Recreational cocaine use is associated with attenuated latent inhibition.

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Abstract

Introduction: Evidence has linked chronic cocaine use with various cognitive deficits; however few studies have investigated the effects of recreational (non-dependent) use. The present study aimed to assess whether recreational users show deficits in latent inhibition (LI: a measure of delayed learning of an association between 2 stimuli, one of which has been previously exposed (PE) without consequence and thus deemed irrelevant).

Methods: Using a quasi-experimental between groups design, recreational cocaine users (n = 21), poly-drug users (n = 17) and drug-naive controls (n = 18) were compared on a LI task. Questionnaires assessing psychological health and drug use were also completed.

Results: There was a statistically significant interaction between condition (PE vs non PE) and group (cocaine, polydrug and control); cocaine users scored lower in the PE condition compared to polydrug users and controls, indicating quicker learning.

Conclusions: Recreational cocaine users show attenuated LI reflecting reduced ability to filter out irrelevant stimuli enabling faster learning of a PE irrelevant and novel stimuli association. This does not appear to be a result of schizotypy and/or other drug use. Thus even at recreational levels, cocaine use may be sufficient to affect inhibitory attentional processes.

Keywords: recreational cocaine, latent inhibition, polydrug, attentional, inhibitory control

1. INTRODUCTION

Cocaine is the second most used substance in Europe after cannabis. Approximately 4 million people reported using cocaine in the last year, 2 million have used it in the last month (EMCDDA, 2011) and 6% of first time users are estimated to meet dependence within 5 years (Wagner and Anthony, 2007). Cocaine's status as a drug of privilege has been receding dramatically; increased trafficking infrastructure and decreasing purity have driven down prices (EMCDDA, 2008) precipitating a considerable increase in recreational consumption.

Clinical guidelines for classifying recreational cocaine use are absent (Smith et al, 2014) and researchers have used various definitions e.g. monthly use without dependence (Colzato and Hommel, 2009); >0.5g per month but not meeting dependence criteria (Vonmoos et al, 2013); intranasal use within the last year, but <10 occasions within the last month (Soar et al., 2012). Given the rapid increase in recreational (non-dependent use) as opposed to compulsive (dependent) use, it is surprising that the focus of most research assessing neuropsychological effects of cocaine have been on chronic (dependent) use (e.g. Verdejo-Garcia et al, 2006; Fillmore and Rush, 2002; Kubler et al, 2005). Only a handful of studies have explored the neuropsychological effects of recreational use (Colzato et al, 2007, 2009a, 2009b, Colzato and Hommel, 2009; Soar et al., 2012; Vonmoos et al, 2013; Sellaro et al, 2014) and with the exception of one study (Vonmoos et al, 2013), all have indicated inhibitory deficits. Colzato et al (2007) reported similar response inhibition deficits (in the stop-signal paradigm) in recreational cocaine users (monthly cocaine use, for a minimum of two years without dependence) relative to chronic users and the magnitude of this deficit was positively correlated with lifetime exposure.

Deficits in inhibitory input processes (i.e., attentional selection) have also been reported in recreational users (Colzato and Hommel; 2009) as measured by inhibition of return (a phenomenon that occurs when, immediately following an event at a peripheral location, responses are delayed for stimuli appearing at that cued location compared to stimuli appearing elsewhere). The magnitude of impairment in this case, however, was not related to lifetime cocaine exposure.

Latent inhibition (LI) is a similar inhibitory input process that refers to the unconscious cognitive mechanisms that ensures attentional resources do not become occupied with stimuli which past experience has shown to be irrelevant. It is an automatic process which prevents an organism from being overwhelmed by sensory and cognitive information. LI occurs after repeatedly presenting a stimulus that does not have any inherent value and is not followed by any important consequence (whether adverse or favourable). After repeated inconsequential presentations, that stimulus is subsequently deemed irrelevant. This suggests that pre-exposure (PE) to a stimulus without consequence results in a reduction in its subsequent processing, and this reduction retards the learning of later associations between it and another stimuli. LI is illustrated by the reduced ability to acquire a new association to a stimulus that has previously been deemed irrelevant by comparison with a novel stimulus. Attenuated or absent LI reflects a weakening of associative learning following a stimulus which has had no consequence associated with it.

The current study was designed to explore potential disruptions in LI in recreational cocaine users whilst controlling for other drug use and trait schizotypy. Given the high rate of polydrug use among recreational drug users (e.g. Kelly and Parsons, 2008; Grov et al., 2009), isolating the effects of cocaine on LI is a difficult task. To minimize polydrug effects a

control group of non-cocaine users who report the use of other drugs except cocaine (polydrug users) as well as a drug-naive (control) group were employed. Elevated levels of schizotypy (a continuum of personality characteristics and experiences ranging from normal dissociative, imaginative states to extreme states related to psychosis) have previously been reported in recreational cocaine users (Soar et al, 2012) and schizotypy itself has been associated with disrupted LI (e.g. Lubow and De la Casa, 2002; Tsakanikos et al, 2003; Tsakanikos and Reed, 2004). Thus schizotypy is a potential confound that needs to be taken into consideration when assessing LI in recreational cocaine users. It is hypothesised that recreational cocaine users will show attenuated LI (i.e. lower scores in the PE condition) compared with non-cocaine poly-drug users and drug-naive controls. Performance on the NPE condition is generally homogenous for all participants (Braunstein-Bercovitz and Lubow, 1998), so no significant group differences are expected here.

2. METHODS

2.1 Design

A quasi-experimental between groups design, with two independent variables: group (cocaine, polydrug, controls) and LI condition (pre-exposed [PE] or non-pre-exposed [NPE]). The dependent variable is the score (number of trials required to detect contingency rule) on the LI task.

2.2 Participants

2.2.1 Cocaine Users: Twenty one recreational cocaine users (i.e. used intranasally within the last 6 months, but no more than 5 times within the last month) (12 male, 9 female; mean age: 24.43±2.09 years*)* were required to refrain from cocaine use for at least one week prior to the

study. Use of other recreational drugs (excluding cannabis and alcohol) was defined by the same parameters (see table 1).

2.2.2 Polydrug Users: Seventeen polydrug users (8 male, 9 female; mean age: 24.12±2.52 years) reporting no cocaine use but use of other recreational substances were recruited as a drug comparison group.

2.2.3 Controls: Eighteen drug-naive individuals (6 male, 12 female; mean age: 28.89±8.04 years) who reported no-drug use within the last year except for nicotine and alcohol were recruited as a control group.

Participants were recruited via word of mouth, through the researchers' social networks and through advertising around the University of East London (UEL). Exclusion criteria were: 1) current use of psychiatric medication or medication for epilepsy, 2) current treatment for any psychological problem or substance/alcohol dependency, 3) head injury, 4) pregnancy, 5) drug and alcohol use at the time of testing (confirmed via Quantum Diagnostics Oral Fluid Test). All participants gave written informed consent, received no remuneration, and the study was approved by the UEL Ethics Committee.

2.3 Questionnaire Measures:

All participants provided demographic details, information regarding personal and family psychiatric histories and completed the well utilised UEL drug use questionnaire (Parrott et al, 2000) to assess drug use within the last 6 months, with additional questions pertaining to patterns of cocaine use and associated subjective effects

Cocaine dependence was measured using the Severity of Dependence Scale (SDS) a reliable, valid scale, with good internal consistency (Gossop et al, 1995). The SDS is a 5-item questionnaire with each item rated on a 4-point scale; 'never', 'sometimes', 'often' and 'nearly always', with scores awarded from 0-3 respectively. Total scores therefore ranged from 0-15, with an overall score of 4 or more indicating cocaine dependence. Participants then completed the following assessment measures in the order presented below.

2.3.1 The Brief Symptom Inventory (BSI; Derogatis, 1993): A reliable and valid (Tate et al, 1993) 53-item questionnaire measuring psychological distress and psychiatric symptoms. Participants indicated the extent to which they agreed with each statement on a 5-point Likert scale ranging from 'not at all' (scored 0) to 'extremely' (scored 4). As well as a total BSI score, there are 9 subscales; Somatisation, Obsessive-Compulsive, Interpersonal Sensitivity, Depression, Anxiety, Anger/Hostility, Phobic Anxiety, Paranoid Ideation and Psychotism.

2.3.2 The Brief Schizotypal Personality Questionnaire (SPQ-B: Raine and Benishay. 1995): A widely used scale with sound psychometric properties, this 22 item questionnaire measures schizotypal traits using a yes/no response, with scores awarded for every 'yes' response. As well as a total score, the scale comprises 3 subscales; cognitive perceptual, interpersonal and disorganized schizotypy. A higher score indicates higher schizotypal proneness.

2.4 National Adult Reading Test (NART-R; Nelson and Willison, 1991):

The NART is a widely used measure of premorbid verbal IQ, which has been demonstrated to correlate highly with IQ scores on the WAIS (Weschler Adult Intelligence Scale) in the range of 0.72 - 0.81 (Lezak, 1995). Participants are required to pronounce a list of 50 English words which do not follow a typical phonetic pattern; correct pronunciation therefore relies

on a knowledge of the word. Responses are scored as 'correct' or 'incorrect' and a total score reflects the number of words pronounced correctly.

2.5 Latent Inhibition (LI) Task:

The LI task was developed from Serra et al (2001) and was presented on a Toshiba Satellite Pro laptop. The task consisted of 2 stages. In stage 1, all participants were presented with an audio recording (via Sony headphones) of a series of nonsense syllables (e.g. yak or gak; 70-78dB) that repeated five times in fixed order. They were instructed to pick any syllable and count how many times it was repeated. This masking task lasted approximately 5 minutes. In the pre-exposed (PE) condition, the nonsense syllables were randomly superimposed with 25 bursts of white noise (the conditioned-stimulus; CS). In the non pre-exposed (NPE) condition, the nonsense syllables were identical but unaccompanied by any other sound. The bursts of white noise varied randomly between five intensities (range: 64±76 dB) and five durations (range: 1±3 seconds), and were presented at inter-stimulus intervals randomly varying between 2±22 seconds (Serra et al., 2001). Computer and headphone volume were kept consistent for all participants throughout the study.

In Stage 2 (test phase), participants in both the PE and NPE conditions were again presented with the audio recording of nonsense syllables, but were also presented with a counter display and asked to predict when the counter increased, by clicking a mouse. Increments (the unconditioned-stimulus; UCS) always followed the CS (white noise) for all participants, and conditioning was measured by the number of trials taken to detect this contingency rule. The learning criterion was defined as five consecutive correct responses (i.e. a button press within

the duration of a CS presentation response) (Serra et al, 2001). The test phase ended when either the learning criteria was met or the counter reached 21 (the maximum possible score).

2.6 Data Analysis

All data was processed and analysed using the Statistical Package for Social Science (SPSS) version 20 in Windows Vista. Chi-square analyses were conducted on categorical demographic and drug use data and an ANOVA used for continuous variables. Where there were significant group effects, post hoc tests were conducted; Bonferroni where variances were assumed and Games-Howell where they were not. An ANOVA was conducted on the LI data, with two between factors: group (cocaine, polydrug and controls) and condition (PE and NPE). Using t-tests, further planned comparisons between groups were conducted on the PE data; the critical comparisons here are cocaine v control and cocaine v polydrug. One-tailed tests were reported for all LI analyses given the clear directional hypotheses, with the threshold for statistical significance for all main effects set at $p<0.05$. Further exploratory Pearsons correlations were conducted between LI total scores and schizotypy scores (total and individual subscales) separately for each group. The threshold for statistical significance for these exploratory correlations was set at the Bonferroni corrected level of $p<0.004$ (0.05/12) to limit the possibility of type 1 errors given the number of comparisons.

3. RESULTS

3.1 Participant Characteristics and Psychological Health

There were no significant differences in the number of participants in each group by gender [$\chi^2(2) = 2.21$, $p=0.331$], ethnicity [χ^2 (10) = 7.821, $p=0.643$] or education [$\chi^2(6) = 4.18$,

p=0.652], nor was there any significant difference in predicted premorbid intelligence as measured by NART [F(2,53)=2.68, p=0.078]. There was a significant group difference in age [F(2,53)=5.33, p=0.008], with controls being significantly older than both cocaine and polydrug users ($p<0.05$). See Table 1.

3.1.1 Psychological Health: There were group differences in the number of participants reporting a psychiatric history of anxiety [$\chi^2(2) = 8.18$, p=0.017] and depression [$\chi^2 (2) = 9.36$, p=0.009], but no other mental health diagnoses. 29% (n=6) of the cocaine users, none of the polydrug users and 6% (n=1) of the controls reported a previous history of anxiety. 43% (n=9) of the cocaine users, 12% (n=2) of the polydrug users and 6% (n=1) of the controls reported a pervious history of depression. There were no group differences in the number of participants reporting any family history of psychiatric problems (all ps >0.05), or on total SPQ-B [F(2,53)=1.24, p=0.298] or the SPQ-B subscales (all p's>0.05), except for the SPQ Disorganised subscale [F(2,53) = 7.74, p=0.001]. Here controls reported significantly lower levels relative to cocaine users (p=0.007) and polydrug users (p=0.002). Total BSI and individual subscales scores did not differ between groups (p's>0.05).

3.2 Drug use data

Table 2 summarises patterns of cocaine use. Cocaine users, on average, reported that they started using at the age of 18 and used on 1.19 occasions within the last month, spending an average of £44.05 per session, consuming 0.94grams per session. The average SDS (0.81), indicates the sample are recreational users, with no participants meeting the cut-off for cocaine dependence.

There were significant group differences in Ecstasy use [F(2,53)=7.34, p=0.002], monthly Cannabis use [F(2,53)=10.76, p≤0.001], duration of cannabis use [F(2,53)=28.63, p≤0.001] and days since alcohol consumption [F(2,53) = 3.62, p=0.034]. Post hoc t-tests indicated that ecstasy use was significantly higher in the cocaine and polydrug users, and monthly cannabis use was significantly higher in polydrug users compared to both cocaine users and controls (all p's<0.05). Time since last used cannabis was also significantly shorter in polydrug users versus cocaine users and controls, and between cocaine users and controls (all p's<0.05). Days since alcohol consumption no longer reached significance in post hoc tests. See Table 3.

3.3 Latent inhibition task performance

As illustrated in Figure 1, there was no main effect of condition [F(1,50) = 0.983, p=0.326], or group [F(2,50) = 1.602, p=0.212], but the hypothesised interaction was borne out [F(2,50) = 4.305, p 0.01]. Planned comparisons revealed that cocaine users scored significantly lower in the pre-exposed condition compared to polydrug users [t(17)=-3.40, p=0.002] and controls [t(19) = -1.93, p = 0.035] indicating a quicker ability to learn the association. There was no significant difference in scores between controls and polydrug users. [t(16)=1.49, p =0.08].

3.4 Correlations between LI and Schizotypy

There were no significant correlations between LI scores and total or sub-scale SPQ-B scores, in any of the three groups (all p's >0.01).

Table 1: Participant characteristics, NART, SPQ-B and BSI measures in recreational cocaine users, polydrug users and controls

	Cocaine	**Polydrug**	**Controls**
Age	24.43(2.09)	24.12(2.52)	28.89(8.04)*
Gender (M/F)	12/9	8/9	6/12
Ethnicity % (n)			
White	76 (16)	94 (16)	78 (14)
Black	10 (2)	-	11(2)
Asian/Chinese	5 (1)	-	12 (2)
Mixed ethnicity	5 (1)	6 (1)	-
Other	5 (1)	-	-
Highest educational achievement %(n)			
A-level	5 (1)	24 (4)	11 (2)
NVQ	5 (1)	-	6 (1)
Degree	67 (14)	59 (10)	56 (10)
Postgraduate	10 (2)	18 (3)	28 (5)
NART	108.52(10.39)	115.29(8.34)	113.72(9.60)
SPQ-B Total	6.62(3.93)	8.18(4.61)	6.00(4.13)
Cognitive Perceptual	1.62(1.75)	2.59(2.03)	2.17(2.07)
Interpersonal	2.52(1.89)	2.53(2.07)	2.09(1.95)
Disorganised	2.48(1.57)	3.06(1.89)	1.06(1.16)**
BSI Total			
Somatisation	3.76(3.82)	4.34(3.01)	3.28(0.32)
Obsessive-compulsive	7.48(4.37)	7.00(2.76)	6.28(3.86)
Interpersonal	3.71(3.21)	3.94(2.44)	3.89(2.49)
Depression	5.62(4.39)	5.24(3.47)	5.00(4.89)
Anxiety	4.67(2.83)	3.29(2.20)	4.00(3.83)
Anger	3.19(2.32)	3.06(2.16)	2.83(2.98)
Phobic anxiety	1.86(2.63)	1.31(1.74)	1.11(1.45)
Paranoid Ideation	3.48(2.91)	3.06(2.28)	3.56(3.03)
Psychotism	2.95(2.18)	2.47(1.62)	2.06(3.00)
Additional Items	4.10(2.77)	4.06(2.14)	3.44(2.55)

*$p \leq 0.05$, ** $p \leq 0.001$

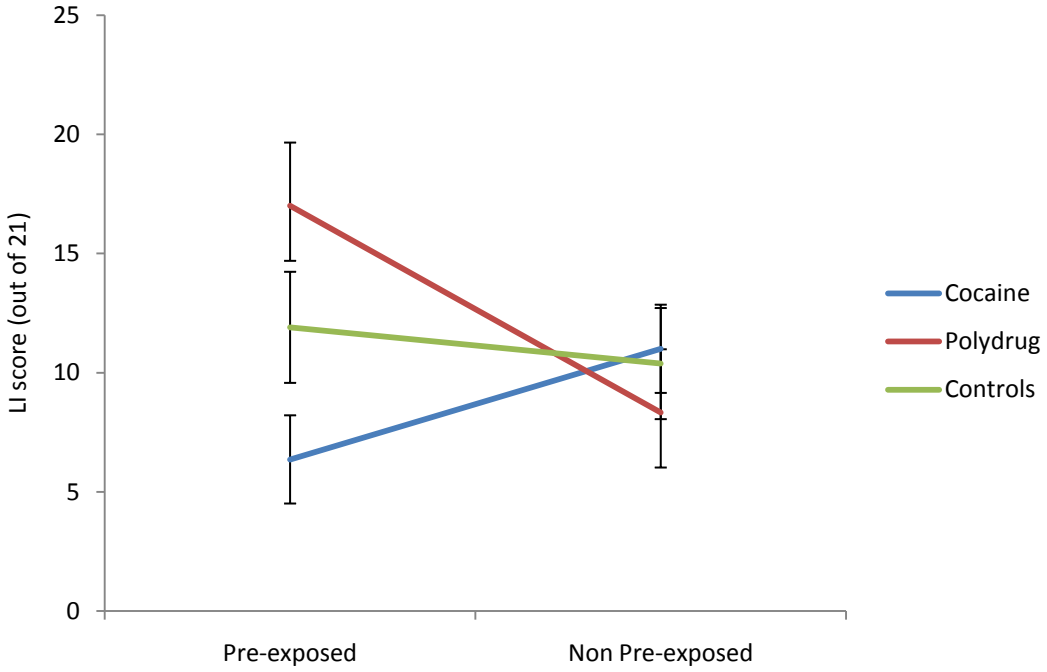
Table 2: Patterns of cocaine use reported by the recreational cocaine users

	Mean (SD)	**Range**
First age of cocaine use (years)	18.38 (3.09)	15-29
Last cocaine use (months)	1.76 (1.55)	0-5
Instances of cocaine use (last month)	1.19 (1.54)	0-4
Instances of cocaine use (last year)	12.05 (11.94)	1-50
Instances of cocaine use (lifetime)	73.33 (82.18)	10-300
Cocaine consumed per session (g)	0.94 (0.56)	0-2
Money spent per session (£)	44.05 (25.67)	0-100
SDS total	0.86 (1.28)	0-4
	N	**%**
Frequency of Use		
Weekly	1	5
Monthly	9	43
Every 3 Months	10	48
Yearly	1	5

Table 3: Mean (SD) number of reported recreational drug use within the last 6 months – aside from cannabis (monthly), tobacco (daily) and alcohol (weekly)

Substance	**Cocaine (C)**	**Polydrug (P)**	**Control (N)**	**P**	**Post Hoc (p<0.05)**
Ecstasy / MDMA	1.38 (2.13)	4.24 (5.57)	-	0.002	C & P > N
Amphetamine	0.62 (1.40)	0.18 (.53)	-	0.096	-
LSD	0.10 (0.44)	0.76 (1.99)	-	0.098	-
Psilocybin (magic mushrooms)	0.14 (0.48)	0.35 (1.00)	-	0.250	-
Amyl Nitrate (poppers)	0.14 (0.48)	0.12 (0.33)	-	0.409	-
Ketamine	0.81 (1.17)	5.76 (14.68)	-	0.083	-
γ-Hydroxybutyric acid (*GHB*)	1.52 (6.10)	5.94 (24.24)	-	0.425	-
Prozac	0.05 (0.22)	-	-	0.442	-
Crack cocaine	-	-	-	-	-
Opiates	0.05 (0.22)	-	-	0.442	-
Benzodiazepine	0.67 (2.01)	0.47 (1.12)	-	0.318	-
Steroids	-	-	-	-	-
Solvents	0.38 (1.24)	-	-	0.215	-
Mephedrone	-	1.76 (5.09)	-	0.105	-
2 C-B	0.10 (0.30)	0.06 (0.24)	-	0.432	-
Cannabis use					
Per month	4.47 (8.62)	22.00 (25.22)	-	<0.001	P>C & N
No. years	5.00 (4.82)	8.24 (2.25)	0.17 (0.71)	<0.001	N>C>P
Days since last used	10.95 (25.40)	7.71 (11.49)	60.56 (184.09)	0.275	
Tobacco / cigarettes					
Per day	10.20 (25.40)	5.20 (11.49)	4.00 (5.70)	0.061	-
Hours since last used	2.83 (2.50)	7.69 (9.87)	55.61 (124.88)	0.103	
Alcohol					-
Units per week	16.95 (9.85)	16.82 (11.26)	11.56 (8.57)	0.180	
Days since last used	2.29 (1.76)	2.18 (1.67)	4.29 (3.96)	0.034	-

Figure 1: Mean Latent Inhibition scores (out of 21) by condition (pre-exposed and non pre-exposed) for each group; cocaine, polydrug and control.



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4. DISCUSSION

Inhibitory deficits have been previously demonstrated in both chronic and recreational cocaine users (e.g. Fillmore and Rush, 2002; Colzato and Hommel, 2009). The current study aimed to further explore inhibitory performance by comparing recreational cocaine users with non-cocaine poly-drug users and drug-naive controls on latent inhibition (a measure of associative learning). The findings supported the hypothesis that recreational cocaine users performed comparatively better (achieving a lower LI score) than the other two groups in the PE condition (i.e. learn the association quicker); demonstrating attenuated LI. Moreover, attenuated LI did not appear to be influenced by psychological health or schizotypal traits (as indicated by the lack of group differences and/or correlations between these variables).

These findings support the emerging literature that recreational cocaine use impairs inhibitory attentional processes (Colzato et al, 2007; Colzato and Hommel, 2009), an effect which is well documented in dependent users (Verdejo-Garcia et al, 2006; Fillmore and Rush, 2002; Kubler et al., 2005). LI operates as an automatic attentional maintenance process which prevents one from being overwhelmed by sensory and cognitive information, as such, it constitutes a vital aspect of efficient cognitive functioning. Attenuated LI, therefore suggests potential for wider cognitive difficulties (Lubow and Gewirtz, 1995) and such deficits have indeed been documented in recreational cocaine users (Soar et al, 2012), akin to those seen in chronic dependent users (Spronk et al, 2013).

Whilst the present results are suggestive of a direct effect of recreational cocaine use on associative learning there are other possible explanations. For example, the groups differed on age with controls being significantly older. However, studies in both animals and humans suggest LI (and indeed other inhibitory functioning) may decrease with age (e.g. Shalev et al, 1998; Serra et al, 2001; Charlot and Feyereisen, 2004,) thus this observation actually strengthens the conclusion that cocaine use, rather than age, is affecting LI.

Schizotypy in the normal population has been associated with inhibitory functioning (e.g. Migo et al, 2006; Taskanikos and Reed, 2004), and LI is reduced in participants scoring high on schizotypal dimensions (Gray et al, 2002). Although the recreational cocaine users did score higher on the disorganised schizotypy sub-scale, correlational analyses failed to indicate a relationship between schizptpy and LI scores, thus it is unlikely that the higher levels of disorganised schizotypy in cocaine users contributed to the attenuated LI.

All participants in the recreational cocaine group met the delineated criteria for recreational use: using between once a month and every 3 months, and on average one gram on each occasion. This level of usage is comparable to other studies assessing recreational cocaine users (Colzato et al., 2007, 2009a, 2009b; Soar et al, 2012). With no clinical guidelines for classifying recreational cocaine use (Smith et al, 2014), one advantage of the current study is the utilisation of a brief screening measure which eliminates psychological dependence on cocaine (the SDS) although it is acknowledged that these findings are based on self-report.

A common problem in recreational drug research is polydrug use (the use of more than one drug), thus isolating the effects of cocaine (or any other single drug) can be a challenge. A strength of the current study was the employment of a polydrug using control group, (in addition to a non-drug using group), which aimed to reduce this possible confound. Whilst other drug use was reported by cocaine users they differed from the polydrug control group only on cannabis use (per month and number of years). Interestingly, the polydrug group reported higher cannabis use relative to cocaine users (and controls), and both drug using groups reported similar levels of ecstasy (MDMA). It is therefore highly unlikely that polydrug use in the cocaine users accounted for the attenuated LI. Furthermore, previous evidence has demonstrated that cocaine is a better predictor of inhibitory control deficits than cannabis and MDMA use (Verdejo-Garcia et al, 2005).

Although drug abstinence prior to task administration was objectively verified, the study does rely on self-report data of past drug use. However, self report and objective indices of drug use in previous studies have shown strong associations (e.g. Glintborg et al, 2008; Basurto et al, 2009). Nevertheless, it is possible that constituents other than cocaine may have contributed to the observed effect. The purity of cocaine has been in decline, with purity

levels down to 20% in 2009 (EMCDDA, 2011). Cocaine is often 'cut' with other substances such as lidocaine and caffeine (EMCDDA, 2010) which could have contributed to the effects observed in the cocaine users. In addition, participants in the current study reported relatively high weekly alcohol consumption (approximately 16 units per week in both cocaine and polydrug using groups) and the co-administration of alcohol and cocaine has been shown to produce cocaethylene (Farre et al, 1993), a psychoactive metabolite with toxic effects similar to cocaine (McCance et al, 1995). Thus it is plausible that the cocaine users' LI performance could be due to cocaethylene rather than cocaine, or indeed a combination of both.

Regardless of the exact mechanisms, the present study has shown that recreational levels of cocaine use may be sufficient to affect inhibitory control processes. In the present sample, these alterations did not appear to be mediated by other drug use or psychological health. These findings are consistent with the emerging literature suggesting subtle differences in neuropsychological functioning in non-dependent, recreational cocaine users. If reduced LI impairs the ability to filter out irrelevant information and to learn what is important, there are further implications for decision making, risk taking and impulsive behaviours in recreational cocaine users.

5. REFERENCES

Basurto FZ, Montes JMG, Cubos PF, Santed FS, Ríos FL, Moreno AM (2009) Validity of the self-report on drug use by university students: Correspondence between self-reported use and use detected in urine 21(2):213-219

Braunstein-Bercovitz H, Lubow, R. (1998) Are high-schizotypal normal participants distractible of limited in attentional resources? A study of latent inhibition as function of masking task load and schizotypal level? Journal of Abnormal Psychology, 107 (4): 659-670.

Charlot V, Feyereisen P (2004). Aging and the deletion of function of inhibition. Aging, Neuropsychology and Cognition, 11(1):12-24.

Colzato L, Hommel B. (2009) Recreational Use of Cocaine Eliminates Inhibition of Return. Neuropsychology, 23 (1): 125-129

Colzato L, Huizinga M, Hommel B (2009a) Recreational cocaine polydrug use impairs cognitive flexibility but not working memory. Psychopharmacology. [Online] Available from from http://bernhard-hommel.eu/Coke_Flex_WM.pdf Accessed 14 Jan 2011

Colzato L, Van den Wildenberg W, Hommel B (2007) Impaired Inhibitory Control in Recreational Cocaine Users. PLoS ONE, 2 (11): e1143. Available via http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0001143 Accessed 14 Jan 2011

Colzato L, Van den Wildenberg W, Hommel B (2009b) Reduced Attentional Scope in Cocaine Polydrug Users. PLoS ONE, 4 (6): e6043. [Online] Available from http://www.ncbi.nlm.nih.gov/pubmed/19557181 Accessed 14 Jan 2011

Derogatis L (1993) Brief Symptom Inventory: Administration, scoring, and procedures manual. Minnesota: National Computer Systems.

EMCDDA (2008). Monitoring the supply of cocaine to Europe. Available via http://www.emcdda.europa.eu/publications/technical-datasheets/cocaine-trafficking Accessed 22 May 2011

EMCDDA (2010) Annual Report 2010: The State of the Drugs Problem in Europe. European Monitoring Centre for Drugs and Drug Addiction. Luxembourg: Publications Office of the European Union.

EMCDDA (2011) Statistical bulletin 2011: General population surveys. Available via http://www.emcdda.europa.eu/stats11/gps Accessed 22 May 2011

Farré M, de la Torre R, Llorente M, Lamas X, et al (1993) Alcohol and cocaine interactions in humans. The Journal of Pharmacology and Experimental Therapeutics 266(3): 1364-1373

Fillmore M, Rush C (2002) Impaired inhibitory control of behaviour in chronic cocaine users. Drug and Alcohol Dependence, 66 (3): 265-273

Glintborg B, Olsen L, Poulsen H, Linnet K, Dalhoff K (2008) Reliability of self-reported use of amphetamine, barbiturates, benzodiazepines, cannabinoids, cocaine, methadone, and opiates among acutely hospitalized elderly medical patients. Clinical Toxicology 46(3):239-242

Gossop M, Darke S, Griffith P, Hando J, Powis B, Hall W, Strang J (1995) The Severity of Dependence Scale (SDS): psychometric properties of SDS in English and Australian samples of heroin, cocaine and amphetamine users. Addiction, 90 (5): 607-614

Gray N, Fernandez M, Williams J, Ruddle R, Snowden R (2002) Which schizotypal dimensions abolish latent inhibition? British Journal of Clinical Psychology, 41 (3): 271-284

Grov C, Kelly BC, Parsons JT (2009) Polydrug Use Among Club-Going Young Adults Recruited Through Time-Space Sampling, Substance Use & Misuse 44(6):848-864

Kelly BC, Parsons JT (2008) Predictors and Comparisons of Polydrug and Non-Polydrug Cocaine Use in Club Subcultures American Journal of Drug & Alcohol Abuse 34(6): 774-781

Kubler A, Murphy K, Garavan H (2005) Cocaine dependence and attention switching within and between verbal and visuospatial working memory. European Journal of Neuroscience, 21 (7): 1984-1992

Lezak MD (1995) Neuropsychological Assessment. 3rd Ed. Oxford University Press; Oxford.

Lubow R, De la Casa G (2002) Latent inhibition as a function of schizotypality and gender: implications for schizophrenia. Biological Psychology, 59 (1): 69-86

Lubow R, Gewirtz J (1995) Latent inhibition in humans: data, theory, and implication for schizophrenia. Psychology Bulletin, 117 (1): 87-103

Migo EM, Corbett K, Graham J, Smith S, Tate S, Moran PM, Cassaday HJ (2006) A novel test of condition inhibition correlates with personality measures of schizotypy and reward sensitivity. Behavioural Brain Research 168(2): 299-306

Nelson H, Willison J (1991) National Adult Reading Test Manual (2nd ed) Windsor: NFER-Nelson.

Parrott, AC, Sisk, E, Turner, JJD (2000) Psychobiological problems in heavy 'ecstasy' (MDMA) polydrug users. Drug Alcohol Dependence 60: 105–110.

Raine A, Benishay D (1995) The SPQ-B: A brief screening instrument for schizotypal personality disorder. Journal of Personality Disorders, 9 (4): 346-355

Sellaro R, Hommel B, Colzato LS (2014). Increased response conflict in recreational cocaine polydrug users. Experimental Brain Research, 232(1): 113-119.

Serra A, Jones S, Toone B, Gray J (2001) Impaired associative learning in chronic schizophrenics and their first-degree relatives: A study of latent inhibition and the Kamin blocking effect. Schizophrenia Research, 48: 273-289

Shalev U, Feldon J, Weiner I (1998) Gender- and Age-dependent differences in latent inhibition following pre-weaning non-handling: implications for a neurodevelopmental animal model of schizophrenia. Int. J. Devl. Neuroscience. 16(3/4):279-288.

Smith DG, Jones PS, Bullmore ET, Robbins TW, Ersche KD (2014) Enhanced orbitofrontal cortex function and lack of attentional bias to cocaine cues in recreational stimulant users. Biol Psychiatry 75(2):124-31

Soar K, Mason C, Potton A, Dawkins L (2012) Neuropsychological effects associated with recreational cocaine use. Psychopharmacology: 222(4): 633-643

Spronk DB, van Well JHP, Ramaekers JG, Verkes RJ (2013) Characterizing the cognitive effects of cocaine: a comprehensive review. Neuroscience and Biobehavioural Reviews, 37: 1838-1859

Tate D G, Forchheimer M, Maynard F, Davidoff G, Dijkers M (1993) Comparing two measures of depression in spinal cord injury. Rehabilitation Psychology, 38(1): 53-61

Tsakanikos E, Reed P (2004) Latent inhibition and context change in psychometrically defined schizotypy. Personality and Individual Differences, 36 (8): 1827-1839

Tsakanikos E, Sverdrup-Thygenson L, Reed P (2003) Latent inhibition and psychosis-proneness: visual search as a function of pre-exposure to the target and schizotypy level. Personality and Individual Differences, 34 (4): 575-589

Verdejo-Garcia, A, Bechara A, Recknor E, Perez-Garcia M (2006) Executive dysfunction in substance dependent individuals during drug use and abstinence: An examination of the behavioural, cognitive and emotional correlates of addiction. Journal of the International Neuropsychological Society, 12: 405-415

erdejo- arc a A, López-Torrecillas F, Aguilar de Arcos, F, Pérez- arc a M (2005) Differential effects of MDMA, cocaine, and cannabis use severity on distinctive components of the executive functions in polysubstance users: A multiple regression analysis Addictive Behaviors, 30:89-101

Vonmoos M, Hulka LM, Preller KH, Jenni D, Baumgartner MR, Stohler R, Bolla KI, Quednow BB (2013) Cognitive dysfunctions in recreational and dependent cocaine users: role of attention-deficit hyperactivity disorder, craving and early age at onset. The British Journal of Psychiatry, 203:35-43

Wagner FA, Anthony JC (2007) Male–female differences in the risk of progression from first use to dependence upon cannabis, cocaine, and alcohol. Drug and Alcohol Dependence 86 : 191–198