

## The Ins and Outs of Sexual Imaging

*Golf and sex are the only two things you don't have to be good at to enjoy.*

Kevin Costner in *Tin Cup*

M. Castillo, *Editor-in-Chief*

What happens inside the human body during sexual intercourse has fascinated artists, scientists, and the public since the start of humanity. Leonardo da Vinci (1452–1519) drew the internal anatomy of a couple engaged in intercourse in “The Copulation” and suggested that connections between the penis, the distal spinal cord, and the brain existed. In the Middle Ages and the Renaissance, the act of sex was not scientifically studied. The term “sexology” was first used in Victorian times to describe the relationship between men and women.<sup>1</sup> The idea of “sexual science” originated in Germany and Italy, and the term “sexual medicine” was not established until the 1970s. In the United States, the first physician who worked full-time in “diseases” of a sexual nature was Harry Benjamin, who studied mostly trans-sexualism. Perhaps one of the most common names associated with sexual medicine is Alfred Kinsey, who collected the sexual clinical histories of more than 18,000 patients (a story entertainingly told by T.C. Boyle in his novel *The Inner Circle*, Viking Adult, 2003). Kinsey was the first to quantitate a few aspects of sexual behavior. His legacy lives on at the Kinsey Institute (<http://www.kinseyinstitute.org>) at Indiana University in Bloomington. A few years after the apparition of the “Kinsey Report,”<sup>2</sup> Masters and Johnson began their studies of sexuality, all of which culminated with the creation of the International Society for Sexual Medicine, which now publishes the *Journal of Sexual Medicine* (Impact Factor: 3.55). Today, sexual medicine is a serious and mature specialty that incorporates physicians, psychiatrists, psychologists, and even neuroradiologists.

Sex has 2 goals: foremost reproduction and then pleasure. The main brain region controlling pleasure and thus orgasm is the medial preoptic area of the hypothalamus. In animals, stimulation of this region elicits pleasurable sexual responses via sympathetic (by way of the paraventricular hypothalamic nucleus) and parasympathetic mechanisms.<sup>1</sup> Axons from this region connect with the nucleus paragangliocellularis in the ventrolateral medulla, and axons from the latter extend down to the tip of the spinal cord (here it is curious to note that during the Renaissance, semen was thought to come down from the brain traveling by way of a canal in the spine and following a path that somewhat matches that of these axons). By way of the periaqueductal gray matter, the medial preoptic area may inhibit the hypothalamic nucleus, terminating the sensations of pleasure.

Direct observations of what occurs at the penis-vagina interface during sex were initially made by Masters and Johnson, who studied the mechanics of this activity by using an artificial penis (a funny episode in the popular TV series “Masters of Sex” recounts

the experiments done with this instrument). Sonography was first used to study copulation in 1999, but the images obtained were of poor quality by today’s standards.<sup>3</sup> Later in 1999, MR imaging was used to study the state of the female genital and pelvic organs during sexual arousal in 8 couples during 13 “encounters.”<sup>4</sup> In this study, in which one author was a radiologist, the main conclusion was that local responses were similar for pre- and postmenopausal women. The article contains no MR images of the act of coitus. In 2001, Faix et al<sup>5</sup> asked a couple to have sex in the MR imaging unit (in face-to-face or “missionary” position). The main observation, among many uninteresting measurements that were perhaps used to justify publishing such an article, was that in this position the contact between the penis and vagina occurs mostly at the anterior cul-de-sac and anterior vaginal wall. One year later the same authors asked a couple (the same one?) to have intercourse in the MR imaging unit again, also in missionary position, and images showed that the internal contact between the organs was different and occurred along the posterior cul-de-sac and posterior vaginal wall.<sup>6</sup> The images illustrating those articles are not too different from the original da Vinci drawing previously mentioned. The conclusions of this latter study were simply silly: “Initially the aim of the study was to ‘copy’ the genius of Leonardo da Vinci. We showed that an MR imaging scan of sexual intercourse in two positions is feasible and artistic but not as artistic as the images drawn by da Vinci.”<sup>6</sup> I wonder whether today any reasonable scientific journal would publish a study with these conclusions!

MR imaging has also been used to map the spread of contraceptive gel during both simulated and real intercourse.<sup>7</sup> These experiments offer important information regarding the spread of intravaginal medications and how it relates to dosage (small or large doses do not appear to make a difference). Studies have found that gels spread evenly, covering the cervix and proving a good contraceptive barrier.

What happens during sex at a local level is, from a neuroradiologist’s point of view, not too interesting and for purposes of this *Perspectives*, I will now attempt to summarize some of what presumably happens in our brains. Using fMRI, Meston et al<sup>8</sup> studied 6 women while being shown neutral and erotic films, and all reported moderate arousal to the latter. Areas that showed activation during sexual arousal included the inferior temporal lobes, anterior cingulate gyri, insular cortex, corpus callosum, thalami, caudate nuclei, globus pallidi, and inferior frontal lobes. In women, the activation was bilateral, while in men it was unilateral (mostly right-sided).<sup>9</sup> A different study in a larger number of men and women showed activations in the same regions and, in addition, in the medial prefrontal cortex, occipitotemporal cortex, and amygdalae, but only men showed significant activation of the hypothalamus.<sup>10</sup> Some of the cortical areas were also activated with other emotional stimuli and presentation of rewards. Thus, it seems that female and male brains respond to sex differently (to me, not surprising).

In males, stimuli leading to initial genital responses activate the left frontal operculum, probably related to imagining the forthcoming sexual act.<sup>10</sup> Then, anticipatory motor and somato-

sensory imagery activates the left supramarginal gyrus and Brodmann area 2, respectively. A positive feedback mechanism consequently increases the response of these brain areas, but the frontal lobes also have the ability to disrupt these pathways and stop related brain activations. During orgasm, prominent activation has been shown in the paraventricular hypothalamic nuclei, periaqueductal gray matter, hippocampus, and cerebellar cortex, confirming observations made previously in animal models. Stimulation of the posterior pituitary lobe with release of hormones such as oxytocin also occurs during orgasm in both animals and humans.

Because fMRI can shed light on what happens during normal sex, it has also been used to evaluate deviant sexual behaviors. It is curious (and somewhat scary) that pedophiles activate the same brain regions, albeit more intensively, than nonpedophile controls.<sup>11,12</sup> It seems that in sexually addicted individuals, the frontal brain loses its ability to stop the positive feedback mechanisms that recruit other brain regions, leading to widespread activations.<sup>13</sup> DTI has also shown low diffusivity in the superior frontal cortex in sexually addicted patients (similar results have been found in other behaviors with abnormal impulsivity such as kleptomania, gambling, and eating).<sup>13</sup> These observations suggest that neurons and axons are abnormal or abnormally organized in these regions in addicted individuals.

Because sex and love are related (not always, but fairly commonly), it is useful to explore what happens to the brain during love. There are 2 types of love: passionate (being in love with someone) and companionate (loving someone). The former is more intense and though both types occur simultaneously early in a relationship, they are different feelings that may not survive together in long-term unions (with time, passionate love becomes companionate). Passionate love is characterized by activations in all dopaminergic brain regions and decreased activity of brain areas associated with anxiety and fear.<sup>14</sup> Most studies have shown that the amygdalae tend to be deactivated during love, sex, and orgasm, decreasing fear and anxiety and contributing to the feeling of well-being experienced with love, sex, and orgasm.<sup>15</sup> Conversely, in deviant sexual behaviors such as pedophilia, the amygdalae activate abnormally.<sup>12</sup> The brains of pedophiles appear to be more severely impaired than those of other sexual offenders, including rapists, and some brain regions (such as the basal frontotemporal ones) are affected in these and other delinquents and criminals of a nonsexual nature.

Romantic love is also ruled by the dopaminergic systems of the brain. Love is primarily motivational and changes our habits to please the person who receives it. Central features that both love and sex share are intrusiveness and obsessive thinking, which are involuntary and difficult to control. In individuals sustaining

long-term partners, the initial reward-value brain circuits remain activated similar to new love. Serotonin production is elevated with certain antidepressants, and this chemical must be present to feel love, so there is a chance that individuals taking these drugs may be unable to fall in love or have a tendency to fall out of it.

So, it seems that the mysteries of love and lust are starting to become clearer with fMRI. Although the study of sex has gone in and out of style many times, thanks to neuroimaging, it is definitively in now.

## REFERENCES

- Schultheiss D, Glina S. **Highlights from the history of sexual medicine.** *J Sex Med* 2010;7:2031–43
- Kinsey AC, Pomeroy WB, Martin CE, et al. *Sexual Behavior in the Human Female*. 1st ed. Philadelphia: Saunders; 1953 (still available on Amazon.com)
- Riley AJ, Less W, Riley EJ. **An ultrasound study of human coitus.** In: Bezemer W, Cohen-Kettenis P, Salob K, et al, eds. *Sex Matters*. Amsterdam: Elsevier; 1999:29–36
- Schultz WW, van Andel P, Sabelis I, et al. **Magnetic resonance imaging of male and female genitals during coitus and female sexual arousal.** *BMJ* 1999;319:18–25
- Faix A, Lapray JF, Courtieu C, et al. **Magnetic resonance imaging of sexual intercourse: initial experience.** *J Sex Marital Ther* 2001; 27:475–82
- Faix A, Lapray JF, Callede O, et al. **Magnetic resonance imaging (MRI) of sexual intercourse: second experience in missionary position and initial experience in posterior position.** *J Sex Marital Ther* 2002;28:63–76
- Pretorius ES, Timbers K, Malamud D, et al. **Magnetic resonance imaging to determine the distribution of a vaginal gel: before, during, and after both simulated and real intercourse.** *Contraception* 2002;66:443–51
- Meston CM, Levin RJ, Sipski ML, et al. **Women's orgasm.** *Annu Rev Sex Res* 2004;15:796–97
- Stoleru S, Gregoire MC, Gerard D, et al. **Neuroanatomical correlates of visually evoked sexual arousal in human males.** *Arch Sex Behav* 1999;28:1–12
- Karama S, Lecours AR, Leroux JM, et al. **Areas of brain activation in males and females during viewing of erotic film excerpts.** *Human Brain Mapp* 2002;16:1–13
- Schiffer B, Krueger T, Paul T, et al. **Brain response to visual stimuli in homosexual pedophiles.** *J Psychiatry Neurosci* 2008;33:23–33
- Sartorius A, Ruf M, Kief C, et al. **Abnormal amygdala activation profile in pedophilia.** *Eur Arch Psychiatry Clin Neurosci* 2008; 258:271–77
- Estellon V, Mouras H. **Sexual addiction: insights from psychoanalysis and functional neuroimaging.** *Socioaffective Neuroscience and Psychology* 2012;2:11814
- Oritgue S, Bianchi-Demicheli F, Patel N, et al. **Neuroimaging of love: fMRI meta-analysis evidence towards new perspectives in sexual medicine.** *Sexual Med* 2010;7:3541–52
- Dickinson RL. *Human Sex Anatomy: A Topographical Hand Atlas*. 2nd ed. London, UK: Balliere, Tyndall and Cox; 1949:84–109