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Your Brain on Porn

IF YOU'VE EVER ENTERED A MAJOR ELECTRONICS store that carries high definition (HD) televisions, you've probably seen the difference between standard and HD images. There is usually an HD television with a split screen showing the differences between the old-fashioned, standard television version and the newer, life-like HD images. The standard television system seems dull and uninteresting when contrasted to the same set of images shown on an HD system. The radiance and fine details of an HD system can be breathtaking. But having an HD television is not enough to get this glorious visual experience. You can't take a standard image and make it HD. An HD signal from your programming provider, an HD receiver and an HD display (television or monitor) all have to be connected to each other in order to get this effect. All three elements must be in place—signal, receiver and monitor—in order to experience HD in its fullness.

Pornography has a similar effect on men due to the uniqueness of our ability to pick up the signal, receive it and experience it. Pornographic images are inherently different from other signals. Images of nudity or sexual intercourse are distinct, different from what we experience as part of our everyday visual experience. They are analogous to the HD signal. The male brain is the built like an ideal pornography receiver, wired to be on the alert for these images of nakedness. The male brain and our conscious visual experience is the internal monitor where we perceive them. The images of sexuality grab our atten-

tion, jumping out and hypnotizing a man like an HD television among a sea of standard televisions.

THE VISUAL MAGNETISM OF PORNOGRAPHY

Human sexuality affects every aspect of human life, but sexual acts are generally understood as private acts, taking place in the bedroom. We live in a culture that is clothed, and we do not regularly stumble across people having sex in public. We have laws against nudity and performing sexual acts in public. This cultural reality along with the intuitive notion that sex is a private, intimate act makes pornography so qualitatively different from the majority of our everyday visual experience. Our culture has trained us so that there is something about the naked form that is distinctive. When we come across it, we reflexively turn our attention toward it. But why do so many men find it difficult to look away after that first glance? Perhaps it is because their receiver is merely locking onto this strong signal.

A man's brain is a sexual mosaic influenced by hormone levels in the womb and in puberty and molded by his psychological experience. Male brains can be very different from female brains because of this (Arnold, 2004, pp. 701-8; Ariely and Loewenstein. 2006, p. 87; Baron-Cohen, Lutchmaya and Knickmeyer, 2004; Brizendine, 2006; Cahill, 2006, p. 477). Although neither superior nor inferior, they are very different in the way they detect stimuli, process information and respond to emotions. This is important because men detect sexual cues rapidly when it comes to nakedness or sex-related stimuli. Men seem to be more sensitive to visual cues for sexual arousal (Lykins, Meana and Kambe, 2006, pp. 569-75; Janssen, Carpenter and Graham, 2003, pp. 243-51; Karama et al., 2002, p. 1; Koukounas and McCabe, 1997, pp. 221-30). The visual scanning of the naked image has a power to it that forces itself onto the male brain. The peculiar proficiency that the male brain has to relay this signal, combined with a man's personal history and thought habits (his experience with looking at pornography), are why so many men have difficulty looking away. The signal is received and then projected onto the display,

the visual experience of the viewer. The depiction of nudity and sexual acts have a hypnotic effect and the ability to hold their attention similar to an HD television.

As men fall deeper into the mental habit of fixating on these images, the exposure to them creates neural pathways. Like a path is created in the woods with each successive hiker, so do the neural paths set the course for the next time an erotic image is viewed. Over time these neural paths become wider as they are repeatedly traveled with each exposure to pornography. They become the automatic pathway through which interactions with women are routed. The neural circuitry anchors this process solidly in the brain. With each lingering stare, pornography deepens a Grand Canyon–like gorge in the brain through which images of women are destined to flow. This extends to women that they have not seen naked or engaging in sexual acts as well. All women become potential porn stars in the minds of these men. They have unknowingly created a neurological circuit that imprisons their ability to see women rightly as created in God's image.

Repeated exposure to pornography creates a one-way neurological superhighway where a man's mental life is over-sexualized and narrowed. It is hemmed in on either side by high containment walls making escape nearly impossible. This neurological superhighway has many on-ramps. The mental life is fixated on sex, but it is intended for intimacy. It is wide—able to accommodate multiple partners, images and sexual possibilities, but it is intended to be narrow—a place for God's exclusive love to-be imaged. This neurological superhighway has been reconstructed and built for speed, able to rapidly get to the climax of sexual stimulation. It is intended, however, for the slow discovery and appreciation of a loving partner. The pornography-built pathway has only a few off-ramps, leading to sexual encounters that have only a fleeting impact and hasten the need for more. But these encounters are intended to be long lasting and satisfying for both partners and have many off ramps for creative expressions of intimacy that are not genitally oriented.

BRAIN SCANNING

You may have heard on the evening news or read in a popular magazine that scientists have found the "pleasure centers" of the brain. Journalists or newscasters need only refer to dopamine or serotonin and they have instant scientific credibility. Throw in a reference to the brain or genetics and you have a rhetorical slam dunk regardless of what the topic is. This appeal to science as the most authoritative voice on any topic extends into various topics of cultural importance such as healthcare and mental health (i.e., obesity and depression), criminal behavior (i.e., brain damage and aggression), and many political hot-button issues (i.e., homosexuality, stem cell research and abortion).

In a recent study conducted at UCLA, students were asked to read an article and evaluate its credibility (McCabe and Castel, 2008, pp. 343-52). The articles were actually fictional and quite flawed with headlines such as "Playing Video Games Benefits Attention" and "Watching TV Is Related to Math Ability." The researchers found that when the article was accompanied by brain images such as those taken during functional magnetic resonance imaging or positron emission tomography, the students tended to assign greater validity to the claims of the article. Articles with brain images came across as more convincing than articles without images or with standard bar graphs and charts.

Underneath our penchant for being seduced by brain science is a sense that what is going on inside our brain is fundamental to our psychological experience. For some this knowledge is a relief. Understanding depression, an anxiety disorder, obesity or addiction as something that is a part of how they are biologically put together can be extraordinarily helpful. It may explain the difficulty they have experienced in dealing with their emotions or breaking destructive habits. For others that same knowledge might lead to a fatalist view of themselves.

Because the human brain, the source of our mental life, is such a remarkable organ, it is important to have a good understanding of how it operates. Knowledge about how it is put together and the re-

gions having greater responsibility for the varied aspects of our psychological experience help us understand why pornography affects us the way it does. When we understand how the brain is flexible and plastic and also how it is unyielding and rigid, we can see not only how pornography can lead a person to a place of mental depravity, but also how hope for redemption and sanctification can be achieved.

THE BRAIN: MORE SIMPLE THAN YOU THINK

The human brain is an incredibly complex organ, and many people do not even bother to try to understand it. This is one of the biggest obstacles I face as a teacher with my students. But the brain is much easier to grasp than most people think. What I have found to be helpful is to focus not on the astronomical number of connections and cells, but on the organizing principles of its structure and connectivity. Focus not on its complexity, but on its major structures and functions. Once this is addressed, the rest falls into place.

The brain has three major sections that are based on what we know about how it develops. As the embryo grows, it develops what is called the neural tube. This tube is much like a garden hose capped at both ends and will form the spinal cord and the brain. As the embryo continues to grow, toward its head the neural tube develops three bumps, which eventually become the brain. These bumps are called the *hindbrain, midbrain* and *forebrain* (see table 4.1). As these regions grow they further divide into a number of regions. These subdivisions become more specialized in their function and connectivity.

HINDBRAIN: MEDULLA, PONS AND CEREBELLUM

The part of the brain closest to the spinal cord is where the hindbrain is located. The hindbrain, whose primary job is to keep us alive and to coordinate movement, has three subdivisions. At the base of the brain where it meets the spinal cord is the deepest part of the hindbrain, the *medulla* (see figure 4.2 on p. 91). The medulla is responsible for maintaining the body's vital functions such as breathing and pumping blood. Just above the medulla is the *pons,* which helps coordinate vol-

Table 4.1. Major Brain Regions

Brain Region	Primary Subdivision	Second Order Subdivision	Third Order Subdivision	Function
FOREBRAIN	Telencephalon	Cortex	Four Lobes / Multiple Gyri	1. Higher order thought processes 2. Perception
		Basal Ganglia	Striatum	1. Movement 2. Implicit learning
		Limbic System	Amygdala	Emotion
			Hippocampus	Memory
			Corpus Callosum	Connects the two hemispheres
	Diencephalon	Thalamus	1. Multiple sensory subregions 2. Lateral Geniculate Nucleus (vision)	Sensory processing
		Hypothalamus	Multiple subregions for drives	1. Primary drives (eating, drinking, sex) 2. Motivation 3. Hormonal control
MIDBRAIN	Tectum	Superior Colliculi	-	Visual reflexes
		Inferior Colliculi	-	Auditory reflexes
	Tegmentum	(Multiple subregions)	VTA	1. Arousal 2. Salience
HINDBRAIN	Pons	-	-	Movement
	Cerebellum	-	-	Movement
	Medulla	-	-	Vital life systems

untary movement. Buckled behind and interconnected with the pons is the *cerebellum*. The cerebellum has many folds and sits like a little brain tucked underneath the back end of the brain. As part of the hindbrain, the cerebellum coordinates involuntary movement, balance and posture. More recent research has suggested that the cerebellum is more than just a motor specific region; it also appears to have some involvement in emotions.

These three regions make up the deepest part of the brain, the hindbrain. Because of the importance of what they do, they are locked into their functions and connections. These brain regions have limited flexibility, and that is a good thing. Damage or dysfunction within these regions can result in severe impairment or death.

MIDBRAIN: TECTUM AND TEGMENTUM

Moving upward from the hindbrain we enter into the second developmental brain region: the *midbrain*. The midbrain and hindbrain together form the brainstem. The midbrain is subdivided into two parts whose subspecialties are critical for sensory-motor integration, neurotransmitter production and body movement. The roof of the midbrain, known as the *tectum,* has two sets of bumps that are the sensory-motor integration centers. These bumps are known as the *superior* and *inferior colliculi.* The superior colliculi process visual information and coordinate head and neck movement. Auditory information (as when reflexively craning your head to pick up where a noise is coming from) is processed by the inferior colliculi.

The floor of the midbrain is known as the tegmentum. The tegmentum has several subregions that influence consciousness, attention, sleep, wakefulness, general arousal and motor behavior. Here is where we find the first major player in what is sometimes called the "reward" system—the ventral tegmental area (VTA). The VTA manufactures the neurotransmitter dopamine and ships it up to several higher brain regions. When the VTA is activated, it releases the dopamine in these higher brain regions and acts as the neurochemical signal that something important is going on that needs significant fo-

cus (Biderman and Vessel, 2006). This dopamine release happens in anticipation of meeting drives (like eating, drinking and sex), in response to pain, and has been thought to underlie the feelings of pleasure (Hakyemez et al., 2008, pp. 2058-65; Utter and Basso, 2008, pp. 333-42; Volkow et al., 2003; Kakade and Dayan, 2002, pp. 549-59; Melis and Argiolas, 1995, pp. 19-38; van Furth, Wolterink and van Ree, 1995, pp. 162-84; Bowling, Rowlett and Bardo, 1993, pp. 885-93; Bitran and Hull, 1987). The VTA releases dopamine in response to nearly all drugs of addiction, and many disorders affecting motivation and attention such as attention deficit disorder, obsessive-compulsive disorder and behavioral addictions (i.e., sex addictions, gambling addictions, compulsive shopping) (Dalley et al., 2008; Biederman and Faraone, 2006, pp. 237-48; Andersen and Teicher, 2000, pp. 137-41, Krause et al., 2003, pp. 605-13; Krain and Castellanos, 2006, pp. 433-44; Castellanos, Glaser and Gerhardt, 2006, pp. 1-4; Sikström and Söderlund, 2007, pp. 1047-75; Russell, 2007, pp. 185-98; Ströhle et al., 2008, pp. 966-72). Dopamine release acts as a signal that teaches what is important in the environment, helps remember what the appropriate response is, and fuels the tension and craving for meeting a need (Berridge, 2007, pp. 391-431; Berridge and Winkielman, 2003, pp. 181-211).

The midbrain is similar to the hindbrain in that its connections are relatively inflexible. Damage to the midbrain is not always as debilitating when compared to the hindbrain, but dysfunction can lead to problems with sensory processing, movement, consciousness and arousal.

FOREBRAIN: DIENCEPHALON AND TELENCEPHALON

Seated above the midbrain sits the highest of the three developmental regions, the *forebrain*. The forebrain is the most complex of the three and has accordingly more subregions with more sophisticated capacities. Like the hindbrain and midbrain, the forebrain has two major subdivisions, the *diencephalon* and the *telencephalon*, but these subdivisions have subdivisions.

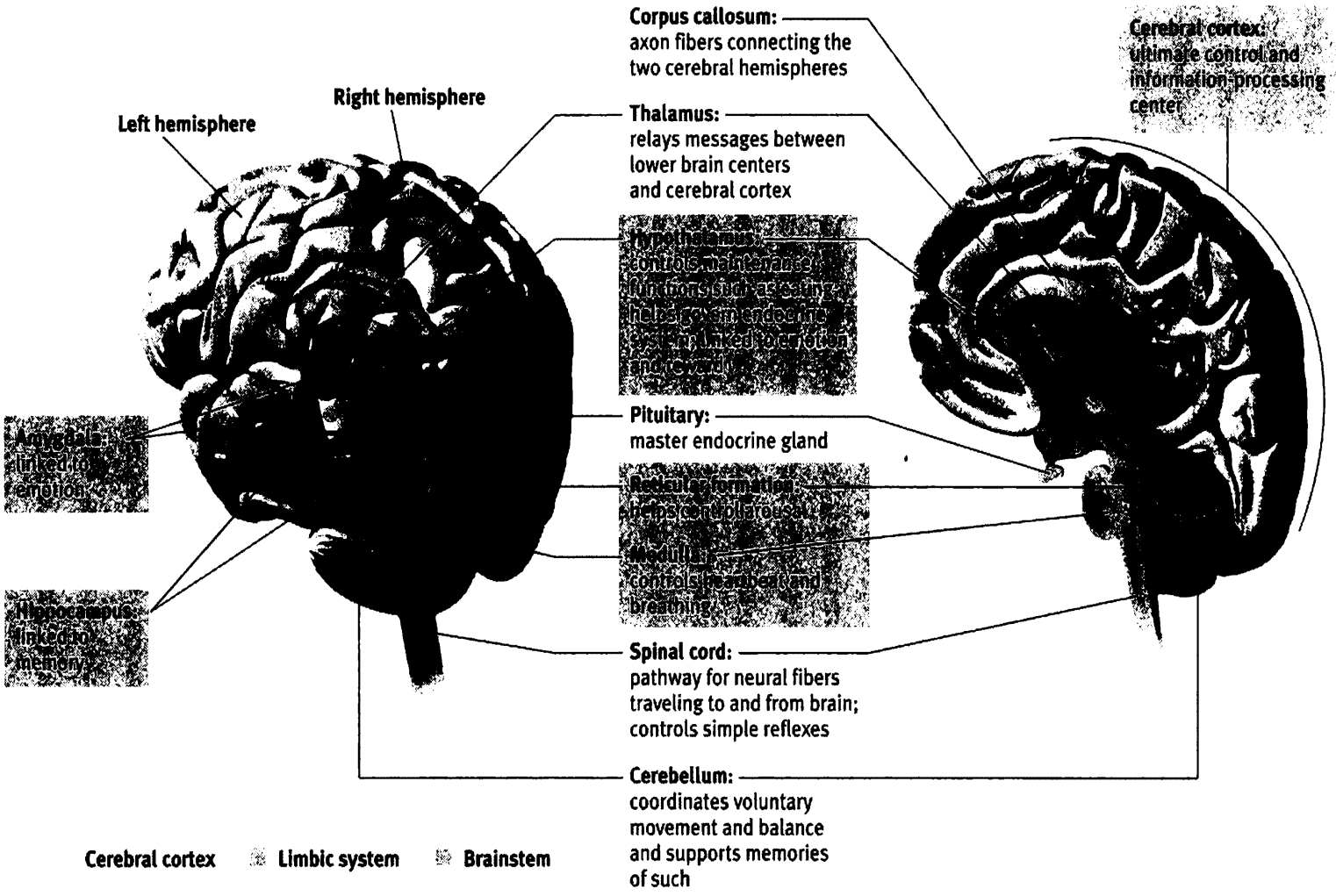
Corpus callosum:
axon fibers connecting the two cerebral hemispheres
Cerebral cortex:
ultimate control and information-processing center
Right hemisphere
Left hemisphere
Thalamus:
relays messages between lower brain centers and cerebral cortex
Hypothalamus:
controls maintenance functions such as eating; helps govern endocrine system; linked to emotion and reward
Amygdala:
linked to emotion
Pituitary:
master endocrine gland
Reticular formation:
helps control arousal
Medulla:
controls heartbeat and breathing
Hippocampus:
linked to memory
Spinal cord:
pathway for neural fibers traveling to and from brain; controls simple reflexes
Cerebellum:
coordinates voluntary movement and balance and supports memories of such
Cerebral cortex
Limbic system
Brainstem

Figure 4.2.

THE DIENCEPHALON: HYPOTHALAMUS AND THALAMUS

The diencephalon sits just above the midbrain and is made up of the *hypothalamus* and the *thalamus*. The hypothalamus is the brain's primary drive center. The three primary drives (eating, drinking and sex) are directed by the functioning of specialized nuclei (clusters of neurons) in the hypothalamus. These nuclei are clustered together and govern each drive. It is important to note that the sexual drive is located in the same region as the centers for eating and drinking. Thus the sexual/reproductive drive is experienced as a survival need similar to the drive for eating and drinking. However, while you can die from not eating or drinking, you can't really die from lack of sexual activity. The hypothalamus is connected with the pituitary gland and coordinates the release of the majority of the body's hormones such as cortisol stress hormones, growth hormone, reproductive hormones (testosterone, estrogen) and many others. Through this hormonal system, the brain coordinates the body's response to prepare it for action and monitor the body's internal state.

The second component of the diencephalon is the thalamus. The thalamus acts as the brain's sensory relay station. Vision, hearing, taste and touch signals from the eyes, ears, mouth and skin all stop off in the thalamus where they are then processed and sent along to the sensory cortex where we see, hear, taste and feel. Where the hypothalamus is primarily responsible for internal drives, the thalamus is responsible for coordinating the information coming in from the outside. The primary nucleus in the thalamus responsible for visual signals is the *lateral geniculate nucleus* (LGN). The LGN serves to sort out the visual signals coming in from the eye and prepares them for more complex processing. The LGN marks the first spot in the brain where visual sexual stimuli are processed. If the eyes are the gateway to the soul, the LGN is the eye's gateway to the brain. More flexible in adapting to challenges than the midbrain, the diencephalon is still better understood as a "hardwired" region showing limited plasticity.

TELENCEPHALON: LIMBIC SYSTEM, BASAL GANGLIA AND CORTEX

Resting atop the thalamus is the second component of the forebrain, the *telencephalon*. The telencephalon is comprised of three major brain systems: the limbic system, the basal ganglia and the cortex. The *limbic system* is a network of regions that is connected with the diencephalon's hypothalamus. It has two major components, the *amygdala* and the *hippocampus*. The amygdala is the brain region that is involved in the expression of emotions and emotional learning. It sits nestled on both sides of the brain underneath the cortex (see Figure 4.2) and damage to it can result in emotional disruptions such as decreased emotionality, a lack of appropriate fear, and hypersexuality known as Klüver-Bucy syndrome. The amygdala is also known to be involved in many mood and anxiety disorders such as post-traumatic stress disorder (Shin, Rauch and Pitman, 2006, pp. 67-79). The drive tension generated by the hypothalamus sends signals to the amygdala where the tension is psychologically experienced.

Connected to the amygdala is the *hippocampus*. The hippocampus's primary role is to take sensory information and store this information as a memory, but it also is important for mapping out the world (i.e., spatial navigation). Death of cells or disruption of connections in the hippocampus can result in memory problems often seen in forms of dementia like Alzheimer's disease. The *basal ganglia* is situated adjacent to the amygdala and hippocampus, and is made up of two major regions, the *striatum* and the *globus pallidus*. Both are associated with a number of functions but are best known for their importance in motor control as the site of Parkinson's and Huntington's diseases.

Above the basal ganglia and limbic system is the thinking part of the brain, the *cortex*. The cortex is the wrinkled gray matter that sits on the outermost part of the brain. It is divided into four lobes (frontal, parietal, occipital and temporal), and each lobe is made up of several folded layers of cortex called *gyri*. Each lobe and gyrus performs specific tasks and functions. For example, the temporal lobe is involved in hearing and language, the occipital lobe in vision, the parie-

tal lobe in touch and the frontal lobe in complex thought. Each part of the cortex is constantly adjusting its synapses, processing, planning and responding to our world. Much of our psychological experience emerges out of the cortex. The cortex is where our most complex thoughts arise and has inherently a greater level of flexibility enabling abstract thought, language, consciousness, virtue and vice.

Those are the basic components of the brain. Now let's examine what happens when pornography is consumed.

PROCESSING THE SEXUAL IMAGE

Visual perception can be understood neurologically as following a straightforward path. The eye picks up the visual signal and sends a neural signal to the LGN. This signal is then relayed to the visual cortex found in the occipital lobe at the back of the head. From here the basics of the stimulus are then processed (what is the stimulus and where is it in the environment). But here is where things get interesting, where pornographic images become "HD" signals.

Men viewing a nude woman spend more time looking at her body and less time at her face. The focus is on her bodily parts. She is an object to be viewed and consumed (Lykins, Meana and Kambe, 2006, pp. 569-75). But there does appear to be a difference when men look at just a naked woman versus a couple engaging in intercourse. Contrary to popular belief, men do not focus just on a woman's bodily parts when they view heterosexual intercourse (Rupp and Wallen, 2007, pp. 524-33). When viewing sexual intercourse, men still spend a significant amount of time looking at the woman's body, but they also spend time examining the woman's face, presumably looking for her response to the sexual act. Men are more preoccupied with a woman's sexual arousal than they are given credit for.

The visual cortex and its primary outputs are more active in men than in women when they view pornography (Bocher et al., 2001, pp. 105-17). There is an increase in hypothalamic and VTA activity, which is likely correlated to the release of dopamine fueling the salience of the sexual signals. A number of sites in the cortex are related to emo-

tional drives and are affected by sexual arousal, activity and response. The *insular cortex* has many connections to limbic regions, has been identified as a center for bodily representation and provides the context for subjective emotional experiences. Increases in insular cortex activity are seen in men when they are exposed to pornographic material. It is where some of the craving and preoccupation with sexual arousal reside (likely fueled by dopamine release). The *orbitofrontal cortex* is another cortical region that is wired with limbic sites and it also increases its activity when viewing pornography. There is also a considerable increase in the ventral portion of the striatum (the site of much of the VTA's dopamine output) (Arnow et al., 2002, p. 1014).

When men view pornography, they experience increased anxiety and tension, resulting in an increase in amygdala activity. Men also show an increase in amygdala activity when shown statements suggesting sexual infidelity by their girlfriend. Sexual arousal and intimate sexual relationships appear to supercharge the male amygdala.

Several brain regions in men are affected by stimulation of the penis and orgasm. There is an increase in activity in the VTA and insular cortex, but there is a decrease in the activity of the amygdala. While the VTA and insula appear to be the sites responsible for the release of dopamine and the psychological experience of euphoria and transcendence. There is also a dramatic reduction in the activity of the amygdala. As sexual tension increases amygdala activity, the orgasm releases this tension and anxiety (Holstege et al., 2003, pp. 9185-93).

MIRROR NEURONS

Another significant finding in brain research is the presence of *mirror neurons*. Mirror neurons are a set of brain cells found in specific parts of the brain, notably the inferior frontal gyrus and the inferior parietal lobe (Mouras et al., 2008, pp. 1142-50). These neurons were thought to be only involved in the production of a behavior but are more than that. They're also involved in the *perception* of that same behavior. They are motor system cells that activate when you see a behavior. If you see someone grab a pen, neurons that would correspond to his or

her grabbing a pen are activated in you as well. Originally called "monkey see, monkey do" neurons since they were first discovered in monkeys, these cells act as mirrors. When we see a behavior, we silently mirror it in our cortex. It's as if the cortex says "I can do that" and mirrors how it would actually do it.

Mirror neurons have been implicated in many other important fields like the study of observational learning and autism (Williams et al., 2001, p. 287; Malle and Hodges, 2005, p. 354). They are located in the same cortical regions that are involved in language development and detecting emotions in others. When you see the face of someone who is afraid, it elicits the same emotional state in you.

How are mirror neurons related to pornography? Consider what happens with mirror neurons when men watch a pornographic video. The brain reacts in such a way as if you were the person engaged in the sexual act. Viewing a pornographic movie creates a neurological experience whereby a person vicariously participates in what he is watching. As a man watches a pornographic movie he can neurologically identify with the performers in the video and place himself into the HD signal. No longer is he restricted to responding to just the nakedness of the woman. To deal with the arousal it creates, the brain mirrors and heightens the arousal, causing even more sexual tension. The sexual drive is fueled even further and screams for an outlet.

THE SEXUAL OUTLET OF CONVENIENCE

In another study of brain activation during human male ejaculation, researchers in the Netherlands discovered that when men are placed in a brain scanner and are stimulated by volunteer female partners, VTA activity increases as well. The VTA is known to have dopaminergic projections to a variety of forebrain structures. The structures, most notably in the nucleus accumbens and the cingulate cortex, have long been known to be involved in the neural circuitry of reward. This connection from the VTA to these limbic regions is the source of the rush from substances of abuse as well as sexual arousal. As researchers have suggested, "The present findings may represent an anatomi-

cal substrata for the strongly reinforcing nature of sexual activity in humans. Because ejaculation introduces sperm into the female reproductive tract, it would be critical for reproduction of the species to favor ejaculation as the most rewarding behavior" (Holstege et al., 2003, pp. 9185-93). This area also shows an increase in activation when cocaine and heroin are administered and is involved in rewarding behaviors such as eating and drinking.

A number of other regions are collectively referred to as the *mesodiencephalic transition zone.* This mesodiencephalic transition zone receives input from the spinal cord so that when the ejaculatory reflex occurs, it is accompanied by a signal sent to the brain that initiates the psychological experience of an orgasm. These connections go throughout the spinal cord, but particularly the region innervating the genitals in other species. Several regions of the cortex were found to be activated while other regions deactivated. The majority of the activation usually occurred on the right side of a brain, which is involved with memory-related inventory while the secondary visual cortex is involved in visual hallucinations. The researchers also noticed that there was an absence of activation in the medial preoptic area (MPOA) and amygdala of these males. The absence of MPOA activation (which in non-primates is incredibly important for arousal and ejaculation) seems to suggest that this region in humans is involved in creating the context for sexual behavior. The deactivation of the amygdala and entorhinal cortex is also seen in subjects who view pictures of loved ones as well as subjects who experience a cocaine rush.

These findings suggest that human ejaculation due to stimulation by a partner (or by oneself) correlates with the euphoric, orgasmic states that are seen in heroin and cocaine use. Because of this activity, many have referred to people being addicted to sex. The orbitofrontal cortex is our emotional modulatory system. This is our decision-making system. To be addicted to something is to release dopamine, which causes you to want it and to make the decision to pursue it. That's our addiction pathway.

What about watching pornography? Well, it comes in through the

retina, goes through the thalamus, when projects up to the visual cortex, goes through the association cortex and the anterior cingulate, which then projects down to the insular cortex, the mirror neuron system, and the basal ganglia, thalamus and the hypothalamus. This is the sexual arousal center, that interstitial nucleus of the anterior hypothalamus that sends projections down to the ventral tegmental area, which then releases dopamine.

Watching sex increases sexual anxiety (myotonia). In an overactive and in a heightened state of emotional arousal, the myotonic state needs to be resolved. What is the easiest route to resolving the myotonia? Ejaculation. This network is why pornography is so insidious in males; it is not the same in females. Females are not aroused like males by visual images of pornography, but this doesn't mean the visual signal is unimportant, just *less* important than in males.

What happens in ejaculation? Usually there's some sort of stimulation coming from the spinal cord, which goes up to the hypothalamus. It also goes to the VTA, because when there's ejaculation, there's a release of dopamine. All this shuts down the amygdala. Why is that important? The amygdala is our emotional center and primarily our fear center in the brain. The amygdala shuts down at the moment of ejaculation. Thus an orgasm is associated with an absence of fear. Men experience a sort of emotional hovering, a transcendent freedom from all worry.

The caudate, the putamen and the pallidum (together the basal ganglia) are implicit learning centers. This is the site of unwritten rules. Consider these thought patterns: *If I scrub my hands, I'll make the anxiety about my dirtiness go away. If I scrub my hands, I'll feel clean. If I check the house, I'll know that the iron isn't on.* Some people know they've already checked the iron but can't get rid of the anxiety. The only way they can get it out of their head is to repeat the behavior involving the basal ganglia.

This leads us to a pathway that makes viewing pornography a seemingly pleasurable experience. Males like looking at pornography. Naked women are interesting and arousing. When sexual images

come through the visual system they stimulate sexual arousal. When there is a male performer, they can (via the mirror neurons) vicariously participate in the sexual act. If they arouse themselves and masturbate to pornography, they now begin to set in place a neurological habit. The images, arousal, masturbatory act and ejaculation are all associated with one another.

This is how a pornography addiction and sexual compulsion is built from scratch. It involves the visual system (looking at porn), the motor system (masturbating), the sensory system (genital stimulation) and neurological effects of orgasm (sexual euphoria from opiates, addictive dopamine in the nucleus accumbens and reduced fear in the amygdale). They have now begun to store this pattern as a reinforced neurological habit.

THE CHEMICALS OF PASSION

Responses to pornography flow through the neurological viaducts through which feelings of love, longing, need and romance are experienced. These neurological circuits are the wires of the system, but there are other players as well. Hormones and neurotransmitters provide the "juice" within this wiring system. Understanding their roles in activating this system is critical. Let's consider some of the major hormonal and neurotransmitter substances that are major players in the brain and body's chemistry of love and sexual intimacy, with special attention to their role in men.

TESTOSTERONE

If any one hormone has the reputation as being the male hormone, it is testosterone. Often blamed for all that is considered bad masculine behavior, from aggression to dominance, it is also heralded as the magic elixir that promises to restore men to their virile, masculine selves. It plays a key role in sexual development, and in the adult it is important for sexual interest and motivation. The adult male produces about forty to sixty times more testosterone than a female, but testosterone levels can vary greatly between men. Testosterone affects

the whole body, increases the size of many organs on average (such as lungs, liver and heart) and is involved in the masculinization of the brain during development (see chapter 6).

Testosterone is released into the bloodstream throughout the day, but is increased in response to sexual cues picked up by the brain. The brain detects these sexual cues and initiates an increased production of testosterone by the testes. This increase in testosterone feeds back to the brain, enhancing sexual anticipation and preparing the brain for further sexual stimuli. This increase in sexual cues can be produced from the outside (the presence of a potential partner or pornographic image) or from within (sexual fantasizing). While testosterone does not enhance sexual performance, it acts as the hormone driving sexual desire. This is why castration is used for the removal of the sexual drive (i.e., eunuchs and chemical castration for sex offenders).

The wave of testosterone, however, is slow to dissipate. It has an extended period of activation, unlike neurotransmitters, which have a much shorter duration time. Testosterone is the hormone that primes both the body and the brain in preparation for sexual intimacy. Pornography (and the mental fantasizing that it enables) crafts a brain that constantly generates testosterone and heightens sexual desire. With this ever-present sexual desire, the brain is ready to interpret any signal (external or internal) and ramp up the perceived need for sexual activity. Interestingly, men in committed relationships tend to have lower testosterone levels. This may be a reason why these men may be less likely to commit adultery (Burnham et al., 2003, pp. 119-22).

DOPAMINE

Dopamine is the neurotransmitter involved in the mesolimbic system that coordinates all natural reinforcing behaviors (eating, drinking, sex). It is also the primary neurotransmitter that most addictive drugs are known to release. Dopamine plays an important role in reinforcement and is part of the reason why craving occurs. Some-

times referred to as a pleasure chemical, dopamine focuses our attention on things that have significance to us. Eating a good meal when hungry, drinking a cool glass of water when thirsty or making love to your wife all have emotional salience. Dopamine helps us know where we should direct our energy. It is not surprising then that dopamine has been implicated in many other mental illnesses such as attention deficit disorder, obsessive-compulsive disorder and schizophrenia.

In the brain, dopamine is involved in movement (Parkinson's disease is an example of this; lack of dopamine results in an inability to move), but it is better known for its involvement in addiction. Dopamine is released into the specific brain regions (the limbic system's nucleus accumbens), but it is not where we experience "pleasure." The activation of dopamine receptors in this area involves how our arousal is directed and how the significance of our needs is determined. This stimulus we are attending to and experiencing is then stored in our memory (along with the consequences of the drug, image, lover, etc.) and prepares us for the next time the need wells up within us.

Sexual cues trigger the release of dopamine in the nucleus accumbens, which is also sensitive to testosterone. This synergy between dopamine and testosterone is such that the elevation of testosterone enhances dopamine's sex significance, and the elevation of dopamine activation propels testosterone levels. Convenient, isn't it? Dopamine focuses a man, initiates his movements, increases his sexual sensitivity and makes him long for his sexual partner.

NOREPINEPHRINE

Norepinephrine (sometimes known as noradrenaline) is a pharmacological switch-hitter. It can act as a hormone or as a neurotransmitter. It is also important in sexual arousal and sexual memory as a hormone and as a neurotransmitter. Norepinephrine is a chemical cousin of dopamine (together they are the *catecholamines*) and is also similar to epinephrine (or adrenaline). It is found throughout the brain and

can act as a stress hormone involved in directing our responses to autonomic arousal (fight or flight, fear, anxiety, panic, excitement, sexual arousal). In autonomic arousal, norepinephrine and epinephrine (produced by the adrenal glands next to the kidneys) increase heart rate, trigger the release of sugar for energy and move the blood from our core to our muscles (for fight or flight). It is involved in alertness and waking you up from sleep (noradrenergic drugs can be stimulants to keep you awake). Epinephrine-based drugs have been used as appetite suppressants.

Important in the context of sexual arousal, norepinephrine and epinephrine are part of the autonomic arousal that occurs throughout the body in preparation for sexual activity. It is this autonomic arousal (specifically what is referred to as the sympathetic division of the autonomic nervous system) that gives some the feeling of being ramped up or energized. However, this autonomic activation is not directed.

A person can be energized in many ways. He can be energized at the prospect of a meal when hungry, for a drink when thirsty or for a sexual encounter. He can also be energized to run away from a fight, avoid a predator, engage in a fight, prepare for an athletic event or cheer on his favorite team. Sometimes our world forces us into arousal (when we are attacked or when we see pornography). Other times we work ourselves into an aroused state (we dwell on an injustice or we fantasize). Regardless of how a man gets aroused, his brain is involved in making sense of the arousal and determining how to respond to it.

When I took my son to an art museum, he saw some paintings of nudes. The images created an autonomic arousal that he had no context to interpret, so he giggled. But in an older man who has been informed about the place of sexuality and nakedness and has a sexual history, the arousal is interpreted as sexual. The neurological process that he has learned is initiated. If he has a history of acting out in an unhealthy manner, he will most likely do so again and reinforce the process. If he has a history of directing his arousal in a

healthy fashion, he will most likely do so again and continue the process of sanctification. Norepinephrine is the hormone that initiates the arousal in our body and creates the sense of energy, however we interpret it.

In the brain norepinephrine is also involved in storing emotional stimuli. It has been implicated in the formation of flashbulb memories and post-traumatic stress disorder. Norepinephrine burns the object that initiated the arousal into our memories because of its physiological and emotional significance. Is it any wonder why so many men can pull up clear memories of uninvited pornographic images that they were exposed to when they were young? Is it any wonder why they have been scarred in a PTSD-like fashion, unable to erase these images? And is it any wonder why men who act out in response to pornography often have these images return (both uninvited and invited) with such ease? We were designed to store significant experiences of sexual intimacy with norepinephrine's help.

SEROTONIN

The use of the antidepressant Prozac and the illegal drug ecstasy have popularized the neurotransmitter serotonin as the brain chemical involved in mood and emotional euphoria. It is true that increased levels of serotonin help people who are depressed, but one of their most notorious side effects is sexual dysfunction. By increasing serotonin levels to elevate mood, there is a decrease in the sexual response of men. Low levels of serotonin in women may make them more likely to become depressed, but in men low serotonin is more likely to make them impulsive and aggressive. This may seem a bit odd; increasing a mood elevator should enhance sexual mood, shouldn't it? But as seen in the use of the street drug ecstasy, why have sex when the high you get off of the drug is better? (Ecstasy works with other neurotransmitter systems to produce this euphoria.) By increasing serotonin levels, interest in sex is diminished. Combined with the fact that dopamine tends to suppress serotonin, reduced levels of serotonin seem to be important for sexual arousal.

ENDOGENOUS OPIATES

The rush that a man gets from seeing an attractive woman is different from the rush he gets from an orgasm. The chemical difference between these two is that sexual arousal is the result of testosterone, dopamine and norepinephrine surges, whereas the transcendence and euphoria experienced during orgasm is related to the release of endogenous opiates. The body produces natural or endogenous opiates involved in pain relief and reinforcement. Artificial drugs like heroine cause euphoria and reduce pain distress. This may be why many men describe the psychological and emotional aspects of orgasm as a "release." The ejaculatory release of semen occurs in concert with opiate activation (Holstege et al., 2003, pp. 9185-93; Moulier et al., 2006, pp. 689-99; Holstege, 2005, pp. 109-14).

The resulting opiate release and orgasm also is connected with two other systems: dopamine release in the nucleus accumbens and decreased amygdala activity. Because of the nature of the wiring, spinal signals arriving from the body that are connected with ejaculation release opiates onto the site which is the primary source of dopamine to the nucleus accumbens—VTA. The amygdala and cingulate cortex interpret the autonomic arousal as fear or anxiety, sometimes referred to in a sexual context as sexual tension.

The movement toward orgasm in men is usually accompanied by an increased state of anxiety. One man once described it to me as a "pre-orgasmic panic." But this elevation in amygdala activity is shut off as a result of the opiate being released with ejaculation. The opiates' activation resulting from ejaculation increases the amount of dopamine released in the VTA and shuts down the fear-based amygdala. This adds significance and pleasure to the euphoria and the removal of all fear.

But the male mind is not made to achieve this orgasmic high on demand. Considerable neurological work goes into preparing a brain for an endogenous release of opiates. It is designed to be preceded by the priming of dopamine, norepinephrine and testosterone. However, repeated activation of opiate receptors (such as with heroin addiction

or repeated orgasm) results in tolerance. With repeated acting out (as well as drug use), the absence of opiate activation results in craving (the drug or sexual release) and diminished euphoria. This is why coupling pornography with masturbation is so significant in the development of pornography problems and ultimately steals the joy from sexual relations.

OXYTOCIN AND VASOPRESSIN

If testosterone gets desire started, oxytocin and vasopressin are what bind men to the object of their affection. Oxytocin and vasopressin are released slowly during sexual activity, but are released in large quantities in response to orgasm. Oxytocin is released in the brain and is detected in several parts of the brain that are implicated in the qualitative experience of sexual satisfaction, such as amygdala, ventromedial hypothalamus and septum (Murphy et al., 1987). Comparative studies of the effects of oxytocin on males indicate that it is involved in erection and that vasopressin released in the brain of males after sexual intercourse increases their social attachment to their partner. In nonsexual experiments, men who are administered oxytocin display a higher level of trust and a reduction of fear in risky situations when compared to non-oxytocin controls. When a man plays a game against a computer opponent, the presence of oxytocin did nothing to create trust or reduce his aversion to risk, indicating that it is about attachment and trust in a person and not the situation (Kosfeld et al., 2005).

Vasopressin is released in the brain during sexual behavior and is particularly important in binding the male to his mate. There is also some indication that vasopressin may be involved in protecting the mate and becoming aggressive toward other males. One study has gone so far as to argue that a gene which codes for vasopressin receptors has been correlated with marital status, marital bonding, and the spouse's perception of marital quality. Unfortunately, with repeated sexual acting out in the absence of a partner, a man will be bound and attached to the image and not a person.

While a man may have many reasons for viewing pornography, the act of viewing activates the mirror system and increases the need for orgasm/ejaculation (usually via masturbation or sexually acting out). When this occurs, this maladaptive pattern is neurologically and neurochemically reinforced.

FROM PORNOGRAPHIC TROUGH TO SANCTIFIED WIRING

When I was young I visited a farm that had an old-fashioned water pump. It was situated in the center of a cement slab and would drip ferociously, long after you stopped pumping. Over the years the left-over dripping water had cut a trough from under the spigot to the edge of the slab. The trough was nearly two inches deep, and any standing water on the slab would be channeled to it, cutting it deeper.

So it is with pornography in a man's brain. Because of the way that the male brain is wired, it is prone to pick up on sexually relevant cues. These cues trigger arousal and a series of neurological, hormonal and neurochemical events are set into motion. Memories about how to respond to these cues are set off and the psychological, emotional and behavioral response begins. As the pattern of arousal and response continues, it deepens the neurological pathway, making a trough.

This neural system trough, along with neurotransmitters and hormones, are the underlying physical realities of a man's sexual experience. Each time that an unhealthy sexual pattern is repeated, a neurological, emotional and spiritual erosion carves out a channel that will eventually develop into a canyon from which there is no escape.

But if this corrupted pathway can be avoided, a new pathway can be formed. We can establish a healthy sexual pattern where the flow is redirected toward holiness rather than corrupted intimacy. By intentionally redirecting the neurochemical flow, the path toward right thinking becomes the preferred path and is established as the mental habit. The path to recovery relies on the very rules that govern how the wounds were initially created. By deepening the "holiness" path-

ways, we are freed from deciding to do what is right and good as they become part of our embodied nature. That is part of the process of sanctification.

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