

**Potential risk groups and psychological, psychosocial, and health
behavioral predictors of pharmacological neuroenhancement among
university students in Germany**

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Dimension	Variable (count)	Scale and/or Reference	Items	'Questions of self-constructed items', <i>answering options</i>
Sociodemographic variables	Gender (1)		1	'Your gender:' <i>male (1) / female (2) / diverse (3)</i>
	Degree (1)		1	'Which degree do you pursue with your current study?' <i>Drop-down list of all degrees at the university of Mainz</i>
	Age (1)		1	'Your age in years:'
	Relationship status (1)		1	'What is your relationship status?' <i>Single (1) / Partnership in one household (2) / Partnership with separate living conditions (3)</i>
	Financial status (1)		1	'What is the amount of money you monthly have at your disposal in average?'
	Employment (1)	Self-constructed items	1	'Are you currently employed?' <i>No (1) / Yes, full-time (2) / Yes, regularly part-time (3) / Yes, marginally or irregularly employed (4)</i>
	Support by parents/relatives (1)		1	'How do you finance your study?' <i>Support by parents or relatives: Yes / No</i>
	Parents' educational background (1)		1	'Please select the highest educational attainment of your mother or your father (the highest of both):' <i>List of attainments, also including , 'other attainment'</i>
	Migration background (1)		1	'Are both of your parents born in the today's area of Germany?' <i>Yes (1) / No (2) / Don't know (3) / No information (4)</i>
Personal migration experience (1)		1	'Are you born in the today's area of Germany?' <i>Yes (1) / No (2) / Don't know (3) / No information (4)</i>	
			1	

	Semester hours and Semester hours with mandatory attendance (2)		2	‘How many semester hours per week do you take this semester? Thereof, how many with obligation to attend?’
	Field of study (1)		1	Grouped variable created of: ‘What is your current study-subject or special-subject?’ <i>Drop-down list of all subjects of the university of Mainz</i>
	First year (Semester/Study progress) (1)		1	‘What is the number of your current university semester?’
Psychological variables	Somatic symptoms (1)	SSS-8 ¹	8	
	Depressive symptoms (1)	PHQ-9 ²	9	
	Symptoms of general anxiety (1)	GAD-2 ³	2	
	Loneliness (1)	UCLA ³	3	
	Emotional Exhaustion (1)	MBI-SS ⁴	5	
	Social Anxiety (1)	Mini-SPIN ⁵	3	
Study-related psychosocial variables	Presenteeism (1)	Töpritz et al. ⁶	1	
	Absenteeism (1)	Töpritz et al. ⁶	1	
	Planning competence and Competence for self-motivation (2)	Dettmers & Clauß ⁷	8	
	Excessive demand (qualitative) (1)	BARI-S ⁸	2	
	Competition (1)	Fend ⁹	4	
	Cognitive irritation (1)	Mohr et al. ¹⁰		
	Self-efficacy expectancy (1)	Self-Efficacy Scale; Adapted from Rigotti et al. ¹¹	6	
	Procrastination (1)	GPS-K ¹²	9	
	Self-endangering behavior (1)	Krause et al. ¹³	4	
	Performance pressure (1)	Fend ⁹	5	
	Self-perceived Employability (1)	Self-constructed	1	
	Autonomy (1)	BARI-S ⁸	6	

	Coping via use of: configuration options and social support (2)	In style of Daniels et al. ¹⁴	4	
	Social support of: fellow students and lecturers (2)	SALSA ¹⁵	3	
General psychosocial variables	Self-criticism (1)	DEQ-SC4 ¹⁶ ; Tibubos et al. ¹⁷	4	
	Self-acceptance (1)	Ryff ¹⁸ ; Ryff & Keyes ¹⁹	3	
	Emotion regulation, emotion suppression, and impulsiveness (3)	ERQ ²⁰	4	
Health behavior variables	Healthy diet (1)	Self-constructed	1	‘Healthy diet consists of eating plentiful whole grains, potatoes, fruit and vegetable several times a day, food low in trans fats, little red meat and sausage, little fast-food (e.g. burger, fries), little sugar-rich food (e.g. lemonade, soft drinks, candy, cake). To what extent did you stick to a healthy diet in the last month?’ <i>Not at all (1) – Very strong (5)</i>
	Moderate-vigorous physical activity (min/day) and Sedentary Behavior (2)	IPAQ short version ²¹	7	
	Alcohol use (1)	AUDIT-C (Cut-Off: 4) ²²	3	
	Smoking cigarettes (1)	Töpritz et al. ⁶	1	
	Coffee, Energy drinks, Caffeine tablets, Cola, Ginkgo biloba (5)	Dietz et al. ²³	1	
	Social media use (1)	Adapted from Stark et al. ²⁴	6	
	Fruit and Vegetable Consumption (2)	European Commission, 2013 ²⁵ ; Fehr et al. ²⁶	4	

Supplementary table 1. List of independent variables differentiated in the five category groups.

‘Count’ means the count of variables if 2 or more variables of the same scale are listed together.

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Association with the 12-month prevalence of PN

	χ^2	<i>p</i>
Gender (<i>n</i> = 3,800)	(2) = 18.802	≤ .001
Degree (<i>n</i> = 3,800)	(7) = 25.169	.001
Relationship status (<i>n</i> = 3,796)	(2) = 3.325	.190
Employment (<i>n</i> = 3,800)	(3) = 8.260	.041
Support by parents/relatives (<i>n</i> = 3,785)	(1) = .675	.411
Parent's educational background (<i>n</i> = 3,798)	(8) = 9.735	.284
Migration background (<i>n</i> = 3,799)	(3) = 10.276	.016
Personal migration experience (<i>n</i> = 3,799)	(3) = 6.484	.090
Field of study (<i>n</i> = 3,791)	(6) = 10.337	.111
First year (<i>n</i> = 3,700)	(1) = 2.284	.131
Healthy diet (<i>n</i> = 3,800)	(4) = 22.792	≤ .001
Alcohol use (AUDIT-C Cut-off: 4) (<i>n</i> = 3,796)	(1) = 73.920	≤ .001
Smoking cigarettes (<i>n</i> = 3,800)	(4) = 262.566	≤ .001
Coffee (<i>n</i> = 3,800)	(3) = 79.112	≤ .001
Energy drinks (<i>n</i> = 3,800)	(3) = 99.658	≤ .001
Caffeine tablets (<i>n</i> = 3,800)	(3) = 151.702	≤ .001
Cola (<i>n</i> = 3,800)	(3) = 80.497	≤ .001
Ginkgo biloba (<i>n</i> = 3,799)	(3) = 40.141	≤ .001

Supplementary table 3. Relationship to the 12-month prevalence of pharmacological neuroenhancement of all selected categorial study variables. χ^2 : Pearson Chi-square value

12-month use of PN

		Step 1: sociodemographic variables ($R^2 = 0.01^{***}$)	Step 2: psychological variables ($R^2 = 0.071^{***}$)	Step 3: study-related psychosocial variables ($R^2 = 0.092^{***}$)	Step 4: general psychosocial variables ($R^2 = 0.1^{***}$)	Step 5: health-behavioral variables ($R^2 = 0.257^{***}$)
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sociodemographic variables						
Gender	Female	Reference ^{***}	Reference ^{***}	Reference ^{***}	Reference	Reference
	Male	1.517 (1.214 – 1.897) ^{***}	1.764 (1.414 – 2.277) ^{***}	1.695 (1.328 – 2.163) ^{***}	1.768 (1.380 – 2.265) ^{***}	1.387 (1.052 – 1.827) [*]
	Diverse	3.190 (1.342 – 7.580) ^{**}	2.183 (0.877 – 5.431)	2.296 (0.919 – 5.736)	2.128 (0.842 – 5.377)	1.780 (0.638 – 4.971)
Psychological variables						
Somatic symptoms			1.019 (0.991 – 1.048)	1.013 (0.985 – 1.042)	1.011 (0.983 – 1.040)	0.993 (0.962 – 1.024)
Depressive symptoms			1.102 (1.067 – 1.139) ^{***}	1.091 (1.054 – 1.130) ^{***}	1.095 (1.056 – 1.135) ^{***}	1.086 (1.044 – 1.129) ^{***}
General anxiety			0.987 (0.902 – 1.079)	1.009 (0.920 – 1.107)	1.021 (0.930 – 1.120)	1.025 (0.926 – 1.134)
Loneliness			0.968 (0.924 – 1.013)	0.954 (0.910 – 1.000) [*]	0.965 (0.920 – 1.013)	0.999 (0.948 – 1.052)
Emotional exhaustion			1.031 (0.940 – 1.132)	0.962 (0.854 – 1.084)	0.961 (0.853 – 1.083)	0.966 (0.849 – 1.101)
Study-related psychosocial variables						
Presenteeism				1.005 (0.996 – 1.014)	1.006 (0.997 – 1.014)	1.005 (0.996 – 1.015)
Absenteeism				1.019 (1.004 – 1.035) [*]	1.019 (1.003 – 1.034) [*]	1.022 (1.005 – 1.040) ^{**}
Planning competency				0.896 (0.728 – 1.104)	0.898 (0.729 – 1.107)	0.894 (0.712 – 1.122)
Excessive demands				1.103 (0.979 – 1.244)	1.082 (0.959 – 1.222)	1.106 (0.969 – 1.263)

Competition		1.084 (0.914 – 1.287)	1.072 (0.902 – 1.275)	0.962 (0.796 – 1.262)
Cognitive irritation		1.057 (0.966 – 1.156)	1.080 (0.985 – 1.183)	1.081 (0.980 – 1.192)
Social support (fellow students)		0.853 (0.749 – 0.970)*	0.856 (0.752 – 0.975)*	0.830 (0.721 – 0.955)**
Competence for self-motivation		1.023 (0.827 – 1.265)	1.005 (0.812 – 1.244)	0.999 (0.795 – 1.256)
Self-efficacy expectancy		1.304 (1.055 – 1.611)*	1.258 (1.010 – 1.567)*	1.230 (0.968 – 1.563)
Procrastination		1.031 (1.008 – 1.056)**	1.028 (1.010 – 1.567)*	1.013 (0.987 – 1.039)
General psychosocial variables				
Self-criticism			0.975 (0.947 – 1.004)	0.955 (0.926 – 0.986)**
Self-acceptance			1.004 (0.954 – 1.057)	0.980 (0.927 – 1.035)
Impulsiveness			1.096 (1.041 – 1.155)***	1.027 (0.971 – 1.087)
Health behavior variables				
Healthy diet				1.264 (1.117 – 1.431)***
Moderate-vigorous physical activity (min/day)				1.001 (1.000 – 1.002)*
Alcohol use				1.612 (1.243 – 2.092)***
Smoking cigarettes				1.468 (1.349 – 1.597)***
Coffee	never (<i>n</i> = 1284)			Reference
	within the last 30 days (<i>n</i> = 1766)			1.531 (1.114 – 2.106)**

	within the last 12 months (<i>n</i> = 387)	1.135 (0.719 – 1.793)
	more than 12 months ago (<i>n</i> = 147)	0.904 (0.425 – 1.926)
Energy drinks	never (<i>n</i> = 2354)	Reference
	within the last 30 days (<i>n</i> = 553)	1.166 (0.844 – 1.612)
	within the last 12 months (<i>n</i> = 374)	1.328 (0.932 – 1.891)
	more than 12 months ago (<i>n</i> = 303)	0.864 (0.557 – 1.340)
Caffeine tablets	never (<i>n</i> = 3222)	Reference***
	within the last 30 days (<i>n</i> = 91)	4.235 (2.552 – 7.027)***
	within the last 12 months (<i>n</i> = 85)	1.763 (1.011 – 3.073)*
	more than 12 months ago (<i>n</i> = 186)	2.117 (1.416 – 3.164)***
Coke	never (<i>n</i> = 1889)	Reference***
	within the last 30 days (<i>n</i> = 1106)	1.669 (1.255 – 2.221)***
	within the last 12 months (<i>n</i> = 453)	2.267 (1.587 – 3.239)***
	more than 12 months ago (<i>n</i> = 136)	1.256 (0.625 – 2.524)
Ginkgo biloba	never (<i>n</i> = 3451)	Reference
	within the last 30 days (<i>n</i> = 37)	2.587 (1.164 – 5.747)*
	within the last 12 months (<i>n</i> = 32)	1.095 (0.442 – 2.711)

more than 12 months ago
(*n* = 64)

1.417 (0.697 – 2.881)

Social media use

0.997 (0.913 – 1.088)

Supplementary table 4. Binary logistic regression analysis to predict the dependent variable ‘12-month prevalence of pharmacological neuroenhancement’ by stepwise inclusion of the 5 independent variable groups. Observed cases: *n* = 3,608; ***: *p* ≤ .001; **: *p* ≤ .01; *: *p* ≤ .05; Step 1: χ^2 (2) = 17.504; Step 2: χ^2 (7) = 129.270; Step 3: χ^2 (17) = 167.444; Step 4: χ^2 (20) = 183.304; Step 5: χ^2 (40) = 490.590

12-month use of PN

Step 5: health-behavioral variables ($R^2 = 0.254^{***}$)

OR (95% CI)

Sociodemographic variables

Gender	Female	Reference
	Male	1.451 (1.064 – 1.979)**
	Diverse	2.910 (0.997 – 8.494)

Psychological variables

Somatic symptoms	1.005 (0.971 – 1.041)
Depressive symptoms	1.075 (1.029 – 1.122)***
General anxiety	1.016 (0.907 – 1.139)
Loneliness	1.009 (0.951 – 1.071)
Emotional exhaustion	0.960 (0.830 – 1.111)

Study-related psychosocial variables

Presenteeism	1.005 (0.995 – 1.016)
Absenteeism	1.026 (1.007 – 1.045)**
Planning competency	0.868 (0.672 – 1.121)
Excessive demands	1.089 (0.938 – 1.266)
Competition	1.049 (0.848 – 1.297)
Cognitive irritation	1.056 (0.946 – 1.179)
Social support (fellow students)	0.900 (0.768 – 1.055)
Competence for self-motivation	1.015 (0.784 – 1.315)
Self-efficacy expectancy	1.180 (0.898 – 1.551)
Procrastination	1.008 (0.979 – 1.037)

General psychosocial variables

Self-criticism	0.966 (0.932 – 1.001)
Self-acceptance	0.978 (0.919 – 1.040)

Impulsiveness		1.045 (0.980 – 1.114)
Health behavior variables		
Healthy diet		1.219 (1.061 – 1.400)**
Moderate-vigorous physical activity (min/day)		1.001 (1.000 – 1.003)*
Alcohol use		1.463 (1.094 – 1.995)**
Smoking cigarettes		1.502 (1.366 – 1.651)***
Coffee	never (<i>n</i> = 1284)	Reference
	within the last 30 days (<i>n</i> = 1766)	1.463 (1.017 – 2.103)*
	within the last 12 months (<i>n</i> = 387)	1.107 (0.659 – 1.860)
	more than 12 months ago (<i>n</i> = 147)	0.867 (0.366 – 2.053)
Energy drinks	never (<i>n</i> = 2354)	Reference
	within the last 30 days (<i>n</i> = 553)	1.101 (0.760 – 1.595)
	within the last 12 months (<i>n</i> = 374)	1.370 (0.920 – 2.041)
	more than 12 months ago (<i>n</i> = 303)	0.915 (0.557 – 1.500)
Caffeine tablets	never (<i>n</i> = 3222)	Reference***
	within the last 30 days (<i>n</i> = 91)	3.934 (2.245 – 6.891)***
	within the last 12 months (<i>n</i> = 85)	1.214 (0.620 – 2.375)
	more than 12 months ago (<i>n</i> = 186)	2.365 (1.527 – 3.663)***
Coke	never (<i>n</i> = 1889)	Reference***
	within the last 30 days (<i>n</i> = 1106)	1.774 (1.282 – 2.455)***
	within the last 12 months (<i>n</i> = 453)	2.477 (1.654 – 3.710)***
	more than 12 months ago (<i>n</i> = 136)	1.064 (0.471 – 2.401)
Ginkgo biloba	never (<i>n</i> = 3451)	Reference
	within the last 30 days (<i>n</i> = 37)	2.462 (1.058 – 5.733)*
	within the last 12 months (<i>n</i> = 32)	0.869 (0.316 – 2.540)
	more than 12 months ago (<i>n</i> = 64)	1.286 (0.579 – 2.857)
Social media use		0.967 (0.877 – 1.067)

Supplementary table 5. Cross-validation of the binary logistic regression analysis to predict the dependent variable '12-month prevalence of pharmacological neuroenhancement' using an 80% random sample. Observed cases: $n = 2,889$; ***: $p \leq .001$; **: $p \leq .01$; *: $p \leq .05$; Step 5: $\chi^2 (40) = 385.123$; correctly classified cases: 89.6%

	Past 12 months use of PN	
	No	Yes
Predictors		
Gender – male	81.4% (<i>n</i> = 903)	13.2% (<i>n</i> = 146)
Reference: female	86.5% (<i>n</i> = 2458)	9.3% (<i>n</i> = 263)
Depressive symptoms (score: 0 – 27), mean ± SD	7.0 ± 4.9 (<i>n</i> = 3380)	9.9 ± 5.8 (<i>n</i> = 416)
Absenteeism (number in days), mean ± SD	1.7 ± 4.5 (<i>n</i> = 3314)	3.4 ± 9.0 (<i>n</i> = 403)
Social support by fellow students, mean ± SD (score: 1 – 5)	3.7 ± 0.9 (<i>n</i> = 3316)	3.5 ± 1.0 (<i>n</i> = 404)
Self-criticism, mean ± SD (score: 7 – 28)	18.6 ± 4.7 (<i>n</i> = 3305)	19.4 ± 5.1 (<i>n</i> = 398)
Healthy diet, mean ± SD (score: 1 – 5)	3.3 ± 1.0 (<i>n</i> = 3384)	3.4 ± 1.1 (<i>n</i> = 416)
Moderate-vigorous physical activity (min/day), mean ± SD	122.9 ± 98.8 (<i>n</i> = 3333)	145.7 ± 119.2 (<i>n</i> = 408)
Risky alcohol use (<i>n</i> = 1634)	40.6% (<i>n</i> = 1373 of 3380)	62.7% (<i>n</i> = 261 of 416)
Smoking cigarettes currently (<i>n</i> = 542)	11.5% (<i>n</i> = 388 of 3384)	37.0% (<i>n</i> = 154 of 416)
Soft neuroenhancers:		
Coffee – never (reference)	94.5% (<i>n</i> = 1,288)	5.5% (<i>n</i> = 75)
Coffee – within the last 30 days	84.8% (<i>n</i> = 1,590)	15.2% (<i>n</i> = 284)
Caffeine tablets – never (reference)	91.1% (<i>n</i> = 3,105)	8.9% (<i>n</i> = 304)
Caffeine tablets – within the last 30 days	63.0% (<i>n</i> = 63)	37.0% (<i>n</i> = 37)
Caffeine tablets – more than 12 month ago	76.0% (<i>n</i> = 152)	24.0% (<i>n</i> = 48)
Coke – never (reference)	93.2% (<i>n</i> = 1,867)	6.8% (<i>n</i> = 137)
Coke – within the last 30 days	84.1% (<i>n</i> = 990)	15.9% (<i>n</i> = 187)
Coke – within the last 12 month	83.4% (<i>n</i> = 396)	16.6% (<i>n</i> = 79)
Ginkgo biloba – never (reference)	89.7% (<i>n</i> = 3,279)	10.3% (<i>n</i> = 378)
Ginkgo biloba – within the last 30 days	64.1% (<i>n</i> = 25)	35.9% (<i>n</i> = 14)

Supplementary table 6. Descriptive statistics of the predictors of PN among survey participants (*n* = 3,984). SD: standard deviation