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***Research Article (CLEAN COPY MANUSCRIPT)***

***Polydrug use typologies of regular ecstasy users visiting electronic dance music events: A Latent Class Analysis.***

Running Head: Polydrug use patterns in ecstasy users

Number of Tables: 4 + 1 supplemental table

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# **Abstract**

## **Introduction**

Polydrug use patterns of young adults using ecstasy vary, as well as their willingness to change them. Polydrug use patterns are likely associated with different adverse health outcomes. It is unknown whether polydrug use patterns of young adults that use ecstasy are similar in different countries. This study aims to identify and compare polydrug use patterns and willingness to change it of young adults that use ecstasy in the United Kingdom (UK) and the Netherlands, two countries with a high prevalence of ecstasy use and a large electronic dance music (EDM) scene.

## **Methods**

The data from the online cross-sectional Electronic Music Scene Survey was used in a latent class analysis. The binary indicators used in the estimation were past year substance use of 21 different substances. The sample consisted of young adults ecstasy users that regularly visit EDM events (age 18-34).

## **Results**

1077 respondents from the UK (age M=23.1 ) and 1178 from NL (age M=23.7) that regularly visit EDM events were included in the analyses. In both countries, three polydrug use patterns of ecstasy users were identified based on BIC fit indices: a traditional polydrug use class (UK: 28%; NL: 40%), a stimulant and ketamine polydrug use class (UK: 48%; NL: 52%), and an extensive polydrug use class (UK: 24%; NL: 8%) characterized by substantial use of stimulants, depressant and psychedelic substances. Overall, young adults that used ecstasy in the UK consumed 3,4-Methylenedioxymethamphetamine (MDMA) more often as powder/crystalline and at higher dosages compared to young adults in NL who preferred MDMA tablets. Regardless of polydrug class or country, most respondents indicated that they had the intention reduce but not quit their use.

## **Discussion/Conclusion**

In both countries, structurally similar polydrug use patterns among young adults that use ecstasy were found, while the use frequencies of individual substances and preferred MDMA form varied between the countries.

## Introduction

Electronic dance music (EDM) has seen a surge in popularity over the last decades [1,2]. Previous research has shown that illicit substance use by visitors of EDM clubs or festivals is common compared to the general population [3–6]. Most studies investigating substance use in the EDM scene show that ecstasy (MDMA), either in tablet, capsule, powder or crystalline form, is the most frequently used substance [4,7,8]. As ecstasy remains the most used substance in nightlife settings and contributes to the largest proportion of presentations at first aid stations at festivals and dance events in the Netherlands [9], the current study focusses on young adults that use ecstasy.

Young adults using ecstasy often also have experience with the use of other illicit or licit substances as well [4,10]. The extent of polydrug use as well as the type of substances that are used vary enormously from individual to individual. Young adult polydrug use is associated with problem behaviour, comorbid psychiatric problems and risky sexual behaviour [11,12]. Risks may vary by the substances that are used, the route of administration (e.g. orally, smoked or injected), the pattern or frequency of use, and characteristics of the user [13].

From a methodological point of view, the definition of polydrug use is sometimes debated. This paper focusses on past year concurrent polydrug use: the use of multiple substances over the past twelve months [14,15].

An often used and suitable statistical method for estimating latent typologies that give rise to the observed patterns of substance use is latent class analysis (LCA), which enables the identification of latent groups in the study population [16–18]. LCA can help identify quantitative and qualitative group differences in young adults that use ecstasy, as well as predictors of group membership [19]. A previous study found three classes of young adults that used ecstasy among 402 college students in Ohio, United States: 1) a limited range class that mostly used cannabis and alcohol; 2) a moderate range class with increased probabilities of daily cannabis use, crack/cocaine, opioids, and hallucinogenic substances; and 3) a final wide range class with high probabilities of having used most of the substances [20]. A study investigating polydrug use in the Brazilian nightlife scene found three similar classes of polydrug users [21]. However, due to differences in terms of drug markets and drug preferences, it is difficult to generalise these findings to European countries [13,22]. There has been one recent European LCA study targeting nightclub visitors in Germany identified four polydrug use classes: 1) a conservative class using only cannabis; 2) a traditional class that additionally uses ecstasy, amphetamine, and lysergic acid diethylamide (LSD); 3) a psychedelic class in which people used the hallucinogens LSD and magic mushrooms as well as ketamine, GHB and traditional club drugs; and 4) a non-specific class which used all of the previous substances and a number of new

psychoactive substance (NPS) as well as prescription medication [10]. However, recent findings have pointed to the limited generalizability of LCA studies [23].

The studies from different countries and continents, as described above, highlight the variability in the groups of young adults that use substances that can be identified. This variability could be caused by the time period in which the data was gathered, the sampled population, the number of substances measured, but also the variability in the geographical region of the study [23]. Obtaining more insight into the possible subgroups of young adults that use ecstasy but also other illicit substances and their characteristics, and their willingness to change their substance use provides important information into the various high-risk subgroups of young adult which might aid prevention efforts. When investigating ecstasy use in Europe, two countries stand out due to their high prevalence rates, the Netherlands and the United Kingdom [13]. These countries also share a large EDM scene that attracts visitors and artists from around the globe [24,25]. Moreover, the drug markets in the two countries share a large number of similarities both in terms of retail markets and drug demand [26], probably due to their geographical proximity. A direct comparison of patterns of young adults using ecstasy between these two countries gives insight into the stability of subgroups of those that use ecstasy and the possible differences in polydrug use patterns due to geographical differences. As the prevalence rates in these countries are increasing despite numerous interventions that have been deployed to prevent use of illicit substances, we considered it very relevant to not only assess substance use in the subgroups, but also their willingness and intention to change substance use in the next year.

To summarize, this study was designed to identify classes of young adults that use ecstasy and visit EDM events in the UK and the Netherlands and to investigate whether the same classes emerge in the two countries. We expected to 1) identify three classes; a) a low polydrug use class that is primarily interested in alcohol and cannabis; b) a moderate use class with elevated stimulant or hallucinogenic substance use; c) and a high use class that uses a wide range of substances [4,20,21,27]; 2) find a higher proportion of males, younger adults, students, and those living in urban settings in the wider range use classes compared to the narrow range use classes [4,20,21,27,28]. Furthermore, we explored the intention for cessation or moderation of substance use [29].

## **Materials and Methods**

### **Design and recruitment**

The data for this study were obtained from the Electronic Music Scene Survey (EMSS), part of the ALAMA (A Longitudinal and Momentary Assessment) nightlife project [30]. This cross-sectional online

survey was conducted among respondents from the UK, Netherlands, Belgium, Sweden and Italy from May to October 2017. For the current study only data from the UK and the Netherlands was used. Respondents were recruited online through advertisements on social media, digital newsletters, websites, and online fora related to the EDM scene. In addition, respondents were recruited offline by fieldworkers at EDM festivals and nightclubs. In the current analysis, we selected participants from the Netherlands and the UK as these countries have the highest rates of ecstasy use in Europe and both countries have a large EDM scene. The age range was restricted to 18-34 years as this comprises the key population that inhabits the EDM scene.

### **Procedures**

Inclusion criteria for this current study were: (1) being resident in the UK or the Netherlands; (2) aged between 18 and 34 years; (3) attended at least six EDM events in the last 12 months; (4) having used ecstasy at least three times in the past 12 months. All respondents provided their informed consent before completing the EMSS.

The following questions from the EMSS were included in the analyses: demographical information, substance use (alcohol, tobacco, illicit substances and prescription medication that are used recreationally), and respondents' intention to change their substance use. Respondents were entered into a prize draw to win an laptop, tablet, Bluetooth speaker, or €20 gift voucher after completing the survey.

### **Measures**

The following questions on demographics were included in the analyses: age, gender, country of residence, level of urbanicity (large town or city, small to midsized town, or rural/ countryside), educational level (International Standard Classification of Education level 1, 2, 3, or 4 or higher) (18), and occupation (full time employed, part time employed, student, or not working or studying). The past year prevalence was assessed for: alcohol, cannabis, tobacco, nitrous oxide, cocaine, ketamine, MDMA, amphetamine, magic mushrooms, synthetic hallucinogens (e.g. 2,5-dimethoxy-4-bromophenethylamine (2C-B)), 4-fluoroamphetamine (4F-A), LSD, amyl nitrates ('poppers'), benzodiazepines (e.g. Valium), 3,4-methylenedioxyamphetamine (MDA), GHB, prescription opiates, dimethyltryptamine (DMT), mephedrone, synthetic dissociative substances (e.g. methoxetamine), synthetic cannabinoids, and heroin. The selection of these substances was based on recent nightlife studies and drug market developments in Europe (19,20). For respondents who indicated using MDMA in any form in the past 12 months, the number of days of MDMA use, the average number of ecstasy tablets and the average amount of milligrams MDMA powder/crystal used on one occasion in

the past 12 months were also assessed. Furthermore, the Alcohol Use Disorder Identification Test – C (21,22) was used to index risky alcohol use. We also assessed respondents' intention to change their alcohol and drug use in the next 12 months (intending to stop use / intending to not change use / intending to decrease use / intending to increase use).

## **Analyses**

First, we checked for obvious careless or erroneous answers in the survey, none were found (n=0). All respondents outside of the predefined age range of (18-34) (n=37), with having visited less than 6 or more than 365 dance events in the past year have been excluded from the analyses (n=1109), and having used ecstasy less than three times in the past year were excluded from the analyses (n=4350). Next, LCA was applied. LCA is a specific form of Finite Mixture Modelling (FMM) that estimates latent groups based on manifest observations on the participant level (23,24). In the present study, past year substance use indicators on the individual level were used to estimate latent classes of young adults that use ecstasy (15). Past year substance use (Yes/No) was used as a binary indicator for all substances except for alcohol. For alcohol use, a scoring above the AUDIT-C cut-off score of risky alcohol use (females: score  $\geq 3$ ; males:  $\geq 4$ ) was included as the binary indicator (25). The LCA models were conducted separately for both countries. LCA models ranging from two to seven classes were estimated based on theoretical tenability (24). The LCA models were compared on the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), adjusted Bayesian Information Criterion (aBIC), Entropy and Bootstraps Likelihood Ratio Test (BLRT) (26–30). The BIC was prioritized over other fit-indices as it most reliably recovers the correct LCA model in simulations with a high number of parameters and moderate to high sample size (31). Furthermore, class sample size, parsimony, interpretability, and comparability of the fitted models were considered while selecting the optimal model. Differences between countries were tested using t-tests or Chi-squared ( $\chi^2$ ), where appropriate. Class membership was determined using the three-step method using modal class assignment [31]. First the latent class model was built. Then subjects were assigned to the latent classes based on their individual responses regarding their substance use. As a third step, the association between class membership and a number of variables was analysed. Differences between latent classes were tested using analysis of variance (ANOVA) or Chi-squared ( $\chi^2$ ) statistics, where appropriate. Bonferroni corrections were applied for comparisons between individual classes and the comparisons between the two countries. R software (version R 3.4.4) with the 'poLCA' package (version 1.4.1), SPSS (v25), and MPLUS (version 7.2) were used to perform the analyses (23).

## **Results**

### **Respondent characteristics**

In total, 4443 respondents (UK: 2236; NL: 2207) completed the survey and fitted the inclusion criteria regarding age, EDM attendance, and country of residence. The survey median completion time was 27 minutes (IQR: 21.4 – 35.3). 2255 respondents (UK: 1077; NL: 1178) met the additional inclusion criterion of having used ecstasy at least three times in the last 12 months. The mean age of respondents residing in the UK was 23.1 (SD = 4.07) years and 34% of these respondents were female. Respondents residing in the Netherlands were on average 23.7 (SD = 4.01) years old and 32% were female.

### **Latent class model and polydrug use classes**

The fit-indices for the estimated models varied between the two countries (Supplemental Table 1). The three class solution was the optimal solution for both countries based on the lowest BIC and parsimony of the model (32). In both countries we identified ‘traditional polydrug use’ classes (TPU) with high probabilities of risky alcohol use, tobacco use, cannabis use, and moderate probabilities of nitrous oxide. Descriptive statistics for the subgroups can be found in Table 1, information regarding substance use in Figure 1 and 2, and in Table 2. A ‘stimulant and ketamine polydrug use’ (SKPU) class that was additionally associated with high probabilities of using at least one stimulant and ketamine in addition to high probabilities of traditional clubs drug use was also identified in both countries. Also a third ‘extensive polydrug use’ EPU class was identified in both countries. This EPU class was associated with the highest probabilities for using the substances used in the previous two classes. Illustrative for the EPU classes were high probabilities of hallucinogenic substances and moderate levels of depressant substance use.

Though both countries show structurally similar polydrug use classes in substance use patterns, a smaller proportion of the respondents in the UK belonged to the TPU class (28% vs 40% in the Netherlands). Key differences between the two TPU classes were higher probabilities of cocaine (60% vs 21%), ketamine (20% vs 7%), and LSD (20% vs 2%) in the UK compared to the Netherlands. However, use of amphetamine (20% vs 7%), 4-FA (33% vs 1%), and nitrous oxide (51% vs 35%) was more prevalent in the TPU class in the Netherlands.

A difference between the countries was also observed in terms of the form of ecstasy consumed (Table 3). In the TPU class in the UK the prevalence of MDMA use in crystalline or powder form was higher compared to the Netherlands (92% vs. 56%). However, the prevalence of MDMA use in tablet or capsule form was higher in the Netherlands (99% vs. 78%) compared to the UK.

‘Stimulant and ketamine polydrug use’ classes (SKPU) were also identified and were the largest class found in both countries (UK: 48%; NL: 52%). Use of cocaine (97% vs 76%) and LSD (27% vs 11%), and



benzodiazepines (29% vs 8%) was higher in the SKPU class in the UK compared to the Netherlands. The use of amphetamine (85% vs 24%), synthetic hallucinogens (42% vs 9%), 4F-A (58% vs 0%), and GHB (19% vs 1%) was higher in the Netherlands. In the SKPU classes the prevalence of MDMA use in crystalline or powder form was also higher in the UK compared to the Netherlands (96% vs. 78%). However, the prevalence of MDMA use in the tablet or capsule form was higher in the Netherlands compared to the UK (98% vs. 90%).

The 'extensive polydrug use' classes (EPU) was the smallest class in both countries, however the EPU class in the UK contained a larger proportion of respondents than the Netherlands (24% vs. 8%). In the EPU class in the UK a larger proportion of respondents was a risky drinker (93% vs 77%), and the use of benzodiazepines (68% vs 41%), prescription opiates (36% vs 17%) and mephedrone (13% vs 1%) was more likely as well. In the EPU class in the Netherlands use of amphetamine (94% vs 57%), 4F-A (67% vs 6%), GHB (59% vs 8%), and synthetic dissociative substances (23% vs 8%) was notably higher. Use of MDMA in powder or crystalline form was slightly higher in the UK EPU class (96% vs. 92%). The use of MDMA in tablet or capsule form was slightly higher in the EPA class in the Netherlands compared to the UK (99% vs. 94%).

### **Associations between latent classes and respondent characteristics**

The one consistent finding was that in both countries, the proportion of females was highest in the TPU class and lowest in the EPU class (UK:  $F(2) = 7.58$ ,  $p < .001$ ; NL:  $F(2) = 10.31$ ,  $p < .001$ ).

Respondents in the TPU class in the UK were slightly older than those in the SKPU and EPU class ( $F(2) = 6.24$ ,  $p < .001$ ), for the Netherlands, there were no significant differences in age between the classes. Also the other comparisons varied somewhat by country, for details see Table 1.

In terms of the intention to change substance use the patterns in the countries were very similar (Table 4). In the TPU class in the UK most respondents did not intend to change their alcohol and drug use (49%) most other respondents indicated intending to decrease their use (42%), this patterns was the same in the TPU class in the Netherlands (56% and 39%). In the SKPU classes in both countries, the majority of respondents intended to decrease use (UK: 56%; NL 56%) and a smaller proportion had no intention to change use (UK: 37%; NL 41%). In the EPU classes, the same pattern was observed in terms of intention to decrease use (UK: 61%; NL 67%) and intention not to change (UK: 35%; NL 30%). In the TPU, SKPU, and EPU classes in both countries the percentage of respondents that intended to quit or increase use was below six percent in all six classes.

## Discussion

In this first study designed to compare classes of young adults that use ecstasy in the EDM scene between two countries, latent class analysis identified three classes in both the UK and the Netherlands. However, differences were observed between the two countries in the specific substances characterizing these classes and the proportion of respondents belonging to each class. Though the observed differences in demographic characteristics of the different classes were small, they were in line with previous studies [4,10,20,21,28,32].

In both countries, we identified a group of polydrug users who are primarily interested in 'traditional' substances such as alcohol, tobacco, and cannabis, in addition to their ecstasy use. However, contrary to the typical low polydrug use classes identified in other studies, the TPU class was also characterized by the use of other substances. In the UK, the majority of young adults that use ecstasy also used cocaine, and in the Netherlands the TPU class showed notably elevated levels of nitrous oxide and 4-FA use in addition to the other substances used. When comparing these findings to previous studies, the TPU classes in the current study mostly resemble the moderate polydrug use classes that have been identified in previous studies [4,21,32,33]. This suggests that polydrug use in this population of young adults who use ecstasy and regularly attend EDM events is high overall.

The SKPU class was the largest class in both countries. The majority of respondents in the SKPU classes also used the traditional substances, but appreciably more respondents used ketamine, cocaine and nitrous oxide, in both countries, compared to the TPU class. Moreover, there were country specific differences. Amphetamine and 4-FA were more commonly used by those in the SKPU class in the Netherlands compared to the UK. The proportion of respondents in the SKPU class using cocaine, ketamine and nitrous oxide was considerably higher compared to the Netherlands. The SKPU classes identified in the current study resemble 'high level polydrug use' and 'polydrug consumer' classes found previously [21,33]. The EPU classes were the smallest classes. In comparison to the SKPU classes, the range of substance used widens further and especially hallucinogenic and depressant substances are included in the EPU classes. In the UK the use of benzodiazepines and prescription opiates is more prevalent compared to the Netherlands. However, the use of GHB is more prevalent in the EPU class in the Netherlands. This finding hints at an underlying necessity for depressants in wider range use classes that is perhaps cross-cultural, possibly to negate the effects of stimulants [34]. The EPU classes are similar to the 'unselective' and 'extensive polysubstance use' classes found in previous studies [4,10]. Across all classes MDMA in powder or crystalline form was consumed more often and at bigger quantity in the UK compared to the Netherlands. This finding is

in line with previous studies indicating that the use of MDMA in different forms may have different patterns of use and associated risks [35,36].

In this population of young adults, risky alcohol use is high across all classes. Simultaneous polydrug use is more harmful than concurrent polydrug use and the use of alcohol in combination with ecstasy poses its risks [37]. This study has also shown that the prevalence of both ecstasy tablets or capsules and MDMA powder or crystal differs between classes and countries. When considering the average amount of MDMA in ecstasy tablets and the historically high levels of purity of MDMA in powder or crystal form, the dosage that users administer far exceeds the dosages deemed safe in studies investigating the therapeutic applications of MDMA [35,38,39]. Especially high dosages of MDMA used in the SKPU and EPU classes, could (temporarily) lead to lower serotonin receptor densities in the brain [40]. Another pattern that emerges is the use of stimulant NPS in both countries. Though not as prevalent as a decade ago, mephedrone was still used by a small proportion of respondents in the UK [41]. In the Netherlands the NPS 4-FA, for some time known as 'ecstasy light', was very prevalent in all classes, possibly for the same reasons that mephedrone emerged in the UK [41].

A recent review highlighted the relatively small body of effective interventions aimed at reducing the harms of substance use or at reducing substance use itself [42]. One intervention which has been available in the Netherlands for two decades and is gaining traction in the UK is drug checking [43–45]. An important component of drug checking is consultation with a prevention expert, aimed to educate about risks associated with substance use and about harm reduction measures. Recent studies show that nightlife visitors express a need for drug checking facilities as well as for access to objective and valid information on illicit substances [46,47]. The findings of our study may aid preventive efforts by highlighting the relevance of informing young adults on (concomitant) polydrug use in addition to single substance use.

The exploratory question on the intention to change alcohol or drug use revealed that most young adults who use ecstasy intend to remain using the same or decrease (but not stop) their substance use depending on class membership. Classes defined by a wider range of polydrug use were more likely to report intention to decrease their substance use compared to the proportion intending to maintain their use at the same level.

### *Limitations*

In the current study, not all fit indices of the latent class analyses favour the same model solution. However, the high posterior probabilities of the risky alcohol use, cannabis, nitrous oxide, and cocaine indicators are likely to have obscured clear delineation between classes, accounting for

diverging fit indices and lower than ideal entropy [48]. Secondary analyses ran with different subsets of indicators also recovered the three class models, providing further evidence for this thesis (results not shown). Because of the use of past 12 month drug use as indicator in the analyses, the identified classes mostly describe the range of substances used, but do not disclose information about the frequency of use. The current study revealed differences in the proportion of females in the identified classes with the proportion of females decreasing as the range of substances increased. Exploring these differences using sex-stratified analyses however, was beyond the scope of the current study. Though validity questions with regard to online surveys, including potential selection bias of online surveys and reliability of the data remain a matter for debate, differences between our online recruited sample and an offline recruited sample acquired using a random intercept method that completed a short paper-and-pencil survey was small [49–51], hence lending some support to the validity of our online survey approach as well as the generalizability of our findings to the wider population of young adult regular EDM event visitors who use ecstasy.

Care should be taken when interpreting the rates of use of benzodiazepines and prescription opiates. The measure did not distinguish between prescribed and off-label use of these substances. Possibly the reported rates of use have been confounded by prescribed use of these substances. However, the prevalence rates of benzodiazepines and prescription opiates in the general population are substantially lower than those observed in the current study [49,50]. It is likely that these numbers mostly reflect off-label and possibly recreational use. The data for this study was collected before the COVID-19 pandemic. The COVID-19 pandemic has at least temporarily changed the use of substance use in this population of regular EDM event visitors due to the closing of nightlife venues [51]. Based on the current evidence, substance use may be reduced or exacerbated, depending on the studied population [52-54]. Whether substance use will return to normal levels in the post-pandemic period will be subjected to future evaluations.

### *Conclusions and future research*

This study revealed both the similarities and differences in polydrug use patterns among young adults who use ecstasy in the UK and the Netherlands. Three similar classes were identified in both countries, while there were also important differences in terms of substance use within the similar classes between the two countries. This highlights the need for national data to tailor preventive and harm reduction strategies, and policy decisions to individual countries, instead of global strategies implemented in multiple countries. Demographic characteristics did not yield clear differences between the three classes, in line with previous research. However, the proportion of females decreased as a function While our study does confirm that young adults that use ecstasy are

polydrug users, more information about the extent to which these substances are used simultaneously is necessary. Finally, the preliminary finding that a substantial proportion of respondents indicated that they had the intention to reduce or moderate but not quit their use should be further explored as this intention is a possible avenue for harm reduction or cessation interventions.

## **Statements**

### **Acknowledgement (optional)**

#### **Statement of Ethics**

This study protocol was reviewed and approved by [committee name withheld for review], approval number [withheld for review]. All respondents provided their informed consent online prior to starting the EMSS survey. The STROBE guidelines for observational cross-sectional epidemiological studies were followed (17).

#### **Data Availability Statement**

All data generated or analysed during this study are included in this article. Further enquiries can be directed to the corresponding author.

#### **Conflict of Interest Statement**

The authors have no conflicts of interest to declare.

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#### **Author Contributions**

Authors 1,2,3,4,5,6,7,8, & 9 designed the experiments. Authors 1,2,3, & 9 analyzed the data. Authors 1,2,3,4,5,6,7,8, & 9 prepared the manuscript. All authors approved the final manuscript.

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## Figure Legends

Fig. 1. Conditional probabilities of last year substance use by class membership United Kingdom (three class model).

Fig. 2. Conditional probabilities of last year substance use by class membership the Netherlands (three class model).