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Who's laughing now?

A study on the associations between recreational N$_2$O use and subsequent drug use intentions.

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Abstract

This study contributes to the existing literature about recreational nitrous oxide (N$_2$O) use by focusing on the possible long-term effects for the users, that is on their substance use intentions for the subsequent year. Following the gateway theory, regular N$_2$O use lowers barriers against other substance use. According to studies on the rural-urban continuum, living in more urban areas increases the risk to use more substances. In addition, prior research has shown older adolescents to have more drug-use intentions, and the perceived harmfulness of N$_2$O could be a protective factor in future drug use intentions. The cross-sectional dataset 'Drug Use Personas (DUP)' with a sample of Dutch adolescents ($N = 1189$) was utilized to test these relations. Results showed that older adolescents, more frequent users, and those who lived in more urban areas had the intention to use more drugs in the subsequent year. N$_2$O users who perceived the substance as more harmful had less intentions. The current results have important implications for practice and policy, as they provide substantiation to add N$_2$O into the opium law. Future research should examine the causal direction of the found relationships and focus on finding measures that might decrease these relationships.

Keywords: nitrous oxide, urbanicity, gateway theory, rural-urban continuum, drug use intentions.

Samenvatting

Dit onderzoek draagt bij aan de bestaande literatuur over het recreationele gebruik van distikstofoxide (N$_2$O) door te focussen op de mogelijke lange termijn effecten voor gebruikers, ofwel: de intentie om middelen in het volgende jaar te gaan gebruiken. Volgens de *gateway theory* verlaagt regelmatig middelen-gebruik de drempel om andere middelen te gaan gebruiken. Volgens de *rural-urban continuum theory* lopen in stedelijke gebieden wonende adolescenten een hoger risico om middelen te gebruiken. Eerdere onderzoeken laten daarnaast zien dat oudere adolescenten meer drug-intenties hebben en dat de ingeschatte schadelijkheid van N$_2$O een beschermende factor voor toekomstig drugsgebruik kan zijn. De cross-sectionele dataset 'Drug Use Personas (DUP)' is gebruikt, bestaande uit een steekproef van Nederlandse adolescenten (*N* = 1189). Uit de resultaten blijkt dat oudere adolescenten, frequente N$_2$O gebruikers en adolescenten die in meer stedelijke gebieden wonen de intentie hebben om meer middelen in het volgende jaar te gaan gebruiken. Adolescenten die de schadelijkheid van N$_2$O hoger inschatten hebben minder intenties. De resultaten bieden onderbouwing om het middel in de opium wet op te nemen. Toekomstig onderzoek moet zich richten op de causale richting van het gevonden relaties en focussen op het vinden van maatregelen die deze effecten zouden kunnen verminderen.

Kernwoorden: distikstofoxide, stedelijkheid, gateway theory, rural-urban continuum, middelengebruik intentie.

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A study on the associations between recreational N$_2$O use and subsequent drug use intentions.

The recreational use of nitrous oxide (N$_2$O), often called laughing gas, has risen substantially in the last couple years among adolescents in the Netherlands (NDM, 2019). Historically, the recreational use of N$_2$O has received much less attention than the use of substances such as cigarettes, alcohol or marijuana. With news stations only recently starting to report on the increased use of the substance, it almost seems as if it has just been discovered. However, research has shown that the recreational potential of N$_2$O was already discovered in 1772 (Randhawa & Bodenham, 2015). Recreational use of N$_2$O is old news, but has been *re*discovered recently, mostly in the party and festival scene (Luijk & Nijkamp, 2019). Currently, N$_2$O still falls under the commodity law, which makes it a legal substance for general stores to sell and easy for users to obtain (Luijk & Nijkamp, 2019; Nabben & Korf, 2016). This also became evident in a study of Dijkshoorn, Schilthuis, Van der Spek and Van der Wal (2017) where results showed that about 40% of 16-18 year old students in Amsterdam had used N$_2$O recreationally in the preceding year.

Current practices

N$_2$O is used recreationally by inhaling the gas via balloons. Often, these balloons are filled with so-called 'whippets' (Kaar et al., 2016). Right after inhaling the gas, users can experience various psychological effects such as feelings of euphoria and intoxication and an uncontrollable need to laugh out loud (hence the term 'laughing gas'; Li, 2006), which disappear after a few minutes (Randhawa & Bodenham, 2015; Van Amsterdam, Nabben & Van den Brink, 2015). Some research suggest that, when used in modesty (defined as 5 to 10 balloons N$_2$O at a time and a maximum of once per month; NDM, 2019), N$_2$O can be considered a relatively safe drug in comparison to other substances (Glijn et al., 2017; Van Amsterdam et al., 2015). However, there is also evidence to suggest that even modest recreational use of N$_2$O brings along a string of immediate, albeit temporarily risks for the user, such as headaches, dizziness and tingling in hands or feet (Luijk & Nijkamp, 2019). Even though N$_2$O quickly leaves your system, coordination can remain slow for another hour or longer, which in turn could lead to traffic accidents (Van Goor, 2018; Van der Woude, 2019). In addition, many users do not throw away the whippets used to fill their balloons, consequently polluting the environment (Kaar et al., 2016). Because of these risks, the Dutch government is reexamining the drug and taking steps to get the substance into the opium law (Kuiper, 2019).

Gateway theory

      One aspect that has rarely been addressed in the rediscovery of N$_2$O and thereby renewed research into the subject is the focus on N$_2$O as a 'gateway' drug. According to the gateway theory, the use of an (illicit) substance may reduce the perceived barriers against the use of other (illicit) substances, which in turn increases the chance of using these substances (Kirby & Barry, 2012; Lynskey et al., 2003). Moreover, this relationship is stronger if the gateway drug is used more frequently (Ellickson, Hays, & Bell, 1992). Research has shown associations between both cannabis and alcohol use -the gateways- and other, more severe, illicit drug use (Fergusson & Horwood, 2000; Kirby & Barry, 2012; Lynskey et al., 2003).

      For recreational N$_2$O use, this association is less clear. First of all, the association has rarely been studied. Moreover, the studies that have focused on N$_2$O as a gateway drug report inconsistent results. A study of Crankshaw (2008) showed that there was an association between the use of inhalants (including N$_2$O) and the subsequent use of marijuana for girls in the sixth and seventh grade in the U.S. Contrary, in a U.S study of Ding, Chang and Southerland (2009) no support was found for the use of N$_2$O as a gateway drug. The effects of a gateway drug (whether it is cannabis, alcohol or N$_2$O) on subsequent illicit drug use could also be explained by a common underlying predisposition to substance use or risk-taking behavior (Fergusson & Horwood, 2000). Following this idea, the sequencing between a gateway drug and illicit drug use merely reflects the fact that those predisposed to using illicit substances find the gateway drugs the most readily available and thus tend to use it before other substances (Fergusson & Horwood, 2000).

      Furthermore, most research that studied the gateway theory have focused on actual substance usage. Due to the cross-sectional nature of the current study, we will focus on the *intention* to use substances in the following year instead. Prior research has shown the intention to use substances to be highly predictive of the actual use (Maddahian, Newcomb & Bentler, 1988; O'callaghan, Callan & Baghlioni, 1999). Overall, more research is needed to be able to draw conclusions about the gateway theory regarding N$_2$O in relation to the subsequent use of other drugs.

Rural-urban continuum

      It is plausible that the intention of N$_2$O-users to use certain drugs in the following year varies between urban and rural areas. It is well known that the social context can have an important effect on adolescent substance use (Duncan, Duncan, Biglan & Ary, 1998; Silberg, Rutter, D'Onofrio & Eaves, 2003). Prior studies have mostly focused on drug use in urban and suburban areas, as these were regarded as the problem areas. Through weakened family control

and higher involvement in deviant peer groups, adolescents were more likely to use drugs (Wilson & Donnermeyer, 2006). Rural areas were viewed to be immune to these problems, as they were often characterized to have tighter social control and less anonymity, that in turn reduce the chance of using drugs (Cronk & Sarvela, 1997; Wilson & Donnermeyer, 2006).

However, rural life has changed substantially over the past few decades due to (among others) globalization, economic restructuring and free-flowing access to information (e.g. via internet) (Judd et al., 2002). Because of this, drug use between rural and urban areas has become more similar in frequency of occurrence, yet there remain differences. Prior studies who have focused on drug use across the rural-urban continuum showed that on average adolescents in urban areas use more drugs - both in the types of drugs used as well as in frequency of use - than adolescents living in more rural areas (NDM, 2019).

Age

Older adolescents have more experience with various substances compared to younger adolescents (NDM, 2019). Research on whether they also have greater intention to use substances is limited. According to Ajzen and Fishbein's (1977) theoretical analysis of the association between attitude and behavior, a behavior is determined by the intention to perform that behavior (Maddahian, Newcomb & Bentler, 1988). Following this line of reasoning, we can assume that, given that older adolescents have generally used more substances, they also have greater intentions to use substances.

Perceived harmfulness

Substance use is never without risks for the users. However, the risk perception (the perceived harm a substance may have on their health) may vary per user. Again, research on risk perception regarding the recreational use of N$_2$O is limited. Nevertheless, it is known that the possible adverse effects do not seem to concern users (Kaar et al., 2016). In addition, prior research on risk perception of other substances such as marijuana has shown that adolescents who perceive regular marijuana use to carry a low risk were 2.1 times more likely to intent to use the substance in the next year than respondents who reported marijuana use to be highly risky (Lopez-Quintero & Neumark, 2010). Similar results were found for both tobacco and alcohol use (Bejarano et al., 2011). However, it is important to note that these studies have focused on the risk of one substance and the subsequent use of said substance, where in the current study, the intention to use *any* substances in the subsequent year is taken into account.

Current study

Although the recreational use of N$_2$O has increased in popularity, little research has been conducted on the subject. The existing studies mostly focus on whether or not the substance is

harmful for the individual in a neurological way and what these harmful effects may be (Egan, Steinberg & Rose, 2018). In the current study we will examine if and how the recreational use of N$_2$O is related to the intention to use substances in the following year. This information is of particular interest for the Dutch government, as it may provide substantiation to add the substance into the opium law.

The current research will focus on two main questions: "To what extent are age, level of urbanicity, frequency of recreational N$_2$O use and the perceived harmfulness of N$_2$O related to the overall substance use intentions in the following year?" and "To what extent do age and perceived harmfulness of N$_2$O moderate the association between frequency of N$_2$O use and the overall substance use intentions in the following year?"

Based on the previously discussed literature, six hypotheses are formulated. First of all, we anticipate that older adolescents have a greater intention to use substances in the following year compared to younger adolescents. Furthermore, it is expected that higher levels of urbanicity are positively related the overall intention to use substances in the following year. Thirdly, it is expected that more frequent N$_2$O use is positively related to the intention to use other drugs. Next, we expect the perceived harmfulness of N$_2$O to be negatively related to the overall drug use intention, meaning that adolescents who perceive N$_2$O to carry high risks for their health have less intention to use substances in the coming year.

In addition, age and the perceived harmfulness of N$_2$O will be taken into account as moderators. It is expected that the association between frequency of N$_2$O use and the intention to use substances in the subsequent year is stronger for older adolescents and less strong for those who perceive N$_2$O as more harmful. Figure 1 shows a graphical display of the proposed theoretical model.
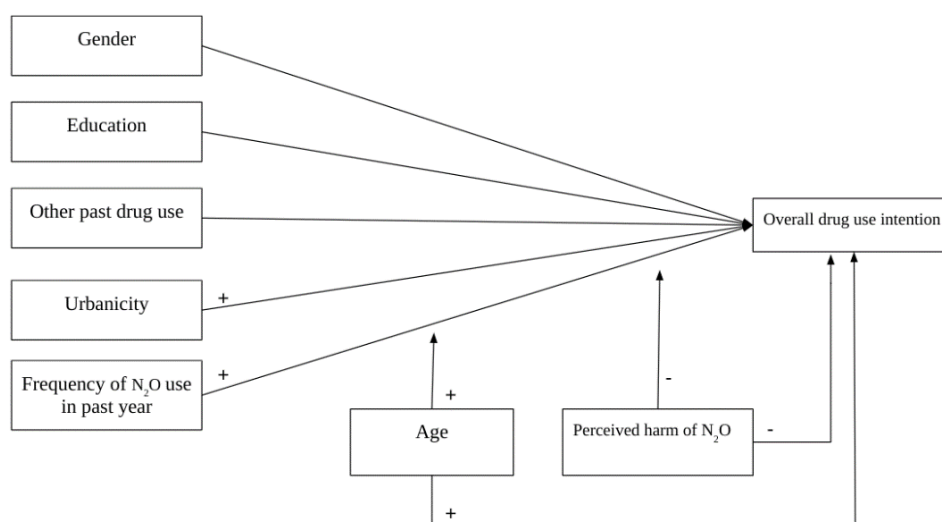

Figure 1. Graphical display of the theoretical model.

Method

Procedure

The dataset from the Drug Use Personas (DUP) research was used for the current study. The DUP includes data from adolescents aged 18-25 from all over the Netherlands. Respondents were recruited via Facebook by Driivn, an online marketing and social media organization. Before starting with answering the questions in the questionnaire, participants had to read and agree with the informed consent protocol, in which the rights of the respondents were described (see Appendix A). Students responded to questions about their use of different substances. Amongst others the questionnaire asked about the frequency of use; the perceived harmfulness of the substance and which substances they expected to use in the subsequent year. After completing the questionnaire, the participants had the opportunity to fill in their e-mail address if they wanted to participate in a lottery to win prizes such as a GoPro Hero or a voucher for the website Bol.com. The data and the e-mail addresses were stored separately and therefore anonymity was guaranteed. The DUP research (65-1807) was approved by the Ethics Committee of the Trimbos Institute (TET), registered under case number 2631587.

Participants

The procedure described above resulted in a total sample of 8028 participants who started the questionnaire. However, to be able to draw conclusions about the current research questions, only those participants who used N₂O in the past year were included. This resulted in a final sample of 1189 adolescents. The average age of the included participants was 21.1 ($SD_{age} = 2.0$), ranging from 18 to 25 years old. Approximately a quarter of the participants were men (26.5%). At the educational level, 1% of the participants followed lower education, 16.8% middle, and 82.2% followed higher education.

Measurements

Control variables. In the current study, we controlled for demographic information concerning gender, and level of education. Prior research has indicated that on average, males use substances more frequently than females (NDM, 2019). Participants could indicate which gender applied to them (1 = *man*, 2 = *woman,* 3 = *other*). As very few participants indicated themselves as 'other', their gender was indicated as missing for easier interpretation of the results. For education level the participants were asked "What is your educational attainment? (current or finished)." They could choose one of nine answer options. These answers were recoded into the new variables 'lower education' (no-, primary-, intermediate secondary-, and pre-vocational secondary education) 'middle education' (secondary vocational-, senior general secondary-, and pre-university education) and 'higher education' (higher professional-, and university education). Finally, we controlled for other past drug use. This construct represents the participants' use of

one or more of the following substances in the past year, other than N$_2$O: Alcohol, cannabis, ecstacy, cocaine, amphetamines, LSD, shrooms, 2CB, GHB/GBL, Ketamine, 4FA/4FMP and performance enhancers such as Modafinil/Ritalin.

The mean scores of all past used substances were calculated, resulting in scores ranging between 0 and 1. Scores closer to 1 indicated more substances used in the past (α = .85).

Frequency of nitrous oxide use. The variable 'frequency of nitrous oxide use in past year' was measured by the question 'On how many days in the past year have you used laughing gas?' Participants could choose from seven answer options ranging from '0 days', '1-2' up to '40 days or more'. As N$_2$O is often used quite infrequently, the choice was made to focus on the usage over the past year instead of the use in the past month.

Overall drug use intention. The construct overall drug use intention represents the participants' intention to use one or more of the following drugs in the coming year: cannabis, ecstasy, cocaine, amphetamines, LSD, shrooms, 2CB, GHB/GBL, ketamine, 4FA/4FMP, performance enhancers such as Modafinil or Ritalin and N$_2$O. Alcohol was excluded from this list to increase the reliability of the construct.

The mean scores were calculated, resulting in scores ranging between 0 and 1. Scores closer to 1 indicate greater substance use intentions in the following year (α = .80).

Level of urbanicity. Participants indicated the area they lived in by providing their postal code. The Central Bureau of Statistics (CBS) has made a distribution on the degree of urbanicity, based on the address density per km^2 and linked to the four digits of postal codes. A distinction was made between five degrees of urbanicity (1 = *not urban (address density of less than 500)* to 5 = *very strongly urban (address density of 2500 or more)*).

Age. The participants' age was asked by means of an open question, in which the participants could only indicate numbers between 18 and 25.

Perceived harmfulness. The construct of perceived harmfulness of N$_2$O was assessed by means of a single question: 'To what extend do you believe that nitrous oxide is harmful for your health?' The response scale ranged from 1 (*not harmful at all*) to 5 (*certainly harmful*).

Analyses

The analyses described below were carried out using IBM SPSS Statistics 25. Hierarchical multiple regression analysis (MRA) was employed to estimate the proportion of overall drug intention that can be accounted for by frequent N$_2$O use, urbanicity and the main and moderating effects of age and perceived harmfulness. As the analysis included interaction terms, all predictor variables, including the control variables were centered or dummy coded.

Before interpreting the results of the MRA, a number of assumptions were tested and checks were performed. Firstly, an inspection of the normal probability plots of standardized residuals and scatterplots of the standardized residuals against the standardized predicted values of all the variables indicated that the assumptions of normality, linearity and homoscedasticity of the residuals were met. Furthermore, all values of VIF were lower than five, indicating that no multicollinearity was present (Field, 2013). However, the Mahalanobis distance did exceed the critical χ^2 for $df = 10$ (at $\alpha = .001$) of 29.59 which indicated there was at least one outlier (Field, 2013). Furthermore, the leverage also exceeded the critical value of .028 with .145, indicating one or more influential cases (Field, 2013). In addition, the maximum value of the standardized residuals exceeded 3.00 with 4.05, also indicating at least one outlier. However, the Cook's distance indicated that the outlier(s) did not have an extreme influence on the parameter estimates. Furthermore, boxplots of the DFBETAs also showed that the potential outlier(s) were not of concern on the parameter estimates. Therefore, the choice was made to keep the outliers in the analyses.

Results

As shown in Table 1, participants had used several substances other than N$_2$O in the past. The frequency of N$_2$O use was low, averaged to somewhere between 1 to 5 days per year. Furthermore, most participants lived in predominantly urban areas. Next, on a scale of 1 to 5, the average perceived harmfulness of N$_2$O was almost 4, which translates to being perceived as quite harmful. Finally, on average, participants had the intention to use multiple substances in the following year.

Pearson correlations of all variables are reported in Table 2. Past drug use was significantly associated with the intention to use drugs in the following year, for both men and women. The association between perceived harmfulness of N$_2$O and other past drug use was stronger for women than for men, indicating that women who used the same amount of substances in the past as their male peers perceived N$_2$O as more harmful. The association between frequency of N$_2$O use and age was also stronger for women, indicating that older women have used N$_2$O less often than older men. Next, the frequency of N$_2$O use was positively associated with the overall drug intention in the subsequent year. This association was stronger for women as well, indicating that when women use N$_2$O equally frequent as men, they have greater intentions to use drugs in the following year. The perceived harmfulness of N$_2$O was significantly associated with the level of urbanicity, age and overall drug intention for women, but not for men.

Table 1

Percentages, Means, Standard Deviations and Range of All Variables.

Measure	(%)	*M*	*SD*	Range
Gender				
Male	26.5			
Educational level		2.83	0.39	1 - 3
Low education	1.0			
Middle education	16.8			
High education	82.2			
Other past drug use		0.41	0.24	0 – 1
Frequency N$_2$O use		1.77	1.21	0 – 6
Urbanicity		3.98	1.32	1 – 5
Age		21.11	1.98	18 - 25
Perceived harm		3.75	1.12	1 – 5
Overall drug intention		0.30	0.20	0 – 1

Note. N = 1189. Uncentered variables were used for easier interpretation

Table 2

Bivariate Correlations amongst All Variables

Measure	1	2	3	4	5	6	7
1. Other past drug use	-	-.01	.19**	.17**	.20**	.17**	.79**
2. Educational level	-.04	-	-.05	.24**	.22**	.00	.01
3. Frequency N$_2$O use	.18**	-.03	-	.01	-.21**	-.12**	.43**
4. Urbanicity	.20**	.29**	.05	-	.22**	.08*	.17**
5. Age	.22**	.15**	-.16**	.17**	-	.12**	.04
6. Perceived harm	.09*	-.05	-.10*	.06	.03	-	.08*
7. Overall drug intention	.80**	-.02	.38**	.20**	.05	-.03	-

Note: N = 1189. Correlations above the diagonal are for women.

p <.05. **p* < .01

      Unstandardized (*B*) and standardized (β) regression coefficients, as well as the standard errors (*SE B*) for each predictor on each step of the hierarchical MRA are reported in Table 3.

The first model of the hierarchical MRA included the control variables 'educational level', 'gender' and 'other past drug use'. Gender was positively associated with overall drug intention, indicating that men intent to use more drugs than women in the following year. Having ever used other drugs besides N$_2$O was also positively associated with future drug intention, indicating that adolescents who have used multiple drugs in the past also intent to use more substances in the following year. No educational effects were found. This first model accounted for a significant 55.4% of the variance in overall drug intention, $R^2 = .55$, $F(4, 1181) = 366.67$, $p < .001$.

In the second model, the main predictors 'frequency of N$_2$O use', 'level of urbanicity', 'age' and 'perceived harmfulness' were added. In line with the first hypothesis, frequency of N$_2$O use was positively related to overall drug use intentions, implying that those who use N$_2$O more often, also intent to use more drugs in the coming year. Next, in accord with the second hypothesis, higher levels of urbanicity were positively related to overall drug use intentions, indicating that adolescents living in more urban areas intent to use more drugs in the subsequent year than those living in more rural areas. Furthermore, contrary to the third hypothesis, age was negatively related to overall drug intention, indicating that older adolescents had less intention to use drugs in the following year. Moreover, perceived harm was negatively related to overall drug intention as well, indicating that adolescents who perceive recreational N$_2$O use as more harmful for their health have less intention to use drugs in the coming year. The second model accounted for a significant additional 5% of the variance in overall drug intention, $R^2_{change} = .05$, $F_{change}(4, 1177) = 36.74$, $p < .001$.

In the third and final model, the interactions for age and perceived harm with frequency of N$_2$O were included as moderators. Both moderators turned out to be non-significant, which indicates that for older adolescents, as well as adolescents who perceive recreational N$_2$O use as more harmful, the frequency of N$_2$O use was not stronger related to the intention to use other substances in the following year than for younger adolescents and those who perceive N$_2$O as not very harmful. The moderators accounted for an additional 0.1% of the variance in overall drug intention, however, this change was not significant as compared to the explained variance by the second model, $R^2_{change} = .00$, $F_{change}(2, 1175) = 0.78$, $p = .459$.

Together, all predictor variables in the second model explained 60.3% of the variance in overall drug intention, $R^2 = .60$, adjusted $R^2 = .60$, $F(8, 1177) = 223.90$, $p < .001$. This combined effect can be considered a "large" effect according to Cohen's (1988) conventions ($f = 1.50$).

Table 3

Parameter Estimates of Frequency N$_2$O Use, Urbanicity, Age and Perceived Harm on Overall Drug Intention, Including Moderators

	Model 1			Model 2			Model 3		
	B [95% CI]	*SE B*	β	*B* [95% CI]	*SE B*	β	*B* [95% CI]	*SE B*	β
Control variables									
Educational level (ref. = high education)									
Low education	-0.04 [-0.14, 0.05]	.05	-.02	-0.04 [-0.13, 0.05]	.05	-.02	-0.04 [-0.13, 0.05]	.05	-.02
Middle education	0.01 [-0.02, 0.03]	.01	.01	0.00 [-0.02, 0.02]	.01	.00	0.00 [-0.02, 0.02]	.01	.00
Gender (ref. = female)	0.03 [0.01, 0.05]***	.01	.07	0.03 [0.02, 0.05]***	.01	.07	0.03 [0.02, 0.05]***	.01	.07
Other past drug use	0.61 [0.58, 0.64]***	.02	.73	0.61 [0.58, 0.65]***	.02	.73	0.61 [0.58, 0.64]***	.02	.73
Main predictors									
Urbanicity				0.01 [0.01, 0.02]***	.00	.07	0.01 [0.01, 0.02]***	.00	.07
Frequency N$_2$O use				0.03 [0.02, 0.03]***	.00	.15	0.03 [0.02, 0.03]***	.00	.16
Perceived harm				-0.01 [-0.02, -0.00]*	.00	-.05	-0.01 [-0.01, 0.00]	.00	-.04
Age				-0.01 [-0.02, -0.01]***	.00	-.13	-0.01 [-0.02, -0.01]***	.00	-.14
Moderators									
Frequency N$_2$O use×Perceived harm							-0.00 [-0.01, 0.00]	.00	-.01
Frequency N$_2$O use×Age							0.00 [-0.00, 0.01]	.00	-.01
R^2	.55			.60			.60		
F change	366.67***			36.74***			0.78		

Note. N = 1189. CI = confidence interval.

*p <.05. **p <.01. ***p <.001

Discussion

Nitrous oxide use has risen in popularity in the last few decades amongst adolescents. Prior research has mostly focused on the biological and environmental harmfulness of the substance, and has thereby overlooked the possible long-term effects for the individual with regard to a potential pathway to subsequent drug use. The current study adds to the limited literature about N$_2$O as a recreational substance, as we have focused on the frequency of use and on the level of urbanicity of users on the intention to use drugs in the following year, exploring the notion that N$_2$O could serve as a 'gateway' to the use of other substances. In addition, the possible direct and moderating effects of age and perceived harmfulness of N$_2$O were taken into account.

In line with predictions, the current results show that frequent N$_2$O users also have the intention to use more drugs in the coming year. This supports the gateway theory, which states that frequent N$_2$O use could lower the perceived barriers against using other substances, which in turn could increase the actual use (Kirby & Barry, 2012; Lynskey et al., 2003). Another explanation for this result could be that frequent N$_2$O users already have an underlying predisposition to substance use or risk-taking behavior, as opposed to non-frequent users (Fergusson & Horwood, 2000).

Next, in line with the second hypothesis, adolescents who indicated to live in more urban areas also had the intention to use more substances in the following year. This can be explained in part by cultural norms. There is more anonymity and less monitoring in more urban areas, which may encourage adolescents to experiment (Cronk & Sarvela, 1997; Wilson & Donnermeyer, 2006). This result could also be explained by the notion that many adolescents aged 18-25 may have moved to live in more urban areas for their studies. Studentship is a time of experimentation and less parental monitoring (Kaynak et al., 2013), which may encourage the adolescents to try new substances.

Contrary to the third hypothesis, age was negatively related to subsequent substance use intentions. One explanation for this could be that older adolescents have moved on from their days of impulsive actions, partying and experimentation, and therefore have less intention to use substances (Bates & Labouvie, 1997). However, more research is needed to determine the effect of age on substance use intentions.

Adolescents who perceived recreational N$_2$O as more harmful for their health had less intentions to use drugs in the coming year than their peers who perceived N$_2$O as not very harmful, which is in line with hypothesis 4. However, the effect was small. It is interesting to note here, that even though most participants perceived the substance as quite harmful, they still

chose to use it. For adolescents the benefits might outweigh the costs. Parsons, Siegel and Cousins (1997) found in their study that among late adolescents, the perceived benefits of risk-taking behaviors (such as substance use) are better determinants of behavior than the perceived risks. Adolescents are often identified as 'sensation seekers', and the results of the current study seem to support this notion.

Next, contrary to expectations, age did not increase the relationship between the frequency of N$_2$O use and the intention to use substances in the following year. It could be the case that a higher frequency of use if normalized for older adolescents (Parker, Parker, Aldridge & Measham, 1998), and therefore their age no longer influences their substance use behavior. However, more research is needed to support this.

Finally, no substantiation was found for the sixth hypothesis. The perceived harmfulness of N$_2$O did not moderate the effect of the frequency of use on the intention to use other substances. Again, this could be explained by the notion that for adolescents the benefits might outweigh the costs. Even though adolescents know that N$_2$O is quite harmful for their health, this does not necessarily stop them from using it (Parsons et al., 1997). Additionally, a study of Tortajada (as cited in Bejarano et al., 2011) found that even though both drug users and non-drug users perceive substance use as potentially dangerous, drug users tend to see regular substance use as less harmful. As the current study only included drug users (those who had used N$_2$O in the past year) it could be the case that even though they know the risks of using N$_2$O, it is not perceived as 'harmful enough' to stop them from using it, or other substances in the future.

Limitations

This study is somewhat limited by its sample, design and method. Even though the sample was quite large, it was not diverse in terms of gender, with only a quarter of the sample being male. This limits the generalizability of the findings to the total population of Dutch adolescents. In addition, the age of the current sample ranged between 18 and 25 years old. Recent literature has suggested that younger adolescents are using N$_2$O as a substitute to other substances such as alcohol and tobacco, as N$_2$O is easier for them to obtain (Ding et al., 2009; Edwards et al., 2007). Thus, it would be interesting for future research to focus on younger adolescents than the current study has done, especially when investigating the gateway theory in relation to recreational N$_2$O use.

Another limitation of this study was that the dependent variable consisted of the mean intention to use all drugs in the following year, instead of looking at the individual substances. Future research could focus more on particular drugs or on drug classifications such as stimulants, hallucinogens and depressants to be able to make more concise conclusions about the

effect of recreational N$_2$O use.

As a third limitation, caution is in order when making conclusions about the causal sequence of the observed relationship, because of the cross-sectional design of the study. Ideally, the gateway theory should be tested with a longitudinal research to be able to see the direction of the relationship. In addition, a longitudinal design is necessary to investigate the actual behavior, where the current study only focused on the intention to portray certain behavior in the future. Nonetheless, the current results do provide some interesting insights in the recreational use of N$_2$O, which may encourage future research to conduct a longitudinal study on the subject.

The present results raise several interesting questions for future research. For example, future research could further investigate whether the effect of frequent N$_2$O use on the intention to use other drugs could be explained by the gateway theory or to an underlying predisposition to substance use or risk-taking behavior. Furthermore, future research should focus on the effect of the level of urbanicity. What exactly makes adolescents in urban areas more at risk for future substance use? And what is the direction of this effect? In addition, it is important to note that even though age and perceived harmfulness of N$_2$O did not moderate the effect, there are still other factors that could be of influence, such as family SES. Research has shown that high SES adolescents are more likely to use substances than low SES (Hanson & Chen, 2007).

Implications

Aside from the limitations, we have provided more insight in an understudied subject. Future research should use the results found in this study and expand them, as they could have important implications for adolescents' health, policy and legislation.

Frequent recreational N$_2$O use is related to a greater intention to use substances in the following year. As the intention to do something is related to the actual behavior, this implies that frequent N$_2$O users will use more substances in the future. This risk, in addition to the direct physical risk for the user and the environmental risks for not correctly disposing the N$_2$O whippets, could strengthen the argument for the government to add the substance into the opium law.

Policy makers should also be more aware of this long-term risk. More research is needed to find a measure or intervention that could decrease the effect of recreational N$_2$O use on the intention to use other drugs and to the actual use of those drugs. Current policies often focus on making users aware of the direct harm their use causes to themselves and their surroundings. However, our findings indicate that even though N$_2$O users recognize the harm, it might not greatly decrease their intentions to use and their actual future drug use. Moreover, policy makers should focus more on the long term risks and warn users that their recreational use of N$_2$O could

be the first step into a world of substance (ab)use that is not expected nor desirable.

Recreational N$_2$O use may not be as harmless as often thought. Both a higher frequency of use and living in more urban areas relate to greater substance use intentions, and therefor possibly greater actual substance use. Policies focusing on the harmfulness of the substance can have a small positive effect, but more is needed to protect the current and future health of adolescents.With regard to the title, "who's laughing now?", we conclude that recreational N$_2$O use is no laughing matter.

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Appendix A: Informed consent

Hoi,

Wat leuk dat je interesse hebt in dit onderzoek naar alcohol en drugsgebruik onder jongeren. Hieronder lees je er meer over.

Waar gaat het over?

Het Trimbos-instituut doet wetenschappelijk onderzoek naar alcohol- en drugsgebruik onder jongeren. Deze vragenlijst gaat over verwachtingen die jongeren hebben van het gebruik van alcohol of drugs. Dat kunnen positieve verwachtingen of negatieve verwachtingen zijn. We willen onderzoeken hoe deze verwachtingen samenhangen met hun gebruik. En of jongeren die van elkaar verschillen in bijvoorbeeld leefstijl, sociale omgeving of ervaring met drugs, ook verschillende verwachtingen hebben van gebruik.

Waarom is dit belangrijk?

Deze informatie helpt professionals zoals preventiewerkers, jongerenwerkers en straatcoaches om contact te leggen met jongeren. Zij snappen beter welke jongeren door hun gebruik in problemen kunnen komen. Ook kunnen ze beter hulp bieden die aansluit bij de behoeften van deze jongeren. Ook informatie van jongeren die geen of weinig alcohol of drugs gebruiken helpt daarbij.

Wat kan je winnen?

Onder de deelnemers verloten we 2x een GoPro HERO, 5x de Fuji Instax Mini 9 met film, 10x een waterdichte bluetooth-speaker van JBL en 20 CoolBlue kadobonnen t.w.v. 20 euro. Aan het eind van de vragenlijst kan je je e-mailadres invullen. Dit wordt APART opgeslagen van je antwoorden, zodat je anoniem blijft. Uit de e-mailadressen trekken we de prijswinnaars. Als je wint dan mailen we je.

Wat vragen we van je?

We vragen naar ieder middel waarmee je (recente) ervaring hebt, of waarvan je van plan bent het binnenkort te gebruiken. Heb je geen ervaring met alcohol of drugs? Dan stellen we een paar vragen over alcohol, cannabis en ecstasy. Daarnaast vragen we naar je: leeftijd, geslacht, opleidingsniveau, woonsituatie, eerste 4 cijfers postcode en ervaren etniciteit. Gemiddeld ben je 15 minuten bezig. Deelname is vrijwillig: je kunt op elk moment stoppen zonder te zeggen waarom.

Hoe gaan we om met jouw gegevens?

Met de info die we vragen kunnen wij geen unieke individuen herleiden. Alle gegevens voor het onderzoek blijven dus anoniem en zijn op geen enkele manier naar jou te herleiden. De

onderzoeksgegevens worden na afronding van het onderzoek tien jaar bewaard of langer wanneer deze gegevens wetenschappelijk nog relevant zijn.

Vragen?

Heb je na het lezen nog vragen? Dan kan je contact opnemen met de projectleider van dit onderzoek: Martha de Jonge (mjonge@trimbos.nl).

Kortom:

- Deelname aan dit is volledig anoniem
- Deelname aan dit onderzoek is vrijwillig
- Alleen voor jongeren van 18 tot en met 25 jaar
- Je mag tussendoor altijd stoppen met de vragenlijst
- Aan het eind vul je je mailadres in als je wilt meedoen voor één van de prijzen.
- Je mailadres wordt apart opgeslagen.

Appendix B: Reflection on interdisciplinarity

An interdisciplinary approach is preferred when investigating complex topics. The recreational use of nitrous oxide could be considered such a complex topic. First of all, very little research has been done on the subject, and the existing literature often provides inconsistent results. Legislation of the substance varies between countries and opinions on the substance vary not alone between the individuals who use it, but between the researchers who study it. Including multiple disciplines and perspectives can help to get a better understanding of the problem. The current study combined an individual perspective with an environmental one. It is important to include these two perspectives. The relationship between an individual and their environment is reciprocal, as both influence each other.

The included theories match the two main perspectives in the current study. The gateway theory provides a psychological perspective for an individual's nitrous oxide use and their intention to use other drugs. The urban-rural continuum helps to understand environmental differences. In addition to these two perspectives, it should be taken into account that other disciplines are of great importance as well. For instance, an individual's upbringing could influence ones drug use, as well as the cultural values regarding drug use. As recreational N$_2$O use as a subject is still widely understudied for its popularity, these other perspectives are important to take into account in future research.

Moreover, the current study had a cross-sectional design. This has as a limitation that no conclusions can be made about the direction of the effect. A longitudinal design would be necessary to make such conclusions. However, a cross-sectional design has the benefit that a large amount of participants can be reached in a short amount of time. Furthermore, as the existing literature on recreational N$_2$O is very limited, it would be interesting to include a qualitative design. The best way to study complex problems would be to include a multi-method design, but given the limited time, a cross sectional quantitative design was preferred to answer the current research question.

Appendix C: Contract RIT

Utrecht University - Interdisciplinary Social Science

Contract research project (RIT)

Research Project Agreement

Student: ....Britt Bilderbeek..

Graduation variant: ....RIT/..Master's in Youth Studies....................................

Supervising lecturer: ....Tom ter Bogt..

Tel: ....030 253 4740..

Faculty: ....Social Sciences..

Second assessor: ....

Internship information

Institution: ....Trimbos Instituut..

Address: ....Da Costakade 45..

Postcode and Town/City: ....3521VS Utrecht..

External supervisor ....Martha de Jonge..

Starting and ending dates: ....03-02-2020 / 30-06-2020..

Agreements

Submission date for work plan/research proposal: ....-..

Period during which the lecturer will review the final product and any interim products:
  June 15
....

Number of working days/working hours per week: ....36 uur per week........................

Topic:
Nitrous oxide
....
....

Agreements concerning papers to be submitted in the interim:

....

The client (host institution or faculty/programme) will provide the facilities needed in order to conduct the assignment properly.

If applicable:
Form and frequency of supervision within the host institution:

30 min per week
....

Number of conferences between the supervising lecturer and the supervisor within the host institution:

1-2 x
....

Prescriptions concerning the confidentiality of information:

The intern is obliged to act confidentiality with regard to his or her activities during the internship at the internship institution if the latter so requests ....

Ownership of the research data, in the event of deviation from the rule (see 16):

The Trimbos institute ....
....

Right to publish based on the research data:

yes .
....

Signed as approved,

Location/date: Utrecht, February 5th 2020
                                              ....

Signature of the student: [   ]

Signature of the supervising lecturer: [   ]

Signature of the external supervisor (if applicable)   [   ]

Signature of the Course Coordinator   [   ]