to be, when it came to conceptualizing the active brain these strategies actually only enlivened a long-established idea of functional localization in the brain through its transparent diagrams and visual juxtapositions. In fact, the push-button diagram exhibited in Dresden was directly based on the 1883 image of the writing brain (produced by Charcot and Marie, as mentioned in chapter one). Above the button indicating the "writing" center is a photo of a hand holding a quill pen.

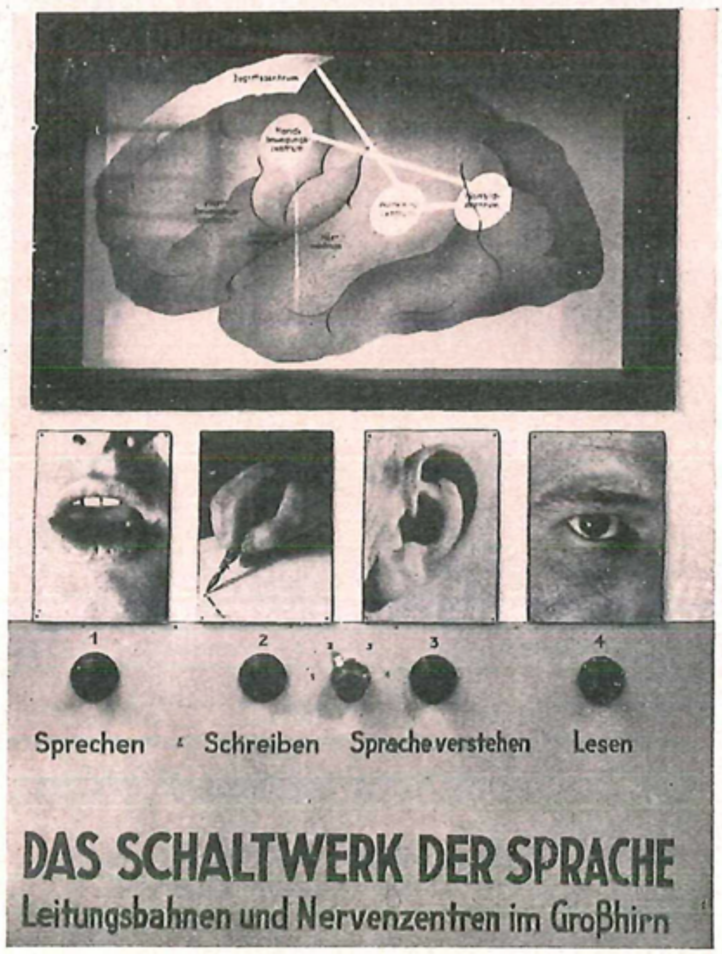

Abb. 3. Nach Druckknopfbetätigung leuchten in der Reihenfolge der Gehirnschaltvorgänge die einzelnen Gehirnzentren verschiedenfarbig auf. Bei der Aufnahme wurde Knopf 2: „schreiben" betätigt, und es leuchteten nacheinander auf: das Begriffs-Zentrum, das Wortklang-Zentrum, das Bild-Zentrum und das Handbewegungs-Zentrum.

Figure 2.4 Push-button brain diagram, c. 1930 (photograph)

45 Ibid.
46 "Tentoonstelling 'De Mensch'," *De Telegraaf*, 31 August 1935.

In contrast, the Luminous Brain model was not meant to serve a theory of rigid specialization. The model's 1931 patent description shows that the colored light tubes inside the metal skull indicated only a few anatomical structures such as the pons, the olfactory bulb, and the motor and sensory areas. Yet an enthusiastic Austrian *Reichspost* review of the model's *Demonstrationsvortrag* suggested that through illumination the model had indicated *processes* arising from light and sound sensations in a "lively (*lebendig*) and understandable (*übersichtlicher*)" manner.[47] The short review indicates the interpretative potential of (sequenced) illumination: intuitively, it was thought to reveal temporal processes in the brain. Sequenced illumination had started to be understood as a strategy to represent active, living processes – a way of seeing the brain in action. The perceived liveliness of the model's colored, glowing activity was thus understood in multiple ways, not only as more attractive and educational, but also as having more access to the living, dynamic, temporally active brain.[48] Indeed, the model makers projected, an improved version of the illuminated model with adjustable lighting would be able to present an entirely new spatio-temporal image of the living, active brain.

Searching for a dynamic image: Between *Gesamtbild* and *Gehirnwahrheiten*

The Luminous Brain ensured popular-science educators the attention and attraction of spectators in darkened lecture rooms. In the future, the creators proposed, this first "dynamic" prototype (better than any previous "static" model) should become even more dynamic. They imagined a model in which the lecturer could select the specific degree and duration of illumination, thus enabling the demonstration of time-based information about brain "processes" in slow-motion, superimposed onto the brain's morphology.[49] With their remarks on a "plastic image" and "dynamic relations," the Luminous Brain makers connected this modern electro-technological device to the most up-to-date contemporary brain research, which had started to show the uncertainties of any rigid spatial mapping of brain function onto brain anatomy. Illumination thus offered a potently ambiguous interpretability that served this uncertainty. Accounts of the model referenced the work of well-known Viennese neuropsychiatrist Otto Pötzl, who was much influenced by holistic perspectives in science and interested in the "dynamical processes" through

[47] "Das Leuchtende Gehirn," *Reichspost*, June 23 1932. It was this capacity for lively attraction (and not the comprehensiveness of the anatomical information) that spurred the conclusion that the model would be "outstanding" (*hervorragend*) for educating doctors.
[48] Ibid.
[49] Exner, "Das Leuchtende Gehirnmodell."; Klemperer, "Demonstration: Das Gehirnmodell, Ein Plastischer Beleuchteter Unterrichtsbehelf Zur Darstellung Der Einzelnen Funktionen," 499.

which neurological patients recovered from brain lesions that proved the integrated or distributed nature of brain function.[50]

If we situate the Luminous Brain project and its imagined future model in relation to the Viennese context of neurological research around 1930, what emerges are contested opinions about making maps of the functioning, active brain. This was a negotiation between a more rigid anatomical schematism on the one hand, and doubts about how to represent the adaptability of cerebral regions on the other. Two Viennese brain researchers who both supported the building of the Luminous Brain characterize the different sides: Otto Pötzl and nerve-cell researcher Constantin von Economo. Following the influence that these two different professors had on the Luminous Brain reveals a turn in the practice of making diagrams and mapping the brain.

A proponent of a distributed and dynamic conception of brain function, Pötzl had been a supporter of the project early on and even promised to finance the expensive model.[51] During the model's construction, however, he withdrew his backing, as he thought the model did not live up to scientific standards and would (as one of the model makers recounted) "move further away from the construction of a real brain."[52] In his own 1928 textbook on aphasia (which included patient observations and cerebral lesion research), Pötzl wrote he had "explicitly avoided" putting his findings on lesions into a drawn topography or a more "general formula."[53] Influenced by a holistic approach to the functioning of the nervous system, Pötzl (an early collaborator of gestalt psychologist Max Wertheimer) argued that readers should draw out the more general formula themselves, and that this process – the movement from complexity towards an *Gesamtbild* (overall picture) of the brain – was in fact cerebropathology's central conundrum at the time.[54]

As Otto Pötzl wanted to avoid a static *Gesamtbild* of the brain, instead emphasizing variability and plasticity, such aspects were clearly not well served in the Luminous Brain's construction of fixed iron wires and glass tubes. Instead, the model was more akin to the colorful anatomical plasters by von Economo, another well-known Viennese professor whose maps and

[50] Otto Pötzl, "Über Die Rückbildung Einer Reinen Wortblindheit," *Zeitschrift für die gesamte Neurologie und Psychiatrie* 52, no. 1 (1919): 265.
[51] Exner recounts Pötzl's involvement (a promise of 2000 Schilling) in Exner, "Das Gehirnmodell."
[52] To my knowledge, Pötzl's critique of the model has not been archived, yet from the reactions of the Luminous Brain makers, we can deduct that the model could not live up to his vision of dynamic relations in the central nervous system. Ibid.
[53] Otto Pötzl, *Die Aphasielehre Vom Standpunkte Der Klinischen Psychiatrie* (Leipzig: F. Deuticke, 1928), 231. Pötzl's research offered detailed descriptions of individual patient cases and lesion studies, yet nowhere in the book did he provide an averaged image or diagram summing up these individual cases.
[54] Citing Goethe, he described the problem, "simply a part of nature, [...] it is easier than we understand, and at the same time more complicated than we can comprehend" (ibid., 232.). It is beyond the scope of this chapter to delve deeper into the holistic approach to mapping, but clearly Pötzl had been influenced by a particular interpretation of wholeness and Goethian science. Harrington, *Reenchanted Science*.

models were an inspiration for the Luminous Brain.[55] [Figure 2.5] Produced in the mid-1920s and made from detachable parts, his models were based on his research on the cortex's different cell types (cyto-architectonics), which he had meticulously mapped out in 170 different areas on the cortex surface. Though these three-dimensional plaster models were focused on representing cell-anatomical information, von Economo also used them to make claims about possible correlations between areas with specific cell types and particular mental functions. For lectures at international venues like the New York Academy of Medicine in 1929, von Economo used his "brain casts" (along with his encephalometric research) to lecture on the brains of exceptional people, conjecturing about localizing musical talent, for example, or a particular visual ability.[56]

Figure 2.5 Constantin Von Economo's plaster models of cyto-architecture, c. 1927 (photograph)

Von Economo's lectures are characteristic of the persistence of the functional-localization paradigm in the 1920s. In various research communities, localization remained an important conceptual background, i.e. a final end towards which different types of research, such as histology (the study of cell types) and electro-cortical mapping (stimulating the cortex of living patients with

[55] Exner, "Das Gehirnmodell."
[56] Constantin Von Economo, "Some New Methods for Studying Brains of Exceptional People (Encephalometry and Braincasts) (Presentation with Models and Demonstration at the New York Academy of Medicine, Section on Neurology, December 3, 1929)," *Journal of Nervous and Mental disease* 72, no. 2 (1930).

electrodes), were compared with, and superimposed on each other.[57] As historian Michael Hagner has argued, the early twentieth-century "calibrated" cartographies (such as Wilder Penfield's famous maps of sensory-motor functions) were extremely attractive, not only as more precise aids for brain surgery (for epilepsy patients, for example), but also as representations of the "psychic apparatus" itself.[58] Functional maps, because of their authoritative epistemic status, could embody and enact what Hagner calls "*Gehirnwahrheiten*" (brain truths) about the localization of physiological and mental functions.[59]

The example of von Economo, lecturing with his colored plaster brains on stage, illustrates the performative potential of striking material models. It is in using a model, in the action of its display, that its epistemic powers are most forcefully exercised. It is in their interaction between model, scientists, and audience that new brainmedia most successfully establish "brain truths." The Luminous Brain similarly utilized the performative strength of models during lectures, augmenting these visual-rhetorical powers even more by the attraction and "impressiveness" of colored illumination. Yet this model's objective was not to claim one persuasive brain truth; the makers emphasized its flexibility – more parts and different types of lighting could be added to adapt to the needs of changing research insights. Indeed, during lecture demonstrations in various *Volkshochschulen*, Exner and Klemperer used the illuminated model as a flexible backdrop for a variety of lectures (serving their different research interests and backgrounds) about the "achievements of the brain" and about human psychology.[60]

Ultimately, the Luminous Model evinces the multiple ambiguities that needed to be navigated in the late 1920s and 1930s. There were the scientific dissonances between spatial localization versus a dynamic and variable structure-function relation, and there was the question of the model's scientific truthfulness versus its objective of impressing audiences. In both cases, the makers invoked the technology of sequenced illumination to suture these debates. "The current light-technical means allow the truthful representation of every neurological research finding, because a model does not have to be a copy of the real central nervous system, so a type of

[57] Katja Guenther gives the example of the exchange between Otfrid Foerster's new epilepsy maps and Oskar Vogt's cyto-cortical research. Guenther, *Localization and Its Discontents*, 110. Michael Hagner argues that the conceptual course of brain research was firmly entrenched in mapping function onto standard anatomies, by which the brain had long been established, as a "material space of representation," an average spatial template onto which functions could be inscribed. Michael Hagner, "Lokalisation, Function, Cytoarchitektonik. Wege Zur Modellierung Des Gehirns," in *Objekte, Differenzen Und Konjunkturen: Experimentalsysteme Im Historischen Kontext*, ed. Hans-Jörg Rheinberger, Bettina Wahrig-Schmidt, and Michael Hagner (Akademie Verlag, 1994), 147.

[58] *Der Geist Bei Der Arbeit*, 270.

[59] Ibid.

[60] Announcements suggest the Luminous Brain was used as a visual centerpiece for a variety of lectures. In 1935–1936, for example, Edith Klemperer gave a three-part lecture series about 'Das leuchtende Gehirnmodell. Die Leistungen des menschlichen Gehirns' at Volksheim Ottakring. "Kurzkurs 'Das Leuchtende Gehirnmodell'."

'Homunculus.' [Instead,] its character is to represent the image that we make as a result of our research, and of this often only a selection for specific teaching and learning purposes."[61] Sequenced illumination was both scientifically flexible (able to associatively and promissorily gesture to "dynamism" and "plasticity") and pedagogically sound (impressive but emphasized as never being mere spectacle). This rhetorical potency of new illumination technologies tied in with the importance of (experimenting with) novel ways and spheres of demonstrating science, allowing expertise to be drawn from illuminated advertising in shopping streets as well as traveling science exhibitions.

In the next section, I analyze another 1930s instance when new illuminated technology – in this case a modern illuminated news ticker, a so-called motograph – served the imagination of mechanisms in the living brain. In the 1930s, this vehicle for imagining "dynamic" activity was strengthened by a new conception of direct, "televisual" access to the nerves' electrical pulses. This, I argue, served one particular interpretation of the illuminated-display analogies that were employed, that of immediate mediation, or instant display.

Streaming headlines and the motograph brain

The rhetoric of crisis and uncertainty regarding functional localization research that I sketched in the first part of this chapter is arguably most visible in the work of the American physiologist Karl Lashley. Time and again, he emphasized that both experimental evidence of animal lesion studies and observations of recuperating neurological patients demonstrated that it was impossible to draw any conclusions regarding rigid locations in the brain dedicated to particular human functions, sensations, or behaviors.[62] Lashley and other scientists thus attempted to find concepts and imaginaries that fitted their plastic and dynamic view of brain function. To address the "fundamental problem of neural integration" (the way structure and function interact), he resorted to a rather obscure vocabulary, explaining integration as functioning through a "localization of fields" within which were "schemata" that were conditioned by "dynamic patterns of organization."[63] Other nerve researchers similarly struggled with dynamic conceptions of structure and function. Cambridge psychologist John MacCurdy thought up "anatomical designs" that were

[61] Exner, "Das Leuchtende Gehirnmodell."
[62] Even in very obviously specialized areas such as the motor and visual areas, Lashley claimed there simply "was no narrowly localized specialization of intercellular connections." Karl Spencer Lashley, "Integrative Functions of the Cerebral Cortex," *Physiological Reviews* 13, no. 1 (1933).
[63] "fundamental problem of neural integration" in "Basic Neural Mechanisms in Behavior," 10. "Localization of fields" and "schemata" in "Integrative Functions of the Cerebral Cortex," 34. Similarly, historian Nadine Weidman notes the inconclusiveness of the pattern vocabulary: "Lashley's solution to the mind-body problem was rather vague," Weidman, *Constructing Scientific Psychology*, 45.

four-dimensional (including time) and determined by "immaterial patterns."[64] MacCurdy's little graphic diagrams depicted single dots building up larger patterns through the rapidly forming and de-forming actions of wandering electrical nerve impulses. How this occurred exactly remained "the fundamental mystery," as he put it.[65]

Summarizing the state of research on neural mechanisms in behavior in a 1930 overview article for *Psychological Review*, Lashley turned to a new analogy to clarify his dynamic outlook. The old model of the point-to-point telephone connection was rather outdated, he felt, as it could only illustrate simple reflexes or habits, and he doubted whether neurons had any kind of individual functional specialization that supported it. Instead, he sought to conceive of functional *organization* (the relation between incoming sensations and outgoing motor-responses) in a way that was not "expressed in terms of definite anatomical connections."[66] To do so, he used the image of a modern electric advertising sign or news ticker bulletin board: "the same cells may not be twice called upon to perform the same function. They may be in a fixed anatomical relation to the retina, but the functional organization plays over them just as the pattern of letters plays over the bank of lamps in an electric sign."[67] This comparison allowed Lashley to imagine neuronal integration in the cortex as "a variable pattern shifting over a fixed anatomical substratum."[68]

Seven years later, neurophysiologists Ralph Gerard possibly borrowed from his University of Chicago colleague Lashley when he compared the brain to a "modern sign" that allowed patterns to "move in time and transcend the spatial structure; and so words move across the sign as individual bulbs flash on and off, while the whole pattern remains intact."[69] With this analogy, Gerard aimed to shape the new conception of nerve activity that had emerged from a decade of recording the electrical impulses of the nerves.[70] Research had revealed that the living brain was characterized by nerve cells' continuous spontaneous impulses and that local masses of cells exhibited intricate patterns of synchronous activity by yet unknown distant causes. Clearly, older images of the functioning brain had to be discarded; just like Lashley had dismissed the telephone, Gerard dismissed the static idea of a "nervous system with a set structural pattern waiting peacefully for nerve impulses to travel through it, like a switch yard set for freight trains."[71] Such Fritz Kahn-

64 John T. MacCurdy, *Common Principles in Psychology and Physiology* (Cambridge University Press, 1928), 183.
65 Ibid.
66 Lashley, "Basic Neural Mechanisms in Behavior," 9. In 1929, Lashley spoke about "non-specialized dynamic function of the tissue as a whole," *Brain Mechanisms and Intelligence: A Quantitative Study of Injuries to the Brain* (Chicago, Ill.: University of Chicago Press, 1989 [1929]), 176.
67 "Basic Neural Mechanisms in Behavior," 9.
68 Ibid.
69 Ralph W. Gerard, "Brain Waves," *The Scientific Monthly* 44, no. 1 (1937): 56.
70 Gerard mentions Edgar Adrian's recordings of single sensory nerve potentials (1926) as an important moment.
71 Gerard, "Brain Waves," 51, 56.

like images of simple railway or telephone circuits had to be dismissed in favor of a "dynamic concept." Even though the mechanisms behind nervous discharges were not yet understood, he claimed such "patterns are in time as well as space, dynamic not static."[72]

Situating the electric display-brain structures imagined by Lashley and Gerard in their metropolitan working environment of Chicago in the 1930s, we can see that the electric-sign analogy they proposed for the changing patterns of nerve activity actually referred to a novel electrical display board, the so-called "motograph."[73] This moving, illuminated news ticker (also called a zipper or revolving blackboard) had become more widespread in 1930s urban spaces, especially after one was mounted in New York's Times Square in 1928.[74] The motograph could show advertising slogans or streaming headlines – like HERBERT HOOVER DEFEATS AL SMITH – by allowing electric bulbs on a fixed grid to alternately flash on and off.

Returning to Charles Sherrington's famous enchanted-loom metaphor mentioned at the opening of this chapter, we can now understand it as part of a lineage of electric-display analogies for the active brain. Citing Gerard and Lashley in his 1938 Gifford lecture, Sherrington employed the twinkling tapestry in a section entitled "The Brain and its Work."[75] Quoting Lashley, Sherrington emphasized that a scheme in which behavior was localized in centers was "over-simplified, and to be abandoned."[76] Instead, he proposed imagining the active brain as "a scheme of lines and nodal points [.] Imagine activity in this shown by little points of light. […] The lines and nodes where the lights are, do not remain, taken together, the same even a single moment."[77] Sherrington's enchanted loom, like the motograph brain, used an engineering analogy to conceptualize dynamic spatio-temporal patterns of nerve activity. In Sherrington's version, the model was not only a conceptual aid to strengthen the argument of dynamic function, but also a way to imagine the brain itself as a site of "remarkable display."[78]

[72] Ibid., 56.
[73] A giant motograph sign (80 meters tall) had attracted ample press attention in 1934 after it had been installed in Chicago, the city where Gerard and Lashley worked. "Giant Electrical Sign Has Its Own Elevator," *Popular Mechanics* (1934): 16.
[74] Dale L. Cressman, "News in Lights: The Times Square Zipper and Newspaper Signs in an Age of Technological Enthusiasm," *Journalism History* 43, no. 4 (2018).
[75] Sherrington's 1938 lecture was first published in 1940. I cite from the adapted lectures in Sherrington, *Man on His Nature*.
[76] Ibid., 223., citing Karl Spencer Lashley, "Functional Determinants of Cerebral Localization," *Archives of Neurology & Psychiatry* 38, no. 2 (1937): 386.
[77] Sherrington, *Man on His Nature*, 223-24. In 1938, Sherrington also signaled that such models might already be outdated because neurophysiology had started to rely more and more on mathematics. Around 1938, Grass and Gibbs introduced frequency analyzers for the statistical analysis of large amounts of recorded nerve impulses.
[78] I cite from the adapted lectures in ibid., 223. In an earlier work, Sherrington had already attempted to describe the whole nervous system as consisting of "patterned networks of threads" with junctional points or intersecting lines where signals may coalesce. *The Brain and Its Mechanism* (Cambridge: Cambridge University Press, 1934), 12.

By using the motograph in their descriptions of the nervous system, these scientists created an electro-cerebral analogy that conveyed the brain's capacity to express any action pattern at any possible spot without a fixed relation between anatomy and activity. At the same time, the motograph analogy also associated the brain with a new emblem of fascination and immediacy. Popular 1930s reports of the arrival of motographs recounted, as historian David Nye has described, how modern citizens were transfixed by their continuous activity and spellbound by their capacity for direct transmission: current news events could immediately be transferred into attention-grabbing motograph messages, which in turn instantly impacted the moods of urban spectators.[79] Situating the motograph brain within the modern environment that offered new electrical-display experiences thus shows that this analogy suggested more than just dynamic nerve-activity patterns. The motograph's appearance in nerve researchers' accounts from the 1930s signals the way researchers sought to negotiate the position of *technical mediation* in the field of nerve physiology prompted by the rapid rise of electrical pulse measurements visible on new types of display screens (or audible as crackly noise through sonification).

Since the 1920s, new records of electric pulses of nerves had been pouring into laboratories, made possible by new vacuum-tube amplifiers and oscillographs. Yet throughout the 1930s it was hard to produce clear nerve recordings, as continuous adjustments were necessary to improve vacuum-tube amplification and create faster, brighter signals on screen.[80] While active nerves – let alone nerve activity patterns – were hard to decipher in practice, the motograph analogy suggested a bright future for the active brain: associating nerve research with both immediacy and meaningfulness, the motograph implied the clear and instantaneous illumination of single active nerves and the visibility of patterns that literally formed messages on screen.

Tele-visual and televisual neurophysiology

It is important to zoom in on the discrepancy outlined in the previous section for a moment: on the one hand, the instantaneity suggested by the motograph image – the nervous system as an

[79] David E. Nye, *American Technological Sublime* (Cambridge: MIT Press, 1996), 191. Nye (p.191n57) describes an exemplary three-part cartoon published in 1931 that mocked the zipper's capacity for instantaneous transmission: 1. Three men look up, transfixed by the Times Square zipper, 2. Distracted, they are hit by a taxi, 3. As they are hit, the display reads: 'Three being hit by Taxi in Times Square.' Cartoon mentioned in Leonard Falkner, "The Sky Is His Blackboard," *American Magazine*, March 1931.

[80] Illumination from the cathode-ray oscillograph was extremely dim, and a nerve impulse had to be captured through many reiterations to be visible on a photograph. This made the cathode-ray tube ineffective for the whole-brain recordings Edgar Adrian would later pursue. He used a capillary electrometer instead. Edgar Douglas Adrian, "The Impulses Produced by Sensory Nerve Endings," *The Journal of Physiology* 61, no. 1 (1926); Joseph Erlanger and Herbert Spencer Gasser, *Electrical Signs of Nervous Activity* (Philadelphia: University of Pennsylvania Press, 1937); Robert G. Frank, "Instruments, Nerve Action, and the All-or-None Principle," *Osiris* 9 (1994): 233; ibid.

illuminated news bulletin – and on the other the *practical* struggle of making nerve recordings in the 1930s. Ralph Gerard, who used the motograph analogy in a 1937 article, argued that the arrival of new measuring tools had changed things: while previous nerve-activity studies relied on inference and "distant observation," being able to record potential changes offered "direct evidence."[81] He described the older situation as a type of physiology by "television or teleaudition," like determining the source of music heard over the radio while never having heard an orchestra; "it would be extremely difficult to deduce, only from the loud-speaker outpourings, anything of its essential character."[82]

While the words television and teleaudition signaled distant observation in Gerard's understanding, it was experimental new electro-neurophysiology practices – based on combined set-ups of (for example) animal-nerve preparations, amplifying tubes, graphic and audio recording mechanisms, oscillographs, photo cameras, and fluorescent screens – that strengthened his idea that active nerve processes could soon be fully heard and viewed in action. Reflecting on this development, historian Max Stadler notes that in the 1920s and 30s recording a nerve was never conceptualized as "simply using an instrument": recording practices were cobbled together in recording systems ("relatively loose and local assemblages") made up of multiple components.[83] Stadler argues that technical nerve-recording procedures were thus not rapidly "black-boxed" in the same way that, for example, electron microscopes had been, as this field "resisted objectification."[84] Yet notwithstanding this persistent effort necessary to produce successful measurements through component systems, what clearly emerged in the 1930s was a new focus on image engineering, tinkering with experimental systems to arrive at better images. As historian Robert Frank summarizes the state of the field of neurophysiology around 1930, "logic yielded to images created by instruments."[85]

This movement towards image-making constituted an epistemic turn in neurophysiology. And yet the extent to which this new direction was also understood as yielding *direct* access to single nerve potentials, *instantaneous* visibility of activity patterns, or *immediate* accessibility of the visible active brain was under both practical investigation and rhetorical negotiation. When neurophysiologists used motograph analogies in the 1930s, they were discursively negotiating the

[81] Gerard, "Brain Waves," 48.
[82] Ibid.
[83] Max Stadler, *Assembling Life. Models, the Cell, and the Reformations of Biological Science, 1920-1960* (Imperial College London (University of London), 2010), 160.
[84] Ibid.
[85] Frank, "Instruments, Nerve Action, and the All-or-None Principle," 233. It is beyond my scope to trace the new image and display character of neurophysiology in the 1920s and 30s with cathode-ray tubes (whose results were photographed) and three-valve amplifiers plus capillary electrometer and (film) camera, for an overview, see Frank's article.

level of directness of their measuring circuits. Within this negotiation, they drew on the symbolic leverage of things like motographs, i.e. on established technologies, models, emblems, or instruments that gave a new sensibility to the technical mediation of neurophysiology.

While Gerard used "television" to denote the status of past nerve measurements as *inferential* and *indirect*, in 1934 American neurophysiologist George Bishop used it to frame the *directness* of new nerve-registering systems by referring to them as a "physiological television apparatus."[86] Here is that rhetorical ambiguity of media-technological analogies again: for Gerard, physiology offered a more direct perception than television, while Bishop explained that when a measurement set-up used the right type of oscillograph, nerve impulses could "be visually observed while they are actually occurring, as if by a physiological television apparatus one could watch the cells concerned in one of their essential activities."[87] The television reference helped to fortify the status of the electrical pulse as the direct concomitant of nerve activity, as, like Bishop put it, "the identification of the electrical response of nervous tissue with the characteristic physiological activity of that tissue is so close that neurophysiology and the electrophysiology of nervous tissue have come to be practically synonymous."[88] With these new recording technologies, he proposed, neurophysiologists could "look directly for changes in the functioning brain itself."[89]

What "television" meant in neurophysiology, both in terms of an experimental practice and the field's imagined future, thus became subject to rhetorical negotiation. On the one hand, Bishop's forward-looking vision referred to "tele-vision" as it had been invoked in longstanding nineteenth-century imaginaries (like Robida's *téléphonoscope* of 1878) of seeing things unfold simultaneously and immediately, even if they were far away (or inside the brain). On the other hand, any reference to television in the 1930s also referred to an actual new system of technologies, and this link made particular sense since nerve-recording circuits were actually made of the very same technical elements for teleauditory and televisual mediation: electronic tube amplification developed in radio technology and oscillograph screens used in television.

In the 1930s, these technological means of transmission and reception were in development, which meant that radio and television were not stable referents in terms of media.[90]

[86] George H. Bishop, "Electrophysiology of the Brain," in *The Problem of Mental Disorder: A Study Undertaken by the Committee on Psychiatric Investigations, National Research Council* (New York (NY): McGraw-Hill Book Company, 1934), 127; Borck, *Brainwaves*, 164.
[87] Bishop, "Electrophysiology of the Brain," 127. Cited in Borck, *Hirnströme*. Bishop does not yet mention the new technology of EEG whole-brain recordings, which became popular in the U.S. after Edgar Adrian's US lecture tour in 1934.
[88] Bishop, "Electrophysiology of the Brain," 127.
[89] Ibid., 126.
[90] On television as an "experimental system" in development in the 1920s and 1930s, see Lorenz Engell, "Fernsehen Mit Unbekannten. Uberlegungen Zur Experimentellen Television," in *Fernsehexperimente: Stationen Eines Mediums*, ed. Michael Grisko and Lorenz Engell (Berlin: Kulturverlag Kadmos, 2009).

Their very status – how attractive, clear, direct, and effective they were understood to be – was in development. As media historians have pointed out, in the 1930s, televisual technologies were predominantly hybrid systems (just like neurophysiological circuits): varying set-ups combined elements of radio, photography, and cinema (Rudolf Arnheim, for example, spoke of *Funkkino*, radio film).[91] These systems could be employed both to transmit (pre-existing) moving pictures or for *immediate* transmissions (called *eigentliches* or *reines Fernsehen*, real or pure television, in the German context).[92] Hence, the immediacy of the television apparatus was itself a compound and hybrid notion that fluctuated according to different set-ups. Just like the direct neurophysiological visual records that Bishop mentioned, the transmission of "direct" television images required laborious tuning and tweaking, as a (physiological) television apparatus was a rather coarse device. Nevertheless, Bishop believed that visual-technological advances had converged in such a way that the future for his research field looked bright. The time was now ripe for neurophysiologists not just to study single nerves, but perhaps even to venture, he hesitantly suggested, connecting them to mental functioning and researching "brain-function as a whole."[93]

In Bishop's forecast, the television analogy resonated with both the longstanding imaginary of tele-vision's potential immediacy and simultaneity, as well as contemporaneous experiments with television systems which were understood as a visualization promise for the future. The 1930s' imagined "physiological television apparatus" may thus be interpreted as instigating a rhetorical shift by which a still-unstable experimental neurophysiological system could become envisioned as a visualization instrument or even a visual medium that would be able to show the active brain. Even though the significance of newly acquired data on nerve activity was still unclear, the physiological experimental system was imagined as a televisual medium to show cerebral activity in direct new ways.[94]

This example of electro-neurophysiology recordings as a possible new instrument or even imaging *medium* to view the brain in action is significant. A closer look at the history of neurophysiology demonstrates that it is necessary to historically situate what we mean when we say

[91] Doron Galili, "Television from Afar: Arnheim's Understanding of Media," in *Arnheim for Film and Media Studies*, ed. Scott Higgins and Doron Galili (New York: Routledge, 2011).

[92] Fritz Banneitz, "Der heutige Stand des elektrischen Fernsehens," in Funkalmanach 1929: Grosse Deutsche Funkausstellung 1929 (Berlin: Rothgiesser und Diesing, 1929), 53, quoted in Anne-Katrin Weber, "Recording on Film, Transmitting by Signals: The Intermediate Film System and Television's Hybridity in the Interwar Period," *Grey Room* 56 (2014).

[93] Bishop, "Electrophysiology of the Brain," 131. While some researchers started to equate these new nerve measurements with mental activity, others were more hesitant to hypothesize the material nature of the mental domain. Borck, *Hirnströme*, 192. On the complex position of neurophysiologists towards the 'mind', see Smith, "Physiology and Psychology, or Brain and Mind, in the Age of C. S. Sherrington."

[94] Here, I borrow the vocabulary of Hans-Jorg Rheinberger, who describes "experimental systems" as offering a "space of representation" for material traces. Hans-Georg Rheinberger, *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube* (Stanford, CA: Stanford University Press, 1997), 105.

that image-making is presented as an immediate practice. In the 1930s, neurophysiologists definitely emphasized what happened on the displays of the oscillograph. Yet rather than suggesting this meant a wholesale epistemic turn toward imaging, I want to argue that technical mediation itself was in being rhetorical negotiated through analogies such as the motograph and television. To understand this discussion, it is imperative to situate the emerging screens of neurophysiology within a broader context of the 1930s rise of display devices. This broader history, I suggest, asks us to historicize what "immediately" seeing visualized activities on new types of screens and displays meant.

Brains at work in office and factory: Living diagrams and a logic of instant display

Around 1930, at the same time that Edith Klemperer filed a patent for the Luminous Brain model built in Vienna, two Austrian engineers patented what they called a "living diagram": an illuminated circuit diagram with colored light indicators (also called a *Leuchtschaltbild*) that enabled instantaneous monitoring of electrical distribution plants.[95] Turning briefly to the history of these new types of displays allows me to situate motograph brains and the Luminous Brain as part of an electro-technical world of display media that enabled direct monitoring of ongoing temporal processes, enacting new conceptions and sensations of immediacy and mediation. Since the 1920s, different illuminated-display media – moving bulletin boards, signaling systems, indicators, control desks, educational models, luminous commercial displays, illuminated circuit diagrams – had invaded urban streets, offices, and factories, instituting the changing, illuminated visibility of ongoing (invisible) temporal processes, such as the activity of power plants, telephone networks, or even seat-occupation in theatres.[96]

Such living diagrams allowed for immediate feedback about work processes and production numbers, and some types of display even allowed for direct manipulation of the on-going processes of work.[97] Writing in the late 1920s, Siegfried Kracauer observed seeing one such living diagram

[95] Johann Latzko and Otto Plechl. Living Diagram. Patent US2042667 A, filed 15 March 1930, and issued 2 June 1936.http://www.google.com/patents/US2042667. Previously, they had patented a similar structure Leuchtschaltbild. Patent AT118723B, filed 28 August 1928, and issued 11 August 1930. Few academic sources mention the history of the *Leuchtshaltbild* or illuminated wiring diagram in the early twentieth century. For a contemporaneous source on the "sinnbildliche Darstellung der Vorgange und Zusammenhange," see Guido Wünsch and Hans Rühle, *Messgeräte Im Industriebetrieb* (Berlin: Julius Springer, 1936), 79; "The Centralisation of Control of Power Networks," *Electrical Communication* 13, no. 3 (1935); Jakob Tanner, "The Visual Culture of Rationalization in the Modern 20th Century Enterprise," *Entreprises et Histoire*, no. 44 (2009).
[96] N.A., "Signal Lights Indicate Vacant Theater Seats," *Popular Science*, no. August (1922).
[97] Mark Seltzer mentions "living diagrams" and "working models" (such as a miniature and operative 1890s model of a coal-mine elevator) in his analysis of machine culture around 1900, though he does not indicate contemporaneous uses of these terms. He describes the nineteenth-century fascination with these maps and models as allowing for the "superimposition of the visible and the calculable, representation and quantification, physical bodies and abstract models." Mark Seltzer, *Bodies and Machines* (New York: Routledge, 1992), 114.

during a visit to the director's room of a German factory, where its colored light bulbs showed an instant overview of all the operations.[98] Kracauer's observations reveal a new physical presence of the *instant display* of work processes as an integral part of the modern workplace, supporting a new culture of rationalization. He saw this indicator diagram as "the principal ornament of the real office," even more impressive, he remarked, than the fictional version integrated in the desk of Fritz Lang's genius villain in his 1928 film, *Die Spione*.[99] [Figure 2.6]

Figure 2.6 Fritz Lang, Die Spione, 1928 (film still)

Kracauer's remarks connect this blinking display of temporal processes – like the Luminous Brain model – to the mesmerizing, flashy surfaces of Weimar Germany's illuminated facades – such as Fritz Giese's cityscape as a "delirium of brains gone mad," cited at the start of this chapter. Keeping with Kracauer's reading, the Luminous Brain and motograph brain can similarly be viewed as part of a "surface culture" of distracting spectacle, the sensational side of the contemporary electro-

[98] Siegfried Kracauer, *The Salaried Masses: Duty and Distraction in Weimar Germany* (London & New York: Verso, 1998 [1930]), 41.
[99] Ibid.

technical environment.[100] Yet simply linking enchanted looms and blinking brains to a new visual culture of spectacular surfaces does not suffice: blinking, living diagrams mediated temporal processes; their surfaces signaled a particular relation to an invisible but underlying patterned presence. This becomes even more apparent when we compare Kracauer's living diagram to one in the office of another of Fritz Lang's notorious villains. In Thea von Harbou's script for *Metropolis*, this evil factory owner is described as the "Brain of Metropolis" who lived in a "brain-pan," equipped with an abundance of contemporaneous display media and "switchboards on all sides."[101] Indicators signaled incoming messages from different cities, a tickertape machine ran continuously, and screens showed images from inside the factory. Information about factory activities and production statistics poured into these headquarters nonstop. Immediately, the villain could respond and give new orders by touching a "blue metal plate" that was undoubtedly modeled on actual indicator diagrams employed in industry.[102] Within the office, the workers themselves had become invisible; as the script mentions, they were only "phantoms" in a brain that was all lights and numbers.[103]

A superficial look at *Metropolis*' Brain connects it to the hyperbolic analogies of Fritz Kahn's early drawings, where we see switchboard operators frantically working inside heads. Yet a deeper reading in relation to a broader culture of display technologies expands our understanding of this clichéd "brain as switchboard" analogy. *Metropolis* shows the ongoing complexity of immediate transmission and sounds an important warning about the "phantoms" left unseen. Culminating in this fictional brain is the modern problem of a newly enacted relationship between the illumination of ongoing temporal processes (invisible yet visible) and the potential of forgetting the phantoms beneath the blinking lights. Electric display media heralded a new experience of immediate mediation based on the perception and anticipation of a virtually direct feed from active yet invisible – real-world or, in the case described here, real-brain – processes: this is what I call an emerging new form of liveness, a logic of *instant display*.

More historical research needs to be done on the conceptions and effects of this emerging world of ubiquitous displays. Erkki Huhtamo notes that while there is abundant cultural analysis of early twentieth-century peepshows, cinemas, and popular entertainment, "visual attractors" in

[100] For a succinct analysis of Kracauer's ambivalent position vis-a-vis Weimar "surfaces" and "the mass ornament," see Ward, *Weimar Surfaces*. Ward does not elaborate on Kracauer's observations in the office and factory, but does point to resemblances he saw between entertainment media and work environments, such as the similarity between the workers-swallowing Moloch machine in Fritz Lang's *Metropolis* and the illuminated entries to cinemas ibid., 164.
[101] Thea von Harbou, *Metropolis* (Fankfurt/M, Berlin, Wien: Verlag Ullstein GmbH, 1984 [1926]), 23.
[102] Ibid., 24. A 1935 article on indicator diagrams describes the control desk of the Tummel Power Station in Scotland, noting how it is "filled in with blue enamel, resulting in a well-balanced and pleasing diagram." "The Centralisation of Control of Power Networks," 273.
[103] *Metropolis*.

public space have remained understudied, and should be studied as "media interfaces that constitute their own peculiar modes of spectatorship."[104] By sketching this new logic of instant display, this chapter's living diagrams, Luminous Brain, motograph brain, and enchanted loom can all be understood as brainmedia assemblages that allowed for a new form of liveness that influenced how the active brain could be thought. Through the logic of instant display, the organ could be spatio-temporally thought according to the abstraction of electrical transmission as having an on/off-light-indicator structure, as fitting new types of surface displays. This instant-display brainmedia promised a new *form of liveness* for the active brain, instantaneous yet mediated access to the brain in action as it blinked activity patterns. The brain itself could now be imagined as a type of display device.

Conclusions

This chapter analyzed 1930s brainmedia assemblages that were part of a contested field that traversed science-educational and scientific discourses: the attempt to create a new conception of - and a novel visual language for the dynamic brain, a brain that was populated by spatio-temporal activity patterns and whose structure and function were dynamically connected. In the Luminous Brain, sequenced illumination technology was imagined as a future possibility for the spatial-temporal animation necessary to depict cerebral processes. Here, the *Lichtlehrmethode* of dynamic displays was both likened to, and seen as a lively antidote for, the distracting illuminated surfaces omnipresent in the modern city. The visual language of illumination could serve as a flexible rhetorical tool that offered modern citizens sensations of liveliness and promised a transparent view of the brain in action. Science-educational models of the brain banked on the cultural position of illuminated surfaces and people's more general association of electrification with active processes. Dynamic illumination also served the challenge of conceptualizing and representing the spatio-temporal brain in other ways. Various scientists also used the analogy of the illuminated electric news ticker for the nervous system, what I have called the motograph brain, to conceptualize a fixed (anatomical) substructure with changing electrical patterns. This instant visibility of temporal processes through display structures helped imagine the brain as part of a new cultural sphere of material surfaces that mediated temporal processes directly. These two

[104] Erkki Huhtamo, "Monumental Attractions: Toward an Archaeology of Public Media Interfaces," in *Interface Critism: Aesthetics Beyond Buttons*, ed. Christian Ulrik Andersen and Soren Bro Pold (Aarhus: Aarhus University Press, 2011), 23. For a more recent contribution to this field, see Rachel Plotnick, "Force, Flatness and Touch without Feeling: Thinking Historically About Haptics and Buttons," *New Media & Society* 19, no. 10 (2017); "Touch of a Button: Long-Distance Transmission, Communication, and Control at World's Fairs," *Critical Studies in Media Communication* 30, no. 1 (2013).

blinking brainmedia thus reveal material-discursive circuits through which electro-technology and cerebral biology were mutually articulated.

Importantly, this chapter shows how the analogy between the active nervous system and particular media devices connected to changing attitudes of nerve researchers who used new display devices to study the electrical activity of the brain. In the 1930s, researchers needed to negotiate processes of technological mediation: producing images on display screens was central, but could not be conceived as a simply instantaneous endeavor. Analogies with the motograph brain, as well as with the emerging medium of television, allowed researchers to negotiate dimensions of immediacy and mediation in such technical processes. Electrical indicators directly showed underlying functional activities, yet their mediating function - as displays, indicators, living diagrams - remained present within such practices. By pointing to this logic of instant display, I nuance and adjust accounts in media philosophy about the "constitutive invisibility" of media or "media marginalism," i.e. the idea that media "erase" themselves in their endless search for immediacy or transparency.[105] The logic of instant display introduced both new visibilities (spatio-temporal complexity) *as well as* invisibilities (the phantoms of active processes below). The ubiquitous signs and living diagrams in both scientific and popular spheres around 1930 shaped a display culture that drew new relations between moving illumination on visible surfaces and previously invisible temporal processes in power plants, factories and brains.

The conjunction of the invisible and the visible, through these emergent display media, makes an important amendment to existing histories of brain and nerve research in the mid-twentieth century. On first glance, the fascinating and immediate display brains of this chapter neatly lay the groundwork for existing cultural histories of the brain which have pointed to a brain-research shift between the mid-1920s and 1940s that Michael Hagner characterized as a move from the brain's anatomy – an "organicist view" focusing on the structure, size, and number of brain structures – towards its functionality – a "technicist view" focusing on the way nervous activity is wired.[106] This technicist interpretation allowed researchers to conceive of the brain as an isolated entity, not a fleshy brain in a body, but a brain on the screen isolated from "distracting physical processes."[107] Towards the 1940s, neurophysiology increasingly focused on interpreting the fast-growing mass of electro-physiological measurements through mathematical correlations and statistics, looking for nerve-activity patterns while moving further away from the material

[105] Krämer, "Was Hat "Performativität" Und "Medialität" Miteinander Zu Tun?," 22. Timo Kaerlein, "Presence in a Pocket. Phantasms of Immediacy in Japanese Mobile Telepresence Robotics," *communication +1* 1, no. 1 (2012): 15.
[106] Michael Hagner, "Das Kybernetische Gehirn," in *Geniale Gehirne: Zur Geschichte Der Elitegehirnforschung* (Gottingen: Wallstein Verlag, 2004), 289.
[107] Ibid., 293.

properties of nerve cells and cerebral tissues.[108] In turn, the 1940s' new computational and cybernetic era developed its own visual language of schematic wiring diagrams of bodily processes and nerve circuits, an iconography that Hagner calls "anti-physiognomic," hardly interested in correlating function with the physical brain or body.[109]

Yet the histories of the Luminous Brain model and the motograph brain are more complex. This means that we should not, as Douwe Draaisma has, present Sherrington's enchanted loom as a simple antecedent to the concept of brains as information processing systems (the rule-based manipulation of symbols).[110] Organicists and technicists' lines of research and thinking intersected in the 1930s; the search for dynamic models of electrical activity did not immediately lead down the path of an informational conception of the nervous system.[111] While an image of the nervous system as an illuminated news ticker may seem to anticipate a conception of electric messages or "code" inside the active brain, I argue that this analogy is part of a more complex history of negotiating technological mediation.

With this chapter I have revealed how, in the 1930s, science-educational and scientific spheres were populated by alternative, hybrid imaginaries and models, part of a more ambiguous logic of display that shaped research into to the active brain. Telling, in this respect, is the reprint of a photograph of the Luminous Brain in a 1934 American newspaper article entitled *Science's Futile attempt to build a perfect mechanical brain* [Figure 2.7]. Here, the model literally featured as a connecting image between fleshy and "mechanical" brains, a techno-anatomical brain model that supplied readers, in a dismissive and ironic way, with the ingredients of a new imaginary, some future project of "building a brain." In the 1930s, rather than a wholesale turn from biology to technology, from tissues to instruments and screens, we see hybrid amalgamations that blended with the material culture of electric display media.

[108] Garson, "The Birth of Information in the Brain," 47. In tandem, Garson notes that nerve researchers such as Edgar Adrian also increasingly used informational vocabulary (especially in popular publications) to speak of nerve elements in terms of messages, signals, and codes.
[109] Michael Hagner, "Bilder Der Kybernetik: Diagramm Und Anthropologie, Schaltung Und Nervenstystem," in *Konstruierte Sichtbarkeiten: Wissenschafts- Und Technikbilder Seit Der Frühen Neuzeit*, ed. Martina Hessler (Munchen: Wilhelm Fink Verlag, 2006), 394.
[110] Douwe Draaisma, for example, mentions the enchanted loom as a connecting thread between Charles Babbage and Ada Lovelace's nineteenth-century Analytical Engine and twentieth-century AI theories. Douwe Draaisma, "An Enchanted Loom," in *Metaphors of Memory: A History of Ideas About the Mind* (Cambridge: Cambridge University Press, 2000).
[111] Max Stadler similarly warns about a sweeping grand narrative of "information discourse" that slips into the history of nerve research and takes center stage after WWII. While computation processes and informational vocabularies definitely impacted nerve and brain research, Stadler argues for a "deliberately unspectacular perspective," pointing to the tedious tinkering that continued in the laboratory with hundreds of measurements of actual, physical nerve cells and tissues. Stadler, *Assembling Life. Models, the Cell, and the Reformations of Biological Science, 1920-1960*, 320.

THE SALT LAKE TRIBUNE, SUNDAY MORNING, NOVEMBER 25, 1934.

Science's Futile Attempt to Build a Perfect Mechanical Brain

The Nearest Approach to a Human "Think Tank" Is Able to Do the Mathematical Work of Five Men But— It Weighs Six Tons!

A PROMINENT Mid-Western clergyman stepped to the pulpit of his church on a recent Sunday morning and his congregation settled back to enjoy another of his brilliant sermons.

But instead of beginning to speak immediately, on this morning the preacher stood silently for fully a minute, gazing out over the assemblage—turning his head from side to side to peer into each corner.

Then, suddenly, he raised both hands high above his head and began twisting them at the wrists. His fingers rippled as though he were playing an imaginary piano. Presently he was whipping his arms about in circles. This continued for another minute.

Nothing he could have said or done would have won such complete attention from his congregation. The pew-holders sat bolt upright, amazed at the unusual scene. There were murmurs and smiles here and there. Dignified men nudged one another and conversed in whispers.

But as suddenly as he had begun his unusual gyrations, the preacher stopped and began speaking:

"My friends," he began, "you may well smile. I have made a spectacle of myself. But—in so doing I have shown you the power of God! Only the Almighty can make a 'machine' which will function as efficiently as the human body!"

And then the scholarly minister held his listeners spellbound with a brilliant sermon on the wonders of the complicated human organs; the hands, eyes, internal parts and especially the brain and nervous system. He closed with the stirring statement that the combined intelligence and ingenuity of the world's greatest scientists will never "manufacture" an artificial man which will function like a human.

Probably never before had this fascinating subject been so dramatically explained to a church congregation. The preacher opened vast vistas for speculation, and repeated a truth which has perplexed the men of science for years and years.

Many efforts have been made to turn out robots—and they have been successful, after a fashion. But the power of reasoning and memory are secrets which science has not been able to uncover. Nothing artificial has ever assumed these duties—and perhaps it is well.

Only the other day it was announced at the University of Pennsylvania that the faculty and students of electrical engineering had built a "mechanical brain" which would do wonders in solving intricate problems of mathematics. But—the machine weighed six tons when it was completed and it required the direction of a man or woman—a God-made brain, if you will—to operate it!

This piece of mechanism, however, is worthy of deep consideration, because it probably comes closer to a human brain than anything else yet devised.

It is able to complete in 15 minutes the mathematical work that would require five technicians about four months to do, according to the designers. And that is a great achievement, of course.

Oscar Schuck, of the faculty of the University of Pennsylvania, designed the machine, which he has called a "differential analyzer." I. A. Travis, also a member of the faculty, was in charge of the construction, and he had the assistance of the university's most talented engineers.

This machine probably will take rank as the outstanding mechanical mathematical invention. But because of its great size, intricacy and cost of construction, it is not likely that it will ever be manufactured on a production basis.

Years ago, of course, other mechanical wizards were able to evolve adding and subtracting machines, bookkeeping machines, automatic check writers and many other business implements which will accomplish almost uncanny results. Most of these are portable, and at least one may be found in nearly every modern business office.

But—and this is the catch—as efficient as they may be, each and every one of them requires the direction of a human operator! And it probably will always be so!

The same problem is faced — and unconquered—by every scientist who ever set out to manufacture a mechanical or electrical "brain."

Charles G. Abbot, secretary of the Smithsonian Institution, recently designed what he called a "Brass Brain" which he had planned to evaluate variations in the sun's radiation, and thereby, assist the experts in forecasting the weather.

A calculator of this kind had been the dream of weather forecasters for many years and Abbot's invention was hailed when it was first shown to the scientific world some weeks ago at the annual meeting of the National Academy of Sciences, in Washington.

The weather men for years have believed that the variations in the sun's radiation might be the cause of cycles in climates — periods of warm and cold, wet and dry years following one another in more or less regular succession. And so, it was thought that if these cycles could be calculated, long range weather forecasts might be possible.

The "Brass Brain" was put into use and according to the experts, functions splendidly. But it will be months and perhaps years before a full report on its efficiency can be prepared.

Dr. Vannevar Bush, vice-president of technology and famed inventor, at the Massachusetts Institute of Technology, also has contributed much to scientific attempts to build a perfect "mechanical brain." He has turned out some truly amazing machines — but all with the same limitations.

Dr. John B. Wilbur, also of the Massachusetts Institute, recently announced that, with the aid of Dr. Bush, he had manufactured a master device for solving mathematical equations involving unknown quantities.

His instrument, through a system of tiny pulleys and glistening steel tapes, refashions and sets up on measured scales the symbols of mathematicians in a purely mechanical form. It is claimed to be of great value in solving problems which engineers encounter in designing wind bracing for skyscrapers and of triangulation met with in geodetic surveys.

The operations of the human mind, of course, have intrigued the specialists almost since the beginning of surgical science. They have conducted literally millions of tests and the studies have run on through many generations. As a result, the experts have been able to solve almost every mystery of the functioning of the human mind—except the everlasting mystery of the powers of reasoning and memory.

For instance, only recently the brain specialists actually have run down and established the causes of headaches which plague so many people. They learned that usually the aches were caused by tiny air pockets forming inside the skull, where they pressed upon the brain and the cranium alike, causing intense suffering until they were dissipated.

The first and only actual photograph of a headache (reproduced on this page) was placed on display at a recent meeting of the Biological Photographic Association, in Rochester, N. Y., and aroused great interest.

The photographer used an Infra-Red Ray and an X-ray machine to take the picture, which plainly revealed the distressing little air pocket which was the root of the trouble.

Other experts have spent years and years in laboriously tracing the countless nerves which carry impulses to and from the brain and their reports have fascinated scholars from time to time. It has been claimed that every nerve running into the brain has been segregated and its duties tabulated.

To realize what this research involved, it is only necessary to imagine the great number of impulses required to simply move an arm. But to get even a greater picture, visualize the nerves which must go into action during moments of strenuous exercise!

Also reproduced on this page is a photograph of a cleverly conceived method of reconstructing the nervous system of the brain. Dr. Edith Klemperer and Dr. Robert Exner, nerve specialists, worked out a plan whereby more than 100 Neon tubes represented the nerves of the brain.

They were twisted and shaped until they approximated the actual position of the nerves inside the skull. Then, to show how the real nerves function, the inventors only had to turn switches and send the Neon lights racing through the tubes.

Of course, all this intensive research on the brain has brought about a number of discoveries which have been of great aid to physicians in treating mental ills. Only recently it was established that some mental trouble was caused by the colloids of the brain becoming either too watery or too much like over-thick syrup. When at either extreme the patient was unbalanced, but when the injections of drugs made the colloids normal, the patient became normal.

As interesting as these discoveries may be and the aid to humanity they promise for the future, the men of science are pretty well agreed today that there are many things about the brain which they will never be able to master. And so—the spectacular sermon of the Mid-Western clergyman should live forever as a lesson that all should learn.

This Large Photograph Shows Only One Small Section of the Huge Six-Ton Mechanical Brain Built at the University of Pennsylvania. I. A. Travis, Background, Was in Charge of Production.

Much of the Important Research Into the Secrets of the Human Brain Has Been Done by German Scientists. In This Specially Posed Photo, Prof. Oscar Vogt, Head of the Brain Institute, in Berlin, Is Surrounded by Assistants While He Examines the Parietal Lobe in the Brain of Hermann Sudermann, Famous German Dramatist.

Mlle. Fernando Conpin, Brilliant Paris Scientist and Brain Specialist, Has Dedicated Her Life to Tracing the Causes of Mental Ills. Here She's Shown at Work in Her Laboratory.

Another Photo from the Berlin Brain Institute. This Is a Close-up of the "Thinking Organs" of a Government Interpreter Who Spoke 70 Languages.

Yes Sir, You May Believe It or Not, But this Is an Actual Photo of a Headache—of All Things! And the Arrow Points to the Ache—a Tiny Air Pocket. The Picture Was Made With an X-Ray Machine and by Using an Infra-Red Ray.

This Weird Conglomeration Really Is an Ingenious "Illuminated Brain." It Is Made From Neon Tubes and When Lighted They Show the Routes Taken by Nerve Impulses Shooting Out of the Mental Center.

Copyright, 1934, King Features Syndicate, Inc.

Figure 2.7 Science's Futile Attempt to Build a Perfect Mechanical Brain, 1934 (newspaper article)

This important ambiguous hybridity of the fleshy and the electro-technical brain is poignantly illustrated if we follow the work of Ralph Gerard from his 1937 motograph analogy for the nervous system to his work after World War II in relation to a growing cybernetic, information-oriented direction in nerve research. When a loosely affiliated group of scientists in cybernetics in the late 1940s proposed that the nervous system could be studied by focusing on the "discrete" nature of the nerve impulse (zero or one, hence a fundamentally digital approach to the nervous system), Gerard vehemently objected.[112] Decades of experience in researching the minute activities of nerve cells and tissue had showed him the many ways in which nervous conduction, synchronicity, and delay characteristics were influenced by the nerves' material properties. Underneath the mesmerizing motograph display, he knew, lay complex material worlds.

112 Ralph W. Gerard, "Some of the Problems Concerning Digital Notions in the Central Nervous System," in *Cybernetics - Kybernetik. The Macy-Conferences 1946-1953. 2: Dokumente Und Reflexionen*, ed. Claus Pias (Zurich: Diaphanes Verlag, 2004).