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Imaging Body Structure and Mapping Brain Function: A Historical Approach

Stacey A. Tovino†

I. INTRODUCTION

Now in its second decade, functional magnetic resonance imaging (fMRI) localizes changes in blood oxygenation that occur in the brain when an individual performs a mental task.[1] Physicians and scientists use fMRI not only to map sensory, motor, and cognitive functions, but also to study the neural correlates of a range of sensitive and potentially stigmatizing conditions, behaviors, and characteristics.[2] Poised to move outside the traditional clinical and research contexts, fMRI raises a number of ethical, legal, and social issues that are being explored within a burgeoning neuroethics literature.[3]

In this Article, I place these issues in their proper historical context. The ethical, legal, and social issues raised by advances in functional neuroimaging are challenging and somewhat distinctive, but they are not entirely new. Earlier methods of body imaging and brain mapping, including phrenology, x-ray, positron emission tomography, and single-photon emission computed

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1 David G. Norris, Principles of Magnetic Resonance Assessment of Brain Function, 23 J. Magnetic Resonance Imaging 794, 794 (2006).

2 See Stacey A. Tovino, Functional Neuroimaging Information: A Case for Neuro Exceptionalism?, 34 Fla. St. U. L. Rev. (forthcoming 2007) (manuscript at Part II, on file with author).

3 See, e.g., Sandra J. Ackerman, Hard Science, Hard Choices: Facts, Ethics, and Policies Guiding Brain Science Today (2006); Michael S. Gazzaniga, The Ethical Brain (2005); Neuroethics: Defining the Issues in Theory, Practice, and Policy (Judy Illes ed., 2006); Neuroethics: Mapping the Field (Steven J. Marcus ed., 2002); Neuroscience and the Law: Brain, Mind, and the Scales of Justice (Brent Garland ed., 2004); Dai Rees & Steven Rose, The New Brain Sciences: Perils and Prospects (2004); Steven Rose, The Future of the Brain: The Promise and Perils of Tomorrow's Neuroscience (2005); Laurence Tancredi, Hardwired Behavior: What Neuroscience Reveals about Morality (2005); Semir Zeki & Oliver Goodenough, Law and the Brain (2006); Symposium, Brain Imaging and the Law, 33 Am. J. L. & Med. (2007); Symposium, Neuroethics, 32 J. Med. Ethics 65 (2006); Symposium, Neuroethics, Am. J. Bioethics, Mar.-Apr. 2005, at 1-63; Symposium, Neuroethics, 50 Brain & Cognition 341 (2002).

tomography,[4] raised similar issues, and perhaps we can use our experiences with these sciences and technologies to help guide current functional neuroimaging policy.

This Article proceeds as follows. Part II explores the legacy of phrenology, the nineteenth-century pseudoscience of the mind in which the character of an individual allegedly could be read by measuring the relative size of bumps and dents on the individual's skull.[5] Phrenology was believed to be capable of identifying whether a particular individual had murderous tendencies, an impulse to propagate, the capacity to love children, or the ability to solve mathematical equations.[6] Because phrenology allegedly could reveal these pieces of information, phrenological examination results were considered valuable.[7] Employers wanted phrenological analyses to determine whom they should hire, insane asylums wanted them to determine how best to treat their patients, and criminal justice officials wanted them to reform their criminals.[8] Nineteenth-century courts also relied on phrenological principles to determine the sanity of testators and individuals accused of murder, as well as the mental states of plaintiffs and defendants in a variety of other judicial proceedings.[9] Individuals even wanted their own heads examined to help them select a vocation, determine their best method of education, and identify whom they should marry.[10] The head examinations were believed to be valuable, although even the subjects were sometimes surprised by their own phrenological results and occasionally tried to keep them private.[11]

After scientists began to dispute the validity of phrenology, the law responded in kind. Some jurisdictions prohibited the practice of phrenology, while others heavily regulated it.[12] National broadcasting codes made it unlawful to advertise phrenology services, and military, federal, and state courts refused to admit into evidence testimony based on phrenological principles.[13]

Part III shows how the discovery of x-ray technology at the turn of the twentieth century led to public amusement as well as ethical, legal, and social concerns. The ability of x-rays to peer inside the body figured prominently in cartoons, advertisements, poems, and plays, at the same time that male physicians were using female servants (and their long-hidden breastbones) to demonstrate the new technology.[14] Policymakers initially worried about the potential for inappropriate uses and disclosures of x-ray information, as illustrated by a New Jersey Assemblyman who reportedly introduced a bill that

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[4] An examination of other methods of brain study, including lesion studies, electroencephalography, magnetoencephalography, and computer-assisted tomography, likely would reveal similar themes. See generally Brain Mapping: The Methods (Arthur W. Toga & John C. Mazziotta eds., 2d ed. 2002) (providing background information on various methods of brain study).

[5] See infra notes 31-39.

[6] See infra note 42.

[7] See infra notes 41-43.

[8] See infra notes 41-43, 139-147.

[9] See infra notes 95-102 and accompanying text.

[10] See infra notes 95, 127-132.

[11] See infra notes 88, 90.

[12] See infra notes 116-123 and accompanying text.

[13] See infra notes 123-119 and accompanying text.

[14] See infra notes 158-168.

would prohibit the use of x-ray eyeglasses in theaters and other public places.[15] However, courts quickly accepted x-rays by admitting them into evidence in both civil and criminal proceedings.[16] The theme underlying these decisions was that the law needed to avail itself of medical and scientific advances.[17]

Fast-forwarding three quarters of a century, Part IV examines how positron emission tomography (PET) and single-photon emission computed tomography (SPECT) intensified ethical, legal, and social concerns in the 1980s and 1990s, especially as the forensic value of these technologies became known.[18] Unlike x-ray and other still photography, which reveal only body structure, PET and SPECT can identify in three-dimension areas of the brain that are metabolically correlated with certain mental functions.[19] These functional capabilities make PET and SPECT desirable in a variety of contexts, including those in which detecting the mental state or capacity of an individual is important.[20] Part IV shows how the existence of PET and SPECT evidence, or the lack thereof, influenced the outcome of many legal cases.[21]

Parts V and VI conclude that both old and new methods of body imaging and brain mapping raise ethical, legal, and social concerns, and that history may have a role in informing current functional neuroimaging policy.[22] The application of truth-in-advertising and other regulatory principles to the provision of fMRI services may be appropriate.[23]

II. PHRENOLOGY

The idea that the brain has specialized functional areas is not new.[24] The earliest surviving writing suggesting a correlation between brain structure and function is the Edwin Smith Surgical Papyrus, a seventeenth-century B.C. reproduction of an earlier manuscript that described several head wound cases and referred to the effects of such wounds on motor control, including walking.[25] Hippocrates recognized in the fifth century B.C. that a wound to the left side of the head could lead to convulsions on the right side of the body.[26] In the second century, Galen noted that hemiplegia could result from a lesion in the opposite

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[15] See infra note 165.

[16] See infra notes 169-184.

[17] See infra note 184.

[18] See infra notes 213-232.

[19] See infra notes 194 and 209.

[20] See infra notes 194-210.

[21] See infra notes 218-234.

[22] See Parts IV and V, infra.

[23] See Parts VI(A)-(D), infra.

[24] William R. Uttal, The New Phrenology: The Limits of Localizing Cognitive Processes in the Brain 1 (2001).

[25] Christine Temple, The Brain: An Introduction to the Psychology of the Human Brain and Behaviour 22-23 (1993); William J. Winslade, Confronting Traumatic Brain Injury: Devastation, Hope, and Healing 18 (1998).

[26] Hippocrates, On Injuries of the Head, in The Genuine Works of Hippocrates 157-58 (trans. and ed. Francis Adams, 1868); see also John C. Marshall & Gereon R. Fink, Cerebral Localization, Then and Now, 20 NeuroImage S2, S2 (2003) ("Hippocrates . . . was well aware that the brain was the material substrate underlying all cognitive, affective, and conative powers and processes.").

side of the brain.[27] Although Vesalius was not particularly receptive to the idea of cerebral localization,[28] Johann Schenk Von Grafenberg discovered in the sixteenth century that many language impairments resulted from injuries to certain parts of the brain, not paralysis of the tongue.[29] In the eighteenth century, Antonio Maria Valsalva verified the connection between an injury to one side of the head and paralysis on the contralateral side of the body.[30] By the end of the eighteenth century, many thinkers were ready to create functional maps of the brain.

A. The Rise of Phrenology

Franz Josef Gall, an anatomist and physiologist living in Austria, observed during his education that students who had good memories also had prominent foreheads.[31] Gall hypothesized that the part of the brain responsible for verbal memory must be located behind and slightly above the eyeballs.[32] To test his broader theory that certain parts of the brain were responsible for particular mental faculties, Gall began to examine the indentations and bumps on the heads of prisoners, insane individuals, and other individuals with extreme character traits.[33] Gall summarized his findings in a 1798 letter addressed to a Viennese censorship official that was subsequently reprinted in Der Neue Teutsche Merkur, the main literary journal of the Holy Roman Empire.[34] In his letter, Gall stated his belief that moral and intellectual qualities are innate; that the brain is composed of as many organs as there are faculties, tendencies, and feelings; that each organ produced a local protuberance, or bump, on the external surface of the skull; and that the size of each organ, which indicated its power of function, could be increased by exercise.[35] Gall also expressed his desire to "show that it is possible to ascertain different dispositions and inclinations by the elevations and depressions upon the head" and "present in a clear light the most important consequences which result therefrom to medicine, morality, education, and legislation a word, to the science of human nature."[36]

Gall's letter led to his ecclesiastical repression.[37] The Emperor Francis I forbade Gall from publicly lecturing in Austria in 1802 on the grounds that his

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[27] Walther Riese, A History of Neurology 81 (1959).

[28] Id.

[29] Arthur L. Benton & Robert J. Joynt, Early Descriptions of Aphasia, 3 Archives of Neurology, Aug. 1960, at 209.

[30] Sven-Göran Fransson & Andrea Rubboli, Antonio Maria Valsalva, 26 Clinical Cardiology 102 (Feb. 2003).

[31] Madeleine B. Stern, Heads and Headlines: The Phrenological Fowlers x (1971).

[32] John D. Davies, Phrenology: Fad and Science; A 19th-Century American Crusade 6-7 (1955); Pierre Schlag, Law and Phrenology, 110 Harv. L. Rev. 877, 880 (1997).

[33] Id.

[34] Franz Josef Gall, Letter from Dr. F. J. Gall to Joseph Fr[eiherr] von Retzer, upon the Functions of the Brain, in Man and Animals, in David G. Goyder, My Battle for Life: The Autobiography of a Phrenologist 143-52 (1857).

[35] Madeleine B. Stern, A Phrenological Dictionary of Nineteenth-Century Americans x (1982); Riese, supra note 27, at 92; Stern, supra note 31, at xi.

[36] Gall, Letter, supra note 34, at 152.

[37] Andrew E. Norman, Introduction to Orson Squire Fowler & Lorenzo Niles Fowler, Phrenology: A Practical Guide to Your Head, at vi (1969).

ideas were subversive of religion and morals.[38] Gall and his pupil, Johann Gaspar Spurzheim, moved to Paris to continue developing and teaching their theories, which later became known as phrenology, or the science of the mind.[39] In 1810, Gall published the first volume of his magnum opus, Anatomie et Physiologie du Système Nerveux en Général et du Cerveau en Particulier, which ultimately contained four volumes, the first two of which were coauthored by Spurzheim, and an atlas of illustrations.[40] Between 1822 and 1825, Gall published a six-volume, revised edition of Anatomie under the title Sur les Fonctions du Cerveau et Sur Celles de Chacune de ces Parties.[41] In these works, Gall identified and numbered twenty-seven different regions, or organs, of the brain, each of which housed an innate, universal faculty such as "Impulse to Propagation (1)," "Murder, carnivorousness (5)," "Larceny, sense of property (7)," "Arithmetic, counting, time (18)," and "Perseverance, firmness (27)."[42] Those who followed Gall's work may have been concerned for their privacy. Gall believed that his brain maps could be used to explain differences among individuals, advise employers regarding individuals with desirable qualities, and govern the masses.[43]

Despite his grand theories, Gall left some portions of his brain maps blank, presumably because he did not know which faculties resided therein.[44] Unlike some of his successors, Gall used more than one word to describe each organ, perhaps to show that he did not completely understand each organ's function.[45] And, because his early research involved individuals who only had striking head protuberances and extreme character traits, Gall expressed reservation regarding whether character actually could be read from the shape of just any person's head: "I have never pretended to distinguish the influence, which modification of the forms of the cranium slightly marked, may have on the character, or how its corresponding shades may be traced."[46] In light of these and other qualifications and admissions, Gall was regarded as an honest investigator and a scientific pioneer at his death in 1828.[47]

Although Spurzheim had worked with Gall on Anatomie et Physiologie du Système Nerveux, Spurzheim's name did not appear on the title pages of the last two volumes. The omission reportedly occurred because Gall and Spurzheim had

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[38] Temple, supra note 25, at 26; Davies, supra note 32, at 7; Norman, supra note 37, at vi.

[39] The word phrenology is derived from two Greek words meaning mind and discourse. Johann Gaspar Spurzheim, Outlines of Phrenology 1 (1832), reprinted in Significant Contributions to the History of Psychology, 1750-1920 (Daniel N. Robinson ed., 1978).

[40] Franz Josef Gall & Johann Gaspar Spurzheim, Anatomie et Physiologie du Système Nerveux en Général et du Cerveau en Particulier (vol. 1, 1810); Franz Josef Gall & Johann Gaspar Spurzheim, Anatomie et Physiologie du Système Nerveux en Général et du Cerveau en Particulier (vol. 2, 1812); Franz Josef Gall, Anatomie et Physiologie du Système Nerveux en Général et du Cerveau en Particulier (vol. 3, 1818); Franz Josef Gall, Anatomie et Physiologie du Système Nerveux en Général et du Cerveau en Particulier (vol. 4, 1819).

[41] Franz Josef Gall, Sur les Fonctions du Cerveau et Sur Celles de Chacune de ces Parties (vol. 1-6, 1822-25); Franz Josef Gall, On the Functions of the Brain and of Each of Its Parts (Winslow Lewis trans., vol. 1-6, 1835).

[42] Davies, supra note 32, at 8.

[43] Id.

[44] Id.

[45] Id.

[46] Id. at 39-40.

[47] Id. at 40.

a falling out before Gall published the last two volumes of Anatomie.[48] In any event, Spurzheim moved to England in 1814 and published a formal, English version of his theories, The Physiognomical System of Drs. Gall and Spurzheim, the following year.[49] In subsequent publications, Spurzheim changed some of Gall's theories, including deleting all faculties that were inherently evil, such as Gall's faculty of "Murder, carnivorousness."[50] Spurzheim also added several organs, changed several of the remaining organs' descriptions, and categorized the organs into propensities, sentiments, and intellect.[51]

The Edinburgh Review, a leading scientific journal, heavily criticized Spurzheim's revised system in 1815 on the grounds that it consisted of "a mixture of gross errors, extravagant absurdities, downright misstatements, and unmeaning quotations from Scripture," and that its lead author was ignorant and hypocritical.[52] Spurzheim defended himself by arranging a brain dissection at Edinburgh during which he responded to each criticism.[53] Perhaps unaware of the scientific criticism, the Victorian public continued to greet Spurzheim's revised phrenology with enthusiasm. They visited phrenological surgeries and consented to have their heads examined by individual practitioners of phrenology as well as phrenometers, machines that measured the relative dimension and distribution of head bumps.[54] Queen Victoria had her children's heads read, and George Eliot had her own head shaved and read twice.[55]

Spurzheim and his student, George Combe, brought phrenology to the United States in 1832 through lecture tours and demonstrations.[56] The following year, Amherst College student Henry Ward Beecher was assigned to debate the negative view of phrenology as a science in a college debate that likely was inspired by one of Spurzheim's or Combe's lectures.[57] After Beecher won the debate, he told the audience that he actually agreed with the theories he had just argued against and was converting to the science of phrenology.[58] Thereafter, Beecher and his classmate, Orson Squire Fowler, attended phrenology lectures and began lecturing on the subject themselves.[59] Although Beecher eventually returned to his theological studies, phrenology became a life-long passion and profession for Fowler and his younger brother, Lorenzo Niles Fowler. In 1835, the Fowler brothers opened a phrenology practice in New York City and charged one dollar for a head examination, a verbal analysis, and the completion of a head chart in which the faculties were marked in seven degrees (very small, small,

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48 Id. at 8.

49 Johann Gaspar Spurzheim, The Physiognomical System of Drs. Gall and Spurzheim: Founded on an Anatomical and Physiological Examination of the Nervous System in General, and of the Brain in Particular, and Indicating the Dispositions and Manifestations of the Mind (1815).

50 Davies, supra note 32, at 8.

51 Spurzheim, supra note 23, at 25-72 (identifying thirty-five different faculties).

52 John Gordon, The Doctrines of Gall and Spurzheim, 25 Edinburgh Rev. 263 (June 1815).

53 Davies, supra note 32, at 10.

54 Temple, supra note 25, at 27.

55 Id.

56 Stern, supra note 35, at x.

57 Norman, supra note 37, at vi-vii.; Davies, supra note 32, at 31; Stern, supra note 35, at xiii.

58 Norman, supra note 37, at vii; Davies, supra note 32, at 32.

59 Norman, supra note 37, at vii.

moderate, average, full, large, and very large), and three dollars for a more comprehensive written analysis.[60] The Fowlers' sale of phrenology services to the general public was the first, but certainly not the last, time the general public has been offered a form of neuroscientific testing. In 2006, the company No Lie MRI began offering fMRI lie detection services to the public at the price of $30 per minute.[61]

When an individual presented for a phrenological examination, the Fowlers quickly reviewed the individual's features to identify his or her general temperament. Coarse, large features suggested a bilious temperament, in which physical strength predominated over mental attributes.[62] Thin hair, small muscles, and pale skin suggested that the individual favored thought, study, and poetry.[63] The Fowlers then conducted a more thorough examination of the individual's skull, using their phrenology charts as a guide.[64] Similar to Gall and Spurzheim's brain maps, the Fowlers' charts were based on the assumption that the distance between the various organs provided information about the magnitude of a trait supported by the underlying brain region.[65] The thirty-seven faculties identified by the Fowlers included "Amativeness (Love between the sexes)," "Parental Love (Regard for offspring)," "Destructiveness (Executiveness—force)," "Self-Esteem (Self-respect—dignity)," "Size (Measuring by the eye)," "Calculation (Mental arithmetic)," and "Causality (Applying causes to effect)."[66] An optimum level existed for each faculty, and too much or too little of a faculty could be problematic.[67] Too little Size could lead to an inability to judge proportions, and too much Size could lead to an overemphasis of physical views.[68] Similarly, too little Calculation was believed to cause difficulty in assimilating and regulating facts and figures.[69]

The Fowlers also provided directions for cultivating and restraining each of the thirty-seven faculties[70] in the first edition of their famous text, Phrenology Proved, Illustrated and Applied,[71] and their monthly American Phrenological Journal, launched in 1838.[72] To cultivate Parental Love, for example, the Unmotherly were told to, "Play with and make much of children; try to appreciate their loveliness and innocence, and be patient and tender and indulgent toward them; and if you have no own children, adopt some, or provide

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[60] Stern, supra note 35, at xiv; Norman, supra note 37, at vi.

[61] E-mail from Joel Huizenga, Chief Executive Officer, No Lie MRI, to Stacey Tovino (May 23, 2006; 12:36:00 p.m.) (on file with Boston University School of Law). See generally No Lie MRI, available at http://www.noliemri.com/default.htm (last visited Oct. 21, 2006).

[62] Stern, supra note 31, at 17.

[63] Id.

[64] Id.

[65] Id.

[66] Norman, supra note 37, at xviii.

[67] Christine Temple, Developmental Cognitive Neuropsychology 255 (1997).

[68] Norman, supra note 37, at xviii.

[69] Id.

[70] Id. at xix.

[71] Orson Squire Fowler & Lorenzo Niles Fowler, Phrenology Proved, Illustrated, and Applied, Accompanied by a Chart, Together with a View of the Moral and Theological Bearing of the Science (1836).

[72] Stern, supra note 35, at xiii. The Journal was edited by the Fowler brothers and, eventually, their children until it ceased publication in 1911. Id.

something to pet and fondle."[73] To restrain Parental Love, the Good Mother was advised to, "Set judgment over against affection; rear them intellectually; give yourself less anxiety about them, and if a child dies, by all means turn your mind from that loss by seeking some powerful diversion."[74] Individuals who needed more Destructiveness were encouraged to, "Destroy anything and everything in your way; killing weeds, blasting rocks, felling trees, using edge tools."[75] Individuals who needed to restrain Destructiveness were directed "never [to] brood over injuries or indulge revengeful thoughts or desires, or aggravate yourself by brooding over wrongs."[76]

Several notable nineteenth-century Americans, including Ralph Waldo Emerson, Oliver Wendell Holmes, Susan B. Anthony, Lizzie Borden, Jenny Lind, Horace Greeley, Brigham Young, Lucretia Mott, Walt Whitman, Horace Mann, and Lola Montez, allowed one of the Fowlers, or another phrenologist, to read their heads.[77] After Lorenzo Niles Fowler read Walt Whitman's head in 1849, Whitman even described the results in two editions of his Leaves of Grass: "Leading traits of character appear to be Friendship, Sympathy, Sublimity, and Self-Esteem, and markedly among his combinations the dangerous faults of Indolence . . . and a certain swing of animal will, too unmindful, probably, of the conviction of others."[78]

B. Phrenological Findings and Applications

Many phrenological findings, perhaps coincidentally, proved true. Orson Squire Fowler reportedly described a particular subject as having "'No Conscientiousness! [N]ot a bit! No Approbativeness! No Feeling of Shame!'" before learning that the subject had killed a female slave.[79] A phrenologist told Allen Pinkerton that he "would make a capital detective; he would smell a rouge three miles" before Pinkerton became known as the father of the American private investigator.[80] Before his raid on Harpers Ferry, abolitionist John Brown presented for a phrenological examination during which it was found that, "This man has firmness and energy enough to swim up the Niagara river and tow a 74-gun ship, holding the tow-line in his teeth. He has courage enough to face anything that man may face, if he think it right, and be the last to retreat if advance be impossible."[81] Lorenzo Niles Fowler told the parents of a very young Clara Barton, the future founder of the American Red Cross, to "throw responsibility" upon young Clara in an effort to improve upon her shy, hypersensitive, and withdrawn personality.[82] Clara later viewed Fowler's analysis as an important moment in her life: "'Know thyself' became my text and my study. . . . It has enabled me to better comprehend the seeming

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[73] Orson Squire Fowler & Lorenzo Niles Fowler, Phrenology: A Practical Guide to Your Head 85 (1969).

[74] Id.

[75] Id. at 101.

[76] Id.

[77] Stern, supra note 35, at xiv, xviii, 14-19, 33-39.

[78] Davies, supra note 32, at 123-24; Norman, supra note 37, at x.

[79] Stern, supra note 31, at 18.

[80] Stern, supra note 35, at xiv.

[81] Id. at xv.

[82] Id.

mysteries about me . . . . It has enriched my field of charitable judgment; enlarged my powers of forgiveness . . ."[83]

Phrenology also "revealed" hidden information about its analysands. Humorist Samuel Langhorne Clemens (whose pen name was Mark Twain) used an assumed name in 1873 when he requested a head examination from Lorenzo Niles Fowler.[84] During this initial, incognito examination, Fowler discovered an indentation in Twain's skull that was interpreted as a "total absence of the sense of humor."[85] Three months later, Fowler welcomed a second visit from Twain, who announced himself using his pen name. During this examination, Fowler discovered a "'Mount Everest' of a 'bump of humor'" on Twain's head.[86] During a third examination conducted in 1901, Fowler's daughter, Jessie, revealed a serious, tragic, and reforming side to Twain's character – a popular view that did not develop until after Twain's death in 1910.[87] Although Twain wrote about his first two experiences with phrenology, he never referred to his third examination, perhaps because he had wanted to keep that part of his identity private.[88]

Like Gall and Spurzheim, the Fowlers believed that phrenology could be used as a basis for vocational counseling.[89] Lawyers required the "Mental-Vital temperament, to give them intensity of feeling and clearness of intellect; large Eventuality, to recall law cases and decisions; large Comparison, to compare different parts of the law and evidence . . . and large Language, to give freedom of speech."[90] Physicians, on the other hand, needed "large Perceptive Faculties, so that they may study and apply a knowledge of Anatomy and Physiology with skill and success . . . [and] full Destructiveness, lest they shrink from inflicting the pain requisite to cure . . . ."[91] American newspaper editor and politician Horace Greeley was so convinced of the usefulness of phrenology in the employment context that he argued in an 1852 editorial that railroad accidents could be reduced if trainmen were selected "by the aid of phrenology, and not otherwise."[92] Some employers apparently agreed with the Fowlers and Greeley and posted job advertisements that requested both personal references and phrenological analyses.[93] Although some job applicants may have preferred to keep the relative size of their faculties private, "[e]rrand boys and candidates for political office would be appraised by [phrenology's] standards."[94]

The perceived ability of phrenology to reveal the inner workings of the mind did not go unnoticed by the American judicial system. Both litigants and judges hoped that phrenology would be capable of determining the sanity of testators and individuals accused of murder, as well as identifying the mental states of plaintiffs and defendants in other judicial proceedings. In Brock v. Luckett's

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83 Id.
84 Id. at xviii.
85 Id.
86 Id.
87 Id. at xix.
88 Id.
89 Id. at xi.
90 Fowler & Fowler, supra note 71, at 200; Stern, supra note 35, at xi.
91 Id.
92 Norman, supra note 37, at x.
93 Davies, supra note 32, at 39; Stern, supra note 35, at x.
94 Stern, supra note 31, at xiv.

Executors,[95] an 1840 case examining the sanity of a Mississippi testator, counsel for the appellants took note of phrenology's then-popularity within the scientific community:

> It is impossible to investigate this cause, without investigating, to some extent, the doctrine of the mind, and the effects of disease on the various organs of which it is composed: for it is not believed to be a conceded fact, that no man having any regard for his reputation in medical science, would dispute that the brain is an aggregate, consisting of distinct organs, each having a distinct function, and that power of function is influenced by organic size.[96]

Judges also incorporated phrenological analyses into their written opinions. In Farrer v. State,[97] an 1853 murder case, the Supreme Court of Ohio was asked to decide whether there was sufficient evidence to prove that the defendant housekeeper was not guilty of poisoning an eight-year-old boy by reason of her insanity.[98] In his opinion, Justice Corwin noted that the defendant was "remarkably ugly" in part because her eyes "encroach[ed] on the space proper to the brain," and that the shape of her head was "unfavorable to the usual presumption of sound mind and full capacity."[99] Although Justice Corwin refused to take a position regarding phrenology as a science, he recognized that an "intelligent physician" could have made a diagnosis of insanity based on phrenological principles.[100] Phrenology continued to influence American legal decisions as late as 1908, when the Superior Court of Pennsylvania granted a divorce to an emotionally abused woman based in part on her husband's testimony that he had deficient self-esteem, as diagnosed by two phrenologists.[101] Today, courts continue to reference phrenology's impact on the civil law's understanding of mental disease and the criminal law's understanding of right and wrong.[102]

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[95] 5 Miss. 459, 1840 WL 2421 (Miss. Err. & App. 1840).

[96] Id. at *6. Counsel also recognized, however, that not everyone agreed with the principles of phrenology: "But whether phrenology is or is not the only true physiology of the brain . . ." Id.

[97] 2 Ohio St. 54 (1853).

[98] Id.

[99] Id. at 60.

[100] Id. ("Whether phrenology is a science or a delusion, we shall not judicially undertake to pronounce. . . . "). Five years after Farrer, Judge Ellsworth of the Supreme Court of Errors of Connecticut continued to struggle with the issue whether the scales of justice could rely on phrenology: "The particular physical theory too of the human mind adopted by some persons, very greatly influences their views about insanity; as for instance, the phrenologists, who maintain that the mind is not a unit . . ." In re Dunham, 27 Conn. 192, 1858 WL 1044, *6 (Conn. 1858) ("as for instance, the phrenologists, who maintain that the mind is not a unit, and that it often is diseased and enfeebled in some of its faculties or organs of manifestation while it is sound and healthy in others, and as to these sound faculties is properly chargeable with responsibility for their exercise while it is not as to the others.").

[101] Russell v. Russell, 37 Pa. Super. 348, 351 (1908).

[102] See, e.g., United States v. Freeman, 357 F.2d 606, 616 (2d Cir. 1966) ("In the pre-M'Naghten period, the concepts of phrenology and monomania were being developed and had significant influence on the right and wrong test. Phrenologists believed that the human brain was divided into thirty-five separate areas, each with its own peculiar mental function. The sixth area for example, was designated 'destructiveness.' It was located, we are told, above the ear

C. The Fall of Phrenology

Scientists began to dispute the validity of phrenology as a science well before Orson Squire and Lorenzo Niles Fowler died in 1887 and 1896, respectively.[103] Scientists argued that the Fowlers' methods were based on anecdotal descriptions of felonious criminals, the insane, and individuals such as Galileo and Edgar Allen Poe, who had extreme characteristics.[104] Scientists also criticized the Fowlers' lack of documented experiments and statistical validation, as well as their inability to replicate their brain maps across individuals.[105] In 1838, American anatomy professor Thomas Sewall published the first edition of his An Examination of Phrenology, in which he attacked phrenology on several grounds.[106] Among other things, Sewall argued that dissection of the brain did not reveal discrete areas, no exact relationship between the size of the brain and intelligence existed, and impairment did not always result to a faculty when the area in which the faculty allegedly resided was injured or destroyed.[107] Four years later, French physiologist Pierre Flourens published the results of his brain excisions, in which he concluded that brain functions were not localized in discrete areas of the brain and, moreover, that the different areas of the brain appeared to work in concert.[108] Although the phrenologists attempted to respond to Sewall, Flourens, and other opponents by amending their charts to include more faculties, the idea of phrenology as a science had collapsed.[109] By the beginning of the twentieth century, the inductive methods of pure science and medicine and Sigmund Freud's psychoanalysis made phrenology seem like a fad.[110] Today, phrenology is referred to either as junk science,[111] pseudoscience,[112] quackery,[113] or a "meaningless medical concept."[114]

Changes in the law reflected the fall of phrenology. In the twentieth century, many jurisdictions passed civil and criminal prohibitions against the practice of phrenology and other methods of fortune telling, character reading, and mind reading. Since 1953, the Georgia Legislature has allowed counties within the State to prohibit by ordinance the practice of phrenology, fortune telling, and

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because this was the widest part of the skull of the carnivorous animals."); Anderson v. State, 276 So.2d 17, 20 (1973) (same); State v. Johnson, 399 A.2d 469, 472 & n.2 (R.I. 1979) (same).

[103] Scott A. Huettel et al., Functional Magnetic Resonance Imaging 1 (2004); Davies, supra note 32, at 174.

[104] Davies, supra note 32, at 174.

[105] Id.

[106] Thomas Sewall, An Examination of Phrenology (1838).

[107] Id.; Davies, supra note 32, at 141.

[108] Riese, supra note 27, at 96.

[109] Huettel et al., supra note 103, at 1. See generally Schlag, supra note 32, at 886-96 (1997) (examining the critique of phrenology).

[110] Stern, supra note 35, at xix.

[111] See, e.g., General Electric Co. v. Joiner, 522 U.S. 136, 153 & n.6 (1997) (Stevens, J., concurring) ("An example of 'junk science' that should be excluded . . . as too unreliable would be the testimony of a phrenologist who would purport to prove a defendant's future dangerousness based on the contours of the defendant's skull.").

[112] Donald Simpson, Phrenology and the Neurosciences: Contributions of F. J. Gall and J. G. Spurzheim, 75 ANZ J. Surgery 475 (2005).

[113] Davies, supra note 32, at ix.

[114] United States v. Freeman, 357 F.2d 606, 616 (2d Cir. 1966).

other kindred practices.[115] The City of Lincoln, Nebraska, made it unlawful for an individual to "exercise, carry on, advertise, or engage" in the business of phrenology.[116] The South Carolina Legislature made phrenology and the "prediction of future events" illegal.[117] The Attorney General of the Virgin Islands, although not specifically mentioning phrenology, has clarified that mind reading violates local prohibitions against fortune telling.[118] National television programming codes even established blanket prohibitions against the advertising of phrenology.[119]

While some jurisdictions prohibited the practice of phrenology, others heavily regulated it. In the mid-1940s, the State of Florida taxed its phrenologists at the rate of $100 per year.[120] In the 1980s, Virginia's Henry County established an annual "license tax" of $2,500 for individuals engaged in the practice of phrenology.[121] Today, the Georgia Legislature continues to permit counties within the State to regulate or impose an annual tax of up to $1,000 on the practice of phrenology, fortune telling, and other kindred practices.[122]

Changes in evidence law also reflected the fall of phrenology. Military, federal, and state courts assigned phrenology to the lowest class of proffered evidence, which included "a junk pile of contraptions, practices, techniques, etc., that have been so universally discredited that a trial judge may safely decline even to consider them, as a matter of law."[123]

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[115] Ga. Code Ann. § 36-1-15 (2006) ("The county governing authority may by proper ordinance prohibit . . . the practice of fortunetelling, phrenology, astrology, clairvoyance, palmistry, or other kindred practices, businesses, or professions where a charge is made or a donation accepted for the services and where the practice is carried on outside the corporate limits of the municipality.").

[116] Lincoln, Nebraska Municipal Ordinances § 9.40.030 (1997), cited in Argello v. City of Lincoln, 143 F.3d 1152, 1152 (1998). See also Azusa Municipal Code § 8.52.060 ("No person shall practice or profess to practice or engage in the business or art of . . . phrenology . . . or any similar business or art, who either solicits or receives a gift or fee or other consideration for such practice, or where admission is charged for such practice."), cited in Spiritual Psychic Science Church v. City of Azusa, 39 Cal. 3d 501, 506 (1985).

[117] S.C. Code Ann. § 16-17-690 (2006).

[118] 1 Virgin Islands Op. A.G. 229, interpreting 14 V.I. Code § 221(a)(6) (2006).

[119] National Association of Broadcasters, The Television Code §§ IV(12) and IX(10) (19th ed. 1976), cited in Gemini Enterprises, Inc. v. WFMY Television Corp., 470 F. Supp. 559, 562 (1979).

[120] Fla. Stat. § 205.41 (1941) ("Every . . . phrenologist . . . shall pay a license tax of one hundred dollars; provided, that this section shall not be construed to require members of any recognized christian denomination who pray for the sick to obtain a license."), cited in Curley v. State, 153 Fla. 773, 776-77 (1943).

[121] Henry County, Virginia, Code art. III, ch. 5, § 5-10 (1983), cited in Adams v. Board of Supervisors, 569 F. Supp. 20, 21 (1983).

[122] Ga. Code Ann. § 36-1-15 (2006) ("The county governing authority may by proper ordinance . . . regulate, or tax the practice of fortunetelling, phrenology, astrology, clairvoyance, palmistry, or other kindred practices, businesses, or professions where a charge is made or a donation accepted for the services and where the practice is carried on outside the corporate limits of the municipality.").

[123] See, e.g., United States v. Gipson, 24 M.J. 246, 249 (1987) ("At the bottom [of the scientific evidence hierarchy] lies a junk pile of contraptions, practices, techniques, etc., that have been so universally discredited that a trial judge may safely decline even to consider them, as a matter of law. To that level have been relegated such enterprises as phrenology, astrology, and voodoo. In the middle is that range of scientific and technical endeavor that can neither be accepted nor rejected out of hand. To this group, based on the information available to us, we assign the polygraph."); Jack B. Weinstein & Margaret A. Berger, 4 Weinstein's Federal Evidence

D. Phrenological Reform

Although phrenology did not become the ultimate science of the mind, its principles formed the basis of several nineteenth-century reform movements in the areas of women's rights, education, mental health care, and criminal justice.[124] These reforms were no accident. The Fowlers repeatedly had expressed their hope and belief that phrenological principles would be used to perfect society: "Phrenologize Our Nation, for thereby it will Reform The World . . . Mould the Now Forming Character of Our Republic . . . Perfect our Republic . . . Reform governmental abuses. . . ."[125]

Women were one focus of the phrenologists. Spurzheim hoped that phrenology would elevate the status of women by giving them equal participation "in the labors of the mind."[126] Orson Squire Fowler was more specific: "Women's Sphere of Industry should . . . be enlarged till it equals that of men. . . ."[127] Fowler further argued that, "Printing, architecture, drawing, engraving, all the arts, all kinds of storekeeping and manufacturing, all departments of literature, telegraphy, law, legislation, public offices and clerkships . . . should be shared and filled equally by both."[128] Other phrenologists were convinced that phrenological tenets required women to be relieved of their binding corsets and, metaphorically, "the 'tight lacing' of their intellectual and moral lives."[129] Referred to as pioneer sex educators, many phrenologists also tried to bring sex out into the open and to encourage its study.[130] Lorenzo Niles Fowler even used phrenology to advise clients regarding whom they should marry.[131] Individuals who had large Amativeness, for example, were advised not to marry individuals who had small Amativeness.[132]

Phrenology impacted more than women, sexual relations, and marriage. Educational reforms also were a particular emphasis of many of the British and American phrenologists. Because the phrenologists believed that the mind was a collection of different organs, they discouraged methods of learning based solely on memorization, reasoning that memorization only trained the organs of Language and Eventuality.[133] Students needed to train all of their mental organs by singing, running, and avoiding unhealthy substances such as coffee and tobacco,[134] and by visiting museums, fields, gardens, and shops.[135] Educators also

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§ 702.05[3] (Joseph M. McLaughlin, ed., 2d ed. 1997) ("The reliability requirement is designed to exclude so-called "junk science" – conjuring up memories of the phrenology craze where the bumps on a person's head were felt in order to determine character traits--from federal courts. At the very least, scientific opinions offered under Rule 702 must be based on sound scientific methods and valid procedures."), cited in Logerquist v. McVey, 196 Ariz. 470, 481 (2000).

[124] Davies, supra note 32, at 71; Stern, supra note 35, at ix.

[125] The American Phrenological Journal for 1849, 11 Phrenological J. 12 (1849).

[126] Stern, supra note 35, at xi.

[127] Stern, supra note 31, at 167.

[128] Id.

[129] Stern, supra note 35, at xi.

[130] Id.

[131] Id.

[132] Id.

[133] Stern, supra note 35, at xi.

[134] George Combe, Lectures on Popular Education (1834); Johann Gaspar Spurzheim, Education, Its Elementary Principles Founded on the Nature of Man (1847); Orson Squire Fowler, Education and Self-Improvement (1847).

were instructed in the principles of phrenology during "Children, Their Health, Growth, Training & Schooling"[136] lectures, and were told not to severely punish students for misbehaving in school, because "no chastisement can ever be inflicted without the exercise of Combativeness and Destructiveness in the punisher."[137] Summarizing the importance of educational reforms, Lorenzo Niles Fowler stated that, "'The training of children is at the very foundation of society . . . . Reformers . . . commence at the beginning.'"[138]

Phrenological principles also were applied to the care and treatment of the insane. Phrenologists believed that insanity was caused by the "sickness of the Organs of the erring faculties, not by depravity of purpose,"[139] and that insanity could be cured.[140] Many insane asylum superintendents adopted these beliefs. A superintendent of two insane asylums located in Maine and Rhode Island, Isaac Ray documented in his famous Treatise on the Medical Jurisprudence of Insanity his belief that insanity was a physical disease that involved derangement of brain structures,[141] and argued in Mental Hygiene that insanity should be treated as a disease, not a behavior requiring punishment.[142]

Phrenology also was applied to principles of criminal justice.[143] The traditional theory of penology during the eighteenth century was that severe penalties would deter criminals from repeating their crimes and serve as an example of what might happen to potential criminals. This theory was based on the assumption that criminals and good citizens had similar minds.[144] Because the phrenologists believed that most criminals acted impulsively and did not have sufficient moral strength to be inhibited by the thought of punishment, they favored a program of moral treatment over severe penalties.[145] Gall perhaps led the call for the more gentle treatment of the insane: "Although we reserve to ourselves the right to prevent these unhappy beings from injuring us, all punishment exercised on them is not less unjust than useless . . . they merit indeed only our compassion."[146] The phrenologists' theories regarding penology worked their way down to the level of the state prison. Eliza Farnham, superintendent of the women's ward at Sing Sing, New York's third state prison, believed that the application of phrenological principles contributed to the reform of criminals in her institution.[147]

Although phrenology ultimately failed as a science, it left behind a formalized concept of cerebral localization[148] and the idea that science, perhaps a

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135 Stern, supra note 35, at xi.

136 Stern, supra note 31, at 190.

137 Id.

138 Stern, supra note 35, at xi.

139 Orson Squire Fowler, Education and Self-Improvement 43 (vol. 1, 1847).

140 Stern, supra note 35, at xii ("'Phrenology enables us to retain a proper balance between our physical and mental functions, to restore loss equilibrium, and to treat successful the various phases of insanity and other disorders.'").

141 Isaac Ray, A Treatise on the Medical Jurisprudence of Insanity (1838).

142 Isaac Ray, Mental Hygiene (1863).

143 Davies, supra note 32, at 98.

144 Id. at 99.

145 Id.

146 Gall, supra note 34, at 311-32.

147 Davies, supra note 32, at 103.

148 Uttal, supra note 24, at 20; Huettel et al., supra note 103, at 2.

science not too different from the pseudoscience of phrenology, could be used to investigate the functions of different regions of the brain.[149]

III. X-RAY

A. Röntgen's Rays

The development of x-ray technology at the turn of the twentieth century also raised ethical, legal, and social concerns, although these concerns grew out of the exposed structure of the human body, not the function of the brain. On November 8, 1895, German physicist Wilhelm Conrad Röntgen was working with a glass vessel into which metal electrodes had been sealed and from which the air has been removed by a vacuum system (also known as the "Crookes vacuum discharge tube") when he accidentally discovered a faint light shimmering on a nearby bench.[150] Röntgen discovered that the source of the light was a barium platinocyanide-coated screen that was lying on the bench.[151] After conducting several additional experiments, Röntgen found that the shimmering light, which he inferred were rays, could actually penetrate glass, air, and a variety of metals, but not a thin sheet of lead.[152] In the process of playing with the rays, Röntgen made an image of two of his fingers on the barium platinocyanide-coated screen and, over the next several weeks, made several other images using a photographic plate.[153] On December 28, 1895, Röntgen summarized his findings in a manuscript submitted to the Proceedings of the Physical Medical Society of Würzburg, entitled "Uber eine Neue Art von Strahlen" ("On a New Kind of Rays").[154] Röntgen's manuscript introduced the world to x-rays.[155] Röntgen's findings, which included a now famous x-ray image of his wife's fingers, one of which was encircled by a rather substantial wedding ring, were first published in Vienna's popular journal Die Presse on January 5, 1896.[156] The Die Presse piece noted the importance of Röntgen's rays to the future of medicine and surgery: "The surgeon could then determine the extent of a complicated bone fracture . . . he could find the position of a foreign body such as a bullet or a piece of shell much more easily than has been possible heretofore . . ."[157]

Notwithstanding their value to medicine and surgery, Röntgen's rays became both a source of public amusement and concern. In the six months following Röntgen's discovery, the fact that x-rays could peer inside the human body was made the subject of theatrical plays, and a London dry goods company began

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149 Stern, supra note 35, at xii; Stern, supra note 31, at 34.

150 Richard I. Frankel, Centennial of Röntgen's Discovery of X-rays, 164 W.J. Med. 498 (June 1996); Bettyann Holtzmann Kevles, Naked to the Bone: Medical Imaging in the Twentieth Century 2 (1997).

151 Frankel, supra note 150, at 498.

152 Id.

153 Id.

154 Id.

155 Id.

156 Andrzej Stasiak, Broken Symmetry, 2 EMBO Rep. 562 (2001).

157 Frankel, supra note 150, at 498.

offering for sale x-ray-proof lead panties.[158] One newspaper cartoon, showing three attractive women frolicking on the beach in swimsuits designed to look like skeletons, read: "Cameramen see through the Bathing Beauties at Malibou Beach."[159] Other cartoons in which tax authorities and highway robbers used x-rays to find hidden moneys and full pockets also were published.[160] Manufacturers of x-ray machines even incorporated privacy themes into their marketing materials. One manufacturer's advertising pamphlets, published in 1896, came with red-tinted glasses.[161] When the demurely dressed cover girl was viewed through the glasses, only her skeleton could be seen.[162] A second x-ray machine advertisement, entitled "Naked Truth," featured two undressed women.[163] Emily Culverhouse even wrote a poem in 1897 about the loss of privacy resulting from Röntgen's rays:

> An Englishman's body belongs to himself,
> But surely that proverb was made
> Before Dr. Roentgen's impertinent rays,
> With furtive, adumbrate, and mystical ways,
> Our structures began to invade.
>
> 'T is an "habeas corpus" of uncanny source,
> A forerunner of agencies evil,
> A gruesome, weird, and mysterious force,
> (But clothed in a garb of science of course)
> A league between man and the devil.
>
> For a steady gaze thrown on the sensitive plate.
> With a one-ness of theme and conception.
> And fixing our minds in a uniform strain.
> Will picture the image begot by our brain.
> And reveal our most inmost perception.
>
> Who among us is safe if this can be done,
> Who can bear such a scrutinization?
> Scant courtesy, too, our friends would afford.
> When they find that our actions are often a fraud.
> And our words but mis representation.[164]

Röntgen's rays also raised legal and ethical issues. A New Jersey Assemblyman reportedly introduced a bill to the New Jersey Legislature on

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[158] Kevles, supra note 150, at 27; Arne Hessenbruch, A Brief History of X-Rays, 26:4 Endeavour 137 (December 1, 2002).

[159] Lisa Cartwright, Screening the Body: Tracing Medicine's Visual Culture 122 (1995).

[160] Hessenbruch, supra note 158, at 137.

[161] Kevles, supra note 150, at 27.

[162] Id.

[163] Id. at 29; Cartwright, supra note 159, at 122.

[164] Kevles, supra note 150, at 28.

February 19, 1896, that would have prohibited the use of x-ray glasses in theaters and other public places.[165] Women became the most frequent subjects of early x-ray research – research that was conducted primarily by men.[166] French physician Charles Bourchard made his female servant the subject of an x-ray demonstration and exposed her breastbone to his colleagues in 1896, a time when women's bodies were still considered somewhat a mystery.[167] Highlights and Shadows, a 1937 film by filmmaker-radiographer James Sibley Watson, contains several sequences featuring an attractive woman in a bathing suit, accompanied by a discussion of how x-rays have made women more vulnerable.[168]

B. Forensic Use of X-Ray

X-rays were first used for forensic purposes two months after Röntgen's discovery.[169] In 1895, Canadian George Holder shot fellow countryman Tolman Cunnings in the leg during a barroom brawl.[170] Although health care providers at Montreal General Hospital were able to stabilize Cunnings following the shooting, they could not find the bullet, and Cunnings continued to suffer great pain even after his hospital discharge.[171] By the time the criminal case against Holder had reached the Court of Queen's Bench in Montreal in 1896, Cunning's lawyer had heard of Röntgen's rays and requested a McGill University physics professor to use the new rays to locate the bullet inside Cunning's leg.[172] An x-ray image was used to guide the surgical removal of the bullet, and then both the bullet and the image were admitted and considered key evidence in Holder's subsequent conviction and fourteen-year prison sentence.[173]

The first American case to admit an x-ray as evidence was tried in Denver, Colorado, in 1896.[174] Although judges in several prior American cases had refused to admit Röntgen's rays as evidence on the grounds that "'there is no proof that such a thing is possible,'"[175] and defense counsel in the Denver case argued against the admission of the proffered impacted femur fracture x-ray for three straight hours, Judge Owen E. Le Fevre decided to admit the x-ray into evidence, reasoning that the judicial system should take advantage of the ability of modern science to uncover hidden mysteries:

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[165] See, e.g., id. at 27 & n.14; Philip C. Goodman, The New Light: Discovery and Introduction of the X-Ray, 165 Am. J. Roentgenology 1041, 1043 (1995). But see Joel D. Howell, Technology in the Hospital: Transforming Patient Care in the Early Twentieth Century 142 & n.39 (1995) ("There is no record of the bill's passage; in fact, there is reason to doubt whether the bill was actually ever introduced.").

[166] Cartwright, supra note 159, at 154.

[167] Kevles, supra note 150, at 30.

[168] Cartwright, supra note 159, at 155.

[169] Kevles, supra note 150, at 30-31.

[170] Id.

[171] Id.

[172] Id.

[173] Id.

[174] Id. at 31.

[175] Id. at 32 & n.17.

> We have been presented with a photograph taken by means of a new scientific discovery . . . . It knocks at the temple of learning; what shall we do or say? Close fast the doors or open wide the portal? Rather let the courts throw open the doors to all well considered scientific discoveries. Modern science has made it possible to look beneath the tissues of the human body and has aided surgery in telling of the hidden mysteries. We believe it to be our duty in this case to be the first, if you please to so consider it, in admitting in evidence the process known and acknowledged as a determinate science. The exhibits will be admitted in evidence.[176]

The following year, the Supreme Court of Tennessee also was asked to admit an x-ray into evidence to prove that the plaintiff had suffered a compound leg fracture.[177] In deciding to admit the x-ray, the Court reasoned that it could identify no "sound reason . . . why a civil court should not avail itself of this invention, when it was apparent that it would serve to throw light on the matter in controversy."[178] The Court analogized x-rays to hand-drawn maps that had been admitted as proof of a scene of an event.[179] The Court warned, however, that not all x-rays would be admissible, and that the trial judge would consider proof of the correctness of the x-ray and its usefulness to the jury, as well as the science, skill, experience, and intelligence of the individual who took the x-ray and testified in support of its admission.[180]

Other judges writing in the late nineteenth century opined that the law should take full advantage of developments in medicine and science in order to shed light on the truth. In an 1897 case involving the alleged negligence of a defendant landowner in failing to keep his property properly fenced, Justice Clark of the Supreme Court of North Carolina argued in his dissent that a photograph taken two months after the accident should not have been admitted because it did not correctly represent the property's condition and its

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[176] Id. at 32 & n.18.

[177] Bruce v. Beall, 41 S.W. 445, 446-47 (Tenn. 1897).

[178] Id. at 446.

[179] Id. ("Maps and diagrams of the locus in quo drawn by hand are often used to aid a judge or a jury to an intelligent conception of the matters to be determined, and no one would think of questioning the competency of the testimony of a witness . . .").

[180] Id. at 447. See also Varner v. Varner, 9 Ohio C.D. 273, 1898 WL 579, *3 (Ohio Cir. 1898) ("It is settled beyond dispute, that in proper cases, maps of places, photographs of places-scenes, lands, machinery, of persons as to identity may be introduced to aid the jury in applying the other evidence . . . . But their introduction must be preceded by some proof of the correctness of the map or the photograph, for there is no legal presumption that they are correct."); Jameson v. Weld, 45 A. 299, 303 (Me. 1899) ("We think it is within the discretion of the presiding judge to admit an X-ray photograph. Whether it is sufficiently verified, whether it appears to be fairly representative of the object portrayed, and whether it may be useful to the jury, are preliminary questions addressed to him . . ."); Miller v. Dumon, 64 P. 804, 805 (Wash. 1901) ("Photographs taken by the common processes are generally held admissible as evidence, and there would seem to be no reason for making a distinction between an X-ray and a common photograph; that is, either is admissible as evidence when verified by proof that it is a true representation of an object which is the subject of the inquiry."). Today, the verification of x-rays prior to their introduction as evidence may require additional proof. See, e.g., D.E. Ytreberg, Preliminary Proof, Verification, or Authentication of X-rays Requisite to their Introduction in Evidence in Civil Cases, 5 A.L.R.3d 303, 303 (1966) (listing the types of proof that may be required).

surroundings at the time of the accident.[181] Justice Clark also stated, however, that, "The law avails itself of every advance in science which renders the investigation of truth more accurate . . . . Law, like medicine, must make use of every improvement that will secure greater certainty in attaining its object."[182] Writing the same year in a medical malpractice opinion, the Court of Common Pleas of Ohio admitted two x-rays of the plaintiff's injured femur into evidence, reasoning that, "Scientists, by the aid of that wonderful and mysterious force we call electricity, have discovered a process by which they are enabled to procure a photograph, showing the size and shape of the living human body with a fair degree of accuracy."[183] The duty of law to keep up with advances in science, regardless of the novel legal questions raised thereby, is a consistent theme in the first three decades of x-ray technology.[184]

While confirming that, "It is the duty of courts to use every means for discovering the truth reasonably calculated to aid in that regard," many courts clarified that the duty did not apply until the discovery had moved beyond the "experimental stage."[185] Other courts recognized that x-rays could be inaccurate and misleading to the jury due to the ability of the individual operating the x-ray machine to magnify or minimize the resulting image.[186] Still other courts recognized the difficulty of balancing the benefits of scientific progress against the risks posed by charlatans.[187] By 1899, four years after Röntgen's discovery, courts were taking official judicial notice of x-ray technology,[188] although courts

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[181] Hampton v. Norfolk & W.R. Co., 27 S.E. 96, 98 (N.C. 1897) (Clark, J., dissenting).

[182] Id. at 98-99 (Clark, J., dissenting).

[183] Tish v. Welker, 5 Ohio Dec. 725, 1897 WL 762, *7 (Ohio Com. Pl. 1897).

[184] See, e.g., Eckels v. Boylan, 136 Ill. App. 258, 1907 WL 2183, *4 (Ill. App. 1 Dist. 1907) ("The law of evidence must be kept up with the advance of science."); Lupton v. Southern Express Co., 86 S.E. 614, 615 (N.C. 1915) ("'The administration of justice profits by the progress of science . . .'"); People v. Sallow, 165 N.Y.S. 915, 100 Misc. Rep. 447 (1917) (publication page references not available) ("Nor does the fact that it [finger print impressions] presents to the court novel questions preclude its admission upon common-law principles. The same thing was true of . . . X-ray photographs, and yet the reception of such evidence is a common occurrence in our courts."); Demopolis Telephone Co. v. Hood, 102 So. 35, 37 (Ala. 1924) ("The evidence afforded by the advance in science, in making discovery of the hitherto unseen and unknown, is generally admitted in American jurisprudence.").

[185] Mauch v. City of Hartford, 87 N.W. 816, 819 (Wis. 1901). See also State v. Matheson, 103 N.W. 137, 139 (Iowa 1905) (same).

[186] Miller v. Minturn, 83 S.W. 918, 919 (Ark. 1904) ("[T]hey are not infallible and may be misleading."); Kruger v. McCaughey, 149 Ill. App. 440, 1909 WL 2061, *2 (Ill. App. 3 Dist. 1909) ("While sufficient foundation was laid to permit the X-ray skiagraph of appellee's arm to be introduced in evidence, such skiagraph is by no means conclusive as to the conditions actually existing in the arm. The skiagraph is not a picture of the object or substance itself, but of the shadow merely which is cast by such object or substance, and the evidence discloses that the picture thus produced is frequently inaccurate and misleading, owing to divergence and distortion. It is easily within the ability of a person operating an X-ray machine to magnify or minimize the appearance of an existing condition.").

[187] Brinkley v. Hassig, 83 F.2d 351, 353 (10th Cir. 1936) ("It is true, as counsel argue, that the great advances in medical science have come about by the courage of pioneers, whose efforts often met with ridicule from their professional brethren . . . . It is also true that charlatans masquerading as doctors defraud the public to their own enrichment by promising to cure cancer with innocuous ointments, and thus endanger the lives of their patients by depriving them of sound medical advice.").

[188] Wittenberg v. Onsgard, 81 N.W. 14, 16 (Minn. 1899) ("Its utility and the reliability of its results are already so well established as scientific facts that courts ought to take judicial notice of them."); People v. Jennings, 96 N.E. 1077, 1082 (Ill. 1911) ("When photograph was first

were not requiring parties to submit to x-ray because its safety had yet to be established.[189]

Although x-ray is capable of showing the detailed structure of the skull, it cannot distinguish among the brain's soft tissues.[190] X-ray also does not reveal how the brain functions,[191] a limitation of which nineteenth-century courts were aware. In an 1898 case in which a will was contested based on the alleged undue influence of the testator's son, the Circuit Court of Ohio was asked to pass on the admissibility of a photograph of the testator that was taken two years after the execution of the will.[192] In holding that the photograph was not admissible, the Court explained:

> [W]e know of no claim of science or the art of photography that a picture or likeness can be taken of the intangible, immaterial mind. The most devout believer in the efficacy of the X rays has never urged them as a means of discovering the mind or any of [its] attributes.
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> This photograph was passed to the jury for inspection, and they were asked for the time being, to become psychologists and mind readers—to determine from the looks and features portrayed, the degree of mental capacity and the power of the disposing memory of the subject of the picture; a class of evidence impossible of cross examination, and making impressions on jurors beyond the touch or reach of argument.[193]

IV. POSITRON EMISSION TOMOGRAPHY AND SINGLE-PHOTON EMISSION COMPUTED TOMOGRAPHY

Although x-ray and other still pictures could not reveal the inner workings of the mind, later technologies, including positron emission tomography (PET) and single-photon emission computed tomography (SPECT), could.[194] The history of PET dates back to the 1940s, when Hungarian George de Hevesy discovered that the radioactivity of an isotope could be tracked.[195] In PET, atoms from certain

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introduced it was seriously questioned whether pictures thus created could properly be introduced in evidence, but this method of proof, as well as by means of X-rays and the microscope, is now admitted without question.").

[189] Id. at 17 ("Hence a party ought not to be required to submit his person to the X-rays until it is so well established as a fact in science that the process is harmless . . ."). The risks of x-ray, including burns that refused to heal and fatal cancers, were discovered almost immediately. See, e.g., Peter Montague, The Major Cause of Cancer, Part I, Rachel's Environmental & Health News, Mar. 16, 2000, available at http://www.ratical.org/radiation/REHW691.html (last visited Oct. 16, 2006). The first actions for damages due to negligent x-ray exposure appeared in 1899. See, e.g., Schmidt v. Balling, 91 Ill. App. 388, 1899 WL 4810 (Ill. App. 1 Dist. 1899).

[190] Uttal, supra note 24, at 61.

[191] Id.

[192] Varner v. Varner, 9 Ohio C.D. 273, 1898 WL 579, *3 (Ohio Cir. 1898).

[193] Id. at *4.

[194] Huettel et al., supra note 103, at 3; Uttal, supra note 24, at 69.

[195] Joseph Dumit, Picturing Personhood: Brain Scans and Biomedical Identity 27-28 (2004).

positron-emitting isotopes[196] are used to "tag" molecules of the compound of interest, which are then injected intravenously into the subject's body.[197] These compounds are referred to as biological tracers because they are used to trace or probe biological processes.[198] The atoms of the isotopes, which are attached to the biological probe, have very short half-lives and emit a positively charged electron, or a positron, in the process of decay.[199] When this positron collides with an electron, the two particles annihilate each other and the result is the emission of two gamma rays in opposite directions, 180 degrees apart.[200] A PET scanner contains circular gamma ray-detectors that detect the gamma rays as they simultaneously leave the patient's body.[201] This information is fed into a computer, which determines the line, called a coincidence line, along which the annihilation took place.[202] By combining coincidence lines from many different angles over time, PET makes it possible to determine the rate of biological processes in which the probe is involved.[203]

In 1973, Michael Phelps, Edward Hoffman, and Michael Ter-Pogossian at Washington University in St. Louis built the first PET scanner, which collected twelve coincidence lines of response between detectors.[204] Phelps eventually moved to UCLA, where he moved PET technology into the mainstream of medical imaging.[205] Today, PET is known for its ability to measure local neuronal activity, neurochemistry, and pharmacology in the human brain.[206] Current clinical uses of PET include diagnosing head trauma and locating cancer in the brain.[207] PET also allows research scientists to see in three-dimension the areas of the brain that are metabolically correlated with certain mental functions, such as seeing faces, reading sentences, and touching or moving a part of the body.[208] Research using PET has contributed to the understanding of oxygen utilization and the metabolic changes that accompany disease, including Alzheimer's disease, Parkinson's disease, epilepsy, coronary artery disease, and

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[196] Simon R. Cherry & Michael E. Phelps, Imaging Brain Function with Positron Emission Tomography, in Brain Mapping: The Methods 192 (Arthur W. Toga & John C. Mazziotta ed., 1996); D. Frank Benson et al., Positron-Computed Tomography in Neurobehavioral Problems, in Localization in Neuropsychology 123 (Andrew Kertesz ed., 1983).

[197] Cherry & Phelps, supra note 196, at 192; Randy L. Buckner & Jessica M. Logan, Functional Neuroimaging Methods: PET and fMRI, in Handbook of Functional Neuroimaging of Cognition, ed. Roberto Cabeza and Alan Kingstone (Cambridge: MIT Press, 2001), 28.

[198] Cherry & Phelps, supra note 196, at 192.

[199] Per E. Roland, Brain Activation 427 (1993).

[200] E. Jeffrey Metter & Wayne R. Hanson, Use of Positron Emission Tomography to Study Aphasia, in Localization and Neuroimaging in Neuropsychiatry 124 (Andrew Kertesz ed., 1994); Roland, supra note 199, at 428; Cherry & Phelps, supra note 196, at 192.

[201] Roland, supra note 199, at 428-29.

[202] Benson et al., supra note 196, at 123-24.

[203] Cherry & Phelps, supra note 196, at 192.

[204] Michael E. Phelps et al., Application of Annihilation Coincidence Detection to Transaxial Reconstruction Tomography, 16 J. Nuclear Med. 210-33 (1975); Dumit, supra note 195, at 27, 29.

[205] Cherry & Phelps, supra note 196, at 197-98.

[206] Robert T. Malison, Positron Emission Tomography and Single-Photon Emission Computed Tomography, in Brain Imaging in Substance Abuse: Research, Clinical, and Forensic Applications 29 (Marc J. Kaufman ed., 2001).

[207] University of Texas Health Science Center at San Antonio, PET Division, available at http://ric.uthscsa.edu/facts/pet.html (last visited Jan. 20, 2007).

[208] Huettel et al., supra note 103, at 3-4.

drug and alcohol abuse.[209] Psychiatrists also have used PET to conduct extensive studies of depression, schizophrenia, and bipolar disorder.[210]

Like phrenology and x-ray before it, PET's ability to peer inside the body and the mind did not go unnoticed by the media. A July 1983 issue of Vogue, the popular fashion magazine, contained an article showing three colorful PET scans: one of a "normal" brain, one of a "depressed" brain, and one of a "schizo" brain.[211] The suggestion was that PET could reveal mental illness in a way unlike any other technology or technique.

The first legal cases involving PET appeared in the 1980s. In Roach v. Martin,[212] a 1985 habeas corpus case, the Fourth Circuit considered whether the petitioner was entitled to an evidentiary hearing based on "newly-discovered evidence."[213] The petitioner, who had been convicted of murder, criminal sexual conduct, armed robbery, and kidnapping, wanted to use a PET scan – which petitioner's counsel described at oral argument as a "breakthrough in neuroscience research" – to prove that the petitioner had Huntington's Disease (HD) even though he had yet to experience any symptoms.[214] The petitioner hoped that proof of his HD would preclude the imposition of the death sentence under the Eighth Amendment's prohibition against cruel and unusual punishment.[215] Because the medical literature the court reviewed confirmed that PET could not then diagnose HD presymptomatically, the Fourth Circuit held that the petitioner was not entitled to an evidentiary hearing.[216]

PET's forensic value increased in the 1990s. In the 1992 case of People v. Weinstein,[217] the defendant allegedly strangled his wife in their twelfth-floor apartment in Manhattan and then threw her body from a window to make her death appear as a suicide.[218] Counsel for the defendant argued that he was not criminally responsible for killing his wife due to "mental disease or defect," and sought to admit PET scans of the defendant's brain showing a cyst and metabolic imbalances in support of this argument.[219] Although the District Attorney argued that PET was not yet sufficiently reliable[220] and that the mathematical formulae used to quantify PET test results had not gained general acceptance in the relevant technological and medical fields,[221] the court did allow testimony concerning the results of the defendant's PET scans, noting that "PET is a highly advanced form of medical technology."[222] Dozens of other cases address the

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[209] University of British Columbia, Triumf PET Programme, Positron Emission Tomography, available at http://www.triumf.ca/welcome/petscan.html (last visited Jan. 20, 2007).

[210] Dumit, supra note 195, at 27.

[211] Joseph Hixson, New Seeing-Eye Machines . . . Look Inside Your Body, Can Save Your Life, Vogue, July 1983, at 238.

[212] 757 F.2d 1463, 1469-70 (4th Cir. 1985).

[213] Id.

[214] Id. at 1473-74.

[215] Id. at 1474.

[216] Id.

[217] 591 N.Y.S.2d 715 (1992).

[218] Id.

[219] Id. at 717-718.

[220] Id. at 718.

[221] Id. at 723. See also id. at 724 ("PET and [skin conductance response] test results in this case pass the test of admissibility . . .").

[222] Id. at 723.

relevance and admissibility of PET and SPECT,[223] which is part of the same family of nuclear imaging techniques as PET, to prove a variety of mental states, brain injuries, and brain abnormalities,[224] and some courts appear to have taken judicial notice of the technologies: "[t]here is no dispute as to the efficacy of SPECT-Scans in measuring brain blood flow and thus metabolism."[225]

The existence of PET and SPECT evidence, or the lack thereof, has been crucial to the outcome of many cases. In Bushell v. Secretary,[226] the parents of a child who received diphtheria, pertussis, and tetanus vaccinations sought compensation under the National Vaccine Injury Compensation Program for the child's seizures and mental retardation, which the parents believed the vaccinations caused.[227] The court rejected the parents' allegations solely because a PET scan showed that a malformation of the child's brain prior to birth caused the child's seizures.[228] In In re Air Crash at Little Rock,[229] the Eighth Circuit refused to award damages under the Warsaw Convention to Anna Lloyd, an international airplane passenger who allegedly suffered post-traumatic stress disorder (PTSD) following the crash of her plane.[230] The Eighth Circuit based its decision on the lack of any PET or SPECT evidence of Lloyd's alleged PTSD:

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[223] Single-photon emission computed tomography (SPECT) also measures local neuronal activity, neurochemistry, and pharmacology in the human brain, but in a slightly different way than PET. Whereas PET infers the site of an annihilation event from the coincidence detection of photons, SPECT infers photon paths from their ability to pass through a collimator that has certain long and narrow holes. Robert T. Malison, Positron Emission Tomography and Single-Photon Emission Computed Tomography, in Brain Imaging in Substance Abuse: Research, Clinical, and Forensic Applications 31-32 (Marc J. Kaufman ed., 2001). Whereas PET employs a circular ring of radiation detectors, SPECT usually collects data through several rotating detector heads. Id. at 33. SPECT is more simple and less expensive than PET, although frequently noted for its lower resolution. Id. Today, SPECT frequently is used in brain perfusion imaging and to study dementia, stroke, trauma, seizures, schizophrenia, and several other neurodegenerative processes. Tuberous Sclerosis Alliance, Images of the Living Brain (Silver Spring, Md.: Tuberous Sclerosis Alliance, 2004), 2.

[224] See, e.g., United States v. Gigante, 996 F. Supp. 194 (E.D. N.Y. 1998); State v. Red Dog, 1993 WL 144867, *2 (Del. Super. 1993) (in which defense counsel argued that a PET or SPECT scan would be necessary to accurately determine the existence of any temporal lobe impairment in the defendant's brain function); Rhilinger v. Jancsics, 1998 WL 1182058 (Mass. Super. 1998) (discussing the appropriateness of using a SPECT scan to diagnose an individual with toxic solvent encephalopathy); Friedrich v. Intel Corp., 181 F.3d 1105, 1108, 1112 & n.6 (9th Cir. 1999) (allowing an abnormal SPECT scan to support a patient's action for long term disability benefits based on her chronic fatigue syndrome); Baxter v. Ohio Dep't of Transp., 2002 WL 31838505, *7 (Ohio App. 10 Dist. 2002) (testimony and opinions by expert witness who testified that SPECT scan provided objective evidence of diminished brain activity should not have been disregarded).

[225] Freels v. Commissioner, 2001 WL 1809412, *3 (Ga. Super. 2001).

[226] 1993 WL 212472, *1 (Fed. Cl. 1993).

[227] Id.

[228] Id. at *2.

[229] 291 F.3d 503 (8th Cir. 2002).

[230] Id.

> [T]here is a complete lack of proof that Lloyd actually suffers from physical changes to her brain as a result of chronic PTSD. Lloyd was not given a magnetic resonance spectroscopy, a position emission tomography (PET) scan or a single positron [sic] emission computed tomography (SPECT) scan, all tests which Dr. Harris testified could have been utilized to show the functioning of Lloyd's brain . . . . The only evidence that Lloyd's brain actually underwent a physical change was Dr. Harris's otherwise unsupported opinion that it did . . . . We find that this testimony was not adequate, as a matter of law, to establish a physical change to Lloyd's brain.[231]

PET's forensic value became so well-known that most of the referrals to the PET Laboratory at the University of California at Irvine during the mid-1990s came from defense attorneys requesting PET scans of the brains of their clients, who had been convicted of felonies and were awaiting sentencing.[232] However, concerns regarding the forensic use of PET also were raised at this time. Some scientists argued that PET should not be used in legal proceedings to predict behavior,[233] while others were concerned that juries would view PET more objectively than the physicians and scientists who were interpreting it.[234]

V. CONTEXTUALIZING FUNCTIONAL MAGNETIC RESONANCE IMAGING

Perhaps fMRI's most striking comparator is phrenology. The phrenologists believed that certain parts of the brain were responsible for particular mental faculties.[235] As I have extensively documented in another article, today's

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[231] Id. at 511-12 (italics in original). Of course, not all courts that are asked to admit PET and SPECT evidence do so. Courts have refused to admit or to order PET and SPECT scans when the scans merely would have been helpful, but not necessary, to locating the existence of brain injury. See, e.g., Robinson v. State, 761 So.2d 269 (Fla. 1999) ("We find no error in the trial court's denial of Robinson's request for the SPECT scan because he has failed to establish any need for such test . . . . As the State points out . . . neither doctor testified that the test was necessary to complete their medical opinion; they merely stated that the exam would have been helpful.") (italics in original); Bottoson v. State, 813 S.2d 31, 34 (Fla. 2002) (refusing to grant a death row inmate leave to obtain a PET or a SPECT scan because he failed to established a particularized need for the test; "merely want[ing] . . . to establish if he has brain damage" is insufficient) (italics in original). Courts also have refused to admit or to order PET and SPECT scans when the scans would have been used to detect and evaluate traumatic brain injury at a time remote from the injury. See, e.g., People v. Protsman, 105 Cal. Rptr.2d 819, 823 (2001) ("In order to establish general acceptance of the use of PET scans to diagnose a prior traumatic brain injury, Protsman had to demonstrate substantial agreement and consensus of a cross-section of the relevant scientific community . . . . It was not enough to show there were differing views regarding the issue. Protsman had to demonstrate a consensus in the field, which [he did not].") (italics in original).

[232] Kevles, supra note 150, at 215.

[233] John C. Mazziotta, The Use of Positron-Emission Tomography (PET) in Medical-Legal Cases: The Position Against Its Use, in Controversies in Neurology, American Academy of Neurology Syllabus, Course No.147 (1997).

[234] Dumit, supra note 195.

[235] See supra text accompanying note 35.

physicians and scientists are using fMRI to study the neural correlates of dozens of physical and mental conditions, behaviors, characteristics, and preferences.[236]

Striking too is how quickly both phrenology and fMRI moved from the clinical and research contexts to being offered directly to the general public for commercial purposes. Although Franz Josef Gall focused on advancing the science of the mind in the late eighteenth and early nineteenth centuries, the American phrenologists, especially Orson Squire Fowler and Lorenzo Niles Fowler, quickly commercialized phrenology by opening public phrenology practices and charging for head examinations.[237] Like phrenology, fMRI also moved relatively quickly from clinical and research uses to possible commercial uses. The first scientists to develop and use fMRI in the early 1990s were focused on mapping the brain to assist with neurosurgery and other clinical and research goals.[238] Now, the Internet websites of two companies, No Lie MRI and the Cephos Corporation, suggest how individuals, employers, government officials, lawyers, and judges could use fMRI for non-clinical and non-research purposes.[239]

Both phrenology and fMRI have been offered to the public as a means of assisting with personal-decision making. Remember the "Phrenological Fowlers," who used phrenology to advise members of the public regarding life choices, such as whom they should marry.[240] Today, No Lie MRI claims on its website that fMRI has "potential applications to a wide variety of concerns held by individual citizens[, including . . .] Risk reduction in dating[;] Trust issues in interpersonal relationships[; and] Issues concerning the underlying topics of sex, power, and money."[241]

Both phrenology and fMRI have been offered to employers for use in hiring decisions. In the nineteenth century, phrenologists marketed their phrenological services to manufacturers for use in selecting apprentices.[242] Today, No Lie MRI proposes that employers use its services for employment screening: "Such testing could potentially substitute for drug screenings, resume validation, and security background checks. Not only would this significantly streamline and speed up

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[236] Tovino, supra note 2, at Part II. These include, but certainly are not limited to, brain abnormalities, stroke, multiple sclerosis, Parkinson's disease, Alzheimer's disease, major depression, schizophrenia, bipolar disorder, obsessive-compulsive disorder, dyslexia and hyperlexia, attention-deficit/hyperactivity disorder, social and racial evaluation, deception, social cooperation and altruism, sexual arousal and love, ethical decision making, pedophilia, cocaine addiction, compulsive gambling, expected and unexpected pleasure, satiety and obesity, anxiety, neuroticism, extraversion, self-consciousness, pain, migraines and cluster headaches, social rejection, intelligence, humanity, empathy (or the lack thereof), trust, humor, recognition of beauty and, even, the differences in the way men's and women's brains function when they are thinking. Id.

[237] See supra text accompanying notes 60-76.

[238] See, e.g., Tovino, supra note 2, at Part II(A) (discussing the first clinical applications of fMRI).

[239] No Lie MRI, http://www.noliemri.com/default.htm (last visited Oct. 21, 2006); Cephos Corporation, http://www.cephoscorp.com/ (last visited Oct. 21, 2006).

[240] See supra text accompanying notes 129-130.

[241] No Lie MRI, Customers—Individuals, http://www.noliemri.com/customers/Individuals.htm (last visited Oct. 21, 2006).

[242] Advertisement for The Phrenological Cabinet, in Barnum's American Museum Illustrated (New York, 1850), available at http://www.lostmuseum.cuny.edu/images/phrenimage1.jpg (last visited Mar. 1, 2007).

the hiring process, it would also reduce the costs associated with hiring a new employee. It would be expected to result in a more honest employee base."[243]

The value of phrenology and fMRI to the government also has been considered. In the late eighteenth and early nineteenth centuries, Gall believed that his brain maps could be used to govern the masses.[244] Today, the websites of both No Lie MRI and the Cephos Corporation state that fMRI may be useful to federal, state, and international governments.[245]

The value of phrenology and the potential value of functional neuroimaging to the American judicial system also have been recognized. In the nineteenth century, phrenology had a large impact on the American judicial system's understanding of mental states and right and wrong.[246] Today, the websites of both No Lie MRI and the Cephos Corporation state that fMRI may be valuable to litigants, lawyers, and judges.[247]

The role of phrenology and fMRI in education also has been recognized. Remember that many of the European and American phrenologists emphasized educational reforms, believing that students needed to train all of their mental organs by singing, running, and avoiding unhealthy substances such as coffee and tobacco,[248] and by visiting museums, fields, gardens, and shops.[249] Today, there is much speculation regarding fMRI's value in the educational setting.[250]

The ethical, legal, and social implications of phrenology and fMRI also are striking in their likeness. During phrenological examinations, for example,

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[243] No Lie MRI, Corporations, http://www.noliemri.com/customers/ GroupOrCorporate.htm (last visited Oct. 21, 2006).

[244] Id.

[245] No Lie MRI, Customers—Government, http://www.noliemri.com/customers/ Government.htm (last visited Oct. 21, 2006) (listing federal, state, and international government agencies that could benefit from its fMRI services); Cephos Corporation, http://www.cephoscorp.com/ (last visited Oct. 21, 2006) ("There are two major target audiences for CEPHOS' planned series of products. The first is government . . .").

[246] See, e.g., United States v. Freeman, 357 F.2d 606, 616 (2d Cir. 1966) (In the pre-M'Naghten period, the concepts of phrenology and monomania were being developed and had significant influence on the right and wrong test. Phrenologists believed that the human brain was divided into thirty-five separate areas, each with its own peculiar mental function. The sixth area for example, was designated 'destructiveness.' It was located, we are told, above the ear because this was the widest part of the skull of the carnivorous animals."); Anderson v. State, 276 So.2d 17, 20 (1973) (same); State v. Johnson, 399 A.2d 469, 472 & n.2 (R.I. 1979) (same).

[247] No Lie MRI, Customers—Lawyers, http://www.noliemri.com/customers/ Lawyers.htm (last visited Oct. 21, 2006) ("The purpose of the justice system is to find the truth. No Lie MRI test results could be used in a similar manner to DNA testing by adding the verification of an individual's mental record. It would also potentially be possible for a witness to validate his or her own statements to the court."); Cephos Corporation, http://www.cephoscorp.com/ (last visited Oct. 21, 2006) ("The second major target audience is the legal marketplace. Truth, integrity and trust form the foundation of our legal system. The objective measure of truth and deception that CEPHOS offers will help protect the innocent and convict the guilty. Cephos technology will also help litigators reach quick, favorable conclusions to high stakes judicial proceedings by providing pre-trial negotiating leverage and by bolstering the credibility of defendants and witnesses in the courtroom.").

[248] George Combe, Lectures on Popular Education (1834); Johann Gaspar Spurzheim, Education, Its Elementary Principles Founded on the Nature of Man (1847); Orson Squire Fowler, Education and Self-Improvement (1847).

[249] Stern, supra note 35, at xi.

[250] See, e.g., Kimberly Sheridan et al., Neuroethics in Education, in Neuroethics: Defining the Issues in Theory, Practice, and Policy 265-75 (Judy Illes ed., 2006).

phrenologists learned information about their analysands, of which even the analysands were unaware.[251] Today, one of the hottest issues in neuroethics involves incidental findings in neuroimaging research.[252] The confidentiality and privacy implications of phrenology, including the concern that phrenological findings would be disclosed to and used by employers, were identified in Part II of this Article. Similar confidentiality, privacy, and identity issues, raised in the context of functional neuroimaging, are under examination.[253] In the nineteenth century, phrenologists believed that their head charts were the key to self-improvement, self-perfection, and societal reforms.[254] Two centuries later, the rhetoric surrounding fMRI and its potential applications suggests similar notions of self-perfection and reform.[255]

Today, we know that the principles on which phrenology was based are not valid.[256] Functional MRI too has been criticized. As an indirect measurement of brain activity based on hemodynamics, aspects of fMRI are incompletely understood, in part because the hemodynamic response lasts longer than the underlying neuronal activity.[257] Experts thus debate what aspects of neural function fMRI actually measure.[258] Some believe that fMRI signals are better correlated with the neurons' receiving input and processing activity compared to their spiking, or output, activity.[259] Others emphasize that fMRI measures very small changes in blood flow, which may not be significant.[260] Still others point to the difficulties associated with identifying the activity or occurrence that triggered the increased blood flow. A particular brain response may be due to the fact that a particular image is shown to the subject; or, it may be due to the brightness of the image, the task of identifying the image, the subject's fear of

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[251] See supra text accompanying notes 84-94.

[252] See, e.g., Jennifer Kulynych, The Regulation of MRI Neuroimaging Research: Disentangling the Gordian Knot, 33 Am. J. L. & Med. 295, 314-315 (2007) (examining the ethical and legal issues raised by incidental findings in MRI research); Judy Illes et al., Incidental Findings in Brain Imaging Research, 311 Science 783, 783 (2006); Proceedings, Detection and Disclosure of Incidental Findings in Neuroimaging Research, Jan. 6-7, 2005, http://www.ninds.nih.gov/news_and_events/proceedings/ifexecsummary.htm (last visited Oct. 23, 2006); Judy Illes et al., Discovery and Disclosure of Incidental Findings in Neuroimaging Research, 20 J. Magnetic Resonance Imaging 743, 743 (2004); Judy Illes et al., Ethical Consideration of Incidental Findings on Adult Brain MRI in Research, 62 Neurology 888, 888 (2004); Judy Illes et al., Ethical and Practical Considerations in Managing Incidental Neurologic Findings in Functional Magnetic Resonance Imaging, 50 Brain & Cognition 358, 358 (2002); Gregory L. Katzman et al., Incidental Findings on Brain Magnetic Resonance Imaging from 1000 Asymptomatic Volunteers, 281 J. Am. Med. Ass'n 36, 36 (1999).

[253] See Tovino, supra note 2; Henry T. Greely, Prediction, Litigation, Privacy, and Property: Some Possible Legal and Social Implications of Advances in Neuroscience, in Neuroscience and the Law: Brain, Mind, and the Scales of Justice 114, 143 (Brent Garland ed., 2004).

[254] See supra text accompanying notes 122-145.

[255] Jose van Dijck, Transparent Body: A Cultural Analysis of Medical Imaging 3-4 (2005).

[256] Sandie Cleland, What Does fMRI Actually Measure?, 17 Psychologist 388 (July 1, 2004).

[257] Buckner & Logan, supra note 197, at 27-29.

[258] Rachel Jones, Neuroimaging: A Bold Step Forward, 2 Nature Rev. Neuroscience 531 (Aug. 2001).

[259] Cleland, supra note 256, at 388; Jones, supra note 258, at 531.

[260] Dennis O'Brien, Mind Readers Scanning Technology Promises to Map the Brain's Pathways, But Some Fear Its Ability to Expose a Patient's Secrets and Lies, Baltimore Sun, Dec. 10, 2004, at 1E.

the fMRI, or her current emotional state.[261] Reading fMRI scans also is considered by some to be a highly interpretive practice: "Sometimes, the difference between seeing higher activity in the parietal lobe compared to the occipital lobe is akin to deciding whether Van Gogh or Matisse is the more colorful artist."[262] Stated another way, "What constitutes a 'significantly greater' activation is, in a way, in the eye of the beholder."[263] Based on these concerns, some believe that fMRI offers nothing more than "pretty pictures that simply show where activity occurs in the brain."[264] Those who recognize the ability of fMRI to show regional activations still argue that, "[just] knowing where something happens does not reveal how it happens."[265] Still others question the reliability of many of the popular fMRI research studies, especially those involving low numbers of research subjects: "The signals they get are highly massaged. It means they clean up their data to make it look good, like applying makeup, for a general audience."[266]

Functional MRI also poses a number of practical issues. Individuals whose brains are being scanned must lie completely still for a period of time within an MRI scanner, which can be loud and claustrophobic.[267] Brain motion resulting from the individual's movement or, even, the individual's respiratory and cardiac cycles, can interfere with data acquisition.[268] In addition, the validity of the test results depends on the willingness and ability of the individual to carry out the assigned mental task.[269] Whether fMRI can be used to examine brain function in employees, applicants for insurance, students, criminals, and other individuals who may have little incentive to complete an assigned task remains to be seen. Because of these theoretical and practical limitations, the use of fMRI outside the clinical and research context has been described by some as "frivolous," a "gimmick," "pseudoscience," and "snake oil,"[270] in much the same way that phrenology has been referred to as junk science,[271] pseudoscience,[272] quackery,[273] and a "meaningless medical concept."[274]

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[261] Id.; Donald Kennedy, Neuroimaging: Revolutionary Research Tool or a Post-Modern Phrenology?, 5 Am. J. Bioethics 19 (Mar.-Apr. 2005).

[262] Sam Jaffee, Fake Method for Research Impartiality, 18 Scientist 64 (July 19, 2004).

[263] Turhan Canli & Amin Zenab, Neuroimaging of Emotion and Personality: Scientific Evidence and Ethical Considerations, 50 Brain & Cognition 425 (Dec. 2002).

[264] David I. Donaldson, Parsing Brain Activity with fMRI and Mixed Designs: What Kind of a State Is Neuroimaging In?, 27 Trends in Neurosciences 442 (Aug. 1, 2004).

[265] Sandra Blakeslee, Just What's Going On Inside that Head of Yours?, N.Y. Times, Mar. 14, 2000, at F6.

[266] Id.

[267] Joan Hamilton, Journey to the Center of the Mind: 'Functional' MRI Is Yielding a Clearer Picture of What Thoughts Look Like, Business Week, Apr. 19, 2004, at 78; Huettel et al., supra note 103, at 14.

[268] Buckner & Logan, supra note 197 at 30-31.

[269] Id. at 30; Martha J. Farah, Emerging Ethical Issues in Neuroscience, 5 Nature Rev. Neuroscience 1126 (Nov. 2002).

[270] Emily Eakin, Looking for that Brain Wave Called Love; Humanities Experts Use M.R.I.'s to Scan the Mind for the Locus of the Finer Feelings, N.Y. Times, Oct. 28, 2000, at B11; Paul Raeburn, The Therapeutic Mind Scan, N.Y. Times, Feb. 20, 2005, at § 6, 20.

[271] See, e.g., General Electric Co. v. Joiner, 522 U.S. 136, 153 & n.6 (1997) (Stevens, J., concurring) ("An example of 'junk science' that should be excluded . . . as too unreliable would be the testimony of a phrenologist who would purport to prove a defendant's future dangerousness based on the contours of the defendant's skull.").

However, fMRI's proven success in pre-neurosurgical brain mapping and other clinical settings[275] shows us that fMRI is not going to be just another phrenology, at least in some of its applications. So, perhaps x-ray, PET, and SPECT, all of which continue to be considered valid sciences and technologies, make for better comparators. Although x-ray only images body structure, not brain function, it too moved outside of the clinical and research contexts quickly after its discovery, gaining special value within the judicial system as a method of truth-seeking.[276] PET and SPECT, which can identify in three-dimension areas of the brain that are metabolically correlated with certain mental functions, also moved beyond the clinical and research contexts shortly after their development, providing crucial evidence in many legal cases.[277] Perhaps our experiences with all of these methods of body imaging and brain mapping can help guide current functional neuroimaging policy.

VI. A GUIDE TO FUNCTIONAL NEUROIMAGING POLICY

Each new method of body imaging and brain mapping discussed in this Article – phrenology, x-ray, PET, SPECT, and fMRI – suggests a desire for greater transparency of the body and brain. Elsewhere in this Symposium and in the larger neuroethics literature, scholars have identified the implications of advances in functional neuroimaging in terms of evidence law;[278] criminal law;[279] criminal procedure;[280] Constitutional law;[281] property law;[282] intellectual

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[272] Donald Simpson, Phrenology and the Neurosciences: Contributions of F. J. Gall and J. G. Spurzheim, 75 ANZ J. Surgery 475 (2005).

[273] Davies, supra note 32, at ix.

[274] United States v. Freeman, 357 F.2d 606, 616 (2d Cir. 1966).

[275] See Tovino, supra note 2, at text accompanying notes 48-56 (discussing some of the clinical uses of fMRI).

[276] See supra Part II(B).

[277] See supra Part III.

[278] See, e.g., Mark Pettit, FMRI and BF Meet FRE: Brain Imaging and the Federal Rules of Evidence, 33 Am. J. L. & Med. 319, 319-340 (2007); Archie Alexander, Functional Magnetic Resonance Imaging Lie Detection: Is a Brainstorm Heading for the Gatekeeper?, Houston J. Health L. & Pol'y (forthcoming 2007).

[279] See, e.g., Symposium, The Mind of a Child: The Relationship Between Brain Development, Cognitive Functioning, and Accountability under the Law, Ohio St. J. Crim. L. (Spring 2006).

[280] See, e.g., Sean Kevin Thompson, A Brave New World of Interrogation Jurisprudence, 33 Am. J. L. & Med. 341, 341-358 (2007) (examining the Fifth Amendment implications of advances in functional neuroimaging); Sarah E. Stoller & Paul Root Wolpe, Emerging Neurotechnologies for Lie Detection and the Fifth Amendment, 33 Am. J. L. & Med. 359, 359-375 (2007) (same); Richard Glen Boire, Searching the Brain: The Fourth Amendment Implications of Brain-Based Deception Devices, 5 Am. J. Bioethics 62-63 (examining the Fourth Amendment implications of advances in functional neuroimaging).

[281] See, e.g., Richard Glen Boire, On Cognitive Liberty (Part I), 1 J. Cognitive Liberties 7-13 (1999-2000) (examining the First Amendment implications of advances in functional neuroimaging); Linda MacDonald Glenn, Keeping an Open Mind: What Legal Safeguards Are Needed?, 5 Am. J. Bioethics 60-61 (2005) (same).

[282] See, e.g., Jeffrey Evans Stake, The Property 'Instinct', in Law & the Brain 185-204, eds. S. Zeki and O. Goodenough (Oxford University Press 2006) (examining the property law implications of advances in neuroscience).

property;[283] and health, employment, and disability law,[284] just to name a few. The question I address here is whether our experiences with phrenology, x-ray, PET, and SPECT can assist us in thinking about the appropriateness of other legal protections for individuals whose brains are scanned using functional neuroimaging technology.

A. A Complete Prohibition on Functional Neuroimaging?

Remember that, after phrenology's demise, the City of Lincoln, Nebraska, passed an ordinance making it unlawful for an individual to "exercise, carry on, advertise, or engage" in the business of phrenology.[285] Several other jurisdictions passed similar prohibitions against the practice of phrenology, character reading, and mind reading.[286] Perhaps, then, we should consider a complete prohibition on the practice of functional neuroimaging. Given fMRI's proven value in pre-neurosurgical brain mapping, its emerging value in the treatment of depression and dozens of other physical and mental health conditions, and its continuing contributions to neurology, psychiatry, and other areas of medicine and science,[287] this option should receive no further consideration. Phrenology was determined to be a pseudoscience in all its applications, thus warranting a blanket prohibition by local governments. Functional MRI, however, has both proven and potential clinical and scientific applications. It has the potential to benefit many individuals who have been diagnosed with brain tumors, other brain abnormalities, acquired and traumatic brain injuries, mental illness, and many other physical and mental health conditions. At the very least, clinical and research uses of fMRI must be continued.

B. A Limited Prohibition on Functional Neuroimaging?

In the first year after the discovery of x-ray, remember that a New Jersey Assemblyman reportedly introduced a bill to the New Jersey Legislature that would prohibit the use of x-ray glasses in theaters and other public places.[288] This legal response suggests a second option, which would be to prohibit the use of fMRI in non-clinical and non-research contexts. For example, we could

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[283] See, e.g., Greely, supra note 253 (examining, among many other things, the intellectual property implications of advances in functional neuroimaging).

[284] See Tovino, supra note 2 (examining the confidentiality, privacy, and identity implications of advances in functional neuroimaging); Committee on Science and Law, Are Your Thoughts Your Own? "Neuroprivacy" and the Legal Implications of Brain Imaging, 60 CBA Record 407-436 (2005) (examining several health law and employment implications of advances in functional neuroimaging).

[285] Lincoln, Nebraska Municipal Ordinances § 9.40.030 (1997), cited in Argello v. City of Lincoln, 143 F.3d 1152, 1152 (1998). See also Azusa Municipal Code § 8.52.060 ("No person shall practice or profess to practice or engage in the business or art of . . . phrenology . . . or any similar business or art, who either solicits or receives a gift or fee or other consideration for such practice, or where admission is charged for such practice."), cited in Spiritual Psychic Science Church v. City of Azusa, 39 Cal. 3d 501, 506 (1985).

[286] See supra Part I(C).

[287] See Tovino, supra note 2, at Part II(A) (discussing some of the clinical uses of fMRI).

[288] See, e.g., Kevles, supra note 150, at 27 & n.14; Goodman, supra note 165, at 1043. But see Howell, supra note 165, at 142 & n.39 ("There is no record of the bill's passage; in fact, there is reason to doubt whether the bill was actually ever introduced.")

prohibit the advertising, marketing, or other offering of fMRI scanning services for non-clinical or non-research uses. Or, we could prohibit the use of fMRI for certain purposes, such as lie detection; or by just certain persons or organizations, such as employers, educators, health and life insurers, governments, lawyers, and judges.

This option has the benefit of allowing physicians and scientists to continue to use fMRI to benefit current and future patients. To the extent that fMRI is not capable, or not yet capable, of accurately identifying deception and other behaviors, conditions, and characteristics, this option also has the benefit of preventing individuals and third parties from wasting money on, relying on, or using inaccurate functional neuroimaging tests to the detriment of individual citizens.

One possible risk of this option is that it could drive commercial fMRI services underground, perhaps increasing the chance that less-than-honest individuals will provide such services illegally, thus lowering the standard of care in the provision of these services. A second, more important, issue relates to the desirability, or the necessity, of establishing limited prohibitions on functional neuroimaging. At a conference held in February 2007, the authors of this Symposium expressed opposing viewpoints regarding this issue. Some authors, including myself, suggested that now may be the time to craft limited prohibitions on the use of functional neuroimaging technology for certain non-clinical and non-research uses.[289] During the peer review sessions, other authors questioned the necessity, and worried about the cost and administrative burden, of additional regulation. Still others suggested that we were lending undue credence to neuroimaging technology by talking about its legal implications and considering potential methods of regulation.

My viewpoint is shaped in large part by fMRI's perceived, rather than its actual, capabilities.[290] Even though fMRI may never be capable of accurately reading an individual's mind, I am concerned that the intense media hype[291] surrounding functional neuroimaging technology may cause employers, insurers, criminal justice officials, governmental agencies, and other third parties to believe that fMRI is capable of doing so.[292] An fMRI that accurately reveals an individual's thoughts is one thing. An fMRI that is incorrectly interpreted to reveal a condition, thought, characteristic, or behavior that does not exist, and that is used to an individual's detriment in an employment, criminal justice, or insurance capacity, is another.[293] Functional MRI, like other sophisticated

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[289] See, e.g., Tovino, supra note 2 at Part VI (arguing that generic privacy protections, including privacy protections applicable to functional neuroimaging information, are needed at least in the employment and insurance contexts); Henry T. Greely & Judy Illes, Neuroscience-Based Lie Detection: The Urgent Need for Regulation, 33 Am. J. L. & Med. 377, 413-418 (2007) (arguing that the federal government or state governments should ban any non-research use of new methods of lie detection, including fMRI-based lie detection, unless or until the method has been proven safe and effective to the satisfaction of a regulatory agency and has been vetted through the peer-reviewed scientific literature).

[290] See Tovino, supra note 2, at Part VI(A).

[291] See id. at Part VI(B) (examining the media hype surrounding fMRI).

[292] See id. at Part VI(A).

[293] See Steve Olson, Brain Scans Raise Privacy Concerns, 307 Science 1550, 1550 (2005).

technologies, possesses an illusory accuracy and objectivity[294] that I think is dangerous in the hands of employers, insurers, jurors, lawyers, judges, and government officials who lack the scientific and statistical training necessary to understand published fMRI studies and interpret fMRI test results.[295] Yet, these are the individuals to whom commercial fMRI services currently are being marketed.[296] For these reasons, I believe that protections against the use of functional neuroimaging technology outside the clinical and research contexts may be desirable.

In light of the varying viewpoints expressed both at this Symposium's Conference and within the larger neuroethics literature, I hope that those who continue this dialogue will examine the following questions. First, which uses of functional neuroimaging technology (e.g., efforts to detect lies, racial and social evaluation, pedophilia, sexual preferences, mental health conditions, etc.) concern us the most? For example, do we think it is simply too dangerous – ethically, legally, and socially – to use fMRI to attempt to identify deception or racial preferences outside of the research context at this point and time? On the other hand, is it safe and acceptable to allow individuals to purchase brain scans for "fun" purposes, such as dating? Second, which organizations (employers, health and life insurers, government agencies, criminal justice officials, educators, lawyers and judges, individual citizens, etc.) are we most worried about using functional neuroimaging technology or obtaining functional neuroimaging information? For example, is it too dangerous – ethically, legally, and socially -- to allow an employer to obtain functional neuroimaging test results about a job applicant? On the other hand, is it acceptable for a judge to use a functional neuroimaging test result to exculpate a criminal defendant? Thinking through these questions may help further the discussion regarding the contexts, if any, in which functional neuroimaging regulation may be needed.

C. Taxing and Licensure of Functional Neuroimaging Services?

Rather than prohibiting phrenology, some jurisdictions taxed or licensed individuals who offered phrenological services to the public.[297] This legal response suggests a third option, which is to permit but tax, license, or otherwise regulate the commercial offering of fMRI in an attempt to protect the public's health and safety. The benefit to the public of licensing or otherwise regulating

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[294] Martha J. Farah, Emerging Ethical Issues in Neuroscience, 5 Nature Rev. Neuroscience 1127, 1127 (2002).

[295] Greely I, supra note 253, at 118-20.

[296] See No Lie MRI, http://www.noliemri.com/ (last visited Mar. 1, 2007); Cephos Corp., http://www.cephoscorp.com/ (last visited Mar. 1, 2007); Malcolm Ritter, Brain Scans as Lie Detectors: Ready for Court Use?, Live Sci., Jan. 29, 2006, http://www.livescience.com/humanbiology/060129_brain_lie.html (last visited Mar. 1, 2007).

[297] Fla. Stat. § 205.41 (1941) ("Every . . . phrenologist . . . shall pay a license tax of one hundred dollars; provided, that this section shall not be construed to require members of any recognized christian denomination who pray for the sick to obtain a license."), cited in Curley v. State, 153 Fla. 773, 776-77 (1943); Henry County, Virginia, Code art. III, ch. 5, § 5-10 (1983), cited in Adams v. Board of Supervisors, 569 F. Supp. 20, 21 (1983); Ga. Code Ann. § 36-1-15 (2006) ("The county governing authority may by proper ordinance . . . regulate, or tax the practice of fortunetelling, phrenology, astrology, clairvoyance, palmistry, or other kindred practices, businesses, or professions where a charge is made or a donation accepted for the services and where the practice is carried on outside the corporate limits of the municipality.").

the offering of medical and other similar services is textbook health law, although such regulation can be criticized as costly, anti-competitive, and administratively burdensome.[298] In light of the safety issues raised by magnetic resonance imaging, perhaps licensure, regulation, or even the imposition of minimum insurance coverage limits should be considered. In her article in this Symposium, Jennifer Kulynych examines several safety issues raised by MRI, including the issue whether MRI scanner operators are adequately trained and whether MRI screening procedures are sufficiently detailed and redundant to minimize the risk of physical injury to individuals.[299] The Food and Drug Administration has found that lapses in screening and safety procedures in clinical uses of MRI have caused patient injury and death, and Kulynych suggests that safety procedures may be even less standardized (and the risks of adverse events may be greater) in the research setting.[300] The question here is whether the commercial provision of fMRI services is or will be performed by credentialed persons and subject to the same safety procedures as scanning performed in the clinical setting.[301] If not, requiring trained radiology technicians, minimum safety and screening procedures, and minimum insurance coverage as part of a licensure process or through other regulation may be desirable.

D. Consumer Law and Truth-in-Advertising

Remember that, after the fall of phrenology, a national television programming code made programming material relating to phrenology "unacceptable if it encourage[d] people to regard [phrenology] as providing commonly accepted appraisals of life."[302] This legal response suggests a fourth option, which would be to adopt a specific law requiring anyone who offers fMRI services in any context to offer and advertise the services truthfully. A variation of this option is to ensure that current federal and state regulatory agencies are aware of commercial and other uses of fMRI and will enforce truth-in-advertising rules with respect to such uses. The Federal Trade Commission Act,[303] state deceptive trade practices acts,[304] and state consumer laws[305] already require some

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[298] See, e.g., Ralph Reisner, Christopher Slobogin, & Arti Rai, Law and the Mental Health System: Civil and Criminal Aspects 74-94 (4th ed., 2004) (examining the state's interest in assuring the quality of professional services offered to the public); Mark A. Hall, Mary Anne Bobinski & David Orentlicher, Health Care Law and Ethics 809-821 (6th ed., 2003) (discussing the public health benefits and the anti-competitive effects of the licensing and regulation of health care providers).

[299] Kulynych, supra note 252, at 311-312.

[300] Id.

[301] Id.

[302] National Association of Broadcasters, The Television Code §§ IV(12) and IX(10) (19th ed. 1976), cited in Gemini Enterprises, Inc. v. WFMY Television Corp., 470 F. Supp. 559, 562 (1979).

[303] See, e.g., 15 U.S.C. § 41 et seq. (2006) (Federal Trade Commission Act); FTC Policy Statement on Deception (Oct. 14, 1983), available at http://www.ftc.gov/bcp/policystmt/ad-decept.htm (last visited Oct. 21, 2006); FTC Policy on Unfairness (Dec. 17, 1980), available at http://www.ftc.gov/bcp/policystmt/ad-unfair.htm (last visited Oct. 21, 2006).

[304] See, e.g., Minnesota Unlawful Trade Practices Act, Minn. Stat. § 325D.09-.16 (2006); Texas Deceptive Trade Practices-Consumer Protection Act, Tex. Bus. & Com. Code § 17.41-17.63 (2006).

[305] See, e.g., Minnesota False Statement in Advertising Act, Minn. Stat. § 325F.67 (2006); Minnesota Prevention of Consumer Fraud Act, Minn. Stat. § 325F.69, subd.1 (2006).

advertisers to be truthful and nondeceptive and advertisers to have evidence backing their claims. The truth-in-advertising principles that underlie these laws certainly could be applied or extended to apply to fMRI.

One company offering fMRI services to the public states on its website that fMRI is the "first and only direct measurement of truth verification and lie detection in human history."[306] This statement presumably is meant to distinguish polygraph, which measures a response of the peripheral nervous system, from fMRI, which involves the central nervous system. But these statements do raise additional questions. For example, is it fair to state that fMRI is a direct measurement of truth verification given that fMRI uses blood-oxygenation-level dependent (BOLD) signal as a proxy for neuronal activity and usually is referred to as an indirect measure of neuronal activity?[307] Or, is it good enough that BOLD signal has been found to be a "close approximation," or a "faithful signal," of neuronal activity?[308] Or, would these descriptions be considered non-material because they likely would not affect a reasonable consumer's decision to purchase an fMRI test? Or, does the complexity of the science behind fMRI give these companies some legal grace in describing their tests to the public?

One company offering fMRI services to the public states that its fMRI tests are "fully automated" and "[o]bserver independent (objective)."[309] A second company states that its fMRI testing is "Non-subjective - humans do not ask the questions or examine the scans."[310] If scientists and radiology technicians do not ask any test questions or otherwise examine or interpret the fMRI scans, then fMRI testing is more objective than I previously thought. But the concept of objective fMRI testing runs counter to the subjective traits attributed to fMRI in both the popular and scientific literature. In the last two years, observers have referred to fMRI as an "interpretive practice," noting that, "Sometimes, the difference between seeing higher activity in the parietal lobe compared to the occipital lobe is akin to deciding whether Van Gogh or Matisse is the more colorful artist"[311] and that, "What constitutes a 'significantly greater' activation is, in a way, in the eye of the beholder."[312] So, is fMRI testing an objective or subjective activity, or is it both? Does it depend on how the fMRI test is designed? To clarify the legal question, is it truthful, fair, non-deceptive, and non-misleading to state that an fMRI test is objective and fully automated? Or, does the complexity of fMRI again require legal grace?

The accuracy of fMRI testing also is featured prominently in these web materials. According to one representation, "Current accuracy is over 90% and is

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[306] See No Lie MRI, http://www.noliemri.com/ (last visited Mar. 1, 2007).

[307] National Institutes of Health, National Institute of Mental Health, FMRI Signal Found "Faithful" to Neuronal Activity (2001), available at http://www.nimh.nih.gov/press/fmrisignal.cfm (last visited Mar. 1, 2007).

[308] Id.

[309] No Lie MRI, http://www.noliemri.com/products/Overview.htm (last visited Mar. 1, 2007).

[310] Cephos Corporation, http://www.cephoscorp.com/ (last visited Mar. 1, 2007).

[311] Sam Jaffee, Fake Method for Research Impartiality, 18 Scientist 64 (2004).

[312] D.I. Donaldson, Parsing Brain Activity with fMRI and Mixed Designs: What Kind of State is Neuroimaging In?, 27 Trends in Neurosciences 442, 442 (2004).

estimated to be 99% once product development is complete."[313] A second company states that its product is "Accurate - currently 90% accuracy in clinical testing."[314] Although there is no suggestion that these statements are untruthful, deceptive, or not backed by evidence – indeed, both companies cite and link to particular scientific studies supporting their claims[315] – one concern is that these statements will cause non-scientifically trained parties to think that "over 90%" means that fMRI is capable of identifying all instances of deception.

VII. CONCLUSION

At first glance, phrenology, x-ray, PET, SPECT, and fMRI are an odd collection of both junk and real sciences, dramatically different methods of imaging body structure and mapping brain function. All of these developments were introduced in the name of science, but quickly moved into the commercial, employment, government, and judicial contexts. The legal responses to these transitions included, but certainly were not limited to, absolute practice prohibitions; limited practice prohibitions; taxing, licensure, and regulation; and the application of consumer law and truth-in-advertising principles. These legal responses can help us think about appropriate responses to advances in functional neuroimaging.

I certainly do not think that functional neuroimaging should be prohibited in the clinical or research contexts. I do think, however, that there may be a role for non-clinical and non-research practice prohibitions that are time-limited, such as prohibitions against using fMRI to detect deception until using fMRI to detect deception has been determined to be highly effective. There also may be a role for the licensure or regulation of the commercial offering of fMRI services (due to safety concerns), and the application of truth-in-advertising principles (due to intense media speculation regarding and public interest in neuroimaging technology). I hope that the desirability and appropriateness of these legal responses continue to be examined as the field of neuroethics develops.

Judicial opinions involving phrenology, x-ray, PET, and SPECT also revealed several themes. These themes include the general duty of the law to keep up with advances in medicine and science, the more specific duty of the law to adopt technologies that will assist the jury in seeking the truth, uneasiness about the illusory objectivity of body imaging and brain mapping (including concern that body images and brain scans can be inaccurate and misleading to jurors, employers, and other non-scientists), and the difficulty of balancing advances in science and medicine against the risks associated with junk science and charlatans. As scientists continue to develop new methods of body imaging and brain mapping, these themes undoubtedly will reappear, and the law will continue to balance individual interests, including interests in confidentiality,

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[313] No Lie MRI, http://www.noliemri.com/products/Overview.htm (last visited Mar. 1, 2007).

[314] Cephos Corporation, http://www.cephoscorp.com/ (last visited Mar. 1, 2007).

[315] No Lie MRI, Publications, http://www.noliemri.com/pressNPubs/Publications.htm (last visited Oct. 21, 2006) (listing and linking to published, peer-reviewed fMRI studies); Cephos Corporation, http://www.cephoscorp.com/fmri_deception.htm (last visited Oct. 21, 2006) (same).

privacy, and identity, against society's desire for greater transparency of the body and the brain.