

## Neurobiology of Pornography Addiction – A clinical review

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### Abstract

The aim of the current review is to provide a clinically oriented overview of the neurobiology of pornography addiction. The review first looks at the basic neurobiology of addiction with the basic reward circuit and structures involved generally in any addiction. The focus then shifts to pornography addiction and studies done on the neurobiology of the condition are reviewed. The role of dopamine in pornography addiction is reviewed along with the role of certain brain structures as seen on MRI studies. fMRI studies involving visual sexual stimuli have been used widely to study the neuroscience behind pornography usage and the findings from these studies are highlighted. The effect of pornography addiction on higher order cognitive functions and executive function is also stressed. The review ends with an outline of newer emerging paradigms and the future research needs in the area.

**Keywords:** Neurobiology, Pornography addiction, Pornography, Addictions, Behavioral addictions, Dopamine, Visual sexual Stimuli, fMRI.

### Introduction

‘Pornography addiction’ is a recent diagnostic label which is used to define patients with a propensity and tendency to view pornography images and videos frequently and regularly and also experiencing distress when not allowed to do so.<sup>(1)</sup> This falls under the broader rubric of ‘sex addiction’ or as a subtype of ‘internet addiction behavior’.<sup>(2)</sup> There is a mixed viewpoint on whether pornography is actually an addiction or whether it must be categorized as a sexual compulsivity or as a subset of hypersexual behavior.<sup>(3)</sup> For the purpose of this review we use the term pornography addiction as described above. The recent revision of the Diagnostic and Statistical Manual (DSM) in its fifth edition did not include pornography addiction as much research was nascent when the classification was released.<sup>(4)</sup> Even current literature is not clear on diagnostic criteria for the disorder while it remains a fact that clinicians are seeing more patients with this problem over the past few years.<sup>(5)</sup> This article aims to provide the clinician a clinical overview of the neurobiology of pornography addiction such that it may provide valuable insights for the diagnosis and management of these patients.

### Method of Conducting this Review

For identifying articles that focused on neurobiology, neuroscience and pornography usage and addiction, the terms ‘neurobiology of pornography’, ‘neurobiology of pornography addiction’, ‘neuroscience and pornography’, ‘pornography addiction’, and ‘neuroscience of pornography use’ were used. For identifying articles that focused on specific brain structures, terms like ‘amygdala and pornography’, ‘hippocampus and pornography’, ‘sexual visual stimuli and pornography viewing’, ‘pornography and the

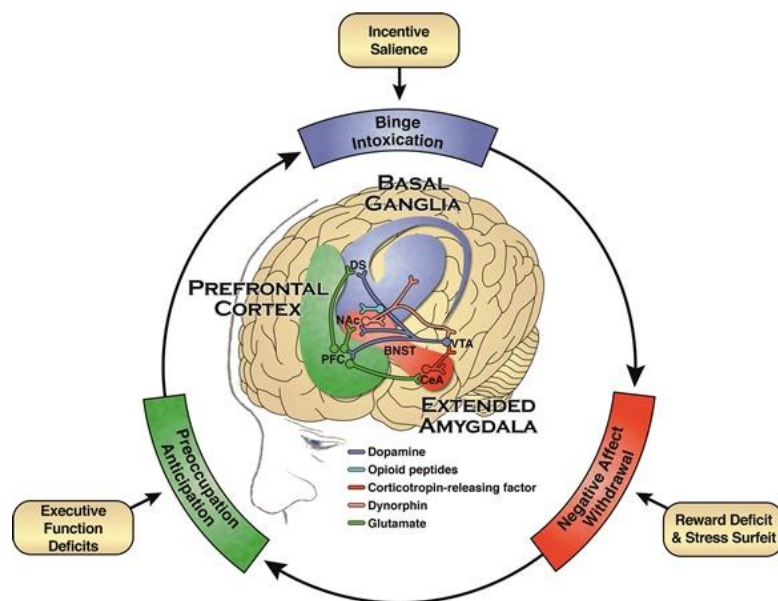
brain’, ‘prefrontal cortex and pornography’, ‘pornography addiction and brain circuits’ and other terms were used. These two search strategy results were combined with an ‘and’ statement in the following databases with the time frame being specified from 2005 through 2017. The databases used were PubMed, Google Scholar and the Cochrane Database on Systematic Reviews. In total, 59 articles were identified which included reviews, mini reviews and original research papers on the issues of pornography usage, addiction and neurobiology. The research papers reviewed here were centered on those that elucidated a neurobiological basis for pornography addiction. We included studies that had decent sample size and sound methodology with appropriate statistical analysis. There were some studies with fewer participants, case series, case reports and qualitative studies that were also analyzed for this paper. Both the authors reviewed all the papers and the most relevant ones were chosen for this review. This was further supplemented with the personal clinical experience of both the authors who work regularly with patients where pornography addiction and viewing is a distressing symptom. The authors also have psychotherapeutic experience with these patients that have added value to the neurobiological understanding.

### Basic Neurobiology of Addictions in General Basic neurocircuit of addiction

All forms of addiction are known to involve the mesolimbic dopamine (DA) pathway, which originates from the ventral tegmental area (VTA) and projects into the nucleus accumbens (NAcc) which forms the reward circuit in addiction. This circuit has been implicated in the pleasure, reinforcement, learning, reward seeking, and impulsivity seen in addictions.<sup>(6)</sup> The mesolimbic

dopamine pathway is linked to three brain regions to form the extended reward circuits called the reward system in addiction.<sup>(7)</sup> The structures involved are the amygdala that codes for positive and negative emotions, fear and emotional memory,<sup>(8)</sup> the hippocampus which is concerned with processing and retrieval of long term memories<sup>(9)</sup> and the frontal cortex that coordinates and determines addiction behavior.<sup>(10)</sup> Different classes of

psychoactive drugs may activate the reward system through different means, however, the universal result is a flood of dopamine in the nucleus accumbens (the reward center).<sup>(11)</sup> This results in acute positive reinforcement of the behavior that initiated the flood and addictive related learning associations.<sup>(12)</sup>



**Fig. 1: Addiction Circuits**

### Role of the prefrontal cortex

Once the dopamine flood has finished its course, there is activation of the extended amygdala, an area associated with pain processing and fear conditioning. This leads to activation of brain stress systems and dysregulation of anti-stress systems with a decreased sensitivity to rewards and an increase in the reward threshold, which is called tolerance.<sup>(13)</sup> Thus, there is a repetition and reinforcement of the addictive behaviors. Specific affected areas within the prefrontal cortex include the dorsolateral prefrontal cortex (DLPFC), responsible for key components of cognition and executive function<sup>(14)</sup>, and the ventromedial prefrontal cortex (VMPFC) responsible for components of inhibition and emotional response.<sup>(15)</sup> They affect the cognitive component of reward processing. The addicted brain enters an “allostatic” state when the reward system is unable to return to its homeostatic (normal) state. The reward system subsequently develops an altered set-point, leaving the individual vulnerable to relapse and dependence. This is what is called the “dark side” of addiction.<sup>(16)</sup>

### Neurobiological Underpinnings of Pornography Addiction

#### Role of the reward areas

In an early study using fMRI scans, researchers showed cocaine addicted patient’s preconscious

sexually related visual cues (erotic images). They found activation of the same limbic system/reward circuitry in subjects shown sexual cues as when shown drug related cues.<sup>(17)</sup> Neurobiological reviews on sexual behavior and drug addiction have confirmed that the networks involved in sexual behavior are similar to those involved in processing other rewards including addictions.<sup>(18)</sup> The overlap of classic reward brain areas involved in sexual arousal, love and attachment has been elucidated with the ventral tegmental area, nucleus accumbens, amygdala, basal ganglia, prefrontal cortex and orbitofrontal cortex being the common substrate.<sup>(19)</sup> A model termed the ‘reward deficiency syndrome’ (RDS) model has been implicated in pornography addiction.<sup>(20)</sup> It implies a brain reward genetic dissatisfaction or impairment that results in aberrant pleasure seeking behavior that includes drugs, excessive food, sexuality gaming, gambling and other behaviors.<sup>(21)</sup>

#### Dopamine and neuroplasticity

It has been stated that the continued release of dopamine into the reward system when an individual compulsively and chronically watches pornography stimulates neuroplastic changes that reinforce the experience. These neuroplastic changes build brain maps for sexual excitement.<sup>(22)</sup> In the brain of the user, previously established brain maps for normal sexuality

cannot match up to newly developed and continuously reinforced maps generated by watching pornography, and the addicted individual progresses to more explicit and graphic pornography use to maintain the higher level of excitement.<sup>(23)</sup> Changes in dopamine receptor density as a result with permanent changes in the reward system have been implicated in this condition.<sup>(24)</sup>

### Cue reactivity

In a landmark study on compulsive sexual behavior, an experiment was conducted designed to measure the subjective experience of cue-reactivity, as well as the neurobiological markers and correlates. The subjects were shown the videos both inside and outside of the fMRI scanner. Compared to the healthy control subjects, the compulsive sexual behavior subjects reported higher desire ratings to the sexually explicit videos, but not to the erotic clips while the former reported higher liking rating to the erotic clips, but not to the explicit cues. These results indicated a divide between liking and yearning by compulsive sexual behavior subjects when watching sexually explicit videos.<sup>(25)</sup>

### Structural MRI findings

In an MRI study on 64 healthy male subjects, the researchers correlated hours of online viewing of explicit material per week and years of use with dorsal striatal structure and connectivity. The longer duration and more hours per week of use correlated with lower grey matter volume in the right caudate nucleus. More years and more hours per week of use correlated with lower left putamen activity in response to brief, still sexual images. Gray matter volume of the brain was measured by voxel-based morphometry and resting state functional connectivity was measured on 3-T magnetic resonance imaging scans. They found a significant negative association between reported pornography hours per week and gray matter volume in the right caudate ( $p < 0.001$ , corrected for multiple comparisons) as well as with functional activity during a sexual cue-reactivity paradigm in the left putamen ( $p < 0.001$ ). Functional connectivity of the right caudate to the left dorsolateral prefrontal cortex was negatively associated with hours of pornography consumption.<sup>(26)</sup> fMRI studies have confirmed that the putamen is activated during sexual arousal and pleasure. The subjective symptom severity was also the only significant predictor in a regression analysis with ventral striatum response as dependent variable and subjective symptoms of Internet pornography addiction, general sexual excitability, hypersexual behavior, depression, interpersonal sensitivity, and sexual behavior in the last days as predictors.<sup>(27)</sup> Lower brain structure volumes and grey matter may be due to a tolerance that has developed due to desensitization. In the above study subjects who consumed more

pornography were found to have less connectivity between the right caudate and left dorsolateral prefrontal cortex (DLPFC). Disruptions in this circuit are implicated in drug and other behavioral addictions as well.<sup>(26)</sup> The clinical implication of the findings are that there are brain related changes in pornography addiction. The greater the intensity and severity of the brain findings, the longer is the patient probably going to take to show treatment response and recovery. Further studies using multiple imaging modalities are needed to get a better perspective one exact neurobiological correlates of pornography addiction.

### Pornography viewing and higher cognitive functions

Multiple studies have also been conducted on the impact of pornography viewing on cognitive functions. Changes in neural structures such as the orbitofrontal cortex (OFC) and subcortical structures have been linked to neurochemical changes in serotonin and serotonin/dopamine ratios. Subjects with excessive pornography viewing have shown impairments on executive functioning thought to involve the DLPFC.<sup>(28)</sup> Greater self-reported executive dysfunction in a sample of hypersexual patients have been reported using neuropsychological tests.<sup>(29)</sup> Several studies reported an interference of the processing of sexual cues and sexual arousal with executive functions.<sup>(30)</sup> Sexual arousal induced by sexual images impaired working memory performance in a study as well as switching and monitoring performance in an executive multitasking paradigm. The finding of an attentional bias towards sexually explicit cues has been replicated in many studies.<sup>(31)</sup> Dorsal anterior cingulate cortex (dACC) activity in those that view pornography regularly may reflect similar underlying processes of attention capture.<sup>(32)</sup> Thus patients with pornography addiction may have problems in activities of daily living and it may affect work functioning. Larger studies in larger samples from diverse populations are needed for generalization of the findings.

### Neuroimaging and visual sexual stimuli studies

There is an increasing number of neuroimaging studies using visual sexual stimuli (VSS), especially within the emerging field of research on compulsive sexual behavior.<sup>(33)</sup> A central question in this field is whether behaviors such as excessive pornography consumption share common brain mechanisms with widely studied substance and behavioral addictions. Depending on how VSS are conceptualized, different predictions can be formulated within the frameworks of 'reinforcement learning' or 'incentive salience theory'.<sup>(34)</sup> In most laboratory settings, VSS play a role of a reward, as evidenced by the (1) experience of pleasure while watching VSS, possibly accompanied by genital reactions, (2) reward-related brain activity correlated with these pleasurable feelings in response to VSS, (3) a willingness to exert effort to view VSS

similarly as for other rewarding stimuli such as money and (4) conditioning for cues predictive of VSS. These studies on VSS serve as a means to provide common grounds for theories of the neurobiology of pornography addiction and other behavioral addictions.<sup>(35-36)</sup>

### Emerging paradigms

There have been multiple neurotransmitters that have been implicated in addictions that range from dopamine to serotonin and now a role for glutamate and dynorphin has been elucidated.<sup>(37-38)</sup> The same has not yet been elucidated in research of pornography addiction. Further studies in this direction are warranted. Evidence regarding neurotransmitter activity in pornography addictions and substance use disorders has tended to be complementary.<sup>(39)</sup> Neurochemical findings suggest differential serotonergic function, compared with control subjects, among people with behavioural addictions and clinical results with dopamine antagonists and medications targeting serotonin (primarily SSRIs) have demonstrated negative or mixed findings in people with pornography addiction.<sup>(40)</sup> Opioid antagonists have tended to be positive for these conditions as well.<sup>(41)</sup> Genetic (especially molecular) and family history evidence is limited for the condition. However, available evidence suggests substantial heritability and there is evidence suggesting familial risk across psychiatric conditions and other behavioral addictions.<sup>(42)</sup> Large scale studies in these areas are warranted to substantiate the meager findings available.

### Conclusions

The neurobiology of pornography addiction is one which is nascent and needs substantiate research to consolidate the findings already done. Researchers need to converge these findings of various studies and come up with an integrated neurobiological model of pornography addiction. There is a need for further larger neuroimaging, biomarker and genetic studies in the area to help determine a biological trajectory for pornography addiction. The first decade of research (2006-2016) has made substantial contributions and it is the next decade of research in this area shall pave the way ahead for things to come.

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