Neuroenhancement among Swiss Students – A Comparison of Users and Non-Users

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Key words
- cognitive enhancement
- ethics
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Abstract

Introduction: This survey aims to contribute to the current discussion about neuroenhancement by comparing cognitive enhancer(s) (CE) users with CE non-users with a focus on their characteristics and attitudes.

Methods: An online survey was sent out to all undergraduate and graduate students of the University of Zürich who allow such e-mails (n = 8 642), accompanied by advertisement for the survey in lectures. 1 765 students completed the survey, which was about healthy people's use of Ritalin, Adderall and/or Modasomil to increase concentration and/or alertness. A complementary paper-and-pencil survey (n = 97 students, response rate: 95.1 %) was also carried out in order to compare data.

Results: Non-therapeutic CE users (6.2 %) were more often male, considered religion to be of less importance and had more experience with drugs. CE had been taken for study purposes by 4.7 % of all students. CE users had tried Ritalin most often, which about half of them received from friends and colleagues. The CE users had more reasons for and fewer concerns about taking CE than non-users. The most common reasons for both groups were "the effects of learning quicker" and "for finishing more work in less time". The most common concerns for both groups were "the worries about possible side effects" and "the goal of CE to achieve more", and "an unnatural interference of such products with our bodies" (CE-users) or "the gut feeling of not using such products" (CE non-users).

Discussion: The comparison of CE users with CE non-users reveals insights about their attitudes, which will add to the understanding of why students take or could imagine taking such products.

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Introduction

Neuroenhancement has been a matter of controversy in recent years, not only with regard to the moral and legal issues involved, but also in consideration of the role of cognitive enhancers (CE) in the everyday lives of different populations [1–3]. A number of studies focus on various user groups and the frequency of usage [4–11], with some concentrating on students [7–11], whereas several others explore the experiences and perceptions of prescribing physicians [12–15]. Even though the ethical and policy issues of CE have been intensely debated in Switzerland [16, 17], so far only a single survey has been carried out investigating the attitudes of the general population in one Swiss community [18].

The goal of our survey was to add empirical data about the characteristics and motives of CE users, defined as students who have already taken Ritalin, Adderall and/or Modasomil for increasing concentration and/or alertness as a healthy person, in comparison to CE non-users in Switzerland. Rather than contributing to what has been called media hype [20], such data will lead to a better understanding of why some students are taking CE and others are not, and how students conceive of these products. By focusing on CE users as well as CE non-users, further aspects of the perception of neuroenhancement in society can be observed. These insights could enrich current debates on how to deal with cognitive enhancers.

Existing literature and surveys include various understandings of CE e.g., [1, 2, 19]. The definition of CE we provided for the survey was purposely very narrow: "The use of Ritalin, Adderall and/or Modasomil for increasing concentration and/or alertness in a healthy person". Products very similar to these three were included (as

explained in the Methods section). By avoiding the term "neuroenhancement", we tried to prevent associations with various other possible definitions.
Our focus on the comparison between users and non-users rather than mainly investigating the users will add new data to the debate about CE and specifically to the situation in Switzerland.

Methods

Hypotheses

The hypotheses were formulated according to possible associations between the usage of CE and the following: demographic data; drug or alcohol use; use of products like coffee; conduction of methods like autogenic training; concerns about and reasons for using CE; self-evaluation of risk behaviour and case studies. The hypotheses were established on the basis of previous studies about the usage of CE [4–7] as well as proposed, possible associations concerning the usage of CE.

Survey design

The online survey of about 10–15 min was constructed with the software "Unipark" – a fee-based software for establishing online surveys. The questions were developed in line with current methodological recommendations (Prost, 2009). To avoid possible bias due to differing definitions of "neuroenhancement", we did not use the term "neuroenhancement" but instead the phrase "Ritalin, Adderall and/or Modasomil to increase concentration and/or alertness in a healthy person". Furthermore, we referred to Ritalin, Adderall and Modasomil as "products", and not as "pharmaceuticals" or even "drugs". We chose these three products as they are dominant in the current literature on neuroenhancement and are also used as reference products in other empirical surveys. The term "Ritalin" was defined as including the products Concerta, Focalin, Equasym, Medikinet, Daytrana and Metadate; the term "Modasomil" included Provigil, Vigilant and Modafinil.
Half-open answer categories were used when we could not be sure of covering all possible answers. The answer categories were presented in random order except when they represented a range.
The questions were grouped into 3 parts: demographic data; usage of CE; and personal attitudes toward such products. A paper-and-pencil version of the questionnaire (in German) is available from the authors (regula.ott@ethik.uzh.ch) upon request.
Students who had already taken Ritalin, Adderall and/or Modasomil to increase concentration or alertness without treating an illness ("CE users") and students who had not yet taken such products or who had taken them only to address the symptoms of an illness ("CE non-users") were separated with the help of filters.
The 2 questions addressing concerns about or reasons for taking CEs were based on arguments presented in the pre-existing Swiss questionnaire [18]. The questions about alcohol consumption and about risk were formulated in accordance with the standards of the Swiss Federal Office of Statistics.
The questionnaire was reviewed by 2 outside survey experts, and tested by 11 individuals who were mostly students and by one person with experience in survey design. In the pilot study, a space for commentary was added after each question, which generated around 60 comments that were then used to improve the questionnaire for the main study. The ethics committee that is responsible for human subject research in the Canton of Zurich exempted the study from review.
Different tools were applied to the survey to improve the quality of the data and to keep participants motivated: Plausibility checks triggering a comment if a participant's answers were ambiguous, filters and page triggers leading to specific phrased questions in response to previous answers.

The administration of the survey

A link to the survey was sent to all the undergraduate and graduate students of the University of Zurich who had already given the University permission to send them e-mails for research purposes (n = 8 642).
In addition, flyers advertising the survey were distributed during 19 major lectures, through which around 3 000 students were informed about the survey. The 32 student councils of the University of Zurich were also contacted and 8 of these then distributed the link among their students (n ≈ 4 300). 63 individual students (personal contacts of one of the authors, R.O.) received a personal e-mail inviting them to participate in the survey. We used different URLs to ensure that we could evaluate how the participant knew about the questionnaire. The survey was online for 4 months during the summer semester in 2011 (14 March 2011–12 July 2011). When cookies were allowed, the survey could not be filled out twice from the same computer.
In order to increase the validity of the convenience sample of the online survey, the same questionnaire was used in a small paper-and-pencil survey of 103 Bachelor and Master's students (biology) in a neurobiology lecture on 10 October 2011. The participants in this small survey were not included in the main survey because of possible bias due to the different method of collecting the data. Therefore, the paper-and-pencil survey was used for comparison purposes only.

Data analysis

Analyses were conducted using SPSS statistic Version 19.0.0 (SPSS Inc., Armonk, NY). Data cleaning was accomplished. We used univariate descriptive statistics to examine the distribution for the answer categories of each question. Bivariate analyses using Pearson's χ^2 tests and one t-test (question about risk) were completed to compare the group of CE users with the CE non-users. A Fisher's exact test was conducted if 20 % or more of expected values below the value of 5 or any expected values below 1 were found. A stepwise binary linear regression was calculated with usage of CE as the dependent variable.

Results

1 765 students of the University of Zurich completed the survey. Most of these students (n = 1 311) participated by responding to the e-mail sent out through the University (74.3 % of the 1 765 participants) and the response rate for this subset was 15.2 % (1 311 of the 8 642 students who received the e-mail). The remaining 25.7 % of participants completed the survey either after receiving an e-mail from one of the student councils (n = 238, 13.5 %), after typing in the link on the flyer (n = 198, 11.2 %) or after clicking on the link in a personal e-mail (n = 19, 1.1 %).

Table 1 Demographic and drug use data for CE users and CE non-users.

Variable	Answer categories	CE non-users	CE users	p-value (χ^2 test)	Odds ratio	Confidence interval	p-value (Odds ratio)
all (n_{Total})	–	1722 (100%)	116 (100%)	–	–	–	–
gender	women*	1096 (63.7%)	49 (43.0%)	0.000	–	–	–
	men	624 (36.3%)	65 (57.0%)		2.330	1.588–3.419	0.000
political orientation	SP (left)	497 (28.9%)	31 (27.2%)	0.042			0.519
	GPS (green, left)	221 (12.8%)	12 (10.5%)				0.390
	CVP (Christian)	82 (4.8%)	0 (0%)				0.997
	FDP (liberal)	161 (9.4%)	20 (17.5%)				0.299
	GLP (green, liberal)	229 (13.3%)	17 (14.9%)				0.853
	SVP (right)*	112 (6.5%)	9 (7.9%)				–
	others	90 (5.2%)	7 (6.1%)				0.950
	none	328 (19.1%)	18 (15.8%)				0.367
religion	evangelical reformed	589 (34.2%)	28 (24.6%)	0.004	0.478	0.296–0.774	0.003
	roman catholic	530 (30.8%)	27 (23.7%)		0.513	0.315–0.835	0.007
	others°	120 (7.0%)	11 (9.6%)				0.817
	no affiliation*	483 (28.0%)	48 (42.1%)		–	–	–
importance of religion	very important	81 (4.7%)	3 (2.6%)	0.003			0.153
	important	186 (10.8%)	5 (4.4%)		0.308	0.123–0.771	0.012
	rather unimportant	488 (28.4%)	22 (19.3%)		0.517	0.320–0.838	0.007
	not important*	964 (56.1%)	84 (73.7%)		–	–	–
drugs*	cannabis	924 (55.0%)	89 (82.4%)	0.000			0.797
	ecstasy (=MDMA)	88 (5.2%)	37 (34.3%)	0.000	2.848	1.385–5.858	0.004
	cocaine	96 (5.7%)	33 (30.6%)	0.000			0.071
	LSD	51 (3.0%)	23 (21.3%)	0.000+	2.157	1.035–4.498	0.040
	amphetamine (e.g. Speed)	60 (3.6%)	29 (26.9%)	0.000			0.100
	thai-pills	5 (0.3%)	4 (3.7%)	0.001+			0.562
	magic mushrooms	120 (7.1%)	22 (20.4%)	0.000			0.272
	crack	6 (0.4%)	3 (2.8%)	0.014+			0.748
	heroine	10 (0.6%)	3 (2.8%)	0.039+			0.222
	none of these drugs taken*	731 (43.5%)	16 (14.8%)	0.000			0.097

* Reference variable for odds ratio; odds ratio only mentioned when p-value was <0.05

° Other Christian churches or communities, other churches or communities, Jewish, Muslim

+ Fisher's exact test was completed. n_{Total} can vary, due to missing values (between 0 and 4) and drop-outs (drug questions was more at the end of the questionnaire: n=110 and n=1679)

Considering all of the students at the University of Zurich, 8.9% of the students (licentiate, bachelor and master) filled out the questionnaire (n_{Total}=18823), as did 5.5% of all Ph.D. students (n_{Total}=4219). In absolute numbers, the most highly represented student groups were medical students (n=275), followed by psychology students (n=192) and law students (n=158).

To compare these results with those generated by a survey with a much higher response rate, students attending one major lecture were asked to fill out the questionnaire on paper (response rate: 95.1%). Of these students, 4.1% had taken CE to increase concentration and/or alertness (n=4, n_{Total}=98). This is not significantly different from the value of 6.2% for CE-users in the main sample (p=0.391).

Demographic data

1197 people in this sample were female (61.9%) and 732 were male (37.9%; 4 people did not choose a gender (0.2%). The median birth year was 1986 (n_{Total}=1923).

114 people in this sample used Ritalin, Adderall and/or Modasomil at least once in their life for increasing concentration and/or alertness as a healthy person (6.2%). 87 of these 114 people had used it for study purposes (4.7% of n_{Total}=1835); the other 27 people had used it as a "party drug" or out of curiosity and not in a specified situation.

A significant univariate association with the usage of CE (p<0.05) was found for gender, political view, and religion (**Table 1**). No difference was found due to age, field of study, level of study (undergraduate, teaching diploma, Ph.D.), average number of semesters, highest completed level of education of the mother or father, participation in student groups at the University, fraternity/sorority members, self-reported grades, housing or the financial situation of the person or their parents.

There were strong associations between the use of CE and drugs (**Table 1**). No difference between the 2 groups was found in the frequency of alcohol consumption (the median for both groups was "1–2 times per week").

A stepwise logistic regression was calculated using the variables that had a positive association with the usage of CE (**Table 2**). These variables are the ones in **Table 1**; the legal products coffee, Red Bull, guarana and cigarettes; autogenic training as a method for the purpose of increasing concentration and/or alertness; and their self-evaluation of the risk behaviour.

The logistic regression model includes gender, Red Bull, guarana, autogenic training, ecstasy, cocaine, LSD and "none of these drugs taken" as predictors for belonging to the group of CE users and can explain 19.4% of the variance (**Table 2**).

The model reveals that there is an increased chance of belonging to the group of CE users if male; having taken Red Bull or guarana; having performed autogenic training for increasing concentration and/or alertness; or having used ecstasy, cocaine or LSD. If none of these drugs had been taken, there was a decreased chance of belonging to the CE-user group.

Table 2 Stepwise logistic regression.

Variable	Regression coefficient	Standard error	p-value	Odds ratio	Confidence interval Lower	Upper
gender	0.478	0.219	0.029	1.613	1.051	2.476
red bull	0.462	0.230	0.044	1.588	1.012	2.490
guarana	0.702	0.264	0.008	2.017	1.201	3.387
autogenic training	0.989	0.422	0.019	2.687	1.175	6.147
ecstasy	1.029	0.342	0.003	2.797	1.430	5.471
cocaine	0.690	0.322	0.032	1.993	1.061	3.746
LSD	0.821	0.354	0.021	2.272	1.135	4.549
none of these drugs taken	−0.797	0.297	0.007	0.451	0.252	0.806

The categorical covariates (all variables except the one about risk) were compared to either the last answer category (political orientation, religion, importance of religion) or the first answer category (all the other variables)

Table 3 Why did you take Ritalin, Adderall and/or Modasomil? (Multiple answers possible).

	CE users (n = 114)
to be more concentrated.	85 (74.6 %)
out of curiosity as to how it takes effect.	66 (57.9 %)
to be more awake.	62 (54.4 %)
because I did not have enough time.	30 (26.3 %)
to receive better grades.	27 (23.7 %)
because I am stressed.	22 (19.3 %)
to get into the mood, e. g. at a party.	16 (14.0 %)
because others did it as well.	7 (6.1 %)
to decrease jet lag.	3 (2.6 %)
for another or additional reason, namely…	7 (6.1 %)

The answer categories one to nine were randomized. More than one of the answer categories could be chosen. No missing values and the median was 3 answers

Features of CE use

A positive association between the use of CE and the use of products to increase concentration and/or alertness in the last 12 months was seen for coffee, Red-Bull, guarana and cigarettes. A negative association with the use of CE was found if there had been no consumption of such products for this purpose. A positive association was also found between the use of CE and autogenic training for the same purpose.

Within our sample of students, 74.1 % knew that Ritalin could be taken as a CE. At least one product from the group containing "Concerta, Focalin, Equasym, Medikinet, Daytrana, Metadate" was identified as a known CE product by 9.1 % of students. "Provigil, Vigil, or Modafinil" were known to be CE products by 6.5 %, "Modasomil" by 3.9 % and "Adderall" by 2.8 % of students. 269 persons knew more than one of these products could be used for such purposes (14.6 %). However around a third of students (25.5 %) had not heard of any of these products being used for such a purpose. CE users knew each category of CE listed above significantly more often than the CE non-users (for all categories: p = 0.000).

164 students had taken at least one of the products (Ritalin [n = 159], Adderall [n = 4] or Modasomil [n = 15]) or brand names mentioned above. 46 of these students had taken these products (Ritalin in all cases) as treatment for a medical condition. Of the remaining 114 students (4 students dropped out), 99 had taken Ritalin for non-therapeutic purposes, 4 had taken Modasomil and 11 students had already taken several of these products. Possible reasons for non-therapeutic use by CE users are presented in **Table 3**.

CE non-users were also asked if they could imagine taking Ritalin, Adderall or Modasomil for the possible reasons mentioned in **Table 3**. Most of them gave the answers "no, rather not" or "no, never" to the reasons provided (n = 1160, 68.8 %). In the cases where they could imagine taking these products, the most commonly chosen answer categories were "out of curiosity" (n = 358, 21.2 %), and "to be more concentrated" (n = 246, 14.6 %).

Most of the CE-users (86.2 %) told at least one other person about their consumption. A little more than a quarter of CE non-users (27.2 %) knew at least one person using CE (most frequently 1–3 persons). Still more CE non-users (42.8 %) had heard about at least one person who was taking CE (without having heard it directly from the individual). Almost half the CE users indicated that they had received a neutral reaction from other people about their use of CEs. This contrasts with only 22.0 % (n = 371) of the CE non-users from this sample claiming they would have reacted neutrally. Two-thirds of CE non-users thought that using CE was not a good thing to do (67.3 %) and only 0.9 % agreed with such use (9.5 % answered that they could not decide; missing values: n = 5, 0.3 %).

Answers to questions about the frequency of CE use revealed that 44.4 % of the students who had taken Ritalin as a CE had already taken it more than 5 times in their life (n = 48). 34 students had taken it 2–5 times in their life (31.5 %) and 26 people once in their life (24.1 %). Modasomil and Adderall were taken much less frequently. Most of the CE users received the product from colleagues, friends or acquaintances (**Table 4**).

When asked about their estimation of side effects, significant differences between the CE users and CE non-users were observed for Ritalin [$\chi^2(5) = 144.87$, p = 0.000], with CE non-users more often choosing the options "rather critical" or "very critical". The CE users formed their opinions about the side effects most often by reading specialist literature (48.3 %, n = 42), whereas the CE non-users formed their opinions most often through the presentation of these products in the media (38.8 %, n = 343).

Personal attitudes towards CE

Study participants were presented with 3 case studies: 1) a 25-year-old healthy person, who is described as a friend of the participant and studies with him/her, taking Ritalin to increase their concentration; 2) the same type of person, but in this case taking anabolics to increase muscle size; and 3) a 65-year-old healthy person taking a product to counteract an age-related decrease in intellectual performance. In all 3 scenarios, more CE users approved of these products being consumed than did CE non-users. Interestingly, significantly fewer students from both

groups were fine with the consumption of anabolics as compared to the consumption of Ritalin for the 25-year-old described.

Around one-third of the CE users agreed with the statement that the intake of such CE will be normal in 10 years, compared to 18.4% of the CE non-users. 90.6% of the CE users would be prepared to try a product without any side effects to increase IQ and a little more than half of them (51.9%) would try this "most probably more than once". This compares with only 57.9% of the CE non-users who claimed they would try such a product. A survey item containing a self-assessment of risk behaviour revealed that CE users considered themselves overall more ready to take risks than did the CE non-users.

2 questions were asked about the acceptability of taking coffee or Ritalin before an exam. As expected, more of the CE users think that the use of Ritalin before an exam is acceptable than do the CE non-users; in general, more of the students in both groups think that the intake of coffee is more acceptable than taking Ritalin.

Table 5 illustrates that CE non-users have more concerns about the use of CE than CE users and **Table 6** shows that CE users more often agreed with possible reasons for taking CE products than did CE non-users.

Table 4 Source of product.

a) Where did you get the product in question? (Multiple answers possible)	**Ritalin (n = 106)**	**Adderall (n = 4)**	**Modasomil (n = 14)**
from colleagues, friends or acquaintances.	59 (55.7)	2	6
from a physician.	25 (23.6)	1	5
from someone in my family.	14 (13.2)	0	0
in a pharmacy.	12 (11.3)	0	1
via the Internet.	5 (4.7)	1	2
via another route, namely…	7 (6.6)	0	2
b) did you require a prescription for the supply of the product? If yes, from where did you get it? (Multiple answers possible)	**(n = 104)**	**(n = 3)**	**(n = 14)**
no, I did not require a prescription.	77 (74.0)	2	11
yes I did require a prescription. I received it from a physician.	23 (22.1)	1	3
yes I did require a prescription. I filled it out by myself.	0 (0.0)	0	0
yes I did require a prescription. I received it from some other non-physician.	4 (3.8)	0	0

The answer categories one to five for the first question were randomized. When the sixth answer category was chosen, no other answer categories were possible. Missing values in the first question: Ritalin: 1, Adderall: 7, Modasomil: 7. Missing values in the second question: Ritalin: 0, Adderall: 7, Modasomil: 7. Median for all products in both questions: one answer

Discussion

This survey was designed to obtain information about attitudes to neuroenhancement from a sample that allowed us to compare CE users with CE non-users. It was not constructed to be a representative study of a population. The values gained for frequency of usage of CE by healthy people for study purposes (4.7%) therefore must be understood with caution. The primary invitation to participate in the survey could only be sent to those students who allowed such e-mails, 33.7% of all students. It was therefore not possible to gain a representative sample from a random selection.

Concern about bias due to the study design could be addressed by comparing our sample results with those generated by a paper-and-pencil survey carried out with a further 97 students (response rate 95.1%), although this comparator sample was also not representative of the whole student population because it included students from only one major subject and semester group. Due to this selection process, some differences exist between the paper-and-pencil survey and the online survey, such as age (a median of 1988 compared to 1986) and the number of semesters (a median of 5.0 compared to 6.0); however, there were no differences with regard to gender. The major subject biology (n = 60 in the paper-and-pencil survey) was also the fourth most common subject in absolute numbers for the online sample.

Table 5 Concerns about the use of CE.

CE users: Which of the following possible concerns, about EXCESSIVE use of Ritalin, Adderall and/or Modasomil to increase concentration or alertness, do you agree with?
CE non-users: Which of the following concerns, about the use of Ritalin, Adderall and/or Modasomil to increase concentration or alertness do you agree with?

CE-users (n = 108); CE-non-users (n = 1 689)	**I agree**		**I don't agree**		**I don't know**		**p-value***
worries about possible side effects.	63.9	**81.9**	**28.7**	11.1	**7.4**	6.6	0.000
the goal when taking these products is that one can achieve more. I find such pressure to achieve more questionable.	59.3	**74.5**	**36.1**	17.5	4.6	**7.6**	0.000
these products represent an unnatural interference with our bodies.	55.6	**73.1**	**39.8**	17.2	4.6	**9.3**	0.000
there is a danger of becoming addicted.	51.9	**68.9**	**38.9**	18.2	9.3	**12.4**	0.000
if a lot of people do this, it could have bad effects on society.	48.1	**57.3**	**41.7**	21.7	10.2	**20.4**	0.000
my gut feeling tells me that we should keep our hands off such products.	40.7	**76.2**	**49.1**	15.8	**10.2**	7.8	0.000
that I would change and not being myself anymore.	33.3	**49.9**	**61.1**	31.8	5.6	**17.8**	0.000
I could not be proud of my own achievements anymore.	18.5	**42.4**	**76.9**	41.5	4.6	**15.7**	0.000
I would somehow be betraying people who do not use such products.	17.6	**34.2**	**76.9**	50.7	5.6	**14.6**	0.000
God created humans according to his plan. we should not try to improve upon this with such products.	2.8	**9.1**	**88.0**	74.3	9.3	**16.0**	0.014

The answer categories were randomized. For each sentence, one answer category could be chosen. There are no missing values for the CE users. Some missing values exist for the CE non-users (n = 4–10, 0.2–0.6%)

*The p-value was calculated with a χ^2-test and the 'I don't know' answers were treated as missing values. The CE users were in the following question asked what they define as an excessive use

Table 6 Reasons for the use of CE.
What are/could be reasons for you to take Ritalin, Adderall and/or Modasomil?
Please evaluate each statement INDEPENDENTLY of how you feel about the consumption of these products overall.

CE users (n = 106); CE non-users (n = 1 665)	I agree		I don't agree		I don't know		p-value*
I could finish much of my work in less time and would therefore have more free time and less stress.	**64.2**	35.6	34.9	**54.3**	0.9	**9.8**	0.000
I could learn more quickly by using these products and perhaps understand things that I did not understand before.	**59.4**	38.9	35.8	**51.7**	4.7	**9.3**	0.000
I could regain lost mental vigour, because sometimes I don't feel as fit mentally as I did previously.	**44.3**	22.9	49.1	**65.3**	6.6	**11.5**	0.000
I could achieve more and better results and would progress more quickly in life. I would earn more money and live a more comfortable life.	**38.7**	21.1	50.9	**68.9**	**10.4**	9.8	0.000
I could gain more acceptance and respect because of a higher level of achievement attained by using such products.	**22.6**	13.1	67.0	**78.7**	**10.4**	7.9	0.010
These products could act as some sort of prevention. If my brain became fitter, I might suffer less from forgetfulness and related problems once I'm old.	**17.9**	9.9	76.4	**78.3**	5.7	**11.5**	0.010

The answer categories were randomized. For each sentence, one answer category could be chosen. There were 3–4 missing values (0.2 %) for the CE non-users, and none for the CE users

*The p-value was calculated with a χ^2-test and the 'I don't know' answers were treated as missing values

Furthermore, the findings from our survey are in line with previous data from surveys of students [7–11], especially with those of German students. A mailed survey from the USA with 10 904 students (data from 2001) revealed a lifetime prevalence of non-medical prescription stimulant use (Ritalin, Dexedrine or Adderall) of 6.9 % [7]. A paper-and-pencil survey carried out in Germany with 512 students and 1 035 school pupils showed that 1.6 % of the students and 0.8 % of the school pupils had taken Ritalin, Concerta, Adderall or Modafinil as a healthy person for non-therapeutic reasons at least once in their lives [8]. An online survey carried out with 8 000 students in Germany showed that around 5 % of participants took prescription substances to deal with the requirements of studying [9]. Using the randomized response technique (RRT) in a paper-and-pencil survey among 2 569 students in Germany, the estimated 12-month prevalence of cognitive-enhancing drug use (stimulant drugs, caffeine tablets, cocaine, methylphenidate and mephedrone) was found to be 20 % [10]. The lifetime prevalence for the non-medical usage of psychostimulants, such as methylphenidate or amphetamine salts was found to be 18 % in an online survey of 2 732 medical students in the USA [11]. Future representative studies in Switzerland will reveal if our data concerning the number of CE-users are biased. In such surveys, we propose to include less common products, such as Metoprolol (a beta blocker), Aricept (an antidementia drug consisting of the substance donepezil) and Strattera (atomoxetine).

The wide range of frequencies for usage found in these studies could be due to different products being defined and included as CE. We focused in our survey on Ritalin, Adderall and Modasomil because these 3 products are the most dominant ones in the current literature about NE as well as in previous surveys. Another reason for the wide range of frequencies could be due to different data collection methods and techniques, such as RRT [10]. This randomized response technique is used to try to overcome the problem of desired responses being given, due to stigmatization and the social norms around illicit products, by offering full privacy protection and by adding random noise to the data [21]. For example, a participant plays a die and marks the answer "yes" to a question whenever a 6 appears; otherwise she/he answers based on the question. Such noise can than be subtracted from the data when the probability properties of the randomized device (here 1/6) are known. Some studies have shown, however, that RRT does not improve the results from online questionnaires [21]. A very recent study revealed that when asking about CE in an online survey, the best results were found with the "crosswise model" technique, as compared to RRT or no technique [21].

To keep the rate of untruthful but "desired" answers as low as possible, we tried hard to phrase the questions in a non-suggestive way and had them tested by survey experts. For the same reason, we also removed any reference to the Institute of Biomedical Ethics as a sponsor of the study, and only referred to the University of Zürich as the place where the survey was generated. We also used the more neutral term "products" instead of drugs or medicines when summarizing different CE. The term "neuroenhancement" did not appear in our survey either, in an attempt to keep the influence of the many media-driven perspectives as low as possible. Such careful use of neutral terms could have been confusing or misleading for participants who may have noticed that the term "neuroenhancement" was missing. However, we believe that the exclusion of this term had a greater benefit on the quality of our data than the negative effect of possibly misleading some participants. None of the 146 comments received from the participants refer to them expecting to have seen the term "neuroenhancement".

Study participants were assured at the very beginning of the survey that their anonymity would be guaranteed. Also, at the start, participants were given more general questions before being gradually and successively guided toward more sensitive questions about CE-use.

To keep the number of drop-outs as small as possible, many filters were used that allowed us to tailor subsequent questions based on previous answers. Another way to further decrease drop-outs could have been to use a paper-and-pencil survey in lectures, which generally leads to a higher response rate [22]. However, we decided to conduct an online survey, and to therefore rely on participants' intrinsic motivation rather than the pressure of filling out a paper questionnaire while being observed. For the same reason, no incentives were offered. In this way, we hope to have kept the rate of false answers as low as possible for this type of study design.

The reliability and validity of each question was not tested in a previous methodological study due to the time frame of this work. We tried to increase the validity of the data through a

pretest of the questionnaire, an attempt to neutrally phrase the questions, the usage of established and well tested questions whenever possible (some about the demographic data and the self-assessment of the risk-behaviour) and different tools like plausibility checks and filters that were applied to the survey.

Understanding the characteristics and motivations of CE users is key to formulating an appropriate public health response. One finding from this survey that might be important with a view to potential future regulation, was that more than half of the CE users received the product(s) from friends or colleagues, and only a little less than a quarter of the students from a physician. Another insight gained from this survey is that the ranking of reasons for, and concerns about, CE given by both of CE users and CE non-users was similar; however, unsurprisingly, possible reasons for CE use are more frequently affirmed by users, and possible concerns about CE use more often by non-users.

We hope that these data about attitudes toward CE use, together with existing empirical data, will lead to a more balanced media presentation of CE use, and a better informed public debate. The findings from this survey can lead to a better understanding of why some students are already taking such products and can also add to the discussion on social norms and values in the context of legalizing or prohibiting such products.

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Conflict of Interest

The authors declare no conflicts of interest.

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