

# Co-Occurrence of Addictive Behaviours: Personality Factors Related to Substance Use, Gambling and Computer Gaming

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## Key Words

Co-occurrence · Personality factors · Addictive behaviours · High impulsivity

## Abstract

**Aim:** To investigate co-occurrence and shared personality characteristics of problematic computer gaming, problematic gambling and substance use. **Methods:** Cross-sectional survey data were collected from 2,553 German students aged 12–25 years. Self-report measures of substance use (alcohol, tobacco and cannabis), problematic gambling (South Oaks Gambling Screen – Revised for Adolescents, SOGS-RA), problematic computer gaming (Video Game Dependency Scale, KFN-CSAS-II), and of twelve different personality characteristics were obtained. **Results:** Analyses revealed positive correlations between tobacco, alcohol and cannabis use and a smaller positive correlation between problematic gambling and problematic computer gaming. Problematic computer gaming co-occurred only with cannabis use, whereas problematic gambling was associated with all three types of substance use. Multivariate multilevel analyses showed differential patterns of personality characteristics. High impulsivity was the only personality characteristic associated with all five addictive behaviours. Depression and extraversion were specific to substance users. Four personality characteristics were specifically associated with problematic computer gaming: irritability/aggression, social anxiety, ADHD, and low self-esteem. **Conclusions:** Problematic gam-

blers seem to be more similar to substance users than problematic computer gamers. From a personality perspective, results correspond to the inclusion of gambling in the same DSM-V category as substance use and question a one-to-one proceeding for computer gaming.

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## Background

The development of DSM-V (Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition) encouraged the discussion about the existence of non-substance-related addictions and their relationship to substance addictions. The concept of non-substance-related (or ‘behavioural’) addiction describes syndromes analogous to substance addiction, but with the focus on a certain behaviour which, similar to substance consumption, produces short-term reward and may persist despite harmful consequences due to diminished control over the behaviour [1]. Taking into account that addictive behaviour is not necessarily restricted to substance consumption, the forthcoming DSM-V will broaden the current category ‘Substance-Related Disorders’ to a ‘Substance Use and Addictive Disorders’ category including both substance- and non-substance-related addictions. In this article the terms ‘addiction’ and ‘addictive behaviour’ refer to both substance- and non-substance-related addictions.

To date, pathological gambling is the non-substance-related addiction which has received most attention and has been examined extensively. Results reveal a number of substantial similarities between pathological gambling and substance-related addictions concerning phenomenology, epidemiology, personality factors, genetics, neurobiological processes, recovery, and treatment [1–5]. In DSM-V, pathological gambling is proposed to be classified as a non-substance-related addiction and, therefore, removed from the former category ‘Impulse-Control Disorders’ and included in the new ‘Substance Use and Addictive Disorders’ category. Another potential non-substance-related addiction is pathological computer and video gaming, though not yet officially defined as an independent disorder, due to a lack of evidence.

Despite a proven substantial overlap, it is still unclear why some people become vulnerable to a certain behaviour like gambling and others to substances (e.g. tobacco or alcohol), a phenomenon referred to as addiction specificity [6]. Insight into this phenomenon may also help explain the frequently observed co-occurrence (co-morbidity) of different addictions. Co-occurrence of gambling problems with different forms of substance abuse such as smoking, drinking, use of cannabis, and other illegal drugs among young people has been repeatedly discussed [7–15]. Given that gambling problems and substance abuse co-occur, it can be hypothesized that they may share common personality characteristics. Adolescents exhibiting substance abuse have been characterized by high sensation seeking [16–19], ADHD (attention deficit hyperactivity disorder) symptoms [20–22], high impulsivity [7], low anxiety [16], aggressive and depressive dispositions [23, 24], extraversion [25, 26] and low self-esteem [23]. In a recent review, Shead et al. [27] reported that adolescents who are likely to experience gambling problems show high impulsivity, sensation seeking and anxiety, as well as symptoms of depression and ADHD. Among adult pathological gamblers a history of ADHD appears to be frequent, especially among those with high levels of impulsivity and anxiety [28]. Young people involved in pathological computer gaming have been characterized by low social competence, low self-esteem and loneliness [29], high impulsivity, depression, anxiety and social phobia [30], lower satisfaction with daily life [31] and depression [9].

These results suggest a substantial overlap between personality characteristics of addictive substance users, gamblers and computer gamers. However, there is a lack of studies which concurrently examined gambling and computer gaming in comparison with substance

use. Such an analysis could provide direct insight into similarities and differences between gambling and computer gaming as forms of non-substance-related addiction.

The aim of the present study was to examine the co-occurrence of substance use, problematic gambling and gaming, as well as their association with a wide range of personality characteristics in a large sample of adolescents and young adults. The specific research question was to what extent substance use, problematic gambling and gaming co-occur, and if there are specific patterns of related personality characteristics.

## Methods

### Data Collection

Data were collected in 2010 through a school survey conducted in 15 randomly selected public secondary and vocational schools in the German federal state of Schleswig-Holstein. An anonymous self-completion questionnaire was administered to adolescents and young adults (aged 12–25 years). Underage students needed written parental consent to participate. Data collection was organized by trained research staff during class time.

All 15 participating schools had 89 classes with vocational school students and 81 classes with secondary school students from the 7th to 12th grade, containing 3,488 students in total. Due to missing parental consent or refusal of participation by students of legal age, 19.4% (n = 678) could not be surveyed. In addition, 4.9% (n = 170) of the students were absent on the day of data collection, leading to a surveyed sample of 2,640 students (response rate: 75.7%). From these questionnaires, 87 (3.3%) had to be excluded from the database because of inconsistent responses (n = 16) or because respondents were older than 25 years (n = 71). Hence, data from 2,553 students were finally analysed.

### Measures

**Substance Use.** Substance use was assessed through frequency measures of alcohol, tobacco and cannabis use (*How often do you drink/smoke/use cannabis currently?*; scale points: *never, less than once per month, at least once per month, at least once per week, daily*). According to their frequency of use, students were classified as ‘current users’ or ‘non-users’. For alcohol and tobacco use a frequency of ‘at least once per week’ and ‘daily’ was rated as current use. Because of the low number of heavy cannabis users, leading to low variance on that variable, any use of cannabis was rated as current.

**Gambling.** Gambling was assessed using the South Oaks Gambling Screen – Revised for Adolescents (SOGS-RA) [32], which is based on DSM-III criteria for pathological gambling (e.g. *Have you ever felt that you would like to stop betting money but didn't think you could?*; dichotomous response: *yes/no*; Cronbach's  $\alpha = 0.77$ ). The original scale was reduced from 16 to 12 items by removing items that were not needed for the calculation of the sum score. Gamblers were classified according to SOGS-RA criteria suggested by Langhinrichsen-Rohling et al. [33]: non-

**Table 1.** Assessment of personality factors

Personality factor	Scale
Depression	Depression scale adapted from Kandel and Davies [37]
Sensation seeking	Inventory of impulsivity, risk behaviour and empathy – IVE [38]
Extraversion	Zuckerman-Kuhlman Personality Questionnaire – ZKPQ [39]
General self-efficacy	Scale for general self-efficacy – WIRKALL_R [40]
Social self-efficacy	Scale for self-efficacy in social situations – WIRKSOZ [40]
Impulsivity	Inventory of impulsivity, risk behaviour and empathy – IVE [38]
Social anxiety	Social Anxiety Scale for Children Revised – SASC-R-D [41]
ADHD	Rating Scale for Attention-Deficit/Hyperactivity Disorder – SBB-HKS [42]
Irritability/aggression	Rating Scale for Oppositional Defiant/Conduct Disorders – SBB-SSV [42]
Loneliness	UCLA-Loneliness-Scale [43]
Self-esteem	Rosenberg-Self-Esteem-Scale [44]
Life satisfaction	Satisfaction with various domains of life – SATIS [40]

gamblers (indicating no gambling in the past 12 months), non-problem gamblers (score 0–1), at-risk gamblers (score 2–3), problem gamblers (score 4–5), and probable pathological gamblers (score 6 and more). For further analyses, a dichotomized variable was generated by merging at-risk gamblers, problem gamblers, and probable pathological gamblers into one group labelled ‘problematic gamblers’ and the non-gamblers together with the non-problem gamblers into another group labelled ‘non-problematic gamblers’.

**Gaming.** Computer and video gaming was measured through 10 items of the original 14-item Video Game Dependency Scale KFN-CSAS-II [34] which covers the ICD-10 (International Classification of Diseases – 10) criteria of dependence syndromes (e.g. *If I don't play for quite a while, I become restless and nervous*; response categories ranging from 0 = *strongly disagree* to 3 = *strongly agree*; Cronbach's  $\alpha = 0.90$ ). Classification of computer and video game players was done according to the cut-off criteria of KFN-CSAS-II: gamers with scores higher than 11 were classified as ‘at-risk gamers’ (on average, no rejection of items). If scores were higher than 20, gamers were classified as ‘addicted gamers’ (approval of all items). A dichotomized variable was generated by putting at-risk gamers and addicted gamers into one group of ‘problematic gamers’ and putting non-problem gamers as well as non-gamers into the group ‘non-problematic gamers’.

**Personality Factors.** We assessed the following personality factors which have been reported to be associated with addictive behaviour: (1) impulsivity, (2) social anxiety, (3) ADHD, (4) depression, (5) sensation seeking, (6) irritability/aggression, (7) extraversion, (8) loneliness, (9) general self-efficacy, (10) social self-efficacy, (11) life satisfaction, and (12) self-esteem. Depression was measured through the frequency of depressive thoughts and feelings in the last 12 months with scores ranging from 0 = *never* to 3 = *very often*. All other personality measures were obtained via 4-point rating scales with scores ranging from 0 = *strongly disagree* to 3 = *strongly agree*. Original scales were reduced to 4 items, internal consistencies (Cronbach's  $\alpha$ ) ranged from 0.56 (social self-efficacy) to 0.83 (irritability/aggression). Life satisfaction, loneliness and self-esteem were assessed using single-item measures. For the analyses, all scale scores were dichotomized via

a median split. More information about personality measures is given in table 1 (in addition see online suppl. material, [www.karger.com/doi/10.1159/000335662](http://www.karger.com/doi/10.1159/000335662)).

**Covariates.** Age, gender, migration background, socio-economic status, and parental monitoring were included as covariates. For migration background, students were asked in which country their father and mother were born (response categories: *Germany, any other*). Socio-economic status was measured through 3 items of the Family Affluence Scale [35]: *Does your family own a car, van or truck?*, *Do you have your own bedroom for yourself?* and *How many computers does your family own?* For assessment of parental monitoring an own 4-item scale (response categories: *nothing, little, moderate, much, very much*) was developed according to Stattin and Kerr's concept of child-reported monitoring [36]: *How much do your parents know about (1) what you are doing on the Internet, (2) what you watch on TV, (3) which computer games you play, and (4) how you spend your free time in general?* Sum scores of socio-economic status and parental monitoring were dichotomized via a median split.

#### Statistical Analysis

Data analyses were conducted with Stata 11.1. The level of significance was set at  $p < 0.05$ . All analyses were performed using dichotomized variables. As measures of co-occurrence, we calculated pairwise correlations for each combination of substance use, problematic gambling and gaming. Univariate associations between measures of substance use, problematic gambling and gaming with personality factors and covariates were analysed through two-way table  $\chi^2$  tests. Analyses of multivariate associations of substance use, problematic gambling and gaming with different personality factors were performed through multilevel mixed-effects logistic regressions with random effects for school and class, taking into account a possible dependence between observations due to hierarchical data structure (students at level 1, classes at level 2 and schools at level 3). Odds ratios (ORs) were adjusted for all covariates.

**Table 2.** Descriptives

	%	n	
<i>Sample characteristics</i>			
Students (total)	100.0	2,553	
Gender			
Male	50.7	1,289	
Female	49.3	1,253	
Age			
12–14 years	29.8	761	
15–17 years	31.1	795	
18–25 years	39.1	997	
School type			
Secondary school	53.7	1,371	
Vocational school	46.3	1,182	
	%	n	Dichotomized coding
<i>Substance use, gambling and gaming</i>			
<i>Alcohol use</i>			
None	28.6	725	0
Less than once per month	22.6	572	0
At least once per month	28.2	713	0
At least once per week	19.9	503	1
Daily	0.7	17	1
<i>Tobacco use</i>			
None	67.5	1,707	0
Less than once per month	5.3	133	0
At least once per month	3.1	78	0
At least once per week	3.8	96	1
Daily	20.3	513	1
<i>Cannabis use</i>			
None	93.6	2,358	0
Less than once per month	3.0	77	1
At least once per month	1.3	32	1
At least once per week	1.0	25	1
Daily	1.1	27	1
<i>Gambling (groups according to SOGS-RA)</i>			
Non-gamblers	66.6	1,700	0
Non-problem gamblers	28.6	730	0
At-risk gamblers	3.5	89	1
Problem gamblers	0.6	15	1
Probable pathological gamblers	0.7	19	1
<i>Computer and video gaming (groups according to KFN-CSAS-II)</i>			
Non-gamers	20.0	511	0
Non-problem gamers	75.6	1,930	0
At-risk gamers	3.3	83	1
Addicted gamers	1.1	29	1

**Table 3.** Correlations of current substance use, problematic gambling and problematic gaming (n = 2,553)

	Tobacco	Alcohol	Cannabis	Gambling
Tobacco	1			
Alcohol	0.36*	1		
Cannabis	0.33*	0.26*	1	
Gambling	0.13*	0.15*	0.15*	1
Gaming	0.00	0.01	0.08*	0.12*

\* p &lt; 0.001.

## Results

### Sample Description

The final sample consisted of 2,553 students of whom 50.7% (n = 1,289) were male (table 2). Mean age was 16.7 years (SD = 3.04) ranging from 12 to 25. The percentage of students aged 18 years and older was 39.1% (n = 997), with almost half of the sample (46.3%, n = 1,371) attending a vocational school.

### Prevalence and Co-Occurrence of Current Substance Use, Problematic Gambling and Gaming

Nearly a quarter of students (24.1%, n = 609) reported current smoking and 20.6% (n = 520) alcohol use. Current cannabis use was reported by 6.4% of students (n = 161; table 2). Prevalence rates of problematic computer gaming (4.4%, n = 112) and problematic gambling (4.8%, n = 123) were similar.

Table 3 shows the correlation coefficients between different types of substance use, problematic gambling and problematic gaming. Apart from the fact that no association was found for tobacco and alcohol use with problematic gaming, all types of addictive behaviour were positively correlated. This indicates that students showing one kind of addictive behaviour have an increased likelihood to also show another. The correlation pattern reveals a stronger co-occurrence of current alcohol, tobacco and cannabis use compared to the co-occurrence of problematic gambling and gaming.

### Univariate Relationships

Table 4 shows the frequencies of substance use, problematic gambling and gaming depending on personality factors and covariates. Among covariates, gender and parental monitoring were consistently associated with all forms of substance use, gambling and gaming, with current or problematic users being predominantly male and



**Table 4.** Relationships of current substance use, problematic gambling and problematic gaming with personality factors and covariates

		Tobacco		Alcohol		Cannabis		Gambling		Computer gaming	
		%	p	%	p	%	p	%	p	%	p
<i>Personality factors</i>											
Social anxiety	low	29.4	0.000	24.5	0.000	7.7	0.000	5.7	0.004	2.6	0.000
	high	14.2		13.3		4.1		3.2		7.5	
ADHD	low	21.5	0.000	18.6	0.003	4.0	0.000	3.8	0.003	2.5	0.000
	high	28.0		23.6		10.5		6.4		7.6	
Impulsivity	low	19.7	0.000	17.0	0.000	4.3	0.000	2.6	0.000	2.6	0.000
	high	30.4		25.9		9.3		8.2		7.1	
Sensation seeking	low	22.6	0.079	15.5	0.000	4.1	0.000	3.2	0.000	3.5	0.008
	high	25.6		26.7		9.4		6.9		5.6	
Depression	low	21.7	0.000	19.5	0.073	5.4	0.006	4.7	0.706	3.8	0.095
	high	28.6		22.5		8.2		5.0		5.3	
Irritability/aggression	low	21.6	0.002	19.5	0.161	4.9	0.000	3.7	0.005	2.4	0.000
	high	26.9		21.7		8.4		6.2		7.0	
Extraversion	low	19.7	0.000	14.8	0.000	5.0	0.000	3.8	0.001	5.1	0.018
	high	32.9		32.1		9.3		6.8		3.0	
Loneliness	low	23.9	0.832	21.3	0.214	5.7	0.040	5.2	0.235	3.4	0.000
	high	24.3		19.0		8.0		4.0		7.2	
General self-efficacy	low	21.1	0.000	18.3	0.002	4.8	0.001	4.2	0.109	4.7	0.415
	high	27.4		23.2		8.1		5.6		4.1	
Social self-efficacy	low	24.5	0.568	22.1	0.039	7.7	0.003	6.1	0.002	6.5	0.000
	high	23.5		18.8		4.8		3.4		1.9	
Life satisfaction	low	24.4	0.817	21.2	0.290	6.8	0.311	4.5	0.335	5.0	0.053
	high	24.0		19.5		5.7		5.4		3.3	
Self-esteem	low	23.8	0.690	19.9	0.304	6.6	0.559	4.6	0.499	5.2	0.010
	high	24.5		21.6		6.0		5.2		3.1	
<i>Covariates</i>											
Gender	female	22.1	0.018	14.6	0.000	3.4	0.000	1.9	0.000	0.5	0.000
	male	26.1		26.4		9.4		7.6		8.2	
Migration background	no	22.8	0.002	21.0	0.084	6.0	0.264	3.7	0.000	4.4	0.685
	yes	29.7		17.3		7.4		9.6		4.0	
Socio-economic status	low	24.9	0.205	17.7	0.000	6.6	0.650	4.7	0.652	3.6	0.020
	high	22.7		24.8		6.1		5.1		5.6	
Parental monitoring	low	30.3	0.000	25.1	0.000	8.9	0.000	6.6	0.000	5.8	0.001
	high	17.9		16.0		3.8		3.1		3.0	
Age	≤16	10.0	0.000	9.2	0.000	2.8	0.000	3.9	0.017	6.4	0.000
	>16	39.8		33.3		10.4		5.9		2.2	

For tobacco and alcohol use current means at least once per week. For cannabis use any consumption was rated as current.

reporting lower parental monitoring. While all current substance users and problematic gamblers were of a higher age, problematic computer gaming was negatively associated with age. Migration background was significantly associated with current smoking and problematic gambling, but had no relation to other forms of problem

behaviour. Concerning socio-economic status, results showed that current alcohol users and problematic gamblers tend to belong to the higher social status group.

Significant univariate associations between personality factors and all five measures of addictive behaviour could be found for social anxiety, ADHD, impulsivity,

**Table 5.** Results of multilevel mixed effect regressions

	Tobacco		Alcohol		Cannabis		Gambling		Computer gaming	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Social anxiety	0.39	0.30–0.51	0.57	0.43–0.75	0.46	0.29–0.72	0.52	0.32–0.85	1.92	1.19–3.09
ADHD		n.s.		n.s.	2.13	1.43–3.19		n.s.	1.75	1.08–2.84
Impulsivity	1.79	1.40–2.30	1.62	1.26–2.08	1.93	1.29–2.88	2.99	1.92–4.66	1.79	1.10–2.93
Sensation seeking		n.s.	1.77	1.38–2.27	1.57	1.05–2.34		n.s.		n.s.
Depression	1.38	1.05–1.81	1.53	1.16–2.02	1.56	1.01–2.41		n.s.		n.s.
Irritability/aggression		n.s.		n.s.		n.s.		n.s.	1.65	1.01–2.69
Extraversion	1.92	1.50–2.46	2.49	1.94–3.19	1.73	1.17–2.56		n.s.		n.s.
Loneliness		n.s.		n.s.		n.s.		n.s.		n.s.
General self-efficacy		n.s.		n.s.	1.52	1.02–2.29		n.s.		n.s.
Social self-efficacy		n.s.	0.77	0.60–0.98		n.s.		n.s.		n.s.
Life satisfaction		n.s.		n.s.		n.s.		n.s.		n.s.
Self-esteem		n.s.		n.s.		n.s.		n.s.	0.57	0.33–0.97

Statistically controlled for age, gender, migration background, socio-economic status and parental monitoring. n.s. = Not significant.

and extraversion. All current substance users, problematic gamblers and problematic gamers had higher values on ADHD and impulsivity. They also showed less social anxiety and more extraversion, except problematic gamers, who were more socially anxious and less extraverted. In addition, problematic gamers reported significantly more irritability/aggression and loneliness, less self-esteem and less social self-efficacy. The pattern of univariate associations reveals that problematic gamers show more distinctive personality characteristics compared to current substance users and problematic gamblers.

#### Multivariate Analyses

Table 5 shows the results of five multivariate regression analyses conducted for each substance use, gambling and gaming measure as the dependent variable displaying adjusted ORs and 95% CIs for each personality factor. For reasons of clarity and readability only statistically significant values are shown. Adjustment was done for all covariates: age, gender, migration background, socio-economic status, and parental monitoring.

Impulsivity and social anxiety were the only personality factors being significantly predictive for all five addictive behaviours. High values of impulsivity consistently predicted current substance use, problematic gambling and gaming. Compared to students describing themselves as low impulsive, students of high impulsivity had a greater chance of being classified as current users of al-

cohol (OR: 1.61), tobacco (OR: 1.77) and cannabis (OR: 1.85) or as problematic gamblers (OR: 3.02) and problematic gamers (OR: 1.77). Social anxiety acted as an inconsistent predictor. Compared to those describing themselves as highly socially anxious, the low socially anxious students had a greater chance of being classified as current users of tobacco (OR: 0.39), alcohol (OR: 0.42) and cannabis (OR: 0.47) or as problematic gamblers (OR: 0.51). However, for problematic computer gaming this relationship was reversed: students classified as highly socially anxious were of higher risk (OR: 1.90).

Extraversion and depression appeared as exclusive predictors of current tobacco, alcohol and cannabis use. Students with higher scores on these two personality factors had a greater chance of being substance users than students with lower scores (table 5).

Problematic computer gamers and gamblers did not match in any personality characteristics apart from high impulsivity. Problematic gaming, but not problematic gambling, was additionally associated with high irritability/aggression (OR: 1.64), higher scores on ADHD (OR: 1.76) and low self-esteem (OR: 0.56).

#### Discussion

The present study explored the co-occurrence of substance use, problematic gambling, and problematic gaming and their association with common personality fac-

tors. Results shed light on the question of whether substance users, problematic gamblers and gamers share certain personality characteristics.

Analyses revealed a substantial co-occurrence of substance use (tobacco, alcohol and cannabis) compared to a rather low co-occurrence of problematic gambling and problematic computer gaming. Remarkably, a significant co-occurrence was also found between problematic gambling and all three forms of substance use. These results were reflected by patterns of overlapping or differing personality characteristics of the people affected.

The study revealed that high impulsivity, which in simple terms means doing things without having thought much about it, seems to characterize all persons involved in any substance use, problematic gambling and problematic gaming. Social anxiety also played an important role for substance users and problematic gamblers, who described themselves as having rather low social anxiety. Noteworthy this relationship was vice versa for problematic computer gamers, who reported higher social anxiety.

Besides common personality factors, high scores on depression and extraversion were specific for substance users. Contrary personality patterns of problematic gamblers and problematic gamers showed a rather small overlap, which was reflected by a relatively small co-occurrence between both problem behaviours. Problematic gamers only matched with problematic gamblers in high values of impulsivity, while problematic gamers also reported ADHD symptoms, high irritability/aggression, high social anxiety and low self-esteem, a result which indicates that gaming is taking a special position among the examined addictive behaviours.

In summary, this study reveals that young people with current substance use, problematic gambling and gaming do share some personality characteristics, while a specific pattern of personality traits was found for substance users. Young people with problematic gambling or gaming did not show such a specific personality pattern. Furthermore, the personality of problematic gamblers seemed more similar to the personality of substance users than to that of problematic computer gamers. Thus, further studies should include some other non-substance-related addictive behaviours (e.g. excessive shopping or exercising) to examine if this finding is due to the specific selection of gaming and gambling in this study. Meanwhile, the present study corresponds to the inclusion of gambling in the 'Substance Use and Addictive Disorders' category of DSM-V and questions a one-to-one procedure for computer gaming, at least from the perspective of personality differences.

There are some limitations that need to be acknowledged. The first limitation concerns the cross-sectional study design which allows no inferences on the direction of associations between personality and addictive behaviour. Further insight into causal relationships may be gained through longitudinal data. Concerning sampling procedure a possible self-selection bias has to be taken into account. It cannot be ruled out that schools which decided to participate in the survey differ systematically from schools that denied participation (e.g. in base rates of gaming and gambling). Another limitation pertains to measurement of the dependent variables. While scales measuring problematic gambling and problematic gaming capture symptoms of non-substance-related addiction according to DSM-III and ICD 10 criteria, respectively, substance use was operationalized solely through frequency of use, which makes both measures only approximately comparable. Likewise, it should be noticed that scales for measurement of personality characteristics were strongly reduced in size. Further research should apply more equivalent as well as more accurate measures.

The strength of the study lies in the variety of different addictive behaviours, personality aspects and covariates considered simultaneously in one large sample. Through multivariate analyses under control of important covariates, patterns of meaningful relations between personality and substance use as well as problematic gambling and problematic gaming were revealed. While the present study focuses on personality, future studies should also consider environmental aspects such as peer influences or cognitive aspects like outcome expectancies, which are considered to influence the onset and progression of addictive behaviours. Comprehensive factors influencing different addictive behaviours may help to explain the phenomenon of co-occurrence and may offer new opportunities for selective prevention.

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### Disclosure Statement

The authors have no conflicts of interest to disclose.

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