Prevalence and correlates of stimulant and depressant pharmacological cognitive enhancement among Norwegian students

Helga Myrseth
University of Bergen, Norway

Ståle Pallesen
University of Bergen, Norway

Torbjørn Torsheim
University of Bergen, Norway

Eilin Kristine Erevik
University of Bergen, Norway

Abstract

Aims: To assess the prevalence and factors associated with stimulant and depressant pharmacological cognitive enhancement (PCE) drug use among Norwegian students. **Design:** In the first wave (T1), 28,553 students were invited to participate, of whom 9370 (32.8%) responded and completed the survey (mean age = 24.9 years, 63.5% female). One year later (T2) those who had responded to some items at T1 were invited to participate in a follow-up survey, where 4783 (47.2%) responded and completed the survey (mean age = 24.8 years, 64.8% female). **Results:** Lifetime prevalence of stimulant PCE drug use was 2.1% at T1 and 3.6% at T2. The lifetime prevalence of depressant PCE drug use was 1.5% at T1 and 3.3% at T2. Stimulant PCE drug use at T2 was predicted by low scores on agreeableness and anxiety, high scores on intellect/openness, and alcohol use, and stimulant and depressant PCE drug use at T1; while depressant PCE

drug use at T2 was predicted by low scores on extroversion, high scores on conscientiousness, intellect/openness, and anxiety, and stimulant and depressant PCE drug use at T1. **Conclusions:** The rates of stimulant and depressant PCE drug use increased from T1 to T2. Pharmacological cognitive enhancement drug use may be explained by a combination of a motivation for improving academic achievements and a general inclination towards substance use. The current results may suggest that stimulant PCE drug users are more antisocial and indifferent to rules, while depressant PCE drug users are more motivated by coping with stress.

A popular nickname in the Norwegian public for youth and young adults today is "generation performance". Students often experience high pressure to excel in many areas of life (Beddington et al., 2008), and smart drugs, enhancement drugs or "nootropics" are increasingly being consumed to enhance or augment cognitive abilities among high school and college students (Cakic, 2009; Johnston, O'Malley, Bachman, Schulenberg, & Miech, 2016). The increase in cognitive enhancement drug use may be understood as an instrumental adaption to cope with increasing demands (Müller & Schumann, 2011) by increasing vigilance and cognitive capacity.

A recent survey among students in Norway found that 19% had serious mental health problems (e.g., anxiety and depression), which were associated with stress and high achievement pressure (Nedregård & Olsen, 2014). Furthermore, 4.2% of the students reported having used enhancement drugs. The probability of using enhancement drugs was twice as high among students experiencing low coping and among those who failed to complete their exams compared to their counterparts (Nedregård & Olsen, 2014).

Pharmacological cognitive enhancement (PCE) has been found to be more prevalent in the US compared to Europe (Maier & Schaub, 2015). A previous study of US college students found past-year prevalence of 6.9% for nonmedical prescription stimulant use, where the rates varied between 0 and 25% at individual colleges/ universities. The rates were highest among students who were male, white, students with a low grade point average, and those who were members of fraternities/sororities (McCabe, Knight, Teter, & Wechsler, 2004). Reported prevalence rates of PCE drug use among students range from 3–11% in the US (Racine & Forlini, 2010), and from 0.8–4.6% in Germany (Franke et al., 2011; Sattler & Wiegel, 2013).

Drug-induced cognitive enhancement can be defined as "pharmaceutical augmentation of mental abilities (e.g., learning or memory) without medical necessity" (Sattler, Sauer, Mehlkop, & Graeff, 2013). The most commonly used enhancement drugs are stimulants, e.g., methylphenidate (e.g., ®Ritalin/Concerta) and mixed amphetamine salts (e.g., ®Adderall) (Greely et al., 2008), which are usually prescribed for attention deficit hyperactivity disorder (ADHD) and are assumed to improve the ability to focus attention, manipulate information in working memory and flexibly control responses (Sahakian & Morein-Zamir, 2007). Modafinil (e.g., ®Provigil/Vigil) also has enhancement potential and is usually prescribed for sleepiness/fatigue caused by narcolepsy, sleep apnoea and shift-work sleep disorder (Greely et al., 2008). Modafinil has further been shown to enhance aspects of executive functions in healthy adults, particularly inhibitory

control (Turner et al., 2003). Other cognitive enhancing drugs include donepezil (e.g., ®Aricept), which is usually prescribed for Alzheimer's disease because it enhances memory functions by raising the levels of acetylcholine in the brain (Grön, Kirstein, Thiielscher, Riepe, & Spitzer, 2005).

Some students also report using depressants for enhancement purposes, e.g., to ease nerves prior to exams or presentations. Next to stimulants, the most frequently abused prescriptions drugs for cognitive enhancement purposes in the US are tranquilisers, sedatives, and opioids which are central nervous system depressants (Center for Behavioral Health Statistics and Quality, 2015). Past-year prevalence of nonmedical depressant use (i.e., in general, not necessarily for cognitive enhancement purposes) among college students has been reported to be 2.8%, 1.2%, and 0.2% for pain relievers, tranquilisers, and sedatives, respectively (Blanchard, Stevens, Littlefield, Talley, & Brown, 2017).

Most studies on PCE drugs have so far been conducted in the US, whereas European studies, especially Scandinavian studies, are few. Mental health among youth seems to have worsened during the last decades, while the availability of drugs for nonmedical purposes has increased dramatically with online pharmacies being a readily accessible source (Katsuki, Mackey, & Cuomo, 2015). Thus, new studies on nonmedical use of different types of drugs, especially outside the US context, are strongly warranted. In addition, little is known about the characteristics of students who choose to use PCE drugs although such knowledge could aid the targeting of potential prevention campaigns. Therefore, the aim of the present study was to assess the prevalence rates of PCE drug use among college/university students in Norway and to investigate possible differences in demographics, personality traits and psychological problems between users and non-users of stimulant and depressant PCE drugs and whether these factors could predict PCE drug use.

Methods

Participants and procedure

All students registered at the four largest institutions of higher education (one university and three colleges) in Bergen, Norway, were invited via email to participate in an online survey on "Drug and social media use among students". Recipients who did not respond within two weeks received a maximum of two email reminders. In the first wave (T1), 28,553 students were invited to participate, of whom 11,236 (39.4%) agreed. The survey had a mandatory response design, and the items assessing PCE drug use were located towards the end of the survey. The sample at T1 consisted of the 9370 participants who completed the survey (response rate, completed survey: 32.8%). Mean age of the T1 sample was 24.9 years (range 17–75 years, $SD = 6.4$), 63.5% ($n = 5957$) were female, and the majority were born in Norway (92.7%, $n = 8690$). All who responded at T1 were invited to complete a follow-up survey one year later. A total of 5217 students responded at T2, yielding a response rate of 51.5%. The participants were contacted via their student emails and since about 40% end their education every year at the institutions included in the study the real response rate is conceivably much higher than 51.5%. The current sample from T2 consisted of the 4783 participants who completed the survey at T2 (response rate, completed survey: 47.2%). Mean age of the T2 sample was 24.8 years (range 18–67 years, $SD = 6.30$) at T1, 64.8% female ($n = 3098$), and the majority were born in Norway (92.8%, $n = 4404$). A comprehensive analysis of dropout from T1 to T2 was reported in a previous article, yielding only few, and very small, significant differences between those who dropped out between T1 and T2, and those who did not (Erevik, Torsheim, Andreassen, Vedaa, & Pallesen, 2017a). In addition, for the current study, we checked the association between PCE drug use at T1 and participation at T2, and found that stimulant

PCE drug users at T1 were significantly more likely to participate at T2, compared to non-users. The effect size of the difference between PCE drug users and non-users was very small (phi = .023). There were no significant differences between depressant PCE drug users at T1 and non-users, in terms of participation at T2.

For each of the surveys, the participants received an individual hyperlink they had to follow in order to participate. Hence, multiple responding was not possible in the current study. The participants' responses from T1 and T2 were linked to their email addresses. The email addresses were stored in locked cabins, separate from the other data. The participants were informed about how their data would be stored, and were given the names of the three researchers who would have accesses to any identifiable information. Among all participants who completed the surveys, two were randomly drawn to receive an iPhone 6s/7, while 50 received gift cards (each worth 500 NOK = ∼ 50 GBP). The study was approved by the Regional Ethics Committee (project number 2015/1154).

Measures

Demographics. Questions regarding demographic variables included: sex (male/female), birth year (response range 1940–2000), relationship status (single: yes/no), and place of birth (Norway, Northern Europe, Other parts of Europe, Asia, Africa, South America, North America, Oceania).

Pharmacological cognitive enhancement drug use. Items regarding PCE drugs included knowledge of drugs used to enhance achievement (stimulant PCE drugs) or drugs used to ease nerves in relation to exams, presentations or studying (depressant PCE drugs), the use of stimulant/depressant PCE drugs (yes/no), and the source of drugs if used (pharmacy, family/relatives, friends, acquaintances, online, on the street, in a store/shop, abroad, other sources – only assessed at T1). Frequency of use during the last six months (never; I have used before, but not during the last six months; 1–4 times; 5–50 times; more than 50 times) was assessed at T2, but not at T1. "Drugs" were in this context widely defined as either illegal or pharmacy drugs.

Five-factor personality traits. Personality traits was measured using the 20-item MINI-International Personality Item Pool (MINI-IPIP) (Donnellan, Oswald, Baird, & Lucas, 2006) assessing the five dimensions extraversion, agreeableness, conscientiousness, neuroticism, and intellect/openness at T1. Examples of items are: "Am the life of the party" (extraversion), "Feel others' emotions" (agreeableness), "Like order" (conscientiousness), "Have frequent mood swings" (neuroticism), and "Have a vivid imagination" (intellect/openness). Participants rated how accurately each item described them on a scale ranging from 1 (very inaccurate) to 5 (very accurate). There are four statements for each of the five personality traits, and the composite score for each trait ranges from 5 to 20. Higher composite scores indicate greater levels of the respective traits. Cronbach alpha levels of .83 (extroversion), .77 (agreeableness), .69 (conscientiousness), .75 (neuroticism), and .74 (intellect/openness) were found in the present study.

Depression and anxiety. The 25-item Hopkins Symptoms Checklist (HSCL-25; Derogatis, Lipman, Rickels, Uhlenhuth, & Covi, 1974) was used to measure symptoms of depression and anxiety. Participants rate on a four-point scale (not at all, somewhat, a great deal, very much) to which degree they have experienced different symptoms during the last two weeks. Total scores range between 15 and 60 for the depression subscale and between 10 and 40 for the anxiety subscale. The Cronbach's alpha was .89 for depression and .81 for anxiety in the present study.

Alcohol use. The 10-item Alcohol Use Disorders Identification Test (AUDIT; Babor, Higgins-

Biddle, Saunders, & Monteiro, 2001) was used to measure levels of alcohol consumption (i.e., frequency of consumption, typical number of alcohol units consumed, and frequency of heavy episodic drinking), alcohol dependence symptoms (i.e., impaired control, increased salience, and morning drinking), and harmful alcohol use (i.e., guilt after drinking, blackouts, alcohol-related injuries, and others' concern about one's own drinking). Composite scores were calculated (ranging from 0 to 40). The Cronbach's alpha for the AUDIT was .78 in the present study.

Statistics

Data were analysed using IBM SPSS Statistics for Windows version 22.0 (IBM Corp, 2013). Descriptives were calculated in terms of frequency distribution. Multivariate Analyses of Variance (MANOVAs) and chi-square tests were performed in order to investigate any initial significant differences between users and non-users of stimulant and depressant PCE drugs at T1 on the following dependent variables: sex, age, relationship status (single: yes/no), place of birth (born in Norway: yes/no), personality traits, psychological problems (depression and anxiety), and alcohol use/misuse. Crude and adjusted multivariate logistic regression analyses were carried out to investigate whether demographics, personality traits, psychological problems or alcohol use could predict PCE drug use at T2. Drug use (yes/no) at T2 comprised the dependent variables, whereas sex, age, extroversion, agreeableness, conscientiousness, neuroticism, intellect/openness, depression, anxiety, alcohol use, stimulant PCE drug use, and depressant PCE drug use at T1 were entered as predictor variables. There were missing data in the logistic regression analyses as some of the respondents who completed the survey at T2 had not answered all items of the survey at T1. Missing data were deleted list-wise, and a total of 458 (9.6%) cases were excluded from the adjusted regression analyses.

Results

Stimulant and depressant PCE drug use at T1

At T1, 43.5% of the total sample ($N = 9370$) reported having knowledge of enhancement drugs to improve concentration, alertness, or energy levels, while 31.5% reported having knowledge of depressant drugs to calm down or ease nerves prior to exams or presentations. While 3.2% of the respondents reported having used either enhancement and/or depressant drugs, only 0.4% of the respondents reported having used both types of drugs. In all, 2.1% (95% CI [1.8, 2.4]) of the total sample reported nonmedical use of enhancement drugs at T1 while 1.5% (95% CI [1.3, 1.7]) reported nonmedical use of depressant drugs. The most commonly reported sources of acquiring enhancement drugs were family/friends (50.8%), pharmacies (29.5%), and acquaintances (21.8%), while the most commonly reported sources of acquiring depressant drugs were pharmacies (61.9%), family/friends (21.6%), and acquaintances (18.0%), see Table 1 for more details.

Differences between users and non-users of stimulant and depressant PCE drugs at T1

Demographic characteristics of the users of stimulant and depressant PCE drugs at T1 are presented in Table 2. The majority of the users of both types of drugs were between 18 and 25 years old.

The MANOVA, where the continuous dependent variables were included, revealed a significant overall main effect of stimulant PCE drug use (users vs. non-users), $F(9, 9360) = 16.07$, $p < .001$; Wilks' Lambda = .99. When the results for the dependent variables were considered separately in univariate ANOVAs and chi-square tests, all dependent variables, except for age, relationship status, and

Table 1. Pharmacological cognitive enhancement drug use among Norwegian students.

Variable		T1 (N = 9370)		T2 (N = 4783)	
		n	%	*n*	%
Knowledge of stimulant PCE drugs		4077	43.5		
Used stimulant PCE drugs to augment cognitive abilities		193	2.1	170	3.6
Source of drug[a]	Pharmacy	57	29.5		
	Family/friends	98	50.8		
	Acquaintances	42	21.8		
	Online	14	7.3		
	On the street	5	2.6		
	In a store/shop	14	7.3		
	Abroad	12	6.2		
	Other	9	4.7		
Frequency of stimulant PCE drug use past six months[b]	Not used			81	47.6
	1–4 times			46	27.1
	5–50 times			26	15.3
	> 50 times			17	10.0
Knowledge of depressant PCE drugs to ease nerves		2950	31.5		
Used depressant PCE drugs prior to exams/presentations		139	1.5	158	3.3
Source of drug[a]	Pharmacy	86	61.9		
	Family/friends	30	21.6		
	Acquaintances	25	18.0		
	Online	3	2.2		
	On the street	3	2.2		
	In a store/shop	3	2.2		
	Abroad	3	2.2		
	Other	9	6.5		
Frequency of depressant PCE drug use past six months[b]	Not used			89	56.3
	1–4 times			48	30.4
	5–50 times			17	10.8
	> 50 times			4	2.5

Note. PCE = pharmacological cognitive enhancement.
[a]Percentages are based on total number of respondents having used enhancement or depressant drugs, 193 and 139, respectively. [b]Percentages are based on total number of respondents having used enhancement or depressant drugs at T2, 170 and 158, respectively.

extroversion, reached statistical significance (see Table 2).

Furthermore, the MANOVA, where the continuous dependent variables were included, revealed a statistically significant overall main effect of depressant PCE drug use (users vs. non-users): $F(9, 9352) = 27.86$, $p < .001$; Wilks' Lambda = .97. When the results for the dependent variables were considered separately, all dependent variables, except for sex, relationship status, and agreeableness, reached statistical significance (see Table 2 for further details).

Stimulant and depressant PCE drug use at T2

McNemar's tests indicated a significant increase in the use of stimulant PCE drugs ($p < .01$) and depressant PCE drugs ($p < .001$) from T1 to T2. At T2, 5.9% of the sample at T2 ($N = 4783$) reported having used either stimulant and/or depressant drugs for cognitive enhancement purposes, while 0.9% reported having used both type of drugs. In total, 3.6% (95% CI [3.1, 4.1]) of the sample reported

Table 2. Differences in demographics, personality traits and psychological problems between users and non-users of stimulant and depressant PCE drugs at T1 (N = 9370).

| | Users and non-users of stimulant PCE drugs | | | | | | | | Users and non-users of depressant PCE drugs | | | | | | | |
| | Users (n = 193) | | | Non-users (n = 9177) | | | Test of group differences | | Users (n = 139) | | | Non-users (n = 9223) | | | Test of group differences | |
Outcome variables	%	M	SD	%	M	SD	χ^2/F	Eta^2	%	M	SD	%	M	SD	χ^2/F	Eta^2
Sex							30.39***								0.05	
Male	55.4			36.1					37.4			36.5				
Female	44.6			63.9					62.6			63.5				
Age		24.9	4.9		24.9	6.5	0.05	.000		26.5	5.9		24.8	6.4	9.31**	.001
17–25 years	66.3			74.2					51.1			73.9				
26–30 years	22.8			15.1					31.7			14.9				
31–40 years	8.8			6.7					14.4			6.5				
> 40 years	2.1			4.1					2.9			4.0				
Single							0.20								0.07	
Yes	48.7			47.1					48.2			47.1				
No	51.3			52.9					51.8			52.9				
Born in Norway							17.67***								12.94***	
Yes	85.0			92.9					84.9			92.9				
No	15.0			7.1					15.1			7.1				
Extroversion		14.5	3.8		14.1	3.6	2.51	.000		12.9	3.8		14.1	3.6	13.29***	.001
Agreeableness		16.4	2.9		16.9	2.8	4.46*	.000		16.7	2.8		16.9	2.8	0.19	.000
Conscientiousness		13.2	3.6		14.7	3.2	38.32***	.004		13.2	3.8		14.7	3.2	29.62***	.003
Neuroticism		11.6	4.2		11.0	3.7	4.44*	.000		13.5	3.9		11.0	3.7	64.86***	.007
Intellect/openness		16.2	3.3		14.6	3.2	49.50***	.005		16.1	3.1		14.6	3.2	28.83***	.003
Depression		27.3	8.7		24.1	7.3	35.33***	.004		30.9	9.6		24.1	7.3	118.17***	.012
Anxiety		16.8	5.0		15.0	4.0	39.13***	.004		19.7	5.9		15.0	4.0	189.71***	.020
Alcohol use		10.5	6.0		8.1	4.8	43.15***	.005		9.5	5.4		8.1	4.8	10.23**	.001

Note. PCE = pharmacological cognitive enhancement.
* $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

stimulant PCE drug use, while 3.3% (95% CI [2.8, 3.8]) reported depressant PCE drug use (see Table 1). Of those respondents who reported stimulant PCE drug use at T2 (and answered items regarding PCE drug use at T1, $n = 150$), only 46.7% reported having used stimulant PCE drugs at T1. Similarly, of those who reported depressant PCE drug use at T2 (and answered items regarding PCE drug use at T1, $n = 136$), only 33.1% reported having used depressant PCE drugs at T1.

Frequencies of drug use during the last six months at T2 are reported in Table 1. Of those who had ever used stimulant PCE drugs at T2 ($n = 170$), 47.6% had not used during the last six months, while 27.1% had used stimulant PCE drugs 1–4 times, 15.3% had used stimulant PCE drugs 5–50 times, and 10.0% had used stimulant PCE drugs more than 50 times during the last six months. The equivalent rates for depressant PCE drugs were 56.3% (not used last six months), 30.4% (1–4 times), 10.8% (5–50 times), and 2.5% (more than 50 times).

Predictors of stimulant and depressant PCE drug use at T2

Prediction of stimulant PCE drug use at T2. In crude logistic regression analyses where stimulant PCE drug use at T2 was entered as the criterion variable (0 = non-use, 1 = use), nine of the 12 predictor variables (sex, agreeableness, conscientiousness, intellect/openness, depression, anxiety, alcohol use, stimulant PCE drug use at T1, and depressant PCE drug use at T1) showed a significant relationship with enhancement drug use, and six of these (agreeableness [$OR = 0.93$], intellect/openness [$OR = 1.11$], anxiety [$OR = 0.92$], alcohol use [$OR = 1.07$], stimulant PCE drug use at T1 [$OR = 83.75$], and depressant PCE drug use at T1 [$OR = 5.41$]) remained significant in the adjusted analysis (see Table 3).

The full model containing all predictors was statistically significant ($\chi^2 = 451.05$, $p < .001$), indicating that the model was able to distinguish between users and non-users of stimulant

PCE drugs. The model explained 38.1% (Nagelkerke's R^2) of the variance in stimulant PCE drug use status, and correctly classified 97.4% of the cases.

Prediction of depressant PCE drug use at T2. In the crude logistic regression analyses where depressant PCE drug use at T2 was entered as the criterion variable (0 = non-use, 1 = use), nine of the 12 predictor variables (extroversion, conscientiousness, neuroticism, intellect/openness, depression, anxiety, alcohol use, stimulant PCE drug use at T1, and depressant PCE drug use at T1) showed a significant relationship with depressant drug use, and six of these (extroversion [$OR = 0.92$], conscientiousness [$OR = 1.08$], intellect/openness [$OR = 1.09$], anxiety [$OR = 1.09$], stimulant PCE drug use at T1 [$OR = 7.56$], and depressant PCE drug use at T1 [$OR = 31.54$]) remained significant in the adjusted analysis (see Table 3). The full model containing all predictors was statistically significant ($\chi^2 = 318.24$, $p < .001$), indicating that the model was able to distinguish between users and non-users of depressant PCE drugs. The model explained 29.1% (Nagelkerke's R^2) of the variance in depressant PCE drug use status, and correctly classified 97.1% of the cases.

Discussion

The results showed that there was an increase in PCE drug use from T1 to T2, both in terms of total prevalence rates and in terms of number of users. This may indicate that there is an increasing achievement pressure among students during their studies. The fact that only 46.7% of those who reported stimulant PCE drug use at T2 and 33.1% of those who reported depressant PCE drug use at T2 had used these drugs at T1 indicates that PCE drug use among students is fluctuating and not stable across time, and further supports the assumption of growing lifetime prevalence rates. As little is known about the risk and long-term concequences of the use of these drugs, this trend may be of concern. The observed increase in prevalence rates of

Table 3. Predictors of stimulant and depressant pharmacological cognitive enhancement at T2 ($n = 4325$).

Predictor variables	Prediction of stimulant PCE ($n = 150$)				Prediction of depressant PCE ($n = 146$)			
	Crude analysis		Adjusted analysis		Crude analysis		Adjusted analysis	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Sex	2.15	[1.58–2.92]***	1.28	[0.79–2.06]	1.01	[0.72–1.41]	0.91	[0.56–1.50]
Age	0.99	[0.96–1.02]	0.99	[0.96–1.03]	1.01	[0.99–1.03]	1.01	[0.98–1.05]
Extroversion	1.03	[0.99–1.08]	1.03	[0.97–1.10]	0.96	[0.92–1.00]*	0.92	[0.87–0.98]**
Agreeableness	0.93	[0.88–0.97]**	0.91	[0.85–0.98]*	0.98	[0.92–1.03]	0.98	[0.91–1.06]
Conscientiousness	0.88	[0.84–0.92]***	0.94	[0.89–1.99]	0.95	[0.90–1.00]*	1.08	[1.01–1.15]*
Neuroticism	1.04	[1.00–1.09]	1.05	[0.98–1.13]	1.15	[1.10–1.20]***	1.00	[0.93–1.07]
Intellect/openness	1.16	[1.10–1.23]***	1.10	[1.03–1.17]**	1.12	[1.06–1.18]***	1.09	[1.02–1.16]**
Depression	1.04	[1.02–1.06]***	1.03	[0.99–1.07]	1.08	[1.07–1.10]***	1.03	[0.99–1.07]
Anxiety	1.05	[1.01–1.08]**	0.92	[0.86–0.98]*	1.16	[1.13–1.19]***	1.09	[1.03–1.15]**
Alcohol use	1.11	[1.08–1.14]***	1.07	[1.03–1.11]**	1.05	[1.02–1.09]***	1.03	[0.99–1.08]
Stimulant PCE, T1	121.01	[74.76–195.86]***	83.75	[49.78–140.88]***	13.98	[8.65–22.61]***	7.56	[3.96–14.41]***
Depressant PCE, T1	13.12	[7.75–22.20]***	5.41	[2.38–12.92]***	66.33	[40.13–109.62]***	31.53	[17.80–55.83]***

Note. PCE = pharmacological cognitive enhancement.
* $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

PCE drug use may also to some extent be explained by selection bias, as those who reported stimulant PCE drug use at T1 were more likely to participate at T2. The selection effect of PCE drug users was, however, quite weak, and thus the observed increase in PCE drug use does not appear to be explained primarily by selection bias.

The combined prevalence rate (for lifetime use of either stimulants and/or depressants) of 3.2% at T1 is likely to be more representative of the student population than the combined prevalence of 5.9% at T2, as the T2 sample were older and did not include first-year students. This rate is comparable, but somewhat lower, than the rate found in a former national survey among students in Norway where 4.2% had used PCE drugs (i.e., stimulants and/or depressants) (Nedregård & Olsen, 2014). The prevalence rates of PCE drug use in the present study were also similar to, although lower than, what has been reported in other European countries, e.g., 4.6% among students in Germany (Sattler & Wiegel, 2013). Further, the prevalence found in the current study is considerably lower compared to those obtained in some studies from the US, reporting prevalence of PCE drug use at 8.2% (Low & Gendaszek, 2002) and 11.0% (White, Becker-Blease, & Grace-Bishop, 2006). Overall, the present finding and those of other studies (Franke et al., 2011; Sattler & Wiegel, 2013) seem to support the notion that prevalence rates of PCE drug use are lower in Europe compared to in the US (Maier & Schaub, 2015).

The current results suggest that users of PCE drugs differ from non-users across a range of characteristics. In the following sections, we will focus on the characteristics that predicted PCE drug use at T2, when the other included variables were held constant. Due to the shortage of research investigating the characteristics of students who choose to use PCE drugs, most of the current findings have, to our knowledge, not been previously reported. The finding that conscientiousness positively predicted depressant PCE drug use is at odds with a previous study of German employees that reported an inverse association between conscientiousness and use of PCE drugs (Sattler & Schunck, 2016).

The present study identified several personality predictors of PCE drug use. These findings are important as they can provide an indication of motivations for PCE drug use, as well as how potential prevention initiatives should be designed to target PCE drug users. The present study found that depressant PCE drug users scored significantly lower on extroversion compared to non-users. Previous studies have found that students characterised by low levels of extroversion are more likely to experience fear of failure and accordingly to pursue avoidance performance goals (Payne, Youngcourt, & Beaubien, 2007). This may explain why students with low extroversion scores are more likely to use depressant drugs. Furthermore, low extroversion scores have also been associated with poorer social skills and anxiety (Anderson, John, Keltner, & Kring, 2001; Argyle & Lu, 1990; Bienvenu et al., 2004). Students with lower extroversion scores may thus have a harder time adjusting to the quite socially demanding student setting, and be more likely to use depressant PCE drugs in order to alleviate discomfort and stress. The users of stimulant PCE drugs scored significantly lower than non-users on agreeableness. Low scores on agreeableness have previously been associated with demotivation and lower academic achievement (Komarraju, Karau, & Schmeck, 2009). Consequently, individuals scoring low on agreeableness may lack the necessary motivation to achieve their academic goals and therefore be more prone to use enhancement drugs in order to facilitate academic achievement. Another explanation of this finding is that subjects with high scores on agreeableness put much emphasis on harmony in their relationships, which often will be incompatible with drug use (Andreassen et al., 2013). Conscientiousness positively predicted depressant PCE drug use. This finding is somewhat surprising as it contradicts the

findings from a previous study on PCE drug use (Sattler & Schunck, 2016). Higher levels of conscientiousness have previously been associated with greater productivity, and it has been suggested that highly conscientious individuals spend more time on a task and show greater persistence in following their goals (Salgado, 2002). Conscientiousness is, however, also related to perfectionism which can be associated with stress (Flett, Hewitt, & Dyck, 1989; Stoeber, Otto, & Dalbert, 2009). Conscientious students' preoccupation with academic performance and perfectionism, and the associated stress, may explain why conscientiousness predicted depressant PCE drug use. Finally, PCE drug use (both of stimulants and depressants) was positively predicted by intellect/openness. Students with higher scores on intellect/openness tend to score higher on IQ-tests and to perform better academically, compared to students with lower intellect/openness scores (Harris, 2004; Komarraju, Karau, Schmeck, & Avdic, 2011). As such, the increased risk of students with higher scores on intellect/openness reporting PCE drug use is unlikely to be explained by them struggling academically. The observed positive relationship between intellect/openness and PCE drug use is more likely to be explained by individuals with high intellect/openness scores being more unconventional and novelty-seeking in nature than those with lower scores (McCrae & Costa, 1997; McCrae & John, 1992), making them more likely to seek out uncommon experiences such as PCE drug use.

Levels of anxiety predicted PCE drug use as well, where lower levels predicted stimulant PCE drug use whereas higher levels predicted depressant PCE drug use. These findings are both novel and important as they clearly demonstrate how stimulant PCE drugs and depressant PCE drugs might be used for different purposes and by somewhat different individuals. Anxiety has been shown to negatively affect academic performance (Andrews & Wilding, 2004; DeRoma, Leach, & Leverett, 2009). Thus, it is possible that the PCE use of

depressants functions as a form of self-treatment for individuals scoring high on anxiety. The inverse relationship between anxiety and stimulant PCE drug use might be related to the psychoactive effects of stimulants, which are known to worsen anxiety (Williamson et al., 1997). Anxious students may hence avoid stimulants altogether due to their anxiety-increasing properties.

Alcohol use positively predicted stimulant PCE drug use, and stimulant PCE drug use predicted depressant PCE drug use (and vice versa). These findings suggest that both stimulant and depressant PCE drug use may be more common among students who have an inclination towards substance use in general. The claim that PCE drug use may partly be explained by a general inclination towards substance use is further substantiated by the fact that several of the characteristics that predicted PCE drug use in the current study (i.e., lower agreeableness scores, higher intellect/openness scores, and higher anxiety scores), have also been associated with alcohol and/or drug use in general (Erevik, Torsheim, Andreassen, Vedaa, & Pallesen, 2017b; Grant et al., 2004; Kotov, Gamez, Schmidt, & Watson, 2010; Malouff, Thorsteinsson, Rooke, & Schutte, 2007). Pharmacological cognitive enhancement drug use (stimulants or depressants) was also predicted by some traits, namely low extroversion scores, high conscientiousness scores, and lower levels of anxiety, which have been negatively associated with alcohol and/or drug use in general (although some studies have suggested that low extroversion scores could be associated with drug abuse) (Erevik et al., 2017b; Grant et al., 2004; Kotov et al., 2010; Merenakk et al., 2003). The finding that PCE drug use was predicted by some characteristics which are not associated with other types of substance use, suggests that PCE drug users differ somewhat from other substance users.

The present study investigated stimulant and depressant PCE drug use, and the results showed that different personality profiles and psychological problems predicted some of the

variance in the use of different types of drugs. Stimulant PCE drug use predicted depressant PCE drug use and vice versa, and stimulant PCE drug users and depressant PCE drug users had high intellect/openness in common. Otherwise, stimulant PCE drug use and depressant PCE drug use was predicted by different traits, suggesting that students who use stimulants versus depressants for PCE purposes may have different motivations, and that the two user groups do not consist solely of the same types of individuals. The current results may suggest that stimulant PCE drug users are more antisocial and indifferent to rules, compared to depressant PCE drug users, as stimulant PCE drug use was predicted by low agreeableness scores and high alcohol use (traits which further have been associated with being antisocial) (Fu et al., 2002; McCrae & John, 1992). Depressant PCE drug use may, on the other hand, be more motivated by coping with stress, as depressant PCE drug users had characteristics (i.e., low extroversion scores, high conscientiousness scores, and higher levels of anxiety) which in some instances can make adjusting to the student setting more challenging (Anderson et al., 2001; Stoeber & Dalbert, 2009). As many prior studies have only investigated cognitive enhancement with the use of stimulants, or have not differentiated between different types of PCE drugs, the present study adds to the literature by expanding the knowledge of the relationship between psychological problems, personality traits, and enhancement drug use.

Limitations of the present study

Sample representativeness may be a limitation of the present study. Although all students at the four largest institutions of higher education in Bergen were invited, only 39.4% responded at T1 (32.8% if only complete responders are included), and 51.5% of those who responded in the first wave responded at T2 (47.2% if only complete responders are included). The results may hence not be generalisable to the Norwegian student population as a whole. Although

these response rates ideally would have been higher, they are higher than or at least comparable with the response rates of several previously published studies (McCabe et al., 2004; Nedregård & Olsen, 2014; Sattler & Wiegel, 2013). Further, the students in the current sample had similar characteristics, in terms of alcohol use, sex, age, and relationship status, to students in other Norwegian studies (Nedregård & Olsen, 2014; Statistisk Sentralbyrå, 2017). As such, the current results appear to be at least as generalisable as the results obtained in other similar studies.

Furthermore, due to non-response, we cannot exclude the possibility that PCE drug use is underreported. The prevalence rates in the present study were lower than those reported in a previous national survey (Nedregård & Olsen, 2014) and compared to other countries (Racine & Forlini, 2010; Sattler & Wiegel, 2013), which may indicate that there is an underreporting of the problem. Previous studies have shown that non-response is usually associated with pathology and there is more likely to be an underreporting of problem behaviours (Torvik, Rognmo, & Tambs, 2012). However, as participation was voluntary, anonymous, and the survey was web-based, there is reason to assume that the data collection procedure would lead to less socially desirable answers compared to classroom-collected data. Further, it should be noted that PCE drug users were equally (or slightly more) likely to participate at T2, compared to non-users. The lack of dropout bias in relation to PCE drug use may suggest that the proportion of PCE drug users in the current sample matches the proportion in the population, as dropout biases might give a cautious indication of characteristics associated with complete non-response (Groves, 2006). Combining survey data with other data sources (e.g., wastewater analyses) is warranted in order to obtain precise estimates of the prevalence of PCE drug use in the Norwegian and other student populations (European Monitoring Centre for Drugs and Drug Addiction, 1999).

The measurements used also involve some limitations. For example, the definition of PCE drugs was quite wide, encompassing both illegal and pharmacy drugs. Hence, the PCE drug users in the current sample may include students using a range of different substances, from caffeine pills to amphetamine. Some of the PCE users may have had a prescription for the drug and used it according to the prescription. These users are likely to differ from those without prescriptions. Future studies should aim to investigate which type of drugs students use for PCE, and to differentiate between different user groups. In addition, it is worth noting that the current study only included measures of individual predictors. Several broader, cultural, and environmental factors (e.g., employers' preoccupation with grades), may also contribute to PCE drug use, and such factors should consequently be investigated in future studies.

Conclusion

Although the rates of PCE drug use increased from T1 to T2, the prevalence rates among Norwegian students were similar to rates reported among German students, but lower compared to the US. A range of characteristics predicted stimulant and/or depressant PCE drug use (e.g., low extroversion scores, low agreeableness scores, high conscientiousness scores, alcohol use, and anxiety). Several of these traits have been associated with aspects relevant for academic function and/or with substance use in general. Pharmacological cognitive enhancement drug use may hence be explained by a combination of a motivation to improve academic achievement and a general inclination towards substance use. Stimulant PCE drug use and depressant PCE drug use had only a few predictors in common. The current results may suggest that stimulant PCE drug users are more antisocial and indifferent to rules, while depressant PCE drug users are more motivated by coping with stress.

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