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The impact of poly drug use on several prospective memory measures in a sample of university students

Impacto del policonsumo de drogas sobre varias medidas de memoria prospectiva en una muestra de estudiantes universitarios

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Abstract

The prolonged consumption of drugs has been associated with neuropsychological and cognitive deficits. The most important deficits are associated with executive functions and memory problems, specifically with prospective memory (PM). This type of memory plays a central role in our daily life. However, there is a lack of studies on the effects of poly drug consumption on prospective memory. In this study we aim to discover to what extent the length and amount of estimated consumption of alcohol, tobacco, cannabis and tranquilizers predicts the scores of self-reported prospective memory, and the scores on two objective tasks designed for this study. Measures included a Spanish version of the UEL Recreational Drug Use Questionnaire and the Prospective Memory Questionnaire, both with objective scores on two experimental tasks. The sample was composed of 164 participants (145 females and 19 males) aged 19-36 (M = 19.85, SD = 2.21). Stepwise regression analysis showed that years of cannabis consumption explained 13% of self-reported long term PM deficits. Years of alcohol consumption explained 18.4% of total variance of self-rated internally-cued PM deficits. Years of alcohol

Resumen

El consumo prolongado de drogas se ha asociado a déficit neuropsicológicos y cognitivos. Los déficits más importantes están asociados con las funciones ejecutivas y los problemas de memoria, y en concreto con la memoria prospectiva (MP). Este tipo de memoria juega un papel central en nuestra vida diaria. Sin embargo, faltan estudios sobre los efectos del policonsumo de drogas en la MP. En este estudio pretendemos conocer en qué medida los años desde el inicio de su consumo y la cantidad de consumo estimada de alcohol, tabaco, cannabis y tranquilizantes predicen las puntuaciones autoinformadas de memoria prospectiva y las puntuaciones objetivas en dos tareas experimentales diseñadas por nosotros. Entre las medidas se incluyeron una versión en español del UEL Recreational Drug Use Questionnaire, el Prospective Memory Questionnaire, junto con las puntuaciones objetivas en dos tareas experimentales. La muestra estuvo compuesta por 164 participantes (145 mujeres y 19 varones) con edades comprendidas entre los 19 y 36 años (M: 19.85 años, DE: 2.21). Los análisis de regresión por pasos mostraron que los años de consumo de cannabis explican un 13% de los problemas autoinformados

consumption and estimated amount of alcohol together predicted 30.2% of variance of objective event-based PM tasks. The estimated amount of tobacco and tranquilizers consumption predicted 33.7% of the time-based PM task.

Keywords: poly drug users, prospective memory, adolescents.

de MP a largo plazo medidos con el PMQ. En el caso de los problemas autoinformados de MP con pistas internas, son los años de consumo de alcohol los que mayor porcentaje de la varianza explican (18.4%). Respecto a las tareas objetivas de MP, los años de consumo de alcohol y la cantidad estimada de alcohol predicen el 30.2% de la varianza de la tarea prospectiva de eventos. El 33.7% de la tarea de MP de tiempo era predicha por la cantidad estimada de consumo de tranquilizantes y de tabaco.

Palabras clave: policonsumidores de drogas, memoria prospectiva, adolescentes.

In recent years, the annual reports of the European Monitoring Center for Drugs and Drug Addiction (2005, 2006, & 2007) revealed that the most consumed drugs in Europe are cannabis, cocaine, ecstasy and amphetamines. In Spain, according to State Survey on Drug Use in Secondary Education (Ministerio de Sanidad y Consumo, 2004), the most extensively abused psychoactive substances by students between 14 and 18 years are alcohol and tobacco. In the 30 days prior to the survey, 58% had consumed alcohol; 27.8%, tobacco; 20.1%, cannabis, and 2.3%, cocaine. Data also reflect an increase in consumption since 1994, especially in the case of cocaine. In addition, the average age of first use has decreased and the level of perceived risk has decreased, especially for students aged 14-18.

Drug use, alone or in combination, affects many basic psychological processes and neuropsychological functions. It is well established that retrospective memory issues (RM, the recall of previously learned material) are associated with substance consumption (e.g., Nixon, Paul, & Phillips, 1998; Selby & Azrin, 1998), but less is known about the effects on prospective memory (PM, the ability we use to formulate intentions, make plans, and retain and execute them at the appropriate place or time). PM is the type of memory that provides recall to buy bread when we go home, remember our appointments, take a medication at a specific time, give a message to a colleague or turn off the oven before burning what we are cooking. It allows recall, at the right time, to perform a pending action. This time may be after the occurrence of an event that recalls the time to perform the intention, or after a specific period of time. Several authors state that prospective memory performance depends on the integrity of prefrontal systems and executive functions (Bisiacchi, 1996; Burgess & Shallice, 1997; Glisky, 1996; Marsh & Hicks, 1998; West, 1996), since they are involved in areas such as the categorization of intentions, their review and maintenance in memory, the recovery at the right time and the deliberate change of focus from the ongoing task to the intentional task. Therefore, drug use may have a direct effect on PM performance (see review in Kliegel, Jäger, Altgassen, & Shum, 2008).

Heffernan studied performance in prospective memory tasks in chronic alcohol consumers (Heffernan, Moss, & Ling, 2002) and adolescents (Heffernan & Bartholomew, 2006) using the self-assessment PM questionnaire (PMQ, Prospective Memory Questionnaire; Hannon, Adams, Harrington, Fries-Dias, & Gibson, 1995). They found significant issues in long and short term PM (e.g., "I forgot to pass on a message to someone"; "I forgot to turn my alarm clock off when I got up this morning") and in internally-cued PM (e.g., "I forgot what I wanted to say in the middle of a sentence"). Similar results were obtained by Ling, Heffernan, Buchanan, Rodgers, Scholey and Parrott (2003) with young people. Additional measures utilized in this study were the EMQ (Everyday Memory Questionnaire; Sunderland, Harris & Baddeley, 1983) and the UEL Recreational Drug Use Questionnaire (Parrott, 2000). They also found significant differences in memory issues associated with the level of alcohol consumption, in both the EMQ and PMQ-Long Term (long-term prospective memory).

In relation to tobacco, results are inconsistent. For example, Rusted, Trawley, Heath, Kettle and Walker (2005) showed that nicotine improved performance in PM tasks at the time of consumption due to an improvement in attentional capabilities. On the contrary, Heffernan, Ling, Parrott, Buchanan, Scholey, and Rodgers (2005) found that smokers had poorer daily PM performance as measured by the PMQ (Hannon et al., 1995) and the EMQ (Sunderland et al., 1983). The results also revealed differences between low and moderate smokers, suggesting that nicotine may have an impact on everyday prospective memory depending on the dose.

The effects of cannabis (and ecstasy) on PM have been measured by Rodgers, Buchanan, Scholey, Heffernan, Ling and Parrott (2001) with the EMQ (Everyday Memory Questionnaire, Sunderland et al., 1983) and the PMQ (Prospective Memory Questionnaire, Hannon et al., 1995). Cannabis consumers reported more EMQ, short term PMQ and internally-cued PMQ failures, while consumers of ecstasy reported more failures in long-term PMQ. In young ecstasy users, Fisk and Montgomery (2009) show how the inhibition process appears to be unaffected, even in heavy users under conditions of high demand. The updating process appears to be impaired in ecstasy users with the deficit being apparently domain general in nature. McHale and Hunt (2008) found that the cannabis users, compared to control groups, had short-interval and long-interval prospective memory deficits.

The studies on the effects of tranquilizers on PM in young people and adults are limited. For example, Rich, Svoboda, and Brown (2005) studied the effects on PM of one dose of diazepam (Valium) using one of the prospective tasks of the RBMT (Rivermead Behavioural Memory Test; Wilson, Cockburn, and Baddeley, 1985), specifically the task "ask for a personal object at the end of the session" (about 25 minutes later). They found significant differences in PM in participants who had consumed diazepam. This group needed more reminders to ask for their possessions than placebo group.

Altogether, these studies show some shortcomings and methodological issues, due to the illegal status of some drugs, small sizes of the samples, heterogeneous consumption profiles, inter-individual differences in susceptibility to substances, variability in the amount of the active ingredient utilized, absence of control groups, difficulty of conducting follow-up studies or premorbid assessments, etc. (Block, Erwin, and Ghoneim, 2002). Furthermore, most studies on the effect of drugs on prospective memory are based on self-reports rather than on experimental evidence. Likewise, many are based on online research in order to obtain samples large enough. Furthermore, results can be misleading if we focus on the effects of a single substance, since this ignores the interrelationships and possible enhancer effects among different drugs. Hence, Block et al. (2002), Lundqvist (2005) and Rogers and Robbins (2001) stress the need for further research on simultaneous consumption of different psychoactive substances.

In the light of these shortcomings, we aim at studying PM in poly-consumer adolescents and young adults with a large sample and using both self-report and experimental tasks of memory performance. This research is part of a larger study that intends to discover to what extent the age of first use and the estimated amount of alcohol, tobacco, cannabis and tranquilizers impact on performance as measured by an executive memory test (Wisconsin Card Sorting Test; Heaton, 1997), a test of organic damage (Benton Visual Retention Test; Benton, 1986), a test for sustained attention (Toulouse-Pieron Test; Toulouse & Pieron, 1998), the scores from a self-report on PM (Prospective Memory Questionnaire; Hannon et al., 1995), the scores in two experimental PM tasks, and the scores on 11 items on self-assessments of cognitive functioning ("Wellbeing of Recreational Poly Drug Users and Non Drug Users"; Milani, 2006).

This study focuses on the effects of drug use on PM (both self-report and the objective tests) and the estimate of cognitive functioning. Given the cumulative effects of drugs in the body, we hypothesize that years of use will affect performance, with participants who started earlier performing worse. This will result in an increase in the number of PM complaints and in a decreased performance on PM tasks, as well as more general deficits of estimated cognitive functioning. We also hypothesize that the higher their perceived consumption, the worse their performance. That is, those who consume larger quantities of drugs will have more PM complaints, will perform worse in objective PM tasks and report more issues when estimating cognitive functioning (except, perhaps, for tobacco, see Rusted et al., 2005). In sum, we hypothesize that high levels of typical poly drug use of university students leads to increases in

PM complaints (self-ratings in the PMQ) and to decreases in objective scores of the two experimental PM tasks, as well as an increase of complaints of estimated general functioning.

Method

Participants

The sample was composed of 164 students from the first year of Psychology program at University of Salamanca (19 males and 145 females) with ages between 19 and 36 (Mean = 19.85, *S.D.* = 2.21) who volunteered to participate. Neither random nor purposeful sampling was utilized.

Materials and method

Six measures were utilized. First, participants completed a Spanish version of the UEL Recreational Drug Use Questionnaire (Parrot, 2000). This instrument evaluates the participants' estimation of the type and quantity of substances used. We extended the survey to include 17 categories of neurotoxic substances, plus information on frequency of daily use, age of first consumption, and estimated consumption for the last month.

Second, the Prospective Memory Questionnaire (PMQ; Hannon et al., 1995) was used as self-report. This measure includes different aspects of prospective memory with a total of 52 items grouped into 4 subscales; 14 items measure long term PM (PMQ-LT, e.g., "I forgot to give a message to someone"), 14 items for short term PM (PMQ-ST, e.g., "I forgot to turn off the alarm clock when I woke up this morning"), 10 measure internally-cued PM (PMQ-IC, e.g., "I forgot what it meant in the middle of the sentence") and 14 items on techniques that people use to help remember intentions (PMQ-T). Long term PM happens when the cue takes place hours or days in advance, and the activity is not a routine task (e.g., buy a particular item when you go to the supermarket). Short term PM refers to cues to do something minutes before it has to be performed and also for fairly routine tasks (e.g., forgetting to close doors behind you). The third subscale measures inner cue PM, which occurs when the cue that reminds us what we should do is self-generated (e.g., forgetting what was being said mid-sentence). The last subscale provides information on techniques and strategies used to remember (making lists, putting post-its, etc.). The PMQ measures self-perceived errors in the last week, month, and year. The items use a 9-point Likert-type scale where 1 indicates little harm and 9 means greatest harm, except in the last sub-scale, (techniques) where 1 indicates "a little used technique" and 9 means "a much used technique". The PMQ has adequate internal validity (r = .76) and a high test-retest reliability (r = .88) (Ling, Campbell, Heffernan, & Greenough, 2007). Alpha index in our study was .70. In addition, the participants performed two experimental tasks; two prospective memory tasks and one retrospective memory task. Additional measures on cognitive and neuropsychological performance were utilized in the larger framework in which this research was performed.

Third, 11 items on the subjective estimation of their own cognitive performance were taken from the survey "Wellbeing of Recreational Poly Drug Users and Non Drug Users", developed by Milani (2006). We selected items of cognitive nature ("mind blank", "concentration deficits", "feelings of sadness," etc.) that are rated on a 5 point Likert-type scale (Cronbach's alpha = 0.86).

Fourth, participants also completed the Toulouse-Pieron Perception and Attentional Test (Toulouse-Pieron, 1998); a task of sustained attention and concentration. Participants were given 3 minutes to cross out as many signs that were the same as two larger models shown at the top of the page as they could.

Fifth, Benton Visual Retention Test (Benton, 1986) of short-term or immediate memory and working, visual and object memory was used. We selected the E form with a medium level of difficulty and administration type D (10 second exposure of each sheet, followed by a 15 seconds delay interval before the subject begins copying). For the purpose of this study, we used the correction criterion of "number of correct reproductions", which measures the overall performance efficiency and ignores the qualitative "assessment errors", which takes into account the specific type of error committed.

Sixth, the Wisconsin Card Sorting Test (WCST; Heaton, 1997) was used for measuring executive processes (cognitive flexibility, abstract conceptualization, the ability to test a hypothesis and use feedback, etc.), which have been related to prospective memory (Dobbs & Reeves, 1996). Initially, a number of stimulus cards are presented to the participant,

who has to classify the deck of cards based on one of three criteria (color, number or shape). Participants are not told how to match the cards; however, feedback is provided whether a particular match is right or wrong. Once the individual correctly performs 10 trials, the experimenter changes the criteria and the individual must do the same. The test takes approximately 12-20 minutes and generates a number of psychometric scores, including numbers, percentages, and percentiles of: categories achieved, trials, errors, and perseverative errors. We used the number of completed categories as a measure, because it has been shown to be more discriminating than other measures of the test (see Kliegel, Martin, McDaniel, & Einstein, 2002; Kliegel, Ramuschkat, & Martin, 2003; Lezak, 1995).

Procedure

To ensure anonymity, participants were identified only with a personal key (nickname). All tests and data for each participant were collected in two sessions; the first was individual and the second was a group session. The total length of both sessions was between 90-105 minutes. In the first session, the Toulouse-Pieron, Benton Visual Retention Test and the Wisconsin Card Sorting Test were applied and lasted 30-45 minutes. The experimental task and the questionnaires on substance consumption, together with the 11 items on the subjective estimation of their own cognitive performance (taken from the Questionnaire Wellbeing of Recreational Poly Drug Users and Non Drug Users, developed by Milani, 2006), and the PMQ were applied in the second session.

We developed a computerized experimental task using E-Prime (Schneider, Eschman, & Zucolotto, 2002) that is based on Maylor's task (1998). It consists of successive pictures presentations of animals divided into three groups. Each involves a different memory task: (1) prospective memory based on the occurrence of an event of remembrance, (2) prospective memory based on a time period after which they should do the prospective task, and (3) a measure of retrospective memory.

In the block that measures event-based PM, participants were presented a sequence of 274 photographs of animals to be classified into mammal / non- mammal (ongoing task). As a secondary or masked task (measuring PM), the individual had to press the spacebar when more than one animal appeared in the photograph. There were a total of 27 prospective trials (10% of trials). In this case, another screen asks the number of animals having seen in the last picture (retrospective memory).

The time-based PM task is identical, but the instructions required the subjects to write their nickname every three minutes. A digital clock was available on the computer with a key press, but it was not available while they were viewing the presentation. The response was considered valid if it appears between 3 minutes and 3 minutes and 15 seconds. In the second block, consisting of 254 photographs, those in which two or more animals appeared were removed to avoid interference from the performance of the previous task.

To measure retrospective memory we used a recognition task: 30 previously seen photographs were combined with another 30 new distractor photographs. The individuals had to decide which of the photographs had been seen previously. The computer automatically computes the results of all the tasks.

After the experimental task, participants completed the questionnaire on substance consumption, the 11 self-report cognitive questions, and the PMQ. The maximum score for each scale of the PMQ is 9 and the scores of the cognitive items were rated from 1 (*nothing*) to 5 (*extremely*) and always referred to the last month. The second session lasted approximately 40-60 minutes.

In addition to demographic variables (age, gender, medication, etc.), data for each substance such as "years since starting consumption" and "estimated amount consumed in last 30 days" were collected.

Analyses

Routine descriptive analyses were performed. Pearson's correlations were analyzed, and several stepwise regression analyses were performed. An alpha level =.05 was set for all the analyses.

Results

For statistical and theoretical reasons, we decided to present and consider for analysis only the data collected on the four most common substances used in our sample: alcohol, tobacco, cannabis and tranquillizers (anxiolytics or benzodiazepines).

Of the 164 participants, 135 (82.31%) had consumed tobacco (mean age of first consumption = 14.10 years, *SD* = 2.042, range = 9-20); 57.9% had not smoked a cigarette in the last month, while 25% smoked daily; the average number of cigarettes smoked per week was 31.68 (*SD* = 42.27). 162 participants (98.78%) had consumed alcohol (mean age of first consumption = 14.10 years, *SD* = 1.884, range = 6-20); during the last month 36.6% consumed once a week, 27.4% two to three times per week and 23.2% consumed less than once per week. The average amount of alcohol consumed by users was 5.93 units (*SD* = 6.74). 113 participants (68.9%) had consumed cannabis (mean age of first consumption = 15.95 years, *SD* = 1.747, range = 12-26); 65.9% had not consumed this month, 18.9% consumed less than once per week during the last month, and only 6.1% consumed daily during the last month; the average frequency of cannabis consumption was 5.7% (*SD* = 12.57). 41 participants (25%) had used tranquilizers (mean age of first consumption = 16.71 years, *SD* = 1.82, range = 11-23); 92.7% had not consumed the last month, 3% consumed from two to three times a week; the average frequency of consumption of tranquilizers by users was 4.75% (*SD* = 7.62).

Table 1 shows the sample in the measured variables (attention test, neuropsychological tests, PMQ, cognitive items, the two prospective memory tasks, and the retrospective memory task). Overall, both attentional and neuropsychological scores were normal, with no signs of deterioration.

No significant associations were found between T-P Perception and Attention Test, Wisconsin, PMQ-ST, PMQ-T, alertness and attention deficits, feeling sad, difficulty making decisions, correct retrospective task, and any of the data on substances use (starting year and estimated quantity of alcohol, tobacco, cannabis, tranquilizers). Table 2 shows significant associations found during the study.

Table 1
Description of the sample (N=164) in selected measures

	Sample data				Normative data		
	Minimum	Maximum	M	S.D.	M	S.D.	z
Toulouse- Pieron (total score)	-240	340	145.81	90.10	230.96	57.63	-1.48
Benton Visual Retention Test	3	10	8.23	1.51			
WCST (nº categories)	0	6	5.36	1.35	4.96	1.47	0.27
PMQ-LT	1.000	6.75	2.53	1.17	2.72	1.25	-0.18
PMQ-ST	0.846	7.00	1.61	0.82	1.47	0.59	0.23
PMQ-IC	1.111	7.37	2.78	1.31	3.09	1.18	-0.26
PMQ-T	1.000	7.14	3.48	1.49	3.75	2.15	-0.13
Deficits remembering	1	5	2.05	0.86			
Deficits planning	1	5	1.54	0.75			
Alertness and attention Deficits	1	5	2.54	1.13			
Feeling stuck	1	5	1.96	0.94			
Sad feelings	1	5	2.60	0.99			
Difficulty making decisions	1	5	2.01	0.93			
Drawing a blank	1	5	1.71	0.87			
Concentration deficits	1	5	2.59	0.95			
Mood swings	1	5	2.54	1.04			
Distraction	1	5	2.76	0.98			
Deficits organizing the mind	1	5	2.03	1.02			
Correct event-based PM Task	0	25	7.09	7.49			
Correct time-based PM Task (time)	0	5	3.38	1.35			
Correct recognizing photos (RM)	33	55	47.07	3.80			

Table 2
Correlations matrix between psychological measures and substance use patterns (calculated values in subjects with all variables)

	Alcohol years since starting	Alcohol estimated quantity	Tobacco years since starting	Tobacco estimated quantity	Cannabis years since starting	Cannabis estimated quantity	Tranquilizers estimated quantity
Benton	-.156*		-.211*				
PMQ - LT	-.199*				-.257**		
PMQ - IC	-.307**	.209**			-.334**	.247**	
Deficits remembering	-.225**	.250**				.258**	
Deficits planning				.211**			
Feeling Stuck	-.163*			.250**		.196*	
Drawing a blank	-.178*	.220**		.216**	-.287**		
Concentration Deficits	-.242**	.180*		.229**	-.194*		
Mood swings	-.215**		-.183*		-.224*		
Distracted	-.246**	.193*		.216**		.165*	
Deficits organizing the mind	-.222**				-.222*	.240**	
Correct prospective task (events)		.167*					
Correct prospective task (time)							-.161*

Note. ** The correlation is significant at the 0.01 level (bilateral).
* The correlation is significant at the 0.05 level (bilateral).

As it can be seen in Table 2, the earlier the start of the consumption of alcohol, the worse their scores in the Benton test in long term PM and in internally-cued PM. Moreover, an early initiation to alcohol correlates with the acknowledgment of having deficits with "remembering", "planning", "being stuck", "decision making", "drawing a blank", "concentration", "mood swings", "distraction" and "organizing the mind".

The higher the estimation of alcohol consumption, the more internal clue use deficits in remembering to perform PM tasks, the more general "memory deficits" they appear to have, and more problems with "blank mind", "concentration" and "distraction."

Years of tobacco use significantly correlate with the Benton Test and subjectively perceived "mood swings"; while the greatest consumers of tobacco had more difficulties with "planning", being "stuck", "drawing a blank", and "concentration" and "distraction".

Early users of cannabis showed more deficits with long term PM and scored lower in the subscale that measures internally-cued PM strategy use. This variable significantly and inversely correlated with the estimate that the participants have difficulties with "drawing a blank", "concentration", "mood swings" and deficits "organizing the mind". That is, the earlier they began, the greater the cognitive deficits they have manifested.

The subjects that consumed the most cannabis have more internally-cued PM deficits and also estimate that they have more deficits with "memory", "being stuck", "being distracted", and "organizing the mind." With regard to tranquilizers, we see that the age of starting does not correlate significantly with any of the variables recorded.

Those who consume alcohol have more success in the event PM task (pressing the space-bar when there is more than one animal in the photograph) than those that drink less ($r = .167$, $p < .05$). On the other hand, the estimated consumption of tranquilizers has a significant and inverse relationship of $r = -.161$, $p < .05$ with success in the task of time (writing, every three minutes, the name of the animal of the current trial); the greater the consumption of tranquilizers, the worse the performance in the time-based prospective task.

To test our hypothesis regarding the impact of years since starting and the amount consumed on the PM, we performed several stepwise regression analyses using the measurements of diverse variables as predictors of the performance of the consumer on PM.

In the first place, we tried to determine which substances (using years since starting and estimated consumption of alcohol, tobacco, cannabis, and tranquilizers) explain PMQ scores. We checked the influence of consumption on the PMQ-LT scale (long term PM) score. The analysis shows that the model explained 13.1% of the variance ($F_{(1,28)}$= 4.213, MSE = 4.622, p = .05, see Table 3). The predictor variable for the first step was "years since starting cannabis" (t_{29}= -2.052, p = .05).

Table 3
Stepwise regression of the dependent variable PMQ-LT on the consumption of substance (calculated with subjects that have scores in these variables)

Step	Predictor Variable	B	Error	Beta	R^2	ΔR^2
Step 1	Cannabis years since starting	-.289	.141	-.362*	.131	.131

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

Next we checked the influence of substance use on the PMQ-scale IC (internally-cued PM) scores. Stepwise regression analysis shows that the model explained 18.4% of the variance ($F_{(1,28)}$= 6.297, MSE = 11.306, p <.05, see Table 4). The predictor variable for the first step was years since starting alcohol (t_{29}= -2.509, p < .05).

Table 4
Stepwise regression of the dependent variable PMQ-IC on the consumption of substance (calculated with subjects that have scores in these variables)

Step	Predictor Variable	B	Error	Beta	R^2	ΔR^2
Step 1	Alcohol years since starting	-.410	.163	-.428*	.184	.184

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

In order to know what substances explain performance in the experimental task, we conducted a stepwise regression analysis in which we tested the influence of the substances consumed on the performance of this test. On one hand, for the variable "correct in event-based prospective memory task" (block 1 of the photographs), the model explains 30.2% of the variance ($F_{(2,28)}$= 6.051, MSE = 192.663, p < .01, see Table 5). The predictor variable for the first step was "estimated quantity of alcohol" (t_{30}= -2.641, p < .05). The variable for the second step was "estimated quantity of alcohol" (t_{30}= -2.433, p < .05) and "alcohol years since starting" (t_{30}= -2.080, p < .05).

Table 5
Stepwise regression with the dependent variable "correct in event-based prospective memory task" on the consumption of substance (calculated with subjects that have scores in these variables)

Step	Predictor Variable	B	Error	Beta	R^2	ΔR^2
Step 2	Alcohol estimated quantity	.255	.105	.389 *	.302	.108
	Alcohol years since starting	-1.423	.684	-.332 *		

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

Next, for the variable "correct prospective timing task" (block 2 of the photos), the model explained 33.7% of the variance ($F_{(2,24)}$= 6112, MSE = 8786, p <.01, see Table 6). The predictor variable in the first step was "tranquilizers estimated quantity" (t_{26}= -2.374, p < .05). The variables in the second step were "tranquilizers estimated quantity" (t_{26}= -2.602, p < .05) and "tobacco estimated quantity" (t_{26}= -2.358, p < .05).

Table 6
Stepwise regression of the dependent variable "correct in time-based prospective memory" task on the consumption of substance (calculated with subjects that have scores in these variables)

Step	Predictor Variable	B	Error	Beta	R^2	ΔR^2
Step 2	Tranquilizers estimated quantity	-.104	.040	-.432*	.337	.153
	Tobacco estimated quantity	-.012	.005	-.392*		

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

Discussion and conclusions

In view of these results, we can conclude that for long-term self-report PM deficits in our sample years since inception in cannabis use predicted a considerable proportion of the variance (13.1%). That is, the earlier a user began, the greater their estimation of difficulties of this type of PM.

This result contrasts with that of Rodgers et al. (2001), where cannabis adversely impacted on the self-report short-term PM and internally-cued, but not with long term PM. One of the reasons why cannabis has the highest explained percentage of variance may be related to the fact that frequent consumption of this substance impairs attentional visual scanning (Ehrenreich, Rinn, Kunert, Moeller, Poser Schilling et al., 1999), which is related to the type of experimental task used in our study. Moreover, according to these authors, the early consumption of this substance predicts this decline on to a greater extent than other indicators.

These results also differ from the findings of Heffernan et al. (2005), because we have not found that the consumption of tobacco is the basis of performance in self-report long term PM. Ultimately, for this type of memory, our results, although obtained with a different methodology, showed that cannabis (years from beginning) also plays a negative role in the subjective self-report estimation by consumers on the functioning of their long term PM.

In the case of the self-reported deficits with internally-cued PM, the years since starting the consumption of alcohol explain the greatest percentage of variance (18.4%). This result is in agreement with those obtained by Heffernan et al. (2002) and Heffernan et al. (2006), who found that consumers of large quantities of alcohol showed global deterioration in PM scores as measured by the PMQ. Specifically, they had a much higher level of forgetfulness in internally-cued PM (in addition to those in the long and short term). However, this partly contradicts the findings of Rodgers et al. (2001), since the self-reported failures in internally-cued PM as measured by the PMQ in their study occurs in cannabis users, something that does not happen in our sample. As we see, cannabis, in our study, does not explain the variance of the internally-cued PM sub-scale.

From the two prospective experimental tasks, we can say that the performance in the event-based PM task is predicted by the estimated quantity of alcohol consumption and the years of consumption. We can conclude that the performance of the time-based PM task is predicted by the years of tranquilizers use and by the estimated quantity of tobacco consumed.

Heffernan et al. (2002), Ling et al. (2003), and Heffernan et al. (2006) have already demonstrated the detrimental effect of consuming large amounts of alcohol on self-reported PM. With our study there is evidence that the negative effects of alcohol on the PM have long-term cumulative effects, such that the negative effect on PM is the result of both the amount of alcohol ingested and the years of use. Our study shows, as Brunfaut, Vanoverberghe & d'Ydewalle (2000) did, the negative effect of alcohol is not only a self-perception, but it also impairs the objective experimental tasks. The result of which is that those who consume alcohol have more success in the event PM task (press the space-bar when there is more than one animal in the photograph) than those that drink less, which is counter-intuitive and unexpected, but could be consistent with the fact that younger subjects (such as the sample used in this study) have brains that are more resistant to the harmful effects of alcohol consumption. Thus, it appears that age has a significant influence on the ability of cognitive recovery after alcohol consumption, as it has been observed by Corral-Varela and Cadaveira (2002), Ellenberg, Rosenbaum, Goldman and Whitman (1980), and Goldman, Williams and Klisz, (1983). Age appears to play an important role in the degree of recovery (Munro, Saxton & Butters, 2000). The results of various investigations suggest that, until the age of 40, the brain is capable of recovering to normal levels from cognitive impairment caused by excessive consumption of alcohol. Beyond age 40, humans increase in vulnerability to the toxic effects of alcohol or are less able to compensate for impairment of the neurological substrate (Goldman, Williams & Klisz, 1983). The subjects of our study are young university students with moderate alcohol consumption and well-developed learning skills, which may explain this apparently contradictory result.

Rich et al. (2005) showed the negative effect of tranquilizers on prospective memory using one of the prospective memory tasks from the RBMT. Our study confirms this result by showing the detrimental effects of this drug, although only on the performance of the time-based PM task and not in the event-based PM task. This could be due to the fact that, while an event-based intention provides an external cue that serves as a signal to the memory of pending intention, time-based intentions require more effective self-initiated processes (Craik, 1986; Einstein & McDaniel, 1990) that might deteriorate further with the consumption of tranquilizers. Following Coull, Frith and Dolan (1999), one could speculate that diazepam may exert its effects on PM through pharmacokinetic changes in the frontal (executive functioning), that is most demanded in time-based prospective memory tasks.

The detrimental effect of tobacco on the PM task of times that we obtained is consistent with the findings of Heffernan et al. (2005), although that study deals with self-report intentional memory faults using the PMQ. However, we recognize that we did not check that participants did not use tobacco two hours prior to participating in the test, so these effects could be confounded with the positive effects of nicotine intake on PM to increase alertness, as was shown by Rusted et al. (2005).

In summary, we have found a relationship between the age of starting consumption of certain substances and both self-reported and objective evidence of reduced cognitive performance. These results are in line with those obtained by other studies such as Ehrenreich, Rinn, Kunert, Moeller, Poser, Schilling et al. (1999) that show how an earlier age of onset of regular consumption of psychoactive substances, such as cannabis, is associated with a deleterious effect on cognitive performance (attention).

Possibly, these results may be due to a population with greater cognitive reserve (Stern, Albert, Tang, & Tsal, 1999) such that the harmful effects of poly substance use is not captured in these tasks. There was no great deterioration in the executive processes measured or in the performance of PM tasks. Another possible explanation is that, as can be seen in the descriptive data, the sample used did not consume many substances or great quantities of them. Moreover, being so young, it means, with few years of consumption, demonstrates that the subjects do not objectively show the deterioration that they subjectively report. A third possibility is that the prospective tasks designed for this study are too easy and do not allow the effects to surface in the performance of such tasks. Finally, another possibility that should be kept in mind, although risky, is that no differences were found because there were really none; the subjects were aware that simply by consuming they have more damage and, thus, two subjects (one a consumer and the other not) with the same PM task error rate in real terms only differ in subjective perception. The consumer self-rates a worse performance, which would imply greater damage, but this is reflected only at the subjective level.

Since our sample is an unselected group of university students, the main drugs of interest reflect the drugs they have taken (alcohol, tobacco, and cannabis). Hence, these findings only reveal that the cognitive deficits are related to the drugs used by this particular sample. We recognize this weakness, and we realize that it would have been desirable to have a broader sample with a higher consumption of substances in order to further generalize the results. The differences between the samples of the studies reviewed in the introduction and our sample would be the basis of the differences in results. While these are limitations in the current study, we believe that this research presents an alternative methodological approach to the studies to date. It is an alternative, considering, among other reasons, the number of possible drugs combinations and study their effect on prospective memory.

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