

# The Genetics of Gambling and Behavioral Addictions

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## ABSTRACT

Behavioral addictions are considered as the repetitive occurrence of impulsive behaviors without consideration of their potential negative consequences. These addictions represent an increasing cost to society and are an important new field of research in psychiatric genetics. There has been a growing body of evidence on the familial aggregation and genetic influences on the development of behavioral addictions and mainly on pathological gambling. The aim of this article is to critically review findings of family and molecular genetic studies on behavioral addictions, focusing on pathological gambling and commenting on other disorders where appropriate. This review provides a comprehensive approach to genetic studies on behavioral addiction and points out the necessity of expanding the genetic research in this field. Future directions for genetic studies in this field are also discussed.

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## INTRODUCTION

The field of behavioral addictions emerged in the psychiatric literature during the 1980s and 1990s, raising questions as to whether or

### Needs Assessment

This review will enrich the understanding of the methodology of genetic association studies, increasing the ability to critically read the articles on this field. The ability to understand and discuss the effects of an addictive behavior on the brain can further help the development of new prevention strategies as well as new pharmacologic treatments (new targets for drugs actions).

### Learning Objectives

At the end of this activity, the participant should be able to:

- Interpret the findings of family and twin studies.
- Understand the basic methodology of candidate gene studies
- Identify the main genetic findings in behavioral addictions.

**Target Audience:** Neurologists and psychiatrists

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Read the three CME-designated articles, reflect on the information presented, and then complete the CME quiz. To obtain credits, you should score 70% or better. The estimated time to complete all three articles and the quiz is 3 hours. Release date: December 2006. Termination date: December 2008.

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not a behavior could be considered addictive.<sup>1-4</sup> The hypothesis that certain dysfunctional but purposeful behaviors could produce changes in the brain's reward system in the same extent as addictive substances have led to neurobiology and genetics studies on behavioral addictions. Despite the fact that there are still ongoing debates on the characterization and diagnosis of some behavioral addictions,<sup>5-8</sup> researchers<sup>9-11</sup> have found significant evidence that supports the construct of behavioral addictions both in clinical and biological grounds.

Behavioral addictions are considered a "repetitive occurrence of impulsive behaviors,"<sup>12</sup> without consideration of their potential negative consequences. Other characteristics of this group of disorders as listed by Marks<sup>1</sup> are the urge to engage in a counterproductive behavioral sequence, the feeling of mounting tension before the behavior is executed, which temporarily is relieved after its completion, the return of the urge after a period of time (hours, days or weeks), the presence of external cues that are unique to a given behavioral addiction with secondary conditioning by external and internal cues, such as dysphoria, and the presence of an hedonic tone in early stages of the addiction. These characteristics resemble the pattern of substance addictions and Marks<sup>1</sup> has stated that the urge in behavioral addictions could be understood as the craving described for substance addictions.

Behavioral addictions are frequently comorbid with substance abuse or dependence, depression, suicide attempts, and anxiety, rendering significant personal, family, and financial distress. Moreover, it has been reported that children of pathological gamblers experience disruption of psychological development, which further increases disease severity.<sup>13,14</sup>

As in most psychiatric disorders, behavioral addictions seem to be the result of a complex interaction between biological and environmental factors. While genetic studies on behavioral addictions are scarce, several interesting results have been reported, especially regarding pathological gambling. The list of syndromes under behavioral addictions may include pathological gambling, compulsive shopping, compulsive sexual behavior, pyromania, trichotillomania, and Internet addiction. This review will focus primarily on pathological gambling and comment on the other disorders where appropriate.

The studies that are cited in this review were obtained through searching PubMed and PsychInfo databases using the keywords: "behavioral addiction," "gambling and family," "gambling and genetics," "compulsive computer use," "Internet," "Internet addiction," "compulsive sexual behavior," "excessive sexual behavior," "compulsive shopping," "compulsive buying," and "oniomania." Studies investigating genetic aspects of behavioral addictions were selected and included in this review.

## **FAMILY AND TWIN STUDIES IN BEHAVIORAL ADDICTIONS**

Family studies are one of the most common strategies to investigate the inheritance of complex traits or disorders, through the assessment of blood relatives of an affected individual (proband). The information is obtained either by asking the proband about their family members (family-history method) or through direct interview of the relatives (family-study method). This study design provides information on the familial segregation of the disorder, which can be the result of not only genetic, but also environmental factors. In order to determine whether a non-Mendelian disorder or trait runs in families, it is necessary to quantify the risk of a proband's relatives to be affected by the disease compared with the population risk of the disease. This measure can be calculated for all relatives and values will be closer to one in distant relatives.<sup>15</sup>

Another approach to family studies is to compare the frequency of the disorder or trait under investigation and comorbid disorders in relatives of the proband and compare the obtained data to relatives of control subjects. These studies are usually conducted on first-degree relatives of the proband and comprise the majority of family studies conducted on pathological gambling.

Twin studies can help elucidate the extent to which genetic factors are responsible for the development of a certain trait or disorder (phenotype). Monozygotic (MZ) or identical twins share 100% of their genes because they are derived from the same zygote. Dizygotic (DZ) or fraternal twins share, on average, 50% of their genes as do any siblings. Thus, when genetic factors account for most of the variance of a phenotype, MZ twins will present a significantly higher concordance rate compared to DZ twins. This study design assumes that twins raised in the same setting are exposed for the most part to the same

environment (shared family environment). Both MZ and DZ twins are raised during the same time period, thus sharing experiences that are related to a specific time frame in the family's history, which might not be possible for non-twins. However, environmental exposure can be different even in twins raised together, for example for experiences with different friends and the type of relationship each twin develops with the parents. This type of environmental exposure is usually referred to as nonshared or unique environmental experiences. Currently, a number of genetic modelling techniques are available that allow for testing of environmental effects in twin studies. It is not the purpose of this review to discuss these statistical procedures, but a thorough description of genetic modelling is available from Neale and colleagues.<sup>16</sup>

### **Family Studies in Pathological Gambling**

Initial evidence towards family aggregation of pathological gambling came from the finding that the risk of pathological gambling was associated with parental gambling,<sup>17-20</sup> and that children of pathological gamblers were more vulnerable to develop dysfunctional behaviors.<sup>14,17</sup> Gambino and colleagues<sup>21</sup> investigated the frequency of perceived addictive problems for parents and grandparents in a sample of 93 United States Veterans Affairs population of drug and alcohol abusers. Gambling behavior was assessed through the South Oaks Gambling Screen in which scores of 3 or 4 indicate a potential pathological gambler or a problem gambler and scores  $\geq 5$  indicate a potential pathological gambler.<sup>22</sup> Through the South Oaks Gambling Screen scores 17.3% ( $n=16$ ) of the subjects were considered as probable pathological gamblers and 14% ( $n=13$ ) as potential pathological gamblers. Subjects who reported gambling problems among their parents had a three times higher liability of scoring as a probable pathological gambler. Interestingly, those who perceived their grandparents as problem gamblers were at 12 times the risk of being a problem gambler compared to those who did not report gambling problems among their grandparents.

Some studies have investigated the exposure to gambling in families. Gupta and Derevensky<sup>23</sup> assessed a sample of 477 children 9–14 years of age who reported gambling on a regular basis, of whom 86% reported gambling with their relatives. Although there is no evaluation regarding

problem or pathological gambling among these youths, this finding points to the importance of family environment in the development of a gambling habit. In a subsequent study,<sup>24</sup> these authors evaluated 817 high-school students among which 4.7% were diagnosed as pathological gamblers. The adolescents who were diagnosed with pathological gambling were also more likely to report having parents with a gambling problem, a finding that has been reported in other samples of adolescents and young adults.<sup>20,25,26</sup> Other studies evaluating adults with substance abuse or dependence,<sup>18,19,27,28</sup> pathological gamblers,<sup>29,30</sup> and prisoners<sup>31</sup> also reported an association of pathological gambling with parental gambling. These results add the familial factor to previous findings that have reported an association of adult problem gambling with exposure to gambling during childhood.<sup>32</sup> The results of a recent investigation on a community sample of 938 adolescents (496 females, 442 males) and their parents showed that the occurrence of gambling problems in adolescents was related only to the father's severity of problem gambling.<sup>33</sup>

Pathological gamblers also reported higher rates of pathological gambling among their first-degree relatives. The assessment of 14 pathological gamblers through the Family History Research Diagnostic Criteria showed that at least 9% of their relatives had a gambling disorder.<sup>34</sup> The comparison group was not assessed for gambling behavior, but the results also show a higher frequency of pathological gambling in first degree relatives of pathological gamblers compared to the population prevalence.<sup>35</sup> In a larger sample of 31 pathological gamblers and 193 first-degree relatives, using both the family-history and the family-interview method, Black and colleagues<sup>36</sup> reported a frequency of 8.3% for pathological gambling and 12.4% for any gambling disorder among first-degree relatives of pathological gamblers which was significantly higher when compared with first-degree relatives of a control group (2.1% for pathological gambling and 3.5% for any gambling disorder). This is, to our knowledge, the only family study in pathological gambling with a similar male-to-female ratio sample (16 men, 15 women) and a gender-matched control group. Although the sample sizes in these family studies are relatively small, the consistency of the reports provides fairly solid support for the importance of heritable factors in pathological gambling.

### Family Studies in Compulsive Buying

The first family history investigation on compulsive buying was conducted on 18 subjects, of which three (16.7%) reported to have one relative with compulsive buying.<sup>37</sup> Black and colleagues<sup>38</sup> investigated psychiatric disorders in 33 compulsive buyers, finding that 13 (9.5%) of first-degree relatives had the same symptomatology. The absence of comparison with a control group and the small sample sizes constitute important limitations of these studies. Nevertheless, it is noteworthy that in both studies the reported frequencies of compulsive buying among relatives are higher than the reported prevalence of 1.1% in a general population sample.<sup>39</sup>

### Twin Studies

The largest twin investigation in pathological gambling derives from the analysis of 3,359 male twin pairs of the Vietnam Era Twin Registry. Eisen and colleagues<sup>40</sup> found that inherited factors explained between 35% and 54% of the liability for developing any symptom of pathological gambling. For example, they reported that the presence of the symptom "gambling larger amounts than intended" was composed by 55% of genetic factors and 45% of environmental factors, thus, both genetic and environmental factors contributed to this symptom with genetic factors accounting for 55% of the variance. Also, inherited factors explained 54% of the liability for the report of two or more symptoms of pathological gambling. The lifetime rates of pathological gambling among MZ and DZ co-twins of pathological gamblers were 22.6% and 9.8%, respectively and heritability estimate for the diagnosis of pathological gambling was 46%.

Family studies can provide important information regarding questions about continuity of a diagnosis by examining the risk of a particular disorder among the relatives of individuals diagnosed with either the disorder itself or with sub-clinical forms of the same condition. Thus, this sample was subsequently analyzed in order to investigate the causes of the high comorbidity between pathological gambling and alcohol dependence, and the hypothesis of a continuity model for pathological gambling.<sup>41</sup> Results showed that the risk of pathological gambling was significantly higher among DZ and MZ co-twins of subjects with subclinical pathological gambling (one to three *Diagnostic and Statistical Manual of Mental Disorders, Third Edition-Revised* pathological gambling symptoms)

compared with co-twins of men with no pathological gambling symptoms.

These results were consistent with the hypothesis that the differences between problem and pathological gambling are solely quantitative, meaning that these disorders represent a continuum of the same phenotype, therefore likely sharing the same risk factors. Men with subclinical pathological gambling were at a significantly higher risk for alcohol dependence when compared with men without pathological gambling symptoms. Also, the risk of alcohol dependence was higher in DZ and MZ co-twins of subjects with subclinical pathological gambling compared with those with no pathological gambling symptoms. The authors suggested that there is at least one genetic locus that increases the susceptibility for both pathological gambling and alcohol dependence.

The relationship between gambling and other psychiatric disorders were also investigated in this large sample. Slutske and colleagues<sup>42</sup> investigated the association of pathological gambling with antisocial behavior disorders (antisocial personality disorder, conduct disorder, and adult antisocial behavior) and the results suggest that the comorbidity of antisocial disorders with pathological gambling is in part a consequence to their sharing a common genetic vulnerability. The results of an investigation on environmental and genetic contributions to the comorbidity of pathological gambling and major depressive disorder in the Vietnam Era Twin registry sample suggest that overlapping genetic factors are strong determinants of the correlation between these disorders.<sup>43</sup> These findings support the results of previous studies in smaller samples regarding a higher comorbidity rate of alcohol dependence, substance addiction, and mood disorders among first-degree relatives of pathological gamblers.<sup>34,36,44</sup>

Another twin study was conducted in a sample of 92 male and 63 female MZ and DZ twins who were assessed for overall gambling behavior during the year prior to the study.<sup>45</sup> The authors found that genetic factors were significantly responsible for "high action" gambling, such as slot machines and roulette, in male twins. No significant genetic influence was found among males for "low action" games (eg, betting on sports events or on games of skill), and no significant genetic influence among the female MZ and DZ twin pairs for both types of games. The results should be viewed cautiously, however, due to the

small sample size of the twins, and the somewhat limited assessment of the gambling behavior. The authors do not report the rate of problem or pathological gambling and do not assess any pathological gambling symptoms in the sample.

Thus far, according to the PubMed and PsychInfo search of the literature, there are no other published family or twin studies available on compulsive buying, compulsive sexual behavior, or compulsive computer use.

### **Molecular Genetic Studies**

Genetic association studies are one of the most useful study designs in the investigation of complex phenotypes because, when done with proper controls, they have good statistical power to detect moderate to small genetic effects. The choice of genes to test for association is usually made according to findings on the neurobiology of the disorder, and these are referred to as candidate gene studies. The analysis will investigate if there is a significant difference in the frequency of a given genetic variant (allele, polymorphism) between case and control groups. One of the main caveats of candidate gene association studies is the potential for false-positive results due to type I error.<sup>46</sup> This type of error is the result of an increased number of independent variables, multiple testing or population stratification. Even so, well conducted genetic association studies represent one of the most valid approaches for psychiatric genetics investigations.<sup>46,47</sup> Another type of molecular genetic investigation is called linkage analysis. To date, there are no linkage studies available on behavioral addictions.

Research on the molecular genetics of behavioral addictions has been conducted mostly in pathological gambling, taking into consideration the diverse clinical and behavioral characteristics of this disorder, and one study has been conducted on compulsive buying. These studies are summarized in the Table.

The involvement of the brain's reward system in addictive behaviors has led to investigations on dopamine system genes. Initial genetic studies reported associations of pathological gambling with allele1 of the dopamine (D)<sub>2</sub> receptor gene (*DRD2*) TaqIA polymorphism.<sup>48,49</sup> These associations are more complicated to interpret given the recent findings that the D<sub>2</sub> TaqIA marker is known to be outside the *DRD2* gene, located in a neighbor gene to *DRD2* called the ankyrin repeat and kinase domain containing-1 gene (*ANKK1*).<sup>50</sup> Thus, it is

currently not possible to determine if this marker is associated with dopamine receptor function, since the relation of *ANKK1* gene function to *DRD2* is unknown to date. An association of comorbid pathological gambling and alcohol dependence with the homozygous genotypes of the D<sub>1</sub> receptor gene (*DRD1 Ddel*) has been reported.<sup>49</sup> Both polymorphisms appear to alter the function of these genes.<sup>50-53</sup> D<sub>1</sub> and D<sub>2</sub> receptors have opposite effects, stimulating and inhibiting, respectively, the enzyme adenylyl cyclase. The interaction between D<sub>1</sub> and D<sub>2</sub> receptors<sup>54</sup> has been associated with craving and drug-seeking behavior.<sup>55</sup>

A polymorphism in exon III of the dopamine D<sub>4</sub> receptor gene (*DRD4*) exon III variable-number-of-tandem-repeats (VNTR) has been reported to encode a receptor with lower affinity for dopamine,<sup>56-58</sup> and to be associated with impulsive personality traits.<sup>59-61</sup> The association of the *DRD4* exon III VNTR with pathological gambling was investigated in two studies,<sup>62,63</sup> and associations with the 7 repeat allele and with the overall long forms of the polymorphism (5–8 repeats)<sup>63</sup> were reported. It should be noted that in one study,<sup>62</sup> this polymorphism was reported to be associated only with the vulnerability to pathological gambling in females.

Deficient impulse control and impulsive personality features also have suggested the involvement of serotonergic and noradrenergic pathways in pathological gambling.<sup>64-67</sup> A variant in the promoter region of the serotonin transporter gene (*5HTTLPR*) was found to be significantly associated with pathological gambling in males.<sup>68</sup> The long variant of this polymorphism is associated with increased promoter activity and thus higher production of the serotonin transporter protein. The genetic association with *5HTTLPR* was not found in females.<sup>68</sup> Subsequent investigations in this same sample revealed an association of the more severe forms of pathological gambling in males with a 3 repeat allele in the promoter region of the monoamine oxidase A (*MAO-A*) gene 30 base pairs VNTR and with a polymorphism in the first intron of the same gene, further suggesting a sex-related effect in the genetics of pathological gambling.<sup>69,70</sup> The *MAO-A* gene is located on the X chromosome, thus, there is a greater likelihood that sex differences in its expression may occur.

Comings and colleagues<sup>71</sup> analyzed the effect of 31 genes involved in dopamine, serotonin, norepinephrine, and  $\gamma$ -aminobutyric acid pathways in 139 pathological gamblers and 139 con-

trols. The most significant associations were found with the D<sub>2</sub> and D<sub>4</sub> receptors, the dopamine transporter, tryptophan hydroxylase, the  $\alpha$ -<sub>2C</sub> adrenergic receptor, the glutamate receptor subunit 1, and the presenilin 1 genes. Dopamine, serotonin, and norepinephrine genes contributed approximately equally to the risk for pathological gambling, with each gene accounting

for <2% of the variance. These results indicate that genes influencing a range of brain functions play an additive role as risk factors for pathological gambling. Nevertheless, the investigation of a large number of polymorphisms and the fact that only male pathological gamblers were assessed constitute important limitations for the interpretation of these results.

**TABLE.****Molecular Genetic Association Studies in Behavioral Addictions**

<i>Authors (Year)</i>	<i>Sample Subjects' Diagnosis</i>	<i>Polymorphism Controls</i>	<i>Gene</i>	<i>Results</i>
Comings et al (1996) <sup>48</sup>	222 PG	714	<i>DRD2</i> Taq I A	Positive association with allele 1
Perez de Castro et al (1997) <sup>62</sup>	68 PG (47 males, 21 females)	68 ethnically, gender, and age matched	<i>DRD4</i> (exon III)	7 repeat allele associated with PG in females
Comings et al (1997) <sup>49</sup>	163*	124	<i>DRD1</i> Ddel	Positive association with allele 1
Comings et al (1996) <sup>48</sup>	186*	138	<i>DRD2</i> Taq I A	Positive association with allele 1
Perez de Castro et al (1999) <sup>68</sup>	68† PG	68*	<i>5HTTLPR</i>	Short allele associated with PG in males
Comings et al (1999) <sup>63</sup>	165* PG	124	<i>DRD4</i> (exon III)	5–8 repeat and 7 repeat alleles associated with PG
Ibañez et al (1999) <sup>72</sup>	68† PG	68*	<i>TH</i> (intron 1)	No association
Ibañez et al (2000) <sup>70</sup>	68† PG	68*	<i>MAO-A</i> (intron 1)	4 repeat allele associated with PG in males
			<i>MAO-A</i> (promoter)	3 repeat allele associated with PG in males
			<i>MAO-B</i> (intron II)	No association
Comings et al (2001) <sup>71</sup>	139 PG	139 ethnically, gender, and age matched	31 genes involved in dopamine, 5-HT, noradrenaline, and GABA neurotransmitters	Genes in dopaminergic, noradrenergic and glutamatergic neurotransmitter systems accounted for <2% of the variance in PG
Perez de Castro et al (2002) <sup>69</sup>	68† PG	68*	<i>MAO-A</i> (promoter)	3 repeat allele associated with more severe forms of PG in males
Devor et al (1999) <sup>73</sup>	21 CB	38	<i>SLC6A4</i> (intron 2) <i>5HTTLPR</i>	No association

\* Derived from the same sample as in Comings et al.<sup>48</sup>

† Same sample as in Perez de Castro et al.<sup>62</sup>

PG=pathological gambling; *DRD2*=dopamine D<sub>2</sub> receptor gene; *DRD1 (Ddel)*=nucleotide substitution in the promoter region of the gene; *5HTTLPR*=promoter polymorphism of the serotonin transporter gene; *TH*=tryptophan hydroxylase gene; *MAO-A*=monoamine oxidase A gene; *MAO-B*=monoamine oxidase B gene; 5-HT=serotonin; GABA= $\gamma$ -aminobutyric acid; CB=compulsive buying; *SLC6A4*=serotonin transporter gene.

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Currently, one study<sup>73</sup> on the molecular genetics of compulsive buying has been published, in which the authors report no association with two polymorphisms in the serotonin transporter gene. This investigation was conducted in a small sample that lacked power to detect association for small effect alleles.

## CONCLUSION

Studies on the molecular and epidemiological genetics of behavioral addictions are few, most of them on pathological gambling, with small samples, and mainly on male subjects. Recent reviews<sup>9,74</sup> emphasize the need for further investigation in larger, well-characterized, and more diverse samples.

The results from family studies, mainly from the Vietnam Era twin sample, further reveal the complexity of the pathological gambling phenotype. In fact, these results point to the complex relationship between different psychiatric conditions, such as addictions, mood disorders, and antisocial personality disorder. It is possible to hypothesize that studies on genetic vulnerability factors could help unravel not only the commonalities between substance and behavioral addictions but also the extent to which addictions, depression, and personality disorders are intertwined. Recently, a classification of mental disorders as a result of internalizing or externalizing factors was proposed, and although pathological gambling was not part of the analysis, addictions presented a better fit in the externalizing factor model.<sup>75</sup> Nevertheless, evidence of a common genetic vulnerability for pathological gambling and major depression raises the question of whether it would be appropriate to classify pathological gambling as an externalizing disorder due to the fact that major depression was considered as an internalizing disorder.<sup>43</sup>

The twin study conducted by Winters and Rich<sup>45</sup> suggested a genetic liability for overall gambling behavior in males and in high-action games. However, this study presents important limitations: the authors only examined the frequency of overall gambling behavior with no further detail; a relatively small sample size; and a participant mean age of 26 years, when gambling may not have been manifested yet.<sup>76</sup>

Clinical studies<sup>77-79</sup> have reported gender differences concerning the diagnosis, course, and treatment of pathological gamblers, which further suggest the possibility of a sex-related effect on

the genetics of pathological gambling. In previous studies,<sup>3738,80-83</sup> females seemed to be the great majority of compulsive buyers. However, the first study conducted on a general population sample of 2,513 adults<sup>84</sup> found similar prevalences of compulsive buying for males (5.5%) and females (6%).

Age at onset of pathological gambling needs to be further investigated in genetic studies. Although the family study conducted by Black and colleagues<sup>36</sup> found no effect of earlier age at onset on pathological gambling, epidemiological and family studies suggest that later onset could be associated with a faster progression from social to problem gambling and pathological gambling.<sup>7785</sup> These results suggest that it may be useful to investigate whether different genetic factors are associated with a faster progression to pathological gambling and later age at onset.

As noted earlier, multiple testing remains an issue in most molecular genetic association studies. Most correction methods available are considered to be overly strict.<sup>86</sup> The consequence of using conservative methods for multiple-testing correction is an exponential increase in type II error, that is, the failure to consider an association when it truly exists. Considering that psychiatric phenotypes are expected to be associated with multiple polymorphisms, each with a small effect size, a more plausible method for multiple-testing correction remains as an important topic to be addressed. Despite limitations, the reported associations should be given full consideration given the consistency of these results with pathological gambling biological hypotheses.

This review and neurobiology studies on pathological gambling and other behavioral addictions suggest that future studies should investigate genes involved in impulsivity and the brain's reward system. Dopamine receptor genes should be further investigated, especially those with a higher possibility for drug development, such as *DRD3*.<sup>87</sup> Serotonin receptor and transporter genes are also associated with impulse control and are important candidate genes in the study of behavioral addictions. Other genes that have been associated with conditions that are highly comorbid with behavioral addictions are also important to be investigated. One of these is the brain derived neurotrophic factor gene, which has been recently associated with depression<sup>88</sup> and nicotine dependence,<sup>89</sup> both conditions being frequently comorbid with pathological gambling. Of interest, brain derived neurotrophic factor and

*DRD3* genes have been shown to interact and this combination may be a fruitful direction to investigate in future genetic studies.

This review also points out the necessity for family studies on other behavioral addictions, such as compulsive buying, compulsive sexual behavior and compulsive computer use. Aside from evidence for family aggregation, these studies can yield important information regarding comorbid conditions and genetic and environmental effects that could help refine the phenotype of behavioral addictions. Compulsive computer use, a rapidly expanding problem, needs more detailed measurement, for example, time spent on different activities, including Internet sites for shopping, pornography, or gambling. Due to the lack of genetic studies on compulsive buying, compulsive sexual behavior and compulsive computer use, it is early to speculate whether genetic findings in these behavioral addictions would be similar to the findings on pathological gambling. However, if neurobiology or neuroimaging studies show that similar areas are activated in pathological gambling and other behavioral addictions, it would be reasonable to hypothesize that molecular genetics findings would be consistent across different behavioral addictions.

It is also of importance to mention that a recent review on substance addiction and genetic vulnerability reports that the *DRD2*, *DRD4*, and catechol-O-methyltransferase genes are the more consistently associated to substance abusers compared to controls.<sup>90</sup> This report represents evidence toward similar molecular genetics findings on substance addiction and pathological gambling. However, further studies with larger samples are paramount to confirm this hypothesis.

Overall, we expect in the near future that developments in the clinical assessment, biology, and genetics will improve the diagnosis, and possibly treatment and prevention strategies in the field of behavioral addictions. **CNS**

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