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A comparative latent class analysis of endorsement profiles of DSM-IV diagnostic criteria for problem gambling among adolescents from a community and a treatment sample

Neda Faregh[1] & Jeffrey Derevensky[2]

[1]*International Centre for Youth Gambling Problems and High Risk Behaviors, McGill University, Montreal, Quebec H3A 1Y2, Canada and* [2]*Education and Counselling Psychology, McGill University, Montreal, Quebec H3A 1Y2, Canada*

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The DSM-IV approach to gambling taxonomy is predicated upon the number of diagnostic criteria with little regard for the nature of the specific items. This study examined the variation in gambling pathology that might exist due to the specific pattern of DSM-IV criteria endorsement, these differences between genders, and in the presence of prior addictions. The likelihood of item endorsement for the DSM-IV criteria for males and females in a community and a treatment sample of adolescents with known prior history of substance abuse was examined. A significant gender effect was found for several DSM-IV items in the community sample but not in the treatment sample. Latent class analyses identified different subtypes or classes of endorsement patterns of DSM-IV gambling criteria in adolescents which differed according to whether we looked at males or females in a community sample of adolescents or at a group of treatment adolescents. The results suggest that there may be a divergence in the pathways that male and female adolescent gamblers negotiate depending on the nature of their gambling behaviours. There seems to be a pathway with physiological components and a separate pathway involving antisocial behaviours. Furthermore, male and female adolescent gamblers with prior addictions have a pattern of gambling behaviours in which the vulnerability to gambling problems is more likely to involve behaviours with physiological or neuroadaptive components than antisocial behaviours and this vulnerability is particularly acute for female substance-dependent gamblers where the development of tolerance plays an especially important role.

Keywords: *Gambling, substance dependence, SDM-IV criteria, latent class analysis, adolescents, gender difference*

INTRODUCTION

The heterogeneity of gamblers and those who develop gambling problems is well recognized by gambling researchers and clinicians. Research results highlight the heterogeneity of the gambling population and many concur that this population is far more diverse than previously believed (Lesieur, 1998). In an attempt to differentiate among pathological gamblers, many theorists have undertaken typological research proposing pathological gambling groupings with each suggesting a set of characteristics that those within a given 'type' are likely to have in common. Typology not only can help to distinguish between gamblers where the differences are not easily detectable, but also has the potential to unravel differing underlying pathology and help with treatment and prognosis. The next step in the study and treatment of pathological gambling may be to shift the research focus and concentrate on subtypes of problem gamblers and the factors that could classify them (Westphal, 2007).

Currently, The DSM-IV approach to gambling taxonomy is predicated upon the number of diagnostic criteria (four out of nine items for adolescents)

Correspondence: Neda Faregh, International Centre for Youth Gambling Problems and High Risk Behaviors, McGill University, Montreal, Quebec H3A 1Y2, Canada. Tel: 514-398-1391. Fax: 514-398-3401. E-mail: neda.faregh@mcgill.ca

endorsed by an individual and was modelled on the diagnostic criteria used for substance dependence (American Psychiatric Association, 2000). The diagnostic criteria are based on maladaptive gambling-related behaviours and on the consequences of those behaviours. The DSM-IV gambling severity levels have traditionally been based on the severity of gambling problems (i.e. on the number of endorsed questionnaire items) with little regard for the nature of the specific items. Hence, problems that might have a physiological and neuroadaptive component (e.g. withdrawal and tolerance) are deemed essentially equal to those with behavioural components (e.g. arguing with family and friends or lying).

When the DSM-IV-J (Fisher, 1992) and the DSM-IV-MR-J (Fisher, 2000) are used for the assessment of problem gambling categories among adolescents, similar to their adult counterparts, there remains little regard for endorsement-divergence based on individual items. However, it has been well established that gender remains a significant factor in gambling behaviour and that young men and women gamble differently and for different reasons (Dickson, Derevensky, & Gupta, 2009; Ellenbogen, Derevensky, & Gupta, 2007). Studies have reported different predictive factors for male and female adolescent problem gamblers, especially for those who also abuse substances (Nower, Derevensky, & Gupta, 2004). Whereas historically gambling was typically a male activity, recent evidence suggests that women are as likely as men to gamble (Welte, Barnes, Wieczorek, & Tidwell, 2004).

Gambling problems have been shown to co-occur with other addictions. As well, substance abuse and problem gambling share many similar features (Grant & Kim, 2003; Potenza, 2006; Potenza et al., 2004). In fact, problem gambling is seldom presented as a discrete disorder as it is commonly accompanied by a number of other mental disorders (Gupta & Derevensky, 2004). In particular, alcohol and illicit substance abuse are often reported as correlates of problem gambling and of each other (Barnes, Welte, Hoffman, & Dintcheff, 1999; Barnes, Welte, Hoffman, & Dintcheff, 2005b; Lesieur, 1998). As well, other research points to similarities between pathological gamblers and substance abusers suggesting that they lie along an analogous continuum with regard to impulsive choices made by these individuals (Petry, 2001). A US study of adult gambling problems reported that the odds of gambling pathology were 23 times higher in the presence of alcohol dependence compared to non-alcohol dependence (Welte, Barnes, Wieczorek, Tidwell, & Parker, 2001). A US-based longitudinal study reported that gambling among adolescents was significantly associated with substance use and delinquency (Barnes, Welte, Hoffman, & Dintcheff, 2005a) and a longitudinal Canadian study reported strong longitudinal links between gambling, delinquency and drug and alcohol use in low-income boys 16 and 17 years old (Vitaro, Brendgen, Ladouseur, & Tremblay, 2001).

No studies have examined the variation in gambling pathology that might exist due to the specific pattern of gambling-related problems, these differences between genders, and in the presence of prior addictions. Given the established gender differences and the common occurrence of dual diagnoses, we hypothesized that gambling behavioural patterns likely differ among males and females and in the presence of other addictive disorders. This study examined the patterns of maladaptive gambling behaviour among adolescents based on endorsement of the DSM-IV gambling questionnaire items. Furthermore, we compared gender-related gambling behaviour based on DSM-IV item endorsement in a community sample as well as a treatment group with known alcohol or psychoactive substance dependence.

METHOD

Participants

The participants comprised two distinctive populations: a treatment and a community sample.

Treatment sample

Between February 2002 and December 2009, 723 adolescents (52.4% males) aged 13–18 years from three addiction treatment centres in Montreal, Quebec City and St. Celestin participated in the study. The three inpatient treatment centres primarily offered addiction treatment for drugs and alcohol to adolescents. Typically, adolescents within these centres receive group and individual therapy lasting between 2 to 6 months. Preliminary studies from data collected in 2002–2004 indicated that approximately 35% of adolescents had a gambling problem. All participants were French speaking and received translated versions of the instruments.

The community sample

This sample consisted of a combined dataset pooled from five studies conducted at McGill University's International Centre for Youth Gambling and High-Risk Behaviors, with youth the same ages between 2002 and 2005 serving as a comparison sample. Participants who failed to identify their gender (38) and those who indicated never to have gambled (2468 participants consisting of 31% of the sample; 849 males, 1619 females) were excluded. The resulting dataset included 7819 Ontario and Quebec high school students aged 12–18. Excluding non-gamblers (31% of the total sample), the final sample consisted of 5313 students (51.7% male). Non-gamblers were excluded because by definition they would have no gambling-related behaviour and endorsed none of pathology items on the instrument. The number of participants who attended French language schools was 350.

The studies were of a similar design and incorporated a convenience sample.

Procedure

Treatment group

All instruments were distributed to participants within 15 days of admission by qualified personnel working with each individual at the treatment centres. The data were kept confidential.

Community group

Participants were administered the questionnaires anonymously in groups in their classrooms, gymnasia, libraries or cafeterias during school hours. Trained research assistants were available to address questions and students were informed that their participation was voluntary, that they could withdraw from the study at any time and that all responses were anonymous. All were provided with the definition of gambling as any activity that would involve elements of risk where money was wagered. The time for questionnaire administration was under 50 min. For further details about the community sample, readers are referred to Ellenbogen et al. (2007).

The instruments assessed the psychological profiles of the clients. For the purpose of this research, only responses to the DSM-IV-J (Fisher, 1992) were included. All participants completed gambling measures (DSM-IV-MR-J (Fisher, 2000)) and the Gambling Activities Questionnaire (Gupta & Derevensky, 2004), both pertaining to past year gambling. Ethics approval was obtained from McGill University Research Ethic Boards. School, student and parental consents were obtained before data collection began. Ethics approval for the study was obtained from McGill University Research Ethic Board. Individual and parental consents were obtained for all participants. We also had consent and support from the three treatment centres involved.

Gupta and Derevensky's (1998) scheme of categorizing gamblers were used to identify gambling severity. Endorsements of 4 or more on the nine categories were categorized as *probable pathological gamblers* (PPG); endorsements of 2 or 3 were categorized as *at-risk gamblers* and endorsements of 0 or 1 were considered *social gamblers*. The resulting categories were then cross-tabulated against the obtained latent classes to examine the make up of latent classes based on gambling profiles.

ANALYSIS

Data from the community sample and those in the treatment sample were analysed separately with all non-gamblers excluded from analyses. Non-gamblers were excluded because they endorsed none of the symptoms of pathology on the DSM-IV-J. Item endorsements were analysed through cross-tabulations and chi-squared tests. Latent Class Analyses (LCAs) were carried out on four samples of gamblers (males and females of the community and the treatment samples).

Similar to factor analysis, LCA is a method of data reduction. LCA is a multivariate profile analysis method and is an empirical method of classification of homogenous subgroups. The basic premise is that the covariation of the observed variables is best explained by a latent variable that can elucidate the relationship between categorical data within multiple populations (McCutcheon, 1987). The LCAs were used to identify discrete patterns of item endorsement on the DSM-IV-J for the treatment sample and item endorsement on the DSM-IV-MR-J for the community sample. Patterns of item endorsement were used to identify latent typology of gamblers in the samples, separated by gender. The prevalence of the latent classes and probability of membership within each class were estimated. These are probabilities of the distribution of classes (or levels) of the latent variables. Each individual has a probability of class membership and his/her highest latent class probability establishes his/her class membership in his/her modal class. When there are three latent classes, it is assumed that the population from which the sample came has three types or three levels of a latent structure. The parameter estimates for each latent class includes the probability of item endorsement which is the likelihood that an item is endorsed by an individual, given his/her class membership. McCutcheon (1987) interprets such classes as relationships that are part of a common complex structure or the effects of a common cause used to study typologies or trends in different populations and can give insight into different social or psychological processes. In essence, the patterns of responses to the DSM-IV questionnaires used in this study may be attributable to latent (not measured) factors.

All cases with missing values on any of the DSM-IV items were removed from the analyses. A step-wise mixture modelling technique was used in *Mplus* 5.21. The analyses consisted of testing successive class models (2-class to 6-class) against the null-model (1-class) until the most parsimonious model was obtained. The global fit indices for model parsimony and model fit (BIC and AIC), the overall classification soundness (entropy), the log likelihoods, the Vuong–Lo–Mendell–Rubin likelihood ratio, the Lo–Mendell–Rubin adjusted likelihood ratio test (LRT) and the bootstrapped parametric LRTs for the K-1 models were used to arrive at the most parsimonious and empirically sound model. The empirical fit of the models were examined considering theoretical implications.

RESULTS

In terms of demographic differences, no significant gender and age differences were found between the two samples. There were 52.4% males in the treatment sample *versus* 51.5% in the community sample.

Although there were no significant age differences between the samples, there were slightly more 16–17-year olds in the treatment sample compared to the community sample, and slightly more 18-year olds in the community sample compared to the treatment sample. In the community sample, 76.9% of males and 90.4% of females were social gamblers. At-risk gamblers consisted of 14.9% of all males and 7.2% of all females, with 8.2% of males being PPGs compared to 2.5% of females ($\chi^2 = 181.14$, $p < 0.001$). In the treatment sample, 65.9% of males and 68.2% of females were social gamblers. At-risk gamblers consisted of 19.8% all males and 21.8% of all females, with 14.3% of males being PPGs compared to 10.0% of females ($\chi^2 = 2.06$, *n.s*). Note that the samples do not include non-gamblers. These results are in line with other prevalence studies carried out internationally including North America, Europe and Oceania (Volberg, Gupta, Griffiths, Olason, & Delfabbro, 2010).

One item from the DSM-IV-J (Fisher, 1992) and one item from the DSM-IV-MR-J (Fisher, 2000) could not be compared. The former questionnaire included the item 'bailout' and the later included the item 'progression' (originally entitled loss of control). Overall, bailout did not discriminate among the latent classes or gender. In the latter, progression did not discriminate among males and females.

Item endorsement

Item endorsements by gender within the two samples were examined. Within the community sample, males were more likely to endorse the items related to preoccupation, tolerance, withdrawal and chasing whereas the females were more likely to endorse items related to lying, stealing and family–school problems. Gender differences in item endorsement were significant for preoccupation, tolerance, chasing and stealing only. In the treatment sample, males and females were almost equally likely to endorse most items except chasing. Independent of gambling severity, females were more likely to endorse tolerance and withdrawal showing a reversal of trend compared to the community sample (see Table I for within gender differences for item endorsements).

The marginal means for likelihood of endorsement for each item for both samples were compared. The marginal means of item endorsement for individuals in the community sample were higher than for individuals in the treatment sample for items related to preoccupation, tolerance, withdrawal, escape and chasing. The reverse was true for items related to lying, stealing and family/school problems where the marginal means of item endorsement were higher for individuals in the treatment group. The *t*-test for equality of means was marginally significant for tolerance ($t = -2.535$, $df = 6$, $p < 0.06$).

Table I. Item endorsement profiles and proportions according to gender and sample.

	Social		At-risk		PPG	
Item	Male $n = 2112$	Female $n = 2311$	Male $n = 410$	Female $n = 183$	Male $n = 226$	Female $n = 63$
Community sample						
Preoccupation	2.4	1.0***	25.7	14.3**	58.8	33.3***
Tolerance	3.6	1.9**	36.6	27.3*	71.2	54.0*
Progression	1.3	0.6*	8.1	4.9	34.1	25.4
Withdrawal	1.3	0.3***	11.2	6.6	32.3	30.2
Escape	0.7	0.2*	6.8	6.9	32.9	44.4
Chasing losses	2.5	0.2***	25.5	10.4***	69.8	54.0**
Lying	2.4	1.0***	37.1	42.3	77.3	84.1
Stealing	5.8	5.7	41.1	61.9***	76.9	82.5
School/family problems	6.5	3.1***	42.7	50.3	78.3	90.5*
	Male $n = 166$	Female $n = 144$	Male $n = 50$	Female $n = 46$	Male $n = 36$	Female $n = 21$
Treatment sample						
Preoccupation	3.0	4.9	28.0	21.7	69.4	71.4
Tolerance	9.6	8.4	58.0	76.1	83.3	76.2
Withdrawal	0.6	0.0	10.0	6.5	50.0	52.4
Escape	3.0	4.2	22.0	37.0	66.7	52.4
Chasing losses	4.8	0.0**	44.0	43.5	86.1	81.0
Lying	1.2	1.4	20.0	21.7	55.6	57.1
Stealing	7.8	5.6	40.0	28.3	69.4	76.2
School/family problems	0.6	0.7	10.0	8.7	44.4	66.7
Bail out	0.0	0.0	4.0	0.0	5.6	4.8

Notes: Percentages given within gender for each DSM-IV item (e.g. among the at-risk gamblers in the treatment sample, 28% of all males endorsed the item 'preoccupation' compared to 21.7% of all females in the same category).
*$p < 0.05$; **$p < 0.01$; ***$p < 0.0005$.

Endorsement profiles

Four series of LCA were carried out separately for the two samples by gender. The LCA results indicate different numbers of classes and different profiles of item endorsement for males and females in both samples. The fit indices for all models are shown in Table II and the conditional probabilities for each item endorsement according to latent class are shown in Figures 1–4. In all four models, class 1 consists mainly of social gamblers and class 2 consists mainly of PPGs.

In the treatment sample, two classes of males and three classes of females were identified. The 3-class model for females in the treatment group was preferred over the 2-class model as the change in BIC from a 2-class model to a 3-class model was negligible but the gain in entropy was considerable. In the community sample, four classes of adolescent male gamblers and three classes of adolescent female gamblers were identified.

Treatment males

A 2-class model was obtained for males in the treatment group (Figure 1). Class 1 ($n = 185$) was the largest class with 73.0% of the sample. It consisted of 99.4% of all social gamblers and 46.0% of all at-risk gamblers. Class 2 ($n = 64$) consisted of 100% of PPGs ($\chi^2 = 178.7$, $p < 0.001$). The average latent class probabilities for most likely latent class membership by latent class are a measure of the models ability to correctly classify each individual into the appropriate class. The probability for class 1 was 0.943 and the probability for class 2 was 0.962.

Table II. Fit indices for LCAs of the treatment and the community samples.

	Males ($n = 249$)			Females ($n = 207$)		
Model	Log likelihood	BIC	Entropy	Log likelihood	BIC	Entropy
Treatment						
Two classes	**−770.14**	**1656.1**	**0.841**	−592.3	1285.93	0.835
Three classes	−754.03	1684.63	0.849	**−565.76**	**1286.17**	**0.964**
Four classes	−774.599	1726.45	0.890	−558.421	1324.818	0.962
	Males ($n = 2747$)			Females ($n = 2557$)		
Community						
Two classes	−7173.94	14498.32	0.856	−3432.60	7014.28	0.888
Three classes	−7078.26	14386.14	0.735	**−3359.09**	**6777.52**	**0.805**
Four classes	**−7011.48**	**14331.77**	**0.776**	−3362.67	7031.363	0.811

Note: Bold values indicate chosen class number.

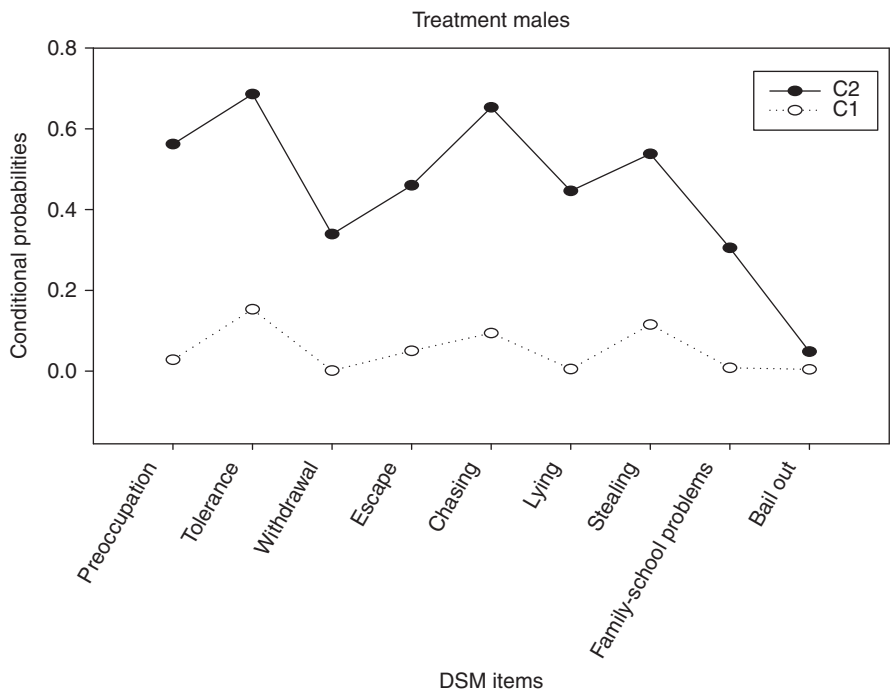

Figure 1. Conditional probabilities for each item endorsement according to latent class for males in the treatment group.

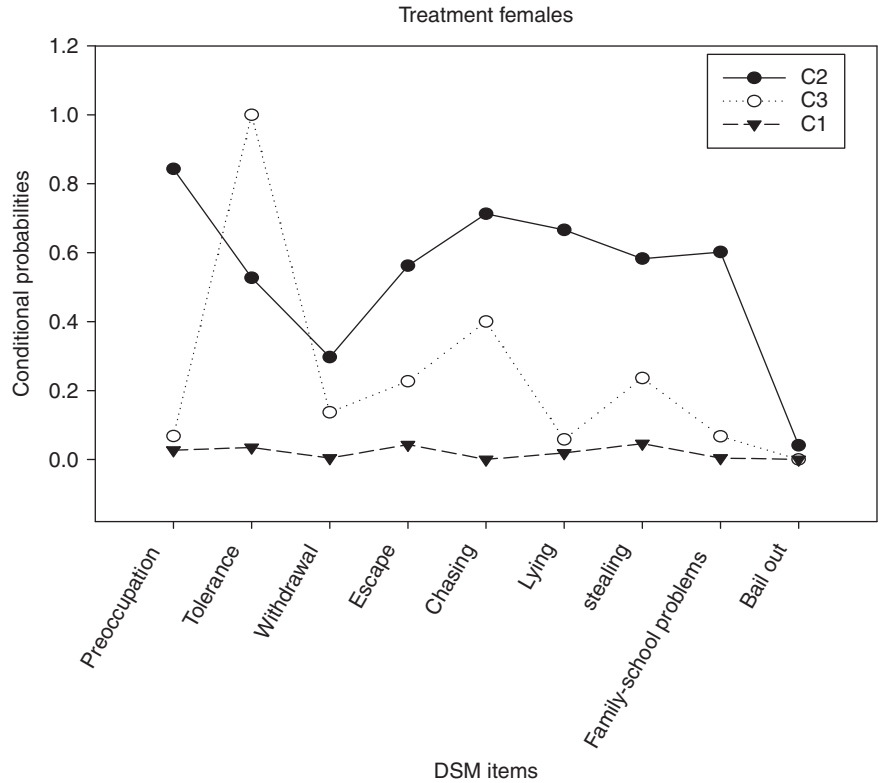

Figure 2. Conditional probabilities for each item endorsement according to latent class for females in the treatment group.

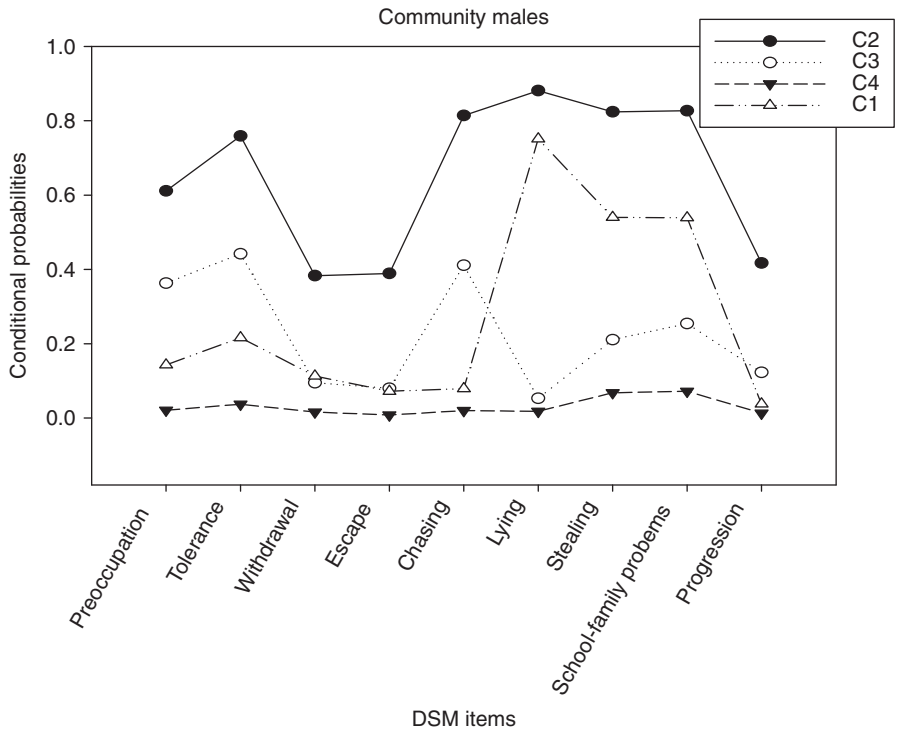

Figure 3. Conditional probabilities for each item endorsement according to latent class for males in the community sample.

Treatment females

A 3-class model was obtained for females in the treatment group (Figure 2). Class 1 ($n = 134$) was the largest class with 64.7% of the sample and class 2 ($n = 23$) was the smallest class with 11.5% of the sample. Class 1 consisted of 92.1% of all social gamblers. Class 2 consisted of 81.0% of all PPGs. Class 3 ($n = 50$) consisted of 76.1% of all at-risk

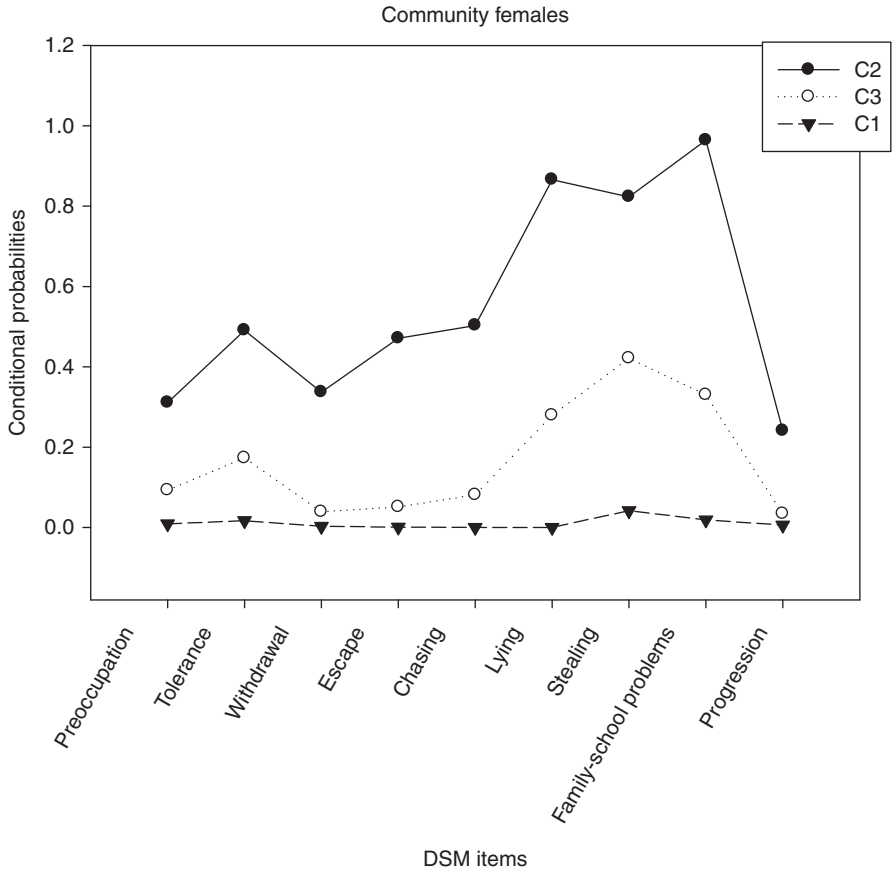

Figure 4. Conditional probabilities for each item endorsement according to latent class for females in the community sample.

gamblers ($\chi^2 = 225.3$, $p < 0.001$). The average latent class probabilities for most likely latent class membership by latent class were 0.997 for Class 1, 0.964 for Class 2 and 0.977 for Class 3.

Community males

A 4-class model was obtained for males in the community sample (Figure 3). Class 1 ($n = 2122$) was the largest class with 73.0% of the sample and class 2 ($n = 141$) was the smallest class with 5.1% of the sample. Classes 3 ($n = 227$) and 4 ($n = 257$) had 9.6% and 12.2% of the sample, respectively. Class 1 consisted of 99.8% of all social gamblers. Class 2 included 61.9% of PPGs (but note that 99.3% of members of this class were PPGs). Class 3 was a mix of mostly at-risk gamblers and some PPGs, 43.9% and 19.9%, respectively. Class 4 was also a mix of mostly at-risk gamblers and some PPGs, 52.4% and 18.1%, respectively. The distinguishing factor between Classes 3 and 4 is the difference in endorsed items. Class 3 members were more likely to endorse lying, stealing and school–family problems but members of Class 4 were more likely to endorse preoccupation, tolerance and chasing ($\chi^2 = 4015.1$, $p < 0.001$).

The average latent class probabilities for most likely latent class membership by latent class were 0.920 for Class 1, 0.862 for Class 2, 0.796 for Class 3 and 0.756 for class 4.

Community females

A 3-class model was obtained for females in the community sample (Figure 4). Class 1 ($n = 2261$) was the largest class with 82.9% of the sample and Class 2 ($n = 49$) had 2.0% of the sample. Class 1 consisted of 98.6% of all social gamblers. Class 2 consisted of 77.8% of all PPGs (note that 100% of class 2 members were PPGs). Class 3 ($n = 227$) contained 100% of at-risk gamblers and the remaining PPGs and social gamblers, 22.2% and 1.4%, respectively ($\chi^2 = 3988.5$, $p < 0.001$). The average latent class probabilities for most likely latent class membership by latent class were 0.926 for Class 1, 0.839 for Class 2 and 0.913 for Class 3.

DISCUSSION

The aim of this study was to examine the patterns of gambling-related problems of males and females for both a community sample of adolescents and adolescents with known psychoactive substance dependence.

We initially examined the likelihood of item endorsement for the DSM-IV-J and DSM-IV-MR-J criteria for males and females in both samples according to gambling severity. In doing so, a significant gender effect for five of the nine items in the community sample was observed. In this sample, the at-risk gambling males were more likely than their

female counterparts to endorse most of the items on the screen. The only exception was the item related to stealing for which the at-risk female gambler endorsement was higher. As well, female PPGs were significantly more likely to endorse having school/family problems than male PPGs. Females with gambling problems in the community sample were more likely to have difficulties with several of the antisocial gambling-related behaviours compared to males with gambling problems. Similarly, community males with gambling problems had greater difficulty with items that have been suggested to have physiological and neuroadaptive components (Franco, Paris, Wulfert, & Frye, 2010; Paris, Franco, Sodano, Frye, & Wulfert, 2010b; Paris et al., 2010a) such as tolerance and withdrawal. These symptoms are likely predicated upon the responses of the hypothalamic-pituitary-adrenal (HPA) axis which are known to attenuate in the presence of chronic or increased exposure to gambling stimuli or psychoactive substance use (Paris et al., 2010b).

In the treatment sample, there were no statistically significant differences between males and females on any of the items endorsed (except chasing), however, a trend reversal in item endorsement of males and females compared to the community sample was found. The reversed trend revealed higher tolerance and withdrawal among females compared to males in the treatment sample whereas the opposite was observed in the community sample.

When we compared the endorsement rates of the samples independent of gender, we found that whereas the antisocial items (lying, stealing and family–school problems) had a higher likelihood of endorsement by the community sample, the maladaptive gambling items (preoccupation, tolerance, withdrawal, escape and chasing) were more likely to be endorsed by the treatment group, with the 'tolerance' item showing a significant difference.

The LCA identified different subtypes or classes of endorsement patterns of DSM-IV gambling criteria in adolescents. These subtypes differed according to whether we looked at a community sample of adolescents or at a group of treatment adolescents with known prior history of substance abuse. The analyses also identified different subtypes of endorsement patterns for males and females. In the community sample, four distinct subtypes of male gamblers were found. One subtype consisted primarily of social gamblers with low probability of endorsement for all items. The second subtype consisted primarily of PPGs with high probability of endorsement for all items. Between these two groups, two classes of primarily at-risk gamblers were found. These two classes differed from each other based on the items they were more likely to endorse. One subtype was more likely to endorse the antisocial items (lying, stealing and school/family problems), whereas the other subtype was more likely to endorse items that have been suggested to have physiological neuroadaptive components (preoccupation, tolerance and chasing).

These findings are consistent with the results of other studies reporting significant correlations between antisocial behaviour and problem gambling (Blaszczynski & McConaghy, 1994; Specker, Carlson, Edmondson, Johnson, & Marcotte, 1996; Steel & Blaszczynski, 1998). Although most related literature underline a causal influence of problem gambling on antisocial behaviour, not all studies have supported the hypothesis of the former influencing the latter. A large community-based twin-study (Slutske et al., 2001) that examined the association between gambling problems and antisocial behaviour found that the hypothesis of causality could not be fully supported. Their study found significant correlations between problem gambling and childhood conduct disorder and adult antisocial behaviour; however, this correlation was due to genetic factors. Slutske and her colleagues found that a substantial proportion of problem gamblers had a history of antisocial behaviour predating their gambling involvement. They also noted that 86% of the overlap between conduct disorder and problem gambling, and 66% of the overlap between antisocial personality disorder and problem gambling, are accounted for by familial risk factors that are fully attributable to genetic factors. They concluded that there may be a genetic locus jointly increasing the susceptibility of individuals to conduct disorder/antisocial behaviour and problem gambling (Slutske et al., 2001).

If we were to assume that at-risk gamblers who persist in their gambling behaviours may progress to PPGs, then our results suggest that there may be two separate paths through which at-risk gamblers become PPGs; one through antisocial behaviours and the other through gambling-related problems with probable physiological and neuroadaptive basis. This distinction is also noteworthy considering that at least some of the at-risk gamblers might be previous PPGs in partial remission. It may be that after a certain point in the progression of their gambling disorder, quantitative changes in problem severity develop into qualitative changes in the disorder where all gambling-related problems occur at higher rates independent of the pathway undertaken. This is an important distinction of subtypes but the suggested trajectory is a hypothesis deserving of further study. Similar considerations have been lent to the study of major depression leading to the distinction between melancholia, non-melancholia and atypical depression, with each disorder verifiable by discrete biological markers and distinctive response to treatment (Shorter & van Praag, 2010).

Three subtypes for female gamblers in the community sample were identified. Similar to males, there was one subtype of female gamblers consisting primarily of social gamblers with low probability of endorsement for all items. The second subtype consisted primarily of PPGs with high probability of endorsement for all

items especially the antisocial items. The third subtype consisted primarily of at-risk gamblers whose endorsement profiles were similar to social gamblers except for the antisocial items which were more highly endorsed. The possible pathway differentiation observed among community males was not present among the community females. The similarity of profiles (i.e. higher endorsement of antisocial items) for both at-risk and PPGs suggest the possibility of a single path for community females involving gambling-related antisocial problems only.

In the treatment group, two subtypes of males were identified. The first subtype consisted primarily of social gamblers with low probability of endorsement for all items. The second subtype consisted primarily of at-risk and PPGs with higher probability of endorsement for most items. Once again, the possibility of a qualitative change is observed. Although no particular path is observed for the two classes, the at-risk and PPG community males are more similar to each other in their gambling-related problem patterns than their community counterparts. It may be that given the usually higher percentage of males than females in gambling research samples, the similarities seen between at-risk gamblers and PPGs elsewhere is due to male item endorsement patterns rather than those of females.

Within the treatment sample, three subtypes of females were identified. Similar to males, the first subtype consisted primarily of social gamblers with low probability of endorsement for all items. The second subtype consisted primarily of PPGs with higher probability of endorsement for all items. Finally, a third subtype consisting primarily of at-risk gamblers with endorsement probabilities that were for the most part close to social gamblers with one major exception were found. Female gamblers in this subtype had a probability of endorsement on the item 'tolerance' that was 1.00. This is an unexpected finding in our results and suggests that there may be a peculiar path of gambling problem development for adolescent females with prior addictions that involves the development of tolerance above all other DSM-IV gambling criteria.

The development of tolerance in problem gambling is probably akin to that in substance addiction. The progressively increasing motivation to obtain a drug's hedonic effects while those effects continue to diminish with repeated exposure is often referred to as drug tolerance (Kalant, 2009). We consider two possible theories that would support this assertion. It is suggested that repeated drug use leads to an allostatic decrease in the brain's reward function in order to maintain homeostasis in the presence of changing conditions. This is achieved through sensitization of the drug effect on the mesolimbic dopaminergic pathways (Ahmed & Koob, 2005). An allostatic decrease in the reward system responsivity is a counterbalancing activity that produces opposing reactions to the introduced change and is slow to decay. This allostatic change in the reward system increases both the compulsive intake of the substance and the motivation for the intake (Ahmed & Koob, 2005). Interestingly, this sensitization is attributed to a qualitative change in the drug effect which in turn causes an allostatic rather than a homeostatic response (Koob, 2003). Although not all addictions are identical in terms of neuronal responses, tolerance is achieved through similar mechanisms with the end result of increasing dopamine activity (Koob, 2003). Hence, an analogous allostatic response mechanism may be at work with gambling. Another well-supported theory is that of autonomic response to physiological or psychological stimuli that activate the HPA axis. Social gamblers have been shown to experience HPA axis activation as evident by increases in cardiovascular activity and salivary cortisone, suggesting acute neuroendocrine activation (Blaszczynski, Winters, & McConaghy, 1986). However, problem and pathological gamblers, similar to alcoholics and cocaine users, show irregular HPA axis responses, suggesting that although initial exposure can result in large HPA responses, chronic or repeated exposure results in diminished HPA response that may play a role in the addiction process (Meyer et al., 2000, 2004). The notion of similarity of tolerance development in problem gambling and substance abuse is not yet empirically supported and remains a hypothesis; however, the parallel remains very plausible. More empirical research is needed to provide definitive answers. These models are two of a number of competing theories that could explain the changes in the reward system. Alternative models may also be supported.

It is well established that female substance users are more sensitive than males to the physiological effect of substances (Zilberman, Tavares, Blume, & el Guebaly, 2003). Nevertheless, current literature provides only an incomplete explanation as to why female at-risk gamblers with prior addictions are particularly vulnerable to the development of gambling tolerance. It may be that a particular neuroadaptive pathway exists for this subpopulation, or that the presence of previous changes in the neurocircuitry of the reward system is differentially related to gambling vulnerability in females.

These results also lend support to Blaszczynski and Nower's (2002) theoretically based pathway model of gambling which acknowledges the possibility of subtypes of problem gamblers where each is influenced by a different set of factors yet displays the same phenomenological features. Blaszczynski and Nower's pathway model proposes three distinct pathways to gambling problem, with one likely involving biological and neurological components. In our study, the four classes of community males show distinct patterns of vulnerability, but the distinctions are especially evident among the at-risk gamblers and not necessarily the problem gamblers as the pathways model

would assume. Where the pathways model suggest a single path for problem gamblers with antisocial and neurological vulnerabilities, we find two distinct classes (one antisocial, the other neurological) of community male at-risk gamblers, and a separate class involving both sets of vulnerabilities for problem gamblers. We believe that these results suggest the possibility of a qualitative change in vulnerability among adolescents with increased gambling problem severity. In addition, our results show separate subtypes of male and female gamblers and more separation of subtypes when the gamblers have comorbid addictions. This distinction is especially evident among at-risk females in the community sample displaying more vulnerability towards antisocial items, and at-risk females in the treatment sample displaying a peculiar and highly significant vulnerability to tolerance.

Given the cross-sectional nature of our data and the theoretical nature of the pathways model, these conclusions can only remain at the hypothesis level requiring further empirical research with longitudinal design.

The item 'bail out' in the treatment sample did not seem to differentiate among either males, females or subtypes. The item 'progression' in the community sample did not differentiate among adolescent males and females. Due to the nature of our results, we were not able to compare the samples on these two items and no particular conclusions can be drawn.

In summary, our results also suggest that males and females differ in their endorsement profiles and that the specific gambling behaviours associated with gambling problems differ across genders. Importantly, these results suggest that there may be a divergence in the pathways that male and female adolescent gamblers negotiate depending on the nature of their gambling behaviours. There seems to be a pathway with physiological components and a separate pathway involving antisocial behaviours. Furthermore, male and female adolescent gamblers with prior addictions have a pattern of gambling behaviours in which the vulnerability to gambling problems is more likely to involve behaviours with physiological (neuroadaptive) components than antisocial behaviours and this vulnerability is particularly acute for female substance-dependent gamblers where the development of tolerance plays an especially important role.

Overall, the present results leave room for consideration of the possibility that pathological gambling may not be a discrete disorder. Not enough is known about the nature of gambling problems from a biological perspective and the verification of such a hypothesis would require laboratory measures and distinctive responses to appropriate treatment (Fink & Taylor, 2008; Guze, 1992). However, such verification for gambling pathology is as yet unfeasible, given the lack of established known biological markers for the disorder.

Nevertheless, these results should be highly relevant to the treatment of adolescents with gambling problems and that based on the configuration of symptom patterns in adolescent males and females and depending on the presence of a dual diagnosis, different therapeutic programmes need to be employed to allow for specifity of treatment and to best address the core problems involved in the gambling pathology of the individual.

As with all research, there are limitations to the generalizability of these findings, the most important being due to the cross-sectional nature of these data. We had no information as to whether adolescents in our community sample had prior histories of psychoactive substance abuse, dependence, and/or treatment and this limits the generalisability of these findings. Additional research is needed to corroborate these findings with different samples and ideally through a longitudinal prospective design.

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