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When sight penetrates the body. The use and promotion of stereoscopic radiography in Britain, 1896-1918.

In December 1895, Conrad Willem Roentgen discovered what we now call x-rays.[1] In the space of a few weeks, everyone marveled about the images produced: one could now see *inside* the body! The invisible was made visible![2] X-rays were seemingly everywhere, in popular magazines and in amusement fairs. They had become a new and fashionable entertainment, part of late nineteenth-century delight for optical illusions and philosophical toys.[3]

For physicians, x-rays happened to be a much more serious affair. The potential of radiography and fluoroscopy for medical diagnosis was immediately understood.[4] However, while some practitioners professed their enthusiasm, others criticized the pictures' lack of reliability.[5] As late as 1907, Mihran Kassabian complained that there were always "numerous shadows […] that defy all efforts of interpretation."[6] The issue was notably due to the fact that the position of these shadows cannot be

[1] About Roentgen's discovery, see, Otto Glasser, *Wilhelm Conrad Röntgen and the Early History of the Roentgen Rays* (San Francisco: Norman, 1993), 1–46 and Bettyann Kevles, *Naked to the Bone: Medical Imaging in the Twentieth Century* (New Brunswick, N.J.: Rutgers University Press, 1997), 9–32.

[2] To paraphrase the question asked by H. J. W. Dam to Roentgen (cited in Simone Natale, "The Invisible Made Visible: X-rays as Attraction and Visual Medium at the End of the Nineteenth Century," *Media History* 17, no. 4 (2011): 345). Lisa Cartwright has rightly stressed that the very significance of this discovery did not lie in the rays themselves but in the pictures they could have produced (Lisa Cartwright, *Screening the Body: Tracing Medicine's Visual Culture* (Minneapolis; London: University of Minnesota Press, 1995), 111).

[3] On the popularization of x-rays, see especially Kevles, *Naked to the Bone*; and Natale, "The Invisible Made Visible." About late nineteenth-century popular science, see notably Iwan Rhys Morus, "Seeing and Believing Science," *Isis* 97, no. 1 (2006): 101–10; Iwan Rhys Morus, "Worlds of Wonder: Sensation and the Victorian Scientific Performance," *Isis* 101, no. 4 (2010): 806–16; and Bernard Lightman, "Victorian Science and Popular Visual Culture," *Early Popular Visual Culture* 10, no. 1 (2012): 1–5.

[4] Numerous names were invented in English to describe the images produced by x-rays, such as roentgenography, skiagraphy, shadowgraphy, or radiography. While they were indifferently used until the late 1910s, the use of "radiography" progressively became the standard in Britain (See Glasser, *Wilhelm Conrad Röntgen*, 231–232).

[5] As a practitioner could wrote in 1897, "[s]ight is a much more satisfactory agent of information than hearing or touch" (cited in Kevles, *Naked to the Bones*, 96). For a good epistemologically-oriented account on x-ray images, see Bernike Pasveer, "Representing or Mediating. A History and Philosophy of X-Ray Images in Medicine," in *Visual Cultures of Science: Rethinking Representational Practices in Knowledge Building and Science Communication*, ed. Luc Pauwels (Hanover, N.H.: Dartmouth College Press, 2006), 41–62.

[6] Cited in Kevles, *Naked to the Bones*, 93. For an overview of the various cultural reasons explaining English practitioners' reticence toward the use of x-rays, see Christopher Lawrence, "Incommunicable Knowledge: Science, Technology and the Clinical Art in Britain 1850-1914," *Journal of Contemporary History* 20, no. 4 (1985): 503–20.

spatially recognized. Unlike a photograph, an x-ray image provides no occlusion cues and thus lacks any depth information. In other words, there is no way one can recognize, from two superimposed shadows, which one of the two objects they represent was in front of the other.

A solution to this issue was quickly identified. A few months after Roentgen's discovery, the application of stereoscopy was suggested to show depth.[7] The use of an adequate instrument to see two pictures taken from a slightly different angle would enable the cognitive reconstruction of depth, the same way it works with the naked eyes in front of a real object.[8] With stereoradiography **[Fig. 1],** it was thus possible to see the *inside* of the body, not as a flat map of shadows, but modelled "as a solid body, illuminated by transmitted light, transparent, like a crystal."[9]

During the second half of the nineteenth-century, stereoscopic photography had met with extraordinarily popular success.[10] A few years after David Brewster displayed his stereoscope **[Fig. 2]** in the 1851 Great Exhibition, nearly every middle-class family in Western countries seemed to have one of these small instruments at home. Hundreds of thousands of pictures, books and devices were manufactured by local producers as well as big companies devoted to the new craze.[11]

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[7] A list of the earliest articles on stereoradiography exemplifies how this solution arose in various countries at the same time: Elihu Thomson, "Stereoscopic Röntgen Pictures," *The Electrician* 36, no. 20 (March 13, 1896): 661–62; Armand Imbert and Henri-Jules Bertin-Sans, "Photographies stéréoscopiques obtenues avec les rayons X," *Comptes rendus des séances de l'Académie des sciences* 122 (March 30, 1896): 786; P. Czermak, "Prove stereoscopiche coi raggi di Röntgen," *Bullettino della Società Fotografica Italiana* 8 (March-April 1896): 64–67; Ernst Mach, "On the Stereoscopic Application of Roentgen's Rays," *The Monist* 6, no. 3 (1896): 321–23; The only valuable account on the early history of stereoradiography I have found is Thierry Lefebvre, "Les reliefs de l'invisible," *1895, revue d'histoire du cinéma* 1, no. 1 (1997): 83–92. However, the following articles may shed some other light: René Van Tiggelen, "In Search for the Third Dimension: From Radiostereoscopy to Three-Dimensional Imaging," *JBR-BTR: organe de la Société royale belge de radiologie (SRBR) = orgaan van de Koninklijke Belgische Vereniging voor Radiologie (KBVR)* 85, no. 5 (2002): 266–70; Theodore Keats, "Origins of Stereoscopy in Diagnostic Roentgenology," in *Classic descriptions in diagnostic roentgenology*, ed. André Johannes Bruwer (Springfield, Ill.: C.C. Thomas, 1964), 983–86; and Steve Webb, *From the Watching of Shadows: The Origins of Radiological Tomography* (Bristol; New York: Adam Hilger, 1990), 94–103.

[8] Of course, artificial stereoscopy can only approximately reproduce natural stereoscopy, as there are several factors featuring the latter that are not reproduced in the former – among them is the relationship between convergence and accommodation which will be discussed later (p. 14).

[9] James Case, "The Stereo-Roentgenography of the Stomach and Intestine," *Archives of the Roentgen Ray* 17, no. 2 (1912): 47.

[10] About the history of nineteenth-century stereoscopy see notably Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambridge, Mass.: MIT Press, 1990), 116–36; Robert J. Silverman, "The Stereoscope and Photographic Depiction in the 19th Century," *Technology and Culture* 34, no. 4 (1993): 729–56 ; Laura B. Schiavo, "From Phantom Image to Perfect Vision: Physiological Optics, Commercial Photography, and the Popularization of the Stereoscope," in *New media, 1740-1915*, ed. Lisa Gitelman and Geoffrey B. Pingree (Cambridge, Mass.: MIT Press, 2003), 113–38.

[11] Helmut Gernsheim and Alison Gernsheim, *The History of Photography from the Camera Obscura to the Beginning of the Modern Era* (London: Thames & Hudson, 1969), 253–62; A. T. Gill, "Early stereoscopes," *The Photographic Journal* 109 (1969): 546–59, 606–14, 641–51.

It is now well-known that stereoscopes did not originate as entertainment devices, but as laboratory tools. The first systematic studies on binocular depth perception were achieved by Charles Wheatstone in the 1830s, thanks to the large instrument he contrived **[Fig. 3]**.[12] However, while Wheatstone's work was of great importance in the development of physiological optics, it remained ignored outside a small community of physicists. Not only was the reflecting stereoscope confined in the laboratory, but its role as the model for Brewster's instrument remained ignored among the public.[13]

However, enthusiasm for Brewster's stereoscopes had waned by the 1870s. An early article on stereoradiography drew attention to the fact that, in the late nineteenth-century, stereoscopy had "fallen so completely out of favor that, until comparatively recently, it had almost been forgotten."[14] Historians have notably argued that the commercial decline may have been due to the lack of standardization among different producers and the low level of innovation in the content of stereoviews.[15]

How then did stereoradiography come to light? While the medical need to provide precise three-dimensional modelling of the different shadows was clear, it is not the only explanation for the importance the medium took among early British radiographers. The practical utility of stereoradiography was obviously the main argument physicians used to promote the technique, but it cannot be easily separated from underlying functions: stereoradiography is not only an instrument mediating between the surgeon's hand and the patient's body, it is also a method anchored in a specific social context – a technique that was discussed, exhibited, criticized by some, and promoted by others. The stereoradiograph is, in turn, a social object whose effective value in medical diagnosis cannot be separated from the values constructed and communicated among medical practitioners.

[12] Charles Wheatstone, "Contributions to the Physiology of Vision.--Part the First. On Some Remarkable, and Hitherto Unobserved, Phenomena of Binocular Vision," *Philosophical Transactions of the Royal Society of London* 128 (1838): 371–94; Id., "The Bakerian Lecture--Contributions to the Physiology of Vision.--Part the Second. On Some Remarkable, and Hitherto Unobserved, Phenomena of Binocular Vision (Continued)," *Philosophical Transactions of the Royal Society of London* 142 (1852): 1–17. About Wheatstone's physiological optics, see Brian Bowers, *Sir Charles Wheatstone FRS, 1802-1875* (London: Institution of Electrical Engineers, 2001), p. 44–54; Nicholas J. Wade, *Brewster and Wheatstone on Vision* (London: Experimental Psychology Society, 1983), p. 29–39. On the prehistory of stereoscopic instruments, see Nicholas J. Wade, "On the Late Invention of the Stereoscope," *Perception* 16, no. 6 (1987): 785–818.

[13] Schiavo, "From Phantom Image to Perfect Vision," 129–30.

[14] Anon., "Stereoscopic Photographs. The Application of Stereoscopy to Clinical Records," *The British Medical Journal* 2, no. 1979 (Dec. 3, 1898): 1697. See also Drouin, Félix. *The Stereoscope and Stereoscopic Photography*, trans. Matthew Surface (Bradford: Percy Lund & Co., 1896), 1.

[15] John Plunkett, "Selling stereoscopy, 1890–1915: Penny arcades, automatic machines and American salesmen," *Early Popular Visual Culture* 6, no. 3 (2008): 239–40.

Between medicine and entertainment: the ambiguous origins of stereoradiography

In April 1896, stereoradiography was introduced by Silvanus Thompson, professor of physics at Finsbury Technical College, during a lecture at the London Clinical Society.[16] A few weeks earlier, however, an article on "Stereoscopic Roentgen pictures" by the American engineer Elihu Thomson had been published in the British periodical *The Electrician*.[17] Thomson mentions the trials he made with objects such as a block of wood full of nails or twisted metallic wires. He then expresses his hope that "the complete skeleton of a mouse, or other small animal may be recorded as to be seen in relief, each bone in its proper space relation to the others."[18]

Neither paper mentions a medical application. In fact, neither Thomson nor his British homologue was medically trained. One of the leaders of the General Electric Company, Elihu Thomson had achieved various improvements to the Crookes tube, hoping that the company might soon be able to manufacture x-ray apparatuses.[19] Meanwhile Silvanus Thompson experimented with the chemical reactions of x-rays with various fluorescent substances in order to improve the sensitivity of radiographic plates.[20] Both men were interested in the physical study of x-rays with a view towards their industrial potential. Consequently, stereoradiography did not appear in Britain to satisfy medical need, but rather as a technological improvement of radiography intended for commercial applications.

These two preliminary works, therefore, had little impact on the medical practice. Stereoradiography remained a dull idea until it was revived, two years later, in a more detailed article.[21] The author, William Hedley, was a medical doctor and the head of the Electrical Department of the London Hospital where he established one of Britain's earliest radiography facilities.[22] His article was published in two different periodicals, *The Lancet* and *The British Journal of Photography*, ensuring a certain impact outside the field of medical practitioners. Not only was stereoradiography offered with a detailed

[16] *The Lancet* 147, no. 3788 (April 4, 1896): 935. For Thompson's biography, see Jane Smeal Henderson Thompson, Silvanus *Phillips Thompson, D.SC., LL.D., F.R.S.; His Life and Letters.* New York: E.P. Dutton and Co., 1920 ; and Edmund H. Burrows, *Pioneers and Early Years: A History of British Radiology* (St Anne, Alderney: Colophon, 1986), 30, 167–68.
[17] Thomson, "Stereoscopic Röntgen Pictures." The same article was also published in the American periodicals, *The Electrical Engineer* 21 (March 11, 1896): 256, and *The Electrical World* 27, (March 14, 1986): 280.
[18] Thomson, "Stereoscopic Röntgen Pictures."
[19] W. Bernard Carlson, *Innovation as a Social Process: Elihu Thomson and the Rise of General Electric, 1870-1900* (Cambridge, Mass.: Cambridge University Press, 1991), 311–28. For a focus on the historical development of the x-ray tube, see Robert G. Arns, "The High-Vacuum X-Ray Tube: Technological Change in Social Context," *Technology and Culture* 38, no. 4 (1997): 852–90.
[20] Thompson, *Silvanus Phillips Thompson*, 185.
[21] William Hedley, "Radiostereoscopy," *The Lancet* 151, no. 3888 (March 5, 1898): 639.
[22] Burrows, *Pioneers and Early Years*, 79.

methodological guidance – which I will discuss later – but it was also ascribed a precise purpose: the localization of foreign bodies.[23]

Shortly after Roentgen's discovery, radiography had indeed appeared especially useful to localize small objects lodged inside the body. In February 1896, James Mackenzie Davidson, an ophthalmic surgeon at the Aberdeen Royal Infirmary, had to remove a broken needle in a young girl's foot. As the traditional method of palpation gave no result regarding the localization of the needle, Davidson chose to use radiography.[24] The operation being successfully achieved, he concluded that "this case confirms the opinion that for the detection of metal in the body, the Roentgen rays will be of marked service."[25] During the following months, he frequently used radiography as an aid for diagnosis.[26] A year later, however, the main pitfall of this method was made clear: a single radiograph "has no relief', and consequently "give[s] no correct idea" of the "relative position" of the object.[27] In October 1897, Davidson, conjointly with Hedley, published an article on a new method of x-ray localization which provided depth information.[28]

It might be expected that the recognition of this issue would have directly led to stereoradiography. However, the solution Davidson developed was a simple mechanical device based on parallactic displacement.[29] After the first capture, the tube is moved up to a certain distance for a second capture in order to impress on the plate a different shadow of the foreign body. By triangulation, then it was possible to ascertain the distance from the skin to the object, and "these data give the surgeon all the information he can possibly desire."[30]

However, when Hedley published a few months later the aforementioned paper on stereoradiography, he made clear that the information given by Davidson's triangulation method, in spite of its relative precision, was not enough:

[23] Hedley, "Radiostereoscopy."
[24] James Mackenzie Davidson, "The Position of a Broken Needle in the Foot Determined by Means of Roentgen's Rays," *The British Medical Journal* 1, no. 1835 (Feb. 29, 1896): 558. For Davidson's biographical elements, see Anon., "Obituary: Sir James Mackenzie Davidson, M.B., C.M., Aberd," *Archives of Radiology and Electrotherapy* 23, no. 11 (April 1919): 338; and Burrows *Pioneers and Early Years*, 41, 98–99, 181–82.
[25] Davidson, "The Position of a Broken Needle."
[26] *The Lancet* 147, no. 3786 (March 21, 1896): 795.
[27] James Mackenzie Davidson and William S. Hedley, "A Method of Precise Localisation and Measurement by Means of Roentgen Rays," *The Lancet* 150, no. 3868 (Oct. 16, 1897): 1001.
[28] Davidson, "A Method of Precise Localisation." Davidson and Hedley were acquainted at least since July 1897 as the former was member of the editorial committee of the *Archives of the Roentgen Ray*, and the latter co-editor (*Archives of the Roentgen Ray* 2, no. 1 (1897): n.p.).
[29] Davidson, "A Method of Precise Localisation."
[30] Ibid.

> the radiographer is able to give the exact position of the foreign body with reference to certain artificial surface marks; *but such information cannot convey to the mind as sight does a clear conception of the various objects that go to make up the picture*. Yet this is what is chiefly wanted.[31]

Unlike Davidson's method, stereoradiography enabled "the surgeon to see with his own eyes at one glance […] the *tout ensemble* of the region he is dealing with."[32] The ability to operate does not only depend on the precision of the information, it also depends on the way by which this information is conveyed to the mind. In other words, an abstract geometrical idea of the distance would not be as efficient as the preliminary visualization of the body's interior. Stereoradiography was thus seen as a direct improvement of the mechanical method, enabling the surgeon to work more efficiently.

For his part, Davidson had been skeptical of stereoradiography. A "beautiful method," he acknowledged in January 1898, stereoradiography was also "difficult and tedious to carry out" and "not precise enough for practical guidance in a surgical operation."[33] At the beginning of 1898, Davidson's position is strikingly at odds with Hedley's. By the end of the year, however, the surgeon had changed his tune:

> A single skiagraph is often confusing, if not misleading, but with two properly taken and viewed in a stereoscope, the picture stands out in true relief, and shows clearly the relation of the parts.[34]

All the previous supposed difficulties of stereoradiography have seemingly vanished. Following Hedley's paper, Davidson may have been convinced that the medium was actually helpful for the localization of foreign bodies, in addition to his own mechanical method.[35] As John Hall-Edwards, a close acquaintance of Davidson, later put it, stereoscopy "is of the greatest possible help, even *after* an exact localisation has been made" since "it shows the relative position of foreign bodies and neighbouring bones."[36] However, unlike his two colleagues, Davidson did not employ stereoradiography alongside his own triangulation method to improve localization. A closer read of the surgeon's article suggests that localization was only a secondary purpose. His primary use was for medical training.

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[31] Hedley "Radiostereoscopy."
[32] Ibid.
[33] James Mackenzie Davidson, "Roentgen Rays and Localisation. An Apparatus for Exact Measurement and Localisation by Means of Roentgen Rays," *The British Medical Journal* 1, no. 1931 (Jan. 1, 1898): 10.
[34] James Mackenzie Davidson, "Remarks on the Value of Stereoscopic Photography and Skiagraphy: Records of Clinical and Pathological Appearances," *The British Medical Journal* 2, no. 1979 (Dec. 3, 1898): 1669–71.
[35] Davidson seems to have always considered that the two methods must be jointly used (see his later book, James Mackenzie Davidson, *Localization by X Rays and Stereoscopy* (London: H.K. Lewis, 1916)).
[36] John Hall-Edwards, "The Roentgen Rays in Military Surgery: Experiences in South Africa," *The British Medical Journal* 2, no. 2121 (August 24, 1901): 473 (my emphasis).

At the end of 1898, Davidson claimed to have used stereoscopic pictures "for years past […] with the greatest benefit to myself and to students."[37] If stereoscopy had already been advocated as an educational tool since the middle of the nineteenth-century, it was scarcely used for medical teaching until the 1900s[38]. Davidson was one of its earliest promoters in Britain, while its use was otherwise quite exclusively devoted to entertainment. Although it remains unclear how stereoscopic pictures were used by the surgeon, it is likely that the educational purpose remained closely connected to the fascination the image could have provoked among young medical students. In fact, it seems that the surgeon's interest in stereoradiography directly followed his use of stereoscopic photography.[39] Rather than relying on Hedley's work, Davidson used his own knowledge of stereoscopic photography to adapt it to radiography. His first trials having probably been unsuccessful, he thus remained little convinced about the utility of stereoradiography in the case of the localization of foreign bodies. He, however, considered another potential utility, directly drawn from his past use of stereoscopic picture, for "recording and illustrating medical and scientific work."[40]

The display of four pairs of stereoscopic pictures in his article clearly supports this view. Only one pair is actually radiographic. Another one shows the face of a patient infected with smallpox, and the two remaining ones show the devices used to take and to display stereoradiography **[Fig. 4]**. While the latter are about stereoradiography, they do not exemplify its actual advantages in medical diagnosis; they rather *illustrate* the technique behind the medium. Davidson's lengthy article deals with the technical aspects, the various methods to enable a good relief, and the pitfalls that one should avoid. There is no mention of a concrete application for accurate diagnosis. To Davidson's eyes, the medium appeared more relevant than its medical purpose. According to the article, Davidson actually only took the x-ray pictures; the surgery was left to another surgeon, Howard Marsh. The latter indeed acknowledged to have used "Mr. Mackenzie Davidson's stereoscopic process," to localize "with great exactness" a bullet "no bigger than a pea," lodged in a boy's leg.[41] While Davidson claimed to have made use of stereoradiography in more than two hundred and fifty cases in the space of only two years, it is likely he was in charge of taking the pictures and that he did not necessarily perform the

[37] Davidson, "Remarks on the Value of Stereoscopic Photography," 1669.
[38] Anon., "Stereoscopic Photographs," 1697. In his 1926 book, Arthur W. Judge considers that the educational value of the stereoscope "is now becoming recognised" and "undoubtedly has a great future before it" (Arthur W. Judge, *Stereoscopic Photography. Its Application to Science, Industry and Education,* (London: Chapman & Hall, 1926), p. 168).
[39] Anon., "Stereoscopic Photographs," 1697.
[40] Davidson, "Remarks on the Value of Stereoscopic Photography," 1669.
[41] Howard Marsh, "A Case of Bullet Wound of the Leg, in which the Bullet Was Located by Skiagraphy," *The British Medical Journal* 2, no. 1979 (1898): 1671.

surgery itself. Davidson's interest in these pictures was driven by a much more ambitious purpose. They were intended to be displayed during the numerous lectures he gave on the subject.[42]

While these lectures obviously bore an instructional purpose, they also hide another function. Stereoradiography was indeed a fascinating medium for radiographers themselves, and the reviewers of Davidson's lectures sometimes mention the beauty of the pictures[43]. In another context, a physicist admired "a very beautiful collection of stereoscopic slides" and hoped they would have been "exhibited at the Roentgen or the Electro-therapeutic Society."[44] During the 1909 Amsterdam Congress of the Roentgen Society, "[a] large room in the exhibition was completely lined by these stereoscopic pictures, each one more beautiful than the last."[45] The image one sees has the solidity of a real body, yet a surrealist transparency, so that it looks like a "glass model" or a "mass of crystal."[46] Radiographers' amazement sometimes led to even more poetical language. For example, William Butcher could admire a stereoscopic picture of a thorax whose heart, "like a bird within its living cage, […] stilled for a brief moment between its lifelong fluttering." At the paroxysm of aesthetic emotion, he added "that no picture of the old masters can easily excel this in poetic beauty or in charm."[47]

The utility of the new medium for the localization of foreign bodies was undoubtedly quickly grasped, yet it was not developed for such purpose. It seems that Davidson had understood that stereoradiography could be valued as an aesthetic object *before* it appeared it could be used as a diagnosis tool.

[42] By 1900, Davidson claimed to have used stereoscopic pictures for no less than 250 cases (Davidson, James Mackenzie, "Observations on Practical X-Ray Work, With Exhibition of Apparatus and Stereoscopic Skiagrams," *Archives of the Roentgen Ray* 4, no. 3 (1900): 61. For reviews of the lectures see notably in *The Lancet* 151, no. 3898 (May 14, 1898): 1352; 152, no. 3909 (July 30, 1898): 302; 153, no. 3932 (Jan. 7, 1899): 29; 153, no. 3934 (Jan. 21, 1899): 163; 153, no. 3936 (Feb. 4, 1899): 304; 153, no. 3942 (March 18, 1899): 786; 153, no. 3952 (May 27, 1899): 1447; 157, no. 4054 (May 11, 1901): 1360; 159, no. 4112 (June 21, 1902): 1794; 161, no. 4148 (Feb. 28, 1903): 590

[43] A reviewer mentionned « the beautiful stereoscopic method of Roentgen photography » (*The Lancet,* 161, no. 4148 (Feb. 28, 1903): 590).

[44] Anon., "*Stereoscopic Skiagrams of the Coronary Arteries of the Human Heart under Normal and Pathological Conditions*. By Professor F. Jamin and Dr. H. Merkel, of Erlangen. Published by Gustav Fisher, Jena [review]," *Archives of the Roentgen Ray* 11, no. 11 (1907): 328.

[45] William Deane Butcher, "The Roentgen Society - The Amsterdam Congress," *Archives of the Roentgen Ray* 13, no. 8 (1909): 219.

[46] Butcher, "The Roentgen Society"; James T. Case, "The Importance of Stereoradiography, Especially of the Alimentary Tract, with Demonstration of Plates," *Proceedings of the Royal Society of Medicine* 5, (1912): 80.

[47] *Archives of the Roentgen Ray* 13, no. 8 (1909): 219.

From showman to expert: the function of the instrument

The aesthetic features of stereoradiography did not *a priori* undermine its practical function: it could be, at the same time, a "beautiful and scientific method."[48] However, when William Butcher applauded the "magnificent" stereoscopic x-ray pictures at the Amsterdam Congress, he immediately felt compelled to specify that "[t]hey were made not as scientific curiosities, but in the daily routine of hospital work."[49] While they recognized the beauty of stereoradiography, medical practitioners could definitely not tolerate the medium to remain in the realms of entertainment and artistic practices, as Hall-Edwards emphasized:

> The state of affairs in London and other large towns, where radiographs are accepted which have been produced at a side show at an exhibition, or by an ordinary professional photographer, is a disgrace; and it is to this practice almost alone that mistakes are due, and discredit is thrown upon an adjunct to surgery which for accuracy and usefulness has never been surpassed in the history of scientific progress.[50]

Stereoradiography was thus in a quite difficult position, since it combined two techniques whose epistemic values were endangered by the "disgrace" that show business could bring upon them. While the beauty of the image was its most significant asset, it was also its main weakness. No medical radiographer could have afforded to be confused with a showman.

There was a quite simple way to get rid of most suspicions regarding stereoradiography's relationship to show business. If entertainers generally recommended the use of Brewster's small stereoscope for the view of stereoscopic photographs, Davidson stressed the necessity for professionals to use Wheatstone's unwieldy stereoscope when dealing with radiography.[51] There might also have been a practical reason: compared to a Brewster lenticular stereoscope, a reflecting stereoscope was an instrument flexible enough to adapt to the peculiar physiological conditions of natural binocular vision, that is to say the constant relation between the accommodation of the crystalline lens and the convergence of the eyes. As Charles Wheatstone had already pointed out:

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[48] E. W. H. Shenton, "A Simple Method of Localizing by Roentgen Rays," *Archives of the Roentgen Ray* 4, no. 1 (1899): 18.
[49] Butcher, "The Roentgen Society."
[50] John Hall-Edwards, "The X Rays in the Diagnosis of Fractures," *The British Medical Journal* 1, no. 2113 (June 29, 1901): 1645.
[51] "It is only necessary to look at two good stereoscopic skiagraphs in a *Wheatstone's stereoscope* to realise at once how thoroughly practical and important this method is in a surgical work." (Davidson, "Remarks on the Value of Stereoscopic Photography," 1669).

> As the inclination of the optic axes corresponding to a different distance is habitually, under ordinary circumstances, accompanied with the particular adaptation of the eyes required for distinct vision at that distance, *it is difficult to disassociate this two conditions* […][52]

Originally, one of the purposes of the Wheatstone stereoscope was to observe the effects produced by various artificial disjunctions between accommodation and convergence.[53] In consequence, the reflecting stereoscope could be settled as to retain the natural conditions of binocular vision and thus provide the "true relief" of the part of the body represented.

However, such an argument was not expressed by Davidson. The latter never gave much importance to the conservation of the natural conditions of binocular vision. In fact, he systematically neglected the relation between accommodation and convergence in his methodological guidance. As a stereoscope was not always available, he even suggested a technique to produce a stereoscopic effect without any instrument, by slightly squinting so that each optical axis would fall on the proper picture.[54] A correct effect requires, as C. Fred Bailey later related, that "the accommodation must *not* be allowed to alter with convergence or the combined picture will be out of focus."[55] No such explanation is found in Davidson's work. While the surgeon claimed that the practice was "not difficult to acquire," most radiographers disagreed.[56] They complained about headaches even when they ignored their distress was the result of altering the physiological conditions to which they were accustomed.[57] Because of the difficulty and the lack of precision of his method, it might be assumed that Davidson was certainly not looking for an exact reconstitution of the process of binocular vision, and that the visual quality produced by the Wheatstone stereoscope was all but necessary.

What is striking is the importance the instrument takes in the early lectures Davidson gave on stereoradiography. Five reviews of his lectures published between 1898 and 1899 specify that a Wheatstone stereoscope was used in order to display the pictures.[58] There was no practical reason to

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[52] Wheatstone, "The Bakerian Lecture," 4 (my emphasis).
[53] Wheatstone, "Contributions to the Physiology of Vision."
[54] Davidson, "Remarks on the Value of Stereoscopic Photography," 1671. Bettyann Kevles's statement that « the drawback of stereoradiology was the fact that many radiologists simply found it difficult to see through a stereopticon [so they] chose, instead, to simply cross their eyes » (Kevles, *Naked to the Bone*, 69) is, as I hope this article will demonstrate, largely oversimplified.
[55] C. Fred Bailey, "Stereoscopic Radiography As A Routine Method Of Examination," *The British Medical Journal* 2, no. 2696 (August 31, 1912): 496 (my emphasis).
[56] Davidson, "Remarks on the Value of Stereoscopic Photography," 1671.
[57] A reviewer mentioned the method in 1898 and admitted "this is a knack which not everyone can acquire" (Anon., "Stereoscopic Photographs," 1698). Another said: "I can only say that I have tried in vain, and succeeded only in getting headache and a painful kind of ocular distress' (William Cotton, "The True and the False of Perspective X-Ray Representation," *Archives of the Roentgen Ray* 7, no. 2 (1902): 28–29).
[58] *The Lancet* 151, no. 3898 (May 14, 1898): 1352; 153, no. 3942 (March 18, 1899): 786; 153, no. 3936 (Feb. 4, 1899): 304; 153, no. 3932 (Jan. 7, 1899): 29; Anon. "Skiagraphy and Stereoscopy," *The Lancet* 153, no. 3952 (May

explain this choice. The device was much bigger and much more complicated to use than a Brewster stereoscope. It could not have been used by more than one viewer, meaning the public had to stand up one by one in front of the instrument to see the pictures properly. By the end of the nineteenth-century, anaglyphic or light polarized devices for stereoscopic projection were already available and would have allowed an entire audience to see the effect simultaneously.[59] As these are not mentioned, it must be assumed that the talk was preceded or, more likely, followed by the display of the pictures placed in the reflecting stereoscope. During others' lectures, it happened that Davidson exhibited stereoscopic pictures "with his mirror-stereoscope and gave demonstrations of his method and its value."[60] We should conclude that Davidson's lectures – including his participation in others' lectures – were not intended to simply illustrate a medical case, but rather the place to exhibit a specific instrument and a particular visual medium.

During the 1900s, Wheatstone's apparatus became the standard instrument for the viewing of stereoscopic x-ray pictures. According to the American radiographer, James T. Case, it could be seen in several London laboratories.[61] Models specifically intended for radiography **[Fig. 5]** were even manufactured around 1910.[62] The reflecting stereoscope was frequently advertised to be better than any other instrument.[63] However, Davidson himself claimed the opposite in his later works. In 1915, he asserted that, although Wheatstone's stereoscope was "one of the most convenient" methods, "it is much more satisfactory" to use an "ordinary lenticular stereoscope."[64] A similar change may be observed in *A Manual of Practical X-Ray Work.* While the 1909 edition only mentions the reflecting

27, 1899): 1447. The Wheatstone stereoscope was also represented in one of the four stereoscopic images in Davidson, "Remarks on The Value of Stereoscopic Photography."

[59] A whole chapter is dedicated to "Stereoscopes of Projection" in Drouin, *The Stereoscope*, 81-89. For an account on stereoscopic methods of projection in the late nineteenth century, see Ray Zone, *Stereoscopic Cinema and the Origins of 3-D Film, 1838-1952* (Lexington: The University Press of Kentucky, 2007), 53-72.

[60] *The Lancet* 153, no. 3932 (Jan. 7, 1899): 29.

[61] Case, "The Importance of Stereoradiography," 76. One may also find some mentions of the Wheatstone stereoscope in *The Lancet* 152, no. 3913 (Aug. 27, 1898): 558; and in Alexander B. Johnson, "Stereoscopic Radiography," *Annals of Surgery* 35, no. 4 (1902): 461; William Cotton, "Twin X-Ray Representation And The Reflecting Stereoscope," *The Bristol Medico-Chirurgical Journal* 23 (1905): 218; Anon., "A Simple Method of Viewing Skiagrams Stereoscopically [Review]," *Archives of the Roentgen Ray* 16, no. 1 (1911): 39; Robert Knox et al., "Discussion on the Localisation of Foreign Bodies by X-Rays," *The Journal of the Röntgen Society* 11 (Jan. 1915): 7.

[62] For the commercial adaptation, see notably the advertisements in the *Archives of the Roentgen Ray* 10 (1905): n.p.; 11 (1906): n.p.; 14 (1909): n.p.; 18 (1912): n.p.; and the reproduction in Judge, *Stereoscopic Photography*, 205.

[63] According to James T. Case, "[t]he picture formed by the blending of the two images is more nearly life-size and life-like than with any available form of prism or lens stereoscope" (Case, "The Importance of Stereoradiography," 78).

[64] James Mackenzie Davidson, "The Principles And Practice Of The Localization Of Foreign Bodies By X Rays," *The British Medical Journal* 1, no. 2818 (January 2, 1915): 2 (see also Davidson, *Localization by X Rays and Stereoscopy*, 19).

stereoscope, the 1917 edition describes other devices including lenticular stereoscopes, those having shown "particularly valuable in localisation of foreign bodies."[65] Such a shift cannot be explained in terms of technological change, and thus suggests that the early emphasis on the Wheatstone stereoscope was neither due to its practicality nor to the quality of its pictures. It was rather due to the *scientific* connotation of the instrument, from the standpoint of professional legitimacy.

Wheatstone's stereoscope indeed belonged to the laboratory environment while Brewster's one remained an "optical" or "philosophical" toy. Although stereoradiography was in practice largely drawn from entertainment practices, it had to move away from such a poor origin. This was especially important at the time, since a large number of medical practitioners remain dubious about the use of instruments for diagnosis.[66]

The Wheatstone stereoscope was a way to distance radiography from entertainment, from the "crystalline" transparency of the medium. As Jonathan Crary stressed, while the Brewster stereoscope 'conceal[ed] the process of production" and "allowed the viewer to believe that he or she was looking forward at something 'out there,'" the Wheatstone device created a "disjunction between experience and its cause."[67] Davidson might have highlighted such a disjunction, as he encouraged the "beginner" to pay attention to the cognitive combination of the two pictures:

> [he might] pull the mirror towards him until he sees the two photographs side by side and overlapping; then, by gradually pushing the mirrors away, keeping the middle line of his forehead close to the apex, he will find that the images gradually approach each other, and finally fuse into one, whereupon this solid stereoscopic effect is immediately realized.[68]

During Davidson's lectures, the emphasis on the artificiality of the stereoscopic effect could have stressed the role of the operator as a performer – a showman – but the use of the Wheatstone instrument drove away any remaining associations with entertainment. Davidson became an *expert* in a *scientific* technique for medical imaging. Stereoradiography was as useful for medical diagnosis as it was for self-advertisement. After he moved from Aberdeen to London in 1897, Davidson might have figured out stereoradiography could be used as a key to enter the medical community and to win recognition as a radiographer. Thanks to his numerous lectures and publications on the topic, Davidson became considered the one true "pioneer" of stereoradiography in Britain; his works were

[65] David Arthur, and John Muir, *A Manual of Practical X-Ray Work* (New York: Rebman, 1909), 127 ; Id., *A Manual of Practical X-Ray Work*, (London: Heinemann, 1917), 184.
[66] Lawrence, "Incommunicable Knowledge."
[67] Crary, *Techniques of the Observer*, 129, 133.
[68] Davidson, *Localization by X Rays and Stereoscopy*, 18–19.

systematically acknowledged while Thompson's or Hedley's earlier papers had fallen into oblivion.[69] Davidson became one of the most successful radiographers in Britain, being knighted in 1912, and remembered later as *the* "leading radiologist of this country."[70] It is not unlikely that stereoradiography was the catalyst of such a brilliant career.

When the gaze penetrates the body: the image of stereoradiography

The quite complex relationship stereoradiography maintained with entertainment practices deeply affected the way the pictures themselves were seen at the beginning of the twentieth century. According to Crary's famous thesis, stereoscopy shows an essential dissemblance between stimulus and sensation.[71] The late nineteenth-century "observer" was confronted with a radical impossibility to reproduce what he sees: the myth of the perfect mimesis collapsed.

Art historian Laura Schiavo has, however, suggested that such a pessimistic conception radically changed when stereoscopy slipped from physiological optics to entertainment practices.[72] Contrarily to Crary's argument, Schiavo shows that the commercialization of stereoviews tended to dismiss such an epistemic gap, while simultaneously reaffirming the possibility of an absolute mimetic representation.[73] Grounded in the tenets of natural theology, as Richard Silverman stresses, the discourse on stereoscopy was no more that of dissemblance: on the opposite, the human visual apparatus became the model for the man-made machine.[74] Reaching back to Kepler's well-known analogy between the eye and the camera obscura, the stereoscopic camera "stand[s] truly for the two eyes," each objective being a crystalline lens, and each sensible plate a retina.[75] Historians have suggested that, as long as human vision was considered the "model for proper depiction," the illusion

[69] Anon., "The American Atlas of Stereoroentgenography [Review]," *Archives of Radiology and Electrotherapy* 21, no. 5 (October 1916): 164; and G. W. C. Kaye, "X-Rays and the War," *The Journal of the Röntgen Society* 14 (January 1918): 4. For other similar testimonies, see *The Lancet,* 161, no. 4148 (Feb. 28, 1903): 590; Hall-Edwards, "The X Rays in the Diagnosis of Fractures," 1646; Johnson "Stereoscopic radiography," 455; Judge, *Stereoscopic Photography*, 203. In his history of tomography, Steve Webb also maintains that Davidson was the "pioneer" of stereoradiography and the one who settled its "basic principles of viewing and measuring" (Webb, *From the Watching of Shadows*, 95, 102).
[70] Anon., "Obituary".
[71] "The relation of the observer to the object is not one of identity but an experience of disjunct or divergent images" (Crary, Techniques of the Observer, 120). See also Crary's account on Johannes Müller's physiology (Ibid., 88–96)
[72] Schiavo, "From Phantom Image to Perfect Vision."
[73] Ibid., 116.
[74] Silverman, "The Stereoscope and Photographic Depiction," 734–42.
[75] Cited in Ibid., 738.

of three-dimensional reality was about the "imitation of the powers of the eyes."[76] The mimetic reproduction thus implies that one follows the configuration of the visual apparatus. Brewster notably insisted that the distance between the two lenses was to be similar to the interocular distance and that the aperture should have been as small as the pupil: a stereoscopic camera was like "a forehead with two eyes in it."[77] Stereoscopic photography could thus recreate the visual process, provided that it reproduces the same triangulation the eyes would have in front of the real object. When this condition is met, the perception of reality and the perception of stereoscopic pictures conflate, leading the latter to be considered as the pinnacle of mimetic representation.

Such a view was not shared by all. Some authors quickly began to claim that the purpose of stereoscopy was not to imitate vision, but to *enhance* it. The distance between the two lenses could be increased in order to give more relief and more solidity to the apparent object. The aesthetic and heuristic possibilities of "telestereoscopy" – the term was coined by Hermann von Helmholtz – made the delight of its proponents, while the deformation induced by the technique was severly condemned by Brewster and his followers.[78]

This debate, especially vivid in artistic and entertainment photography, was never raised among medical practitioners. Telestereoscopy was implicitly condemned, since radiographers unanimously expressed their fear that "the relief is exaggerated or otherwise untrue."[79] For Hedley, it was vital "to ascertain […] what are the physical and physiological considerations upon which the extent of this displacement must be made to depend."[80] In other words, the stereoscopic method should reproduce to some extant the physiological conditions of natural binocular vision in order to provide a true relief. Hedley relied on the laws of the "*stéréoscopie de precision*," a series of relatively simple equations developed by Louis Cazes in 1895 and adapted to radiography by the French physicians Théodore Marie and Henri Ribaut.[81] The "*stéréoscopie de précision*" was driven by the need to maintain the relation between accommodation and convergence. In natural vision, there is a constant relation between convergence and accommodation **[Fig. 6a]**, while artificial stereoscopy implies a fundamental disparity: convergence is related to the *virtual distance* between the eyes and the figured object, and accommodation is defined by the *real distance* between the eyes and the material picture **[Fig. 6b]**.

[76] Cited in Schiavo, "From Phantom Image to Perfect Vision," 126; Silverman, "The Stereoscope and Photographic Depiction," 747.
[77] Cited in Ibid., 741.
[78] Ibid., 747–54.
[79] Hedley, "Radiostereoscopy."
[80] Ibid.
[81] Louis Cazes, *La Stéréoscopie de précision, théorie et pratique* (Paris: J. Michelet, 1895); Théodore Marie, and Henri Ribaut, "Stéréoscopie de précision appliquée à la radiographie," *Archives de physiologie normale et pathologique* [Serie 5] 9 (1897): 686–97.

According to Cazes, there is, however, a "*tolérance*" in accommodation, such as it is possible to obtain a certain range of variation in convergence while accommodation remains the same. The range of variation is inferred by experiments and enables Cazes to provide a formula defining the maximal thickness of the object in relation to the latter's distance from the observer.[82] By this alone, one could hope to obtain a correct relief.

While its purpose was the same, Hedley's method appears to be quite far from the precepts of Brewster and his followers. Those were *in fine* concerned with the triangulation of the two eyes and they neglected the relations between accommodation and convergence. However, Hedley's precision stereoscopy had little concern with the reproduction of the true dimensions of the human visual apparatus; it was motivated by considerations inspired by Helmholtzian physiological optics, accounting for the role of empirical acquisition in the development of the visual apparatus.[83]

Although it is undoubtedly more accurate than Brewster's approach, Hedley's method was little followed. Most radiographers continued to rely on Brewster's system. No mention was made about Ribaut and Marie in the following years, and when James Case acknowledged their work in a 1912 article, he specified, however, that he did not follow their method, but rather took a six centimeters distance.[84] The reproduction of the interocular distance appears to have been the only rule that was considered worthy of being followed. Once again, Davidson seems to have been at the origin of such a convention, although he did not give much importance to it. He firstly agreed that "[a]ny desired displacement […] may be given to the tube" before he admitted it would be better "to displace it about 6 cm., which may roughly be taken as the distance between our eyes."[85]

Of course, Hedley's method might have been neglected because of its complexity. In the late 1910s, Davidson complained that stereoradiography was still considered a "difficult […] process."[86] He clearly accused Hedley's followers who "complicate the subject by directions as to varying the displacement of the tube with its distance from the plate, and also with the thickness of the part to be radiographed."[87] However, even though Hedley's method was obviously quite impractical, that was

[82] Louis Cazes, *La Stéréoscopie de précision*, 31–39
[83] Timothy Lenoir, "The Eye as Mathematician. Clinical Practice, Instrumentation, and Helmholtz's Construction of an Empiricist Theory of Vision," in *Hermann von Helmholtz and the foundations of nineteenth-century science,* ed. David Cahan (Berkeley ; University of California Press, 1993) 109–53.
[84] Case, "The Importance of Stereoradiography," 76.
[85] Davidson, "Remarks on the Value of Stereoscopic Photography," 1669. See also *The Lancet* 152, no. 3909 (July 30, 1898): 302; *The Lancet* 153, no. 3936 (Feb. 4, 1899): 304.
[86] James Mackenzie Davidson, "Stereoscopic Radiography," *Archives of Radiology and Electrotherapy* 23, no. 11 (April 1919): 340.
[87] Davidson "Stereoscopic Radiography," 340–41.

not the reason it was neglected. Most radiographers favored Brewster's method because they considered it as a way to reach a perfect mimetic representation.

Indeed, the integration of stereoscopy with radiography led to curious considerations about the "realism" of the medium. When a reviewer marveled at "excellent and realistic stereoscopic x-ray photographs," one might wonder how could a picture be considered "realistic" while its main purpose was precisely to show what the eye cannot see.[88] When another author said, "[w]e are deceived into supposing we are directly viewing the object itself, and not two representations of it," it eludes that one did not actually see anything that looks like a real object – a real part of the body.[89] What was seen was, as I have already stressed, a "glass model" or "a mass of crystal," as James Case described it.[90] However, Case was himself confused by the nature of such a singular object. He claimed that the viewer of a stereoscopic x-ray picture "seems to be looking not merely *at* the organ, but *into* the organ."[91] The materiality of the picture disappears in favor of the object which is seemingly observed. It is tempting to consider that the viewer does not see a *representation* of a radiographed object, but a *real* object into which his sight penetrates. In view of the pervasive analogy between stereoscopy and the visual process, sight became *something like* an emanation of x-rays, a "monstrous" sight – as might have said Brewster if he knew about it – that "*no eye and no pair of eyes ever saw or can see*."[92] Obviously, no one expressed such a fanciful idea, but the terminological ambiguities evoke the fundamental ambiguity that existed in the very heart of stereoradiography.

Such ambiguity would not have been possible if radiography had not maintained such a close relation to photography. Bettyann Kevles has indeed stressed that radiography was widely considered among late nineteenth-century public "as the equivalent of taking a photograph with a flashlight inside the body."[93] Efforts to get rid of this confusion soon became necessary to radiographers.[94] Radiography was not to be compared with photography: it was just "a mere flat record of shadows," the "light and shade" being "nothing more than indications of relative opacity to the x rays."[95]

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[88] *The Lancet* 151, no. 3898 (May 14, 1898): 1352.
[89] Cotton, "The True and the False Perspective," 28.
[90] Case, "The Importance of Stereoradiography," 80.
[91] James Case, "The Stereo-Roentgenography of the Stomach and Intestine," *Archives of the Roentgen Ray* 17, no. 2 (1912): 47 (my emphasis).
[92] Cited in Silverman, "The Stereoscope and Photographic Depiction," 740 (my emphasis).
[93] Kevles, *Naked to the Bone*, 95. See also Natale, "The Invisible Made Visible," 349. According to Otto Glasser, this idea would have contributed to the early dismissal of radiography (Glasser, *Wilhelm Conrad Röntgen*, 43).
[94] About early debates on the reliability of radiographs, see Tal Golan, "The Emergence of the Silent Witness: The Legal and Medical Reception of X-Rays in the USA," *Social Studies of Science* 34, no. 4 (August 1, 2004): 480–92; Kevles, *Naked to the Bone*, 92–95.
[95] Hedley, "Radiostereoscopy." See also *The Lancet* 161, no. 4148 (Feb. 28, 1903): 590; Bailey, "Stereoscopic Radiography," 495; Cotton, "The True and the False Perspective," 26; Davidson, "A Method of Precise

However, if early radiographers repeatedly reassessed the peculiar status of x-ray pictures, it is likely they were still struggling with the temptation to conflate the two media.[96] The integration of stereoscopy with radiography undermined the objective status of the latter by bringing it from the realm of material pictures to that of mental objects. It is only because the underlying assimilation of radiography to photography never completely disappeared that x-rays can be considered "realistic." If one could have said that stereoradiography "really ceases to be a shadow," it is because radiography itself has always been more than just about shadows.[97]

Conclusion

In his short account on three-dimensional medical imaging, René Van Tiggelen briefly asserted that stereoradiography "never had a great success" and "found itself overtaken by tomography."[98] While it is true that the precision of tomography made depth cues given by stereoscopy obsolete, it is difficult to observe any correlation between the rise of the former and the progressive decline of the latter. It should be stressed that there has never been a complete disappearance of the medium, despite the enormous technical progresses of tomography.[99]

The importance of the medium for British radiography should be neither underestimated, nor reduced to its usefulness in medical diagnosis. Stereoradiography was also useful as a fashionable technique gathering and attracting medical practitioners; it was useful as a means of self-promotion within the profession; finally, it was useful as a way to entertain and to delight the eyes of even the most serious physicians. It was the solution to satisfy the "desire to see beneath or around other bones and internal organs," a desire, as Kevles has pointed out, that could not have been fully satisfied with a flat picture.[100] Stereoradiography not only brought the three-dimensionality that was hitherto lacking, but also became an avatar of vision itself. The lack of interest radiographers had for understanding the

Localisation"; J. F. Halls-Dally, "On the Use of the Roentgen Rays in the Diagnosis of Pulmonary Disease," *The Lancet* 161, no. 4165 (June 27, 1903): 1800; Case "The Importance of Stereoradiography," 80.

[96] Interestingly, in 1896, there was a terminological confusion: some of the first articles on radiography issued in *The Lancet* and T*he British Medical Journal* were entitled "new photography"(*The Lancet* 147, no. 3786 (March 21, 1896): 795–97; 147, no. 3787 (March 28, 1896): 875; 147, no. 3791 (April 25, 1896): 1159–61 ; and *The British Medical Journal* 1, no. 1840 (April 4, 1896): 874–76; 1, no. 1842 (April 18, 1896): 997–98).

[97] Emil G. Beck, "Roentgenology 1910. Stereoscopic Radiography as Diagnostic Aid in Pulmonary Tuberculosis," *American Journal of Roentgenology* 137, n° 4 (10 janvier 1981): 890–91.

[98] Tiggelen, "In Search for the Third Dimension," 266; Kevles, *Naked to the Bone*, 69.

[99] Although most contemporary handbooks on medical imaging do not even mention stereoscopy, some recent works on medical imagery have stressed the eventual benefits of the stereoscopic imaging (see Samei Ehsan, and Elizabeth Krupinski, *The Handbook of Medical Image Perception and Techniques* (Cambridge: Cambridge university press, 2010), 87).

[100] Kevles, *Naked to the Bone*, 107.

physiological features of binocular vision explains why they were quite confident that stereoscopy was as "perfect as actual binocular vision" the same way an 1852 article could claim that stereoscopic vision "is but perfect vision."[101] Thanks to the pervading analogy between the human visual apparatus and the machine, stereoradiography provided something of a *truer* reality. Indeed, to get rid of the opacity of the human body, one needed an x-ray picture, but the latter remained a tangible object that acted as the medium between sight and the reality of the inside body. One sees at the same time the picture as an object and the picture as a representation. On the contrary, stereoscopic pictures require to be observed *into* the instrument, in a such a way that the latter is itself not seen. With stereoradiography, the apparatus has vanished, leaving the viewer with the curious and fascinating impression that it is his sight itself that penetrates into the body.

[101] Cotton, "The True and the False Perspective," 28. As Davidson put, with a stereoscope, the two retinal images "will combine (as usual) and give rise to a single image in perfect relief" (Davidson "Remarks On The Value Of Stereoscopic Photography," 1671)