



The interest in eight new psychoactive substances before and after scheduling



Anders Ledberg*

Centre for Social Research on Alcohol and Drugs, SoRAD, Stockholms universitet, SE-106 91 Stockholm, Sweden

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ABSTRACT

Background: In recent years the recreational use of new psychoactive substances (NPS) has increased. NPS are considered a threat to public health and the main response to this threat is to make the selling and buying of these substances illegal. In Sweden, during the last 5 years, 62 new substances have been classified as narcotics but little is known of the effects of making a particular substance illegal. The aim of this work is to study how legal status influences the interest in NPS in Sweden.

Methods: Forty-five thousand posts made in a Swedish Internet discussion forum (Flashback Forum) related to eight NPS (MDPV, Methylone, 4-MEC, 4-HO-MET, MXE, 6-APB, AH-7921, and 3-MMC) were used to derive time-dependent measures of interest in these substances. Intervention analyses were used to investigate the effects of legal status on the forum interest.

Results: For all eight substances the activity on the forum (measured as number of posts per day) showed a drastic decrease around the time of classification. The statistical analysis showed that in seven of eight cases, the drop in activity could be accounted for by the legal status of the substances.

Conclusions: The legal status of the substances was shown to have a substantial effect on the interest in the substances. The novel measure used to trace the interest in particular NPS could be a useful tool to follow trends in substance use in almost real-time.

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1. Introduction

The number of new psychoactive substances (NPS) available on the drug markets has increased substantially during the last years (e.g. UNODC, 2013). NPS are substances that are often not controlled by national or international law and which have putative psychoactive properties. They constitute a heterogeneous group, are often synthesized in labs (Collins, 2011), and often sold openly through websites on the Internet (Schifano et al., 2006; EMCDDA, 2009; Schmidt et al., 2011; Bruno et al., 2013).

The scientific knowledge of pharmaceutical and medical effects of NPS is limited. Consequently users of NPS often have to rely on other users to learn about dosage, ways of administration, and possible interactions with other substances (e.g. Schmidt et al., 2011; Corazza et al., 2012). Moreover, the labeling on purchased NPS might not always agree with the content (Brandt et al., 2010), further increasing the difficulty of safe usage. Indeed, there is a growing fear that the usage of NPS might constitute a serious concern to public health (EMCDDA, 2011; UNODC, 2013) and there are

several case-reports where use of NPS are claimed to be causally involved in fatal intoxications (Wikström et al., 2010; Kronstrand et al., 2011).

When introduced on the drug markets, NPS are typically not controlled by international treaties and are often legal to sell and buy according to national legislations. New substances are regularly evaluated by the WHO Expert Committee on Drug Dependence (e.g. WHO, 2012) and might be appended to the list of controlled substances according to the Convention on Psychotropic Substances of 1971 (United Nations, 1971). In many countries the national regulation of psychoactive substances follows the same route: individual substances are identified, evaluated, and classified as illegal. This implies that relatively minor changes of the chemical structure might, from a legal point of view, turn an illegal substance into an unregulated one, legal to sell and buy. Given the large number of NPS detected every year (73 new substances reported within the European Union (EU) in the year 2012 (EMCDDA, 2013)) this route presents a substantial challenge. Indeed, when a substance becomes illegal, new unscheduled substances might be introduced as a replacement (Shanks et al., 2012; Jebadurai et al., 2013). An investigation of the effects of making a certain substance illegal should therefore include an analysis of interest and use of other related substances.

* Tel.: +46 8163250.

E-mail address: anders.ledberg@sorad.su.se

Which are the effects of making a psychoactive substance illegal to sell and possess? For the more “traditional” psychoactive drugs it is clear that punitive legislation does not necessarily quench the supply. Indeed, even if controlled by international treaties since a long time (United Nations, 1961, 1971) cannabis, amphetamines, cocaine and opiates are still used extensively throughout the world (UNODC, 2010). In the case of NPS much less is known about the effects of scheduling, but it is possible that the “legal” marketing of these substances (i.e. that they are sold openly on the web) will make classification have a more direct effect on the supply. There are some indications that this is indeed so (Anderson et al., 2010; Advisory, 2011; Carhart-Harris et al., 2011; Stogner et al., 2012; Loeffler and Craig, 2013) but there are also reports of users whose use seem to be relatively unaffected by the legal status (Winstock et al., 2010; Wood et al., 2012). Interestingly, a few reports support the notion that scheduling removes the substance from the web, at least from websites on the ‘surface web’, but might remain available via more ‘traditional’ routes such as street dealers (Winstock et al., 2010; Advisory, 2011) and possibly from “dark net” websites as well.

To accurately follow trends in NPS usage it is important to analyze information available on the Internet (Schifano et al., 2006). Indeed, in the 2010 report from the International Narcotics Control Board (INCB) it is recommended that

Governments should monitor Internet forums to identify the substances that might replace mephedrone as a result of that substance being placed under national control in a growing number of countries (INCB, 2011, p. 44)

Internet fora focusing on drug use have been used in previous research: to detect new NPS entering the market (Deluca et al., 2012); to recruit subjects for web-based surveys and interviews (Baggott et al., 2010; Carhart-Harris et al., 2011; Van Hout and Bingham, 2013); and to describe users’ experiences with NPS (Kjellgren and Jonsson, 2013). In the work presented here, a novel measure of the activity on a Swedish Internet forum is used to follow the interest in eight NPS before and after they were made illegal.

As a measure of NPS-related activity the number of posts related to a particular substance was followed as a function of time. This study used Flashback Forum (FB), which is the largest Swedish Internet discussion forum, and eight NPS were followed for a time period that included the scheduling of the substances. More than 45,000 posts made by approximately 3700 users were used to derive time-dependent activity profiles for the substances. A detailed analysis of the content of the posts of 200 users showed that approximately half of the users explicitly claim to have tried the substance under discussion. The main question addressed is if the interest in a particular substance (on FB) depends on its legal status.

2. Methods

In this section the Internet forum is described, the selection of the substances investigated is motivated, and the extraction and analysis of data is explained. First, however, a brief description of the Swedish legal regulations of NPS is given.

2.1. The Swedish legal regulation of psychoactive substances

In Sweden substances of misuse are controlled according to three different laws. Substances classified as narcotics are regulated by two laws SFS 1968:64 (1968), and SFS 1992:860 (1992), and the controlled substances are listed in the Narcotic Drug Control Ordinance (SFS 1992:1554, 1992). Narcotic substances are illegal to

trade, possess, and use. Substances can also be classified under the law Prohibition of Certain Goods Dangerous to Health (SFS 1999:42, 1999). This makes it illegal to sell and possess the substance but not to use it.

There is also a recent law according to which police and customs can destroy substances of misuse that are likely to be scheduled in the future (SFS 2011:111, 2011).

2.2. Flashback Forum

Flashback Forum (<http://www.flashback.org>, henceforth FB) is an online discussion forum that covers a wide range of topics (most not related to drugs). The site is hierarchically organized around “topics”, for example a particular substance. Only members can post messages and membership is anonymous and free of charge. The website is open for anyone to read. Each post has a time-stamp and may refer to other posts. The posts belonging to a particular topic will be referred to as a “thread”. There are strict rules that forbid posts aiming at trading (selling, buying, changing, providing information of where to buy, etc.) narcotics. Flashback Forum is by far the biggest internet forum in Swedish and has more than 850,000 members (March 2014). It is perhaps important to notice that a member does not necessarily correspond to a unique physical person, but that misuse of multiple memberships is prohibited.

2.3. The substances

The intended focus of the study was on substances that changed status from legal to illegal during the last 5 years in Sweden. Of the more than 60 such substances a further selection was made to include only those that were discussed with some frequency in a dedicated thread on FB (else the measure used here is not applicable). Many of the NPS that have been scheduled are so-called synthetic cannabinoids and these seem to be marketed and used in combination with smokable herbal mixtures. The particular cannabinoids in the mix are often not declared, e.g. products labeled ‘Spice’ has been found to contain a number of different synthetic cannabinoids (EMCDDA, 2009). Consequently, few synthetic cannabinoids were discussed in dedicated FB-threads and synthetic cannabinoids were therefore not included in this work. This should not be taken as an indication that these substances are not discussed or used in Sweden. For example, the main thread on FB discussing ‘Spice’ had more than 11,000 posts made by 1710 unique members and a recent study of hospital emergency admission indicate that synthetic cannabinoids are among the more used NPS in Sweden (Helander et al., 2013). These considerations lead to the following selection of NPS to be included in the study: MDPV, Methylone, 4-MEC, 4-HO-MET, MXE, 6-APB, AH-7921, and 3-MMC (see Table 1).

2.4. Data analysis

For each of the eight substances the major thread on FB was identified and the corresponding pages were downloaded. These downloaded html files were parsed using the Beautiful Soup module (<http://www.crummy.com/software/>) for the programming language Python (<http://www.python.org>). For each thread the number of unique members were identified and the dates of each post was used to form a time series of number of posts per day.

2.4.1. Statistical analysis. To test if there was a change in mean activity in a particular thread around the date a substance became illegal the following procedure was used. Data from $N=180$ days preceding and following the scheduling date were extracted and the square root of the counts on each day was used as the dependent measure (except for 3-MMC, where data from 90 days before

Table 1

Substances investigated. The long names are according to Swedish conventions and are the ones given in the legal documents. All the substances were classified as narcotics (SFS 1992:1554) except 6-APB that was classified as dangerous to health (SFS 1999:42).

Short name	Long name	Group	Date of classification
MDPV	Methylenedioxypropylvalerone	Stimulant	1st of February, 2010
Methylone	2-Methylamino-1-(3,4-methylenedioxyphenyl)propan-1-ol	Stimulant	21st of September, 2010
4-MEC	2-Etylamino-1-(4-metylfenyl)-1-propanon	Stimulant	1st of September, 2011
4-HO-MET	3-(2-(Etyl(metyl)amino)etyl)-1H-indol-4-ol	Hallucinogen	1st of May, 2012
Methoxetamine (MXE)	2-(Etylamino)-2-(3-metoxifenyl)cyclohexanon	Hallucinogen	1st of May, 2012
6-APB	6-(2-Aminopropyl)bensofuran	Stimulant	18th of September, 2012
AH-7921	3,4-Dichloro-N-[(1-Dimetylamino)cyclohexylmetyl]benzamide	Opioid	1st of August, 2013
3-MMC	1-(3-Metylfenyl)-2-(metylamino)propan-1-ol	Stimulant	1st of December, 2013

and after scheduling was used). For each substance separately, the data was modeled as

$$y_n = \mu + \beta I_n + \epsilon_n, \quad (1)$$

where y_n is the square root of the number of posts on day n , μ is a constant (mean value), I_n is a step function that models the effect of scheduling and is 0 if $n < s$ and 1 if $n \geq s$ where s is the index of the date of scheduling. The constant β is the parameter of interest and measures the magnitude of the effect of scheduling. The error term ϵ_n was modeled as a zero mean autoregressive moving average (ARMA) time series model. This model (Eq. (1)) was fit to the data using the `arima` procedure in `SAS`. All models with $p < 5$ (autoregressive order) and $q < 5$ (moving average order) were fit to the data. Within this parameter range the best fitting model was selected using Akaike's information criterion (AIC). If the residuals in the model with lowest AIC value also passed the test for white noise, the fit was judged to be adequate. The estimate of β was then used as a measure of the association between scheduling and forum activity. It should be noted that the distributional assumptions underlying the statistical test might not be fulfilled (in particular, when the activity levels are low (i.e. few or no posts per day) the normal distribution will not be a good approximation). This will imply that the p -values might not be exact, and should be interpreted with some care. However, as we will see in Section 3, the magnitude of the effects makes the exact p -value of the test less of a concern.

2.4.2. Post contents. To investigate the contents of the posts a random sample of 25 members from each thread were selected and all the post made by these members, in the particular thread, were extracted. These posts were read and each member was classified according to if a clear statement was made declaring that he/she had taken the drug.

2.4.3. Reference data set. The main interest in this study was to see if mean posting activity changes around the time of scheduling. However, it is relevant to also investigate if the members posting on a thread related to a given substance will stop their drug-related activity on FB, or if they will continue to post on other threads after the banning. These questions were addressed by studying the posting activity (by the members posting on a given thread) also in a reference data set. This reference data set was taken as all the threads on FB about central stimulants (approximately 16,000 threads). The corresponding webpages were downloaded and parsed, and the member identity and date of posting of the approximately 390,000 posts were extracted. For the members posting on the threads related to the five stimulant substances (MDPV, Methylone, 4-MEC, 6-APB, and 3-MMC), the total posting activity in the reference data set was extracted. For example, the posting activity in the reference data set for all members posting on the thread related to 4-MEC was extracted. By comparing the number of posts made in the reference set before and after scheduling

(of 4-MEC in this case) it is possible to see how the posting activity on other threads changed in relation to the scheduling.

3. Results

The eight major threads dealing with the substances of interest comprised 3816 web-pages in total. The number of posts for the eight substances ranged from 1831 to 11,734 (Table 2) showing that these substances were discussed with some intensity on the Swedish internet forum.

Many members were active in more than one thread, and in total there were 3711 unique members active on the eight threads.

A careful reading of posts from a random sample of 200 members showed that 50% of members clearly state that they have used the substance of interest (25 members per thread where studied and the fraction of proclaimed users per thread varied from 40 to 70%).

3.1. Activity as a function of time

In Fig. 1 the FB activity on the thread discussing 4-HO-MET, a hallucinogen substance, is shown as a function of time.

This particular substance seem to have been introduced in beginning of 2008 and since this point the activity shows substantial variability including long periods of high (>10 post per day) activity. On the 1st of May 2012 (arrow in Fig. 1), 4-HO-MET was classified as a narcotic substance in Sweden and after this point in time the FB activity decreased to very low levels.

In Fig. 2 the activity profiles of the seven other substances are shown as functions of time, relative to the date of scheduling.

The activity profiles are highly variable. In some cases there is almost no activity after scheduling (e.g. AH-7921) whereas in other cases the activity levels are reduced after scheduling but do not vanish completely (e.g. MXE).

The mean level of activity dropped after scheduling for all eight substances (Table 3). To test if this drop in forum activity was statistically related to scheduling, an intervention analysis was performed (see Section 2). In particular, the activity levels during 180 days before and after scheduling were compared using time-series models to account for serial correlations in the data. According to this analysis the mean activity level was significantly reduced for seven of the eight substances, $p < 0.001$ in all cases (Table 3). For

Table 2

Total activity of the threads investigated.

Substance	First date	# Pages	# Posts	# Unique members
MDPV	September 2006	207	2475	578
Methylone	July 2005	493	5893	814
4-MEC	July 2010	396	4732	555
4-HO-MET	April 2006	979	11,734	1455
MXE	September 2010	471	5651	585
6-APB	July 2010	603	7199	687
AH-7921	August 2012	153	1831	248
3-MMC	May 2012	514	6146	597

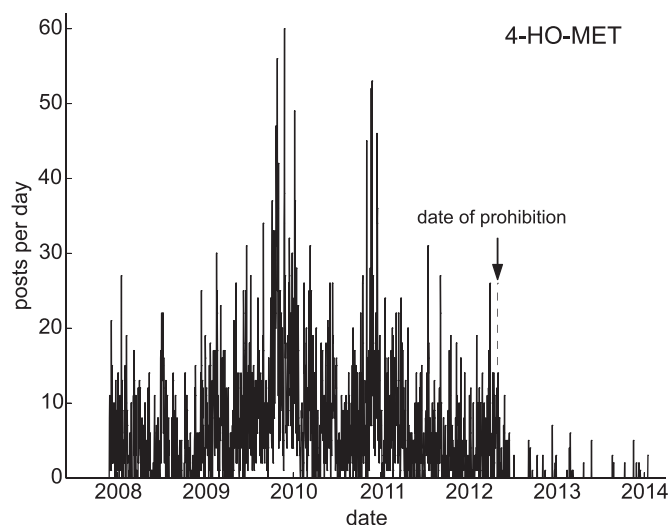


Fig. 1. FB-activity for 4-HO-MET. The curve shows the number of posts per day made for 4-HO-MET. The arrow and dashed line indicate the time point when the substance became illegal.

MXE, scheduling did not have a significant effect on mean activity in the best fitting model. However, extending the observation interval to 360 days before and after made the drop in activity significant.

3.2. Activity on other drug-related threads

An important question is if the decrease in posting activity on a particular thread implies that the related members reduce their drug interest in general, or if it is diverted to other related substances. To investigate this, the members posting on the threads related to the five stimulant substances were followed also in all other threads related to stimulants (see Section 2). The posting activity in this extensive reference set, 180 days before and after scheduling of a particular substance, was investigated. For three out of these five substances (3-MMC, 4-MEC, and Methylone) the posting activity in the reference set, of the corresponding members, actually increased after scheduling. For the two other substances (MDPV and 6-APB) it decreased.

4. Discussion

The amount of online discussions about eight so-called NPS were investigated with a particular focus on the impact of the legal status of the substances. A clear pattern emerged from these data: the intensity of the discussions (number of posts per day) were much lower after scheduling compared to before. These results are discussed below.

The main measure used here was the number of posts per day related to a given substance made on an Internet discussion forum. In previous work similar Internet fora have been used (Schifano et al., 2006; Carhart-Harris et al., 2011; Deluca et al., 2012; Kjellgren and Jonsson, 2013; Van Hout and Bingham, 2013) but the approach taken here is novel in that a time-dependent measure of the activity was extracted. This measure is similar in spirit to the search-history intensity obtained from web-based search-engines (Deluca et al., 2012; Forsyth, 2012) but it has advantages compared to such measures:

- (i) The content of the posts can be analyzed to get a more precise characterization of the interest in the drug. For example, in this work the fraction of members stating that they have used the substances were investigated.

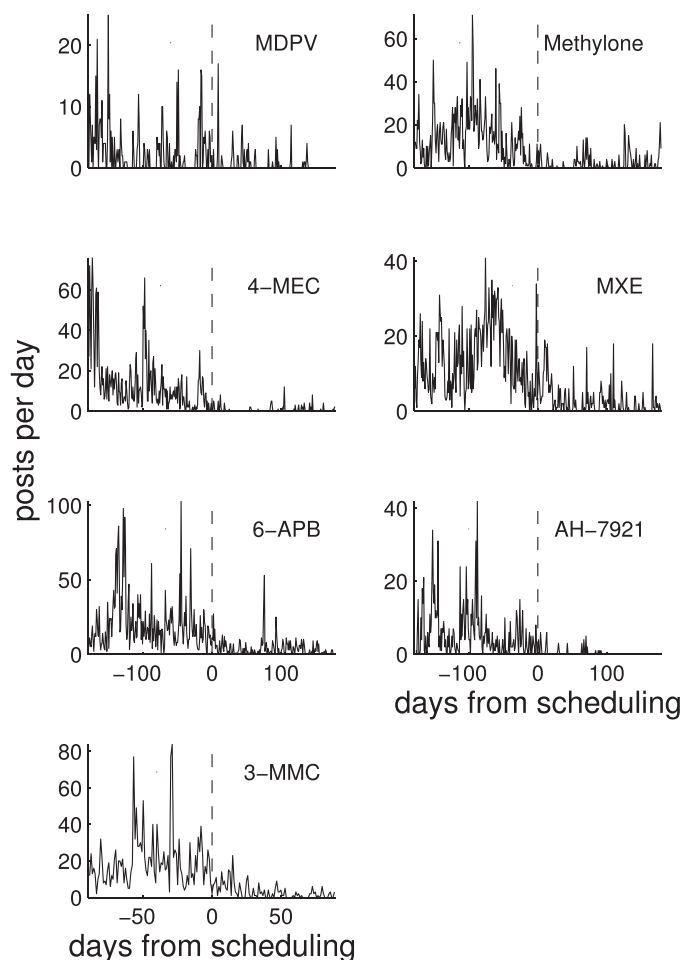


Fig. 2. FB-activity for four substances as a function of time. The curves show the number of posts per day made for the seven substances indicated in the plots. The date is centered on the time point when the substances became illegal and this is also indicated by the dashed line.

Table 3

Mean number of posts per day, 180 days before and after the substances were made illegal and parameter estimates from fitting Eq. (1) to the data. The asterisks show parameters for which $p < 0.001$ under the null-hypothesis that $\beta = 0$. The data for 3-MMC is for 90 days before and after scheduling.

Substance	Average posts per day		Model parameters				
	Before	After	μ	β	Std. err. β	p	q
MDPV	2.8	0.6	1.2	-0.8*	0.2	2	1
Methylone	13.8	2.2	3.0	-1.8*	0.5	4	1
4-MEC	13.4	0.6	3.2	-2.6*	0.4	4	0
4-HO-MET	4.3	0.7	1.6	-1.2*	0.2	3	1
MXE	14.1	2.7	2.75	0.07	0.6	2	1
6-APB	20.8	3.9	3.9	-2.4*	0.4	2	1
AH-7921	5.8	0.3	1.9	-1.6*	0.3	1	1
3-MMC	20.0	3.1	4.2	-2.8*	0.3	3	1

- (ii) The algorithms behind many of the commercial search-engine-providers' products are not publicly available and the data are not produced primarily for scientific purposes.

From reading a random selection of posts it became clear that about half of the members explicitly state that they have used the drug, but the true fraction of users might be even higher. This shows that the data sampled has high relevance for the main question investigated. Moreover, one of the most common topics of discussion is dosage: how much, through which route,

and in which combinations should the substances be taken. Furthermore, descriptions of subjective experiences when taking the substances are quite common. It is therefore likely that substance usage (among the persons active on FB) is positively correlated with the measure of activity used here.

The forum discussions were 'passively' observed, i.e. the investigator did in no way interact with the discussants. The data analyzed therefore represent actual interactions among FB members. Given the large number of members on FB it is a valuable and accessible source of information on attitudes and interest towards drugs in general and NPS in particular (c.f. Schifano et al., 2006; Deluca et al., 2012). Approximately 3700 members were followed on the eight threads and this is, in Swedish contexts, quite a large number (for comparison: there are approximately 600,000 persons between 19 and 24 in Sweden).

For seven of eight substances there was a strong statistical association between legal status of the substance and activity on the internet forum. This does not necessarily imply that there is a causal connection between the two, but other considerations make this seem likely. A factor that is crucial in NPS use is availability. While legal, the drugs can be purchased from online vendors and delivered to a desired address. Indeed, the 'best' vendor is a topic frequently discussed in the threads and the recommendation is often to buy from domestic dealers (to avoid that the goods are confiscated by the customs). When a substance is scheduled, on the other hand, selling from within Sweden is a serious crime which could lead to several years of imprisonment. It is therefore likely that once it becomes known that a particular substance will be scheduled (this typically is known at least one month in advance of the date when it comes into force) the particular site selling the drug will remove it from its stock (c.f. Shanks et al., 2012). Thus the following causal chain seems likely, X is up for scheduling $\rightarrow X$ is removed from the market \rightarrow interest in X decreases. This would presumably hold for substances where there already are 'competitive' alternatives on the illegal market. Perhaps MXE (where the decrease was less strong) is a case where there are few alternatives and the interest therefore prevails. This seem to be what happened in some circles when Mephedrone was banned in the UK (Wood et al., 2012).

The data analyzed in this work do not speak directly to the interest and use among other groups of users. To the extent that the decrease in activity on FB reflects a decrease in availability on the drug markets, it seem likely that the use in other groups will go down as well. However, the dynamics of NPS usage in the general population is not well understood and need to be better studied in order to properly evaluate the effects of scheduling.

From the data presented in Figs. 1 and 2 one could perhaps argue that making a substance illegal essentially removes it from parts of the Swedish drug market, and that scheduling therefore is the right thing to do. However, as shown here, even if the prohibition of a particular substance can make the interest in this substance drop dramatically, the general interest in drugs might not be dampened. Indeed, for three of the five stimulant substances, posting activity on other related threads actually increased after scheduling. This indicates that, in the current situation, evaluating policies by focusing on individual substances might give a biased view of the effects. Future studies might focus on groups of NPS with similar psychoactive effects and investigate the dynamics of interest and how it is influenced by changes in legal status and other relevant events.

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Conflict of interest

None declared.

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