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Does Alcohol Drinking Behaviour in First Year Students Relate to Executive Function Performance Under Stress?

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ABSTRACT

Executive Function (EF) is a mental process which involves the ability to plan and control behaviour; an important function for university students as it is linked to academic outcomes. Stress and alcohol drinking behaviour have previously been found to impact negatively upon executive function yet the combined effects of both of these factors has not been widely investigated. The present study aimed to investigate the relationship between alcohol drinking behaviour in first year undergraduate students and scores on a test of EF measuring aspects of working memory and cognitive fluidity after acute psychological stress was induced. Through experimental design 30 participants were recruited using opportunity sampling and asked to provide information about an average month of alcohol drinking. Stress was then induced through a task with time and performance elements provoking a stress response. EF was then assessed using the trail making task - a neuropsychological test of EF. Stress was measured subjectively and through the physiological measures of electro-dermal activity and heart rate in rest and throughout the stress procedure. Inconsistent with previous research the present study indicated no relationship in the whole sample, yet a positive correlation emerged in the male participants suggesting the more alcohol they consumed in an average month the worse they performed on a test of EF in stress. Future research needs to consider how results might vary dependant on year of study and type of stress.

KEY WORDS:	EXECUTIVE FUNCTION	STRESS	ALCOHOL DRINKING BEHAVIOUR	ELECTRO-DERMAL ACTIVITY

Introduction

Executive function (EF) refers to a group of mental processes required for concentration and attention (Diamond, 2013). EF is involved in the control and planning of behaviour, thus requiring effort. There is a general agreement on three core EF's: inhibition, working memory (WM) and cognitive fluidity (Miyake et al., 2000). EF's have been attributed to different neural substrates of the brain in particular the prefrontal cortex (Alvarez & Emory, 2006), an area of the brain linked to academic outcomes (Best et al., 2011) and therefore of key importance to learning.

The research surrounding the combined effects of alcohol drinking behaviour and stress on EF is limited. The current study is centred on the combination of two separate lines of research: firstly, the impact of alcohol drinking behaviour on EF, and secondly the impact of stress on EF is considered. Then the combination of effects is explored and long term implications considered.

Alcohol drinking behaviour has been shown to have a large impact on all aspects of EF including WM, cognitive fluidity and response inhibition, with research showing that increased alcohol intake has a relationship with reduced EF (Townshend & Duka, 2005; Scaife & Duka, 2009; Lyvers & Tobias-Webb, 2010; Houston et al., 2014). Research has used different tests to assess EF, but all tested for the components of WM and cognitive fluidity using various tools that assessed alcohol drinking behaviour.

The literature discusses gender differences with regard to the relationship between alcohol drinking behaviour and EF. Rodgers et al. (2005) found men classed as harmful/hazardous drinkers performed significantly worse on a WM task than harmful/hazardous female drinkers. Scaife and Duka (2009) found functions linked to dorsolateral prefrontal cortex (PFC) may be more impaired in women, while functions attributed to the temporal lobe may be equally impaired in male and female binge drinkers. Gender differences observed in the literature with regards to the adverse impact of drinking behaviour on EF are inconclusive. This may be due to the range of tests used to investigate EF performance and the differences in alcohol drinking behaviour observed. For example Rodgers et al. (2005) found differences only when drinking was classed as hazardous/harmful, and no differences when participants were light drinkers, while Scaife and Duka (2009) found differences in participants classed as binge drinkers.

Increasing awareness of the drinking culture associated with university life has led to research interest in this area, with Ray et al. (2012) investigating protective and risk alcohol drinking behaviours in first year American college students using self-report methods. They found the majority of participants participated in risk alcohol drinking behaviour, such as participation in pre-gaming/preloading; defined as consuming alcohol before going to a social event which is also often alcohol orientated, or drinking games. Students participating in these behaviours report higher levels of alcohol drinking behaviour or 'binge drinking' (Pedersen and LaBrie, 2007). Binge drinking is defined as heavy episodic drinking to the level of 0.08 in blood alcohol concentration, defined as 4 or more alcoholic drinks for females, and 5 or more for males in a two-hour estimated period (Wechsler et al,. 1995). The World Health Organisation (2014) report that 28% of the UK population binge drink, and it is most prevalent in young adults. Student drinking has been found to impact upon academic performance, is linked to engaging in risky sexual behaviour and later alcohol dependence (Grant & Dawson, 1997; Vik et al., 2000; Jennison, 2004).

The effects of student drinking behaviour on EF has been investigated in the literature (Weissenborn & Duka, 2003; Piechatzek et al., 2009; Parada et al., 2012; Gil-Hernandez & Garcia-Moreno, 2016), indicating that students who consume more alcohol and report binge-drinking behaviour performed worse on tests of EF, compared to students reporting lower levels of these behaviours. With a student sample, it is important to consider other factors that can affect EF, such as the use of other substances. Piechatzek et al. (2009) found that while substances such as ecstasy have a big impact upon EF, the effects of alcohol consumption and cannabis use are limited to that of increased impulsive personality traits. In contradiction, other research has demonstrated that alcohol drinking behaviour negatively affects behavioural aspects of EF in students, even when exclusion criteria have been put in place for use of other substances (Gil-Hernandez and Garcia-Moreno, 2016).

As well as drinking behaviour, stress also has adverse effects on EF. Stress creates a range of immediate physiological changes that are in the body; physiological changes then contribute to cognitive functioning (McEwen and Sapolsky, 1995). Animal research has investigated the effect of stress on EF; Arnsten and Goldman-Rakic's (1998) monkey experiment investigated the effects of mild stress on cognitive function in a spatial WM task. Findings suggest increased stress equates to reduced scores on spatial WM performance. Arnsten and Goldman-Rakic (1998) suggest this reduction in performance is due to a hyperdopinergic mechanism whereby stress increases levels of the neurotransmitter dopamine in the PFC. They found that by blocking dopamine receptors with a pre-treatment drug prior to testing, the stress induced deficit in WM could be reversed. This demonstrates how changes in the balance of neurotransmitters due to stress can alter EF. This is proposed to as a survival mechanism as the PFC is taken 'offline', allowing automatic responses to take over and act on the stressor. The effect of stress on PFC activity related to EF may depend on the nature of the stress; mild acute stress has been stated to cause a dramatic loss in PFC ability yet prolonged stress exposure can cause changes in PFC dendrite structure, causing long term damage to cognitive function (Arnsten, 2009)

Human studies have furthered our understanding of the effects of stress on EF, with a focus upon exploring the effects of acute stress on WM performance (Qin et al., 2009; Gartner et al., 2014). Qin et al. (2009) investigated the neural activity of 27 female participants during a WM test after the induction of acute psychosocial stress. The results show that induced stress results in a reduction in WM related activity in the dorsolateral PFC. Gartner et al. (2014) supported the result that acute stress reduces WM performance by investigating frontal theta activity, linked to WM performance in 31 male participants after acute stress induction. Results highlight how frontal theta related WM activity decreased under acute stress. Therefore, the research demonstrates the relationship between stress and the reduced performance on the EF WM in both male and female samples.

Plessow et al. (2011) investigated the effects of stress on cognitive fluidity, they studied 48 healthy volunteers and found participants with induced stress from the Tier Social Stress Test displayed increased goal shielding (the process of protecting focus on a goal by inhibiting other goals on a task measuring cognitive performance). Errors during the task highlighted participant's poor cognitive fluidity. Acute stress did not directly reduce the EF of cognitive fluidity; however, the induced stress did increase goal shielding on the task, which in turn reduced cognitive fluidity. More recently EF cognitive fluidity has been considered as a multicomponent concept rather than unitary function involving multiple brain areas. Goldfarb et al. (2017) suggest that in addition to flexibility, a function of the PFC, there is the component of updating to incorporate relevant information, suggested to be a function of the dorsal striatum of the midbrain. Previous research has demonstrated how stress impairs function of the PFC including cognitive fluidity, however Goldfarb et al. (2017) suggest the second component of updating is actually enhanced by stress as the participants cortisol stress response to an acute stressor positively correlate with increased accuracy on updating flexibility.

In addition to looking at the individual impacts of drinking behaviour and stress on EF performance, it is important to consider how the combination of these variables impact upon EF in a student population. Stress is a prevalent factor in university life as students negotiate a major life transition, academic workload pressures and social stresses which can put them at risk of developing mental health problems (Stallman & Hurst, 2016). The negative impact of the interaction of both stress and alcohol has been demonstrated in animal research. Rats that were taught self-induced alcohol consumption in adolescence led to stress induced alcohol consumption when the same rats were stressed by being restrained (Siegmund et al., 2005; Füllgrabe et al., 2007; Fernández et al., 2016). In a study of 98 students it was found that after a stress procedure implicit associations to alcohol increased, indicating that stress could lead to alcohol consumption in this student sample, perception of these implicit messages were mediated by the levels of EF control each participant had (Zvorsky, 2012).

The combination of alcohol drinking behaviour and stress in students may therefore increase the risk of reduced EF performance, as demonstrated in recent research by Goldstein et al. (2016), they found that heavy alcohol use, elevated stress and depression was associated to deficits in a WM task. A second experiment analysed data from previous research, finding higher alcohol consumption and early onset of drinking behaviour was associated with deficits in a broader range of EF. Goldstein et al.'s (2016) research therefore highlights the adverse effects of stress and alcohol drinking behaviour combined in a sample of students.

The research on the separate effects of stress and alcohol drinking behaviour on EF is established, whilst research highlighting the combined effects is limited. Previous research on the combined effects measured stress retrospectively, making use of scales (Goldstein et al., 2016). Although a useful measure, it cannot be inferred how EF is affected by acute stress naturally induced in the university environment, for example in exams and presentations. As explored previously EF is not only important for students' academic attainment but also for their maintenance of future non-harmful levels of drinking behaviour, as reduced control of EF could lead to dependency and stress induced drinking at a later age.

The present study proposes to induce acute stress and then directly measure EF performance to investigate the influence acute stress has, while drinking behaviour will be retrospectivity measured from a participant's self-report of an average month's alcohol consumption. Previous research on the effects of alcohol drinking behaviour and stress looked at individually has tested the aspects of EF cognitive fluidity and WM, yet the combined research by Goldstein et al. (2016) only investigated WM in relation to both stress and alcohol drinking behaviour. Therefore, this study proposes to advance our understanding of the combined effects of stress and drinking behaviour by testing two components of EF, WM and cognitive fluidity.

Aims and Objectives

The research aims to investigate the relationship between the alcohol drinking behaviour of first year psychology undergraduate students and scores on an executive function test, measuring aspects of WM and cognitive fluidity after stress was induced.

The objectives are to gather information regarding alcohol drinking behaviour of the student through a questionnaire self-report method; to induce stress through a task using timed and performance elements; to measure participants' levels of stress through both the physiological measures of electro-dermal activity (EDA) and heart rate (HR), as well as subjectively through a self-report method. Lastly, to measure EF using a well-established neuropsychological test. The data from both student drinking behaviour and scores on the EF task after stress induction will be analysed to see if relationships exist within the data.

Hypothesis

Considering conclusions drawn from previous empirical work, in the present study it is hypothesised that higher levels of alcohol drinking behaviour reported by first year psychology students will relate to reduced performance on an EF task incorporating aspects of WM and cognitive fluidity measured under stress.

Method

Design

This quantitative experiment used within subjects correlational design. The predictor variable being the quantity and frequency of alcohol consumed by the student, calculated to give the volume of alcohol consumed in an average month, while the criterion variable was participants' scores of EF under stress. Further measures were taken to ensure stress was induced during the experiment.

Participants

Inclusion criteria limited participants to first year psychology students, selected to control for the varying levels of stress likely to be experienced within the different years of study. Inclusion criteria also applied to an age range of 18-25 reflective of the age range in which increased levels of alcohol consumption is most prevalent (National Institute on Alcohol Abuse and Alcoholism, 2006).

30 participants consisting of 22 females and 8 males between 18-24 with an average age of 22 were recruited through opportunity sampling advertised on the Manchester Metropolitan University (MMU) participation pool. An incentive being 60 participation pool points awarded for taking part (Appendix 1).

Participants were under no circumstances asked to drink alcohol during or prior to the experiment. This study followed the BPS code of ethics (BPS, 2010) and was approved by the ethical board at MMU (Appendix 2).

Materials, Apparatus and Measures

A series of questionnaires, subjective measures and physiological measures were taken from participants during the experiment's duration; these are outlined below.

The Student Health and Lifestyle Questionnaire.

A self-report measure developed by Engs (1991), has items regarding health, lifestyle and behaviour of students while at university. Only items regarding demographics and drinking behaviour will be used for analysis. The scale has been licensed as creative commons as part of the IUScholorworks records for the University of Indiana (Appendix 3 and 4). Items regarding consumption of beer, wine and spirits have been merged into one question asking about the consumption of units of alcohol, frequency and quantity of consumption in one average month, a unit guide was provided to aid accuracy of participants' responses. These changes were made to accommodate for binge drinking and mixing of drinks seen in the student population. Quantity responses will be multiplied against frequency to gain an approximate score for volume of alcohol consumption.

The Montreal Imaging Stress Test (MIST) Based Task.

The MIST original task was devised to induce acute psychological stress for use in fMRI imaging studies (Dedovic et al., 2005). The present study, using Psychopy software for cognitive experiments (Peirce, 2007; Peirce, 2008) has adapted the task for use outside a scanner, utilising a keypad and mouse for participant response. Participants given the MIST based task are shown a series of mental arithmetic questions within time limits indicated by a bar at the top of the screen. Participants are asked to answer using the computer keyboard, immediate feedback showing "correct", "incorrect", or "timeout" is given. Participant performance is indicated on a bar, with an arrow indicating how on average peers have previously performed adding another performance element to the test (Appendix 5).

The Trail Making Task (TMT).

The TMT measures cognitive fluidity and aspects of WM (Reitan, 1955; Sanchez-Cubillo et al., 2009; Salthouse, 2011). The measure is free to use as part of the public domain (Lezak et al., 2004). Part A asks participants to draw a line connecting letters in sequential order, while part B asks participants to connect alternating letters and numbers in sequential order; each section is timed separately. The more time the participant takes to complete the task the poorer EF performance and ability (Appendix 6).

Measurement of Stress.

a) Physiological measures

Physiological data of students at rest and during the MIST based task was measured using the Biopac-MP45 and analysed using the Biopac student lab 4.0. The Biopac-MP45 was connected to a laptop to produce an image of the results as a polygraph, Appendix 7 displays a section of the produced results. The top graph in red indicates channel 1 the EDA measure, the second graph in blue indicates channel 2 the HR measure. Event markers were made to indicate different phases of testing, 1-2 for baseline at rest measure and 3-4 indicating participation in the MIST based task. Data between these markers was averaged to create participants average EDA and HR at rest and during the MIST based task. Any noise from the surrounding area during the testing period was noted down and taken into consideration.

Electro-dermal activity (EDA)

EDA was recorded with a pair of 11 mm contact Ag-AgCl disposable electrodes (Biopac EL507) filled with isotonic gel (0.5% saline in a neutral base, Biopac GEL101).

The electrodes were placed on the index and ring finger of the non-dominant hand after using an abrasive pad and extra electronic recording gel placed on the electrodes, before being secured using medical tape. The SS57L transducer connected the electrodes to the MP45 for signal transformation.

Heart Rate (HR)

HR was measured using BSL Pulse Plethysmogram Xdcr, on the participant's non-dominant hand. The light sensor of the Plethysmogram transducer was placed on the middle finger and secured using the Velcro strap. From this measure of peripheral blood circulation HR was derived.

b) Subjective Measure.

A five point Likert scale was used to gain a subjective measure of changes in stress with 1 indicating not stressed at all and 5 extremely stressed, participants recorded how stressed they felt the moment before electrodes were attached and then after the MIST based task to gauge how stressful participants believed the task was (Appendix 8).

Procedure

Data collection was controlled for extraneous variables, adhered to the ethical guidelines and was replicated for all participants. On signing up participants received the full participant information sheet (Appendix 9). On arrival at the laboratory, participants were asked to read the informed consent form (Appendix 10). Having consented participants provided a unique identifier code by following the instructions given. Before starting the experiment, participants were reminded that they were free to withdraw at any point without giving reason.

Subsequently participants were provided with the Student Health and Lifestyle Questionnaire to complete (Appendix 3). On completion, participants were asked to indicate how stressed they felt at that moment on a 5-point Likert scale (Appendix 8). They were then informed that arousal was being measured through EDA and HR using the Biopac-MP45. They were asked if electrodes and a light sensor could be placed on the opposite hand they personally use to control a computer keypad. Safety precautions were put in place, participants were instructed to sit still and place the hand with equipment facing up, resting on their leg and asked to restrict movement to that required for the task.

The participants' basal at rest measure was taken whilst the experimenter left the room for a two-minute period, to allow the participants to relax. Upon the experimenter's return the MIST based task was set up on the computer screen in front of the participant and brief instructions given regarding the task. EDA and HR were measured throughout this task. On completion of the task a 5-point Likert scale was administered asking how stressed participants were during the task (Appendix 7). Equipment was then removed from the participant.

The TMT (Appendix 6) materials were laid out to the side of the computer, and participants asked to move over to a comfortable position to complete the task. A demonstration with brief instructions was given to aid understanding of the task. Participants were instructed to use the pencil provided to link the circles without lifting the pencil off the page and to return to the previous circle if mistakes were made.

Different instructions applied to each section of the task. Parts A and B of the task were timed separately, and results recorded in seconds.

On completion of the experiment the participant was thanked for their participation; and a full debrief given (Appendix 11). The aims of the experiment were fully revealed and each participant reminded of their right to withdraw their data up to the date provided on the consent form. Before leaving participants were given points of contact for further questions or issues. Participation pool points were awarded within 48 hours.

Data Analysis

Raw data was entered and analysed using IMB® Statistical Package for the Social Science 23.0 (SPSS) for Windows. Quantity and frequency of alcohol consumption was multiplied to create volume of alcohol consumed in an average month, the approximate value for drinking behaviour of each participant. Average EDA and HR for at rest and during the MIST based task were calculated using Biopac student lab 4.0. and transposed into SPSS for analysis.

The data failed to meet the parametric requirements for normal distribution, therefore non-parametric tests of difference (Wilcoxon rank sum) and correlations (Spearman's rho) were applied.

Results

Descriptive Statistics

Descriptive statistics were created for all measures of stress before and during the MIST based task including subjective scores and average EDA and HR. Descriptive data was also created for participant's volume of alcohol consumed on an average month and performance scores on the TMT, parts A and B measured in seconds taken to complete each part. Table 1 shows the mean and standard deviation scores.

Table 1.
Mean (M) and Standard deviations (SD) of subjective stress rest and during the MIST based task, EDA and HR average at rest and during MIST based task, volume of alcohol consumed in an average month and TMT scores during stress part A and B (N=30).

	M	*SD*
Subjective stress at rest	1.53	.73
Subjective stress scores during MIST	4.37	.72
EDA average at rest	4.14	3.88
EDA average during MIST based task	7.18	4.92
HR average at rest	82.17	10.32
HR average during MIST based task	92.91	12.39
Volume of alcohol consumed	72.26	61.92
TMT part A during stress	24.02	8.86
TMT part B during stress	50.83	10.75

Inferential Statistics.

To assess the effectiveness of the MIST based task in inducing a stress response as measured by subjective ratings, EDA and HR, a t test was applied to investigate any significant differences in measures at rest and during the task. All variables failed the Shapiro-Wilk test of normality being below $p<0.05$, therefore a Wilcoxon rank order test was applied. Table 2 summarises the scores which are used to assess whether the MIST based task significantly increased participant's levels of stress.

Table 2.
Wilcoxon rank sum test for scores of stress at rest and during MIST based task (N=30).

	At Rest Mean score	*During MIST Mean score*	*Z*	*P*
Subjective Stress	1.53	4.37	-4.84	<0.001
Average EDA	4.14	7.20	-4.78	<0.001

Average HR	82.17	92.91	-4.74	<0.001

The results from table 2 show the scores from all three measures of stress were significantly increased from at rest to during the MIST based task ($p<.001$).

Correlation

Correlations were conducted to determine if a relationship existed between the volume of alcohol consumed in an average month, and time taken to complete the TMT parts A and B. Spearman's rank order correlations are summarised in the correlation matrix below in table 3.

Table 3.

Summary of Correlation Coefficients (N=30).

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.Subjective stress at rest	-								
2.Subjective stress in MIST	.24	-							
3.EDA average at rest	-.30	.14	-						
4.EDA average in MIST	-.48**	.15	.91**	-					
5.HR average at rest	.35	-.14	-.08	-.21	-				
6.HR average in MIST	.29	-.18	-.24	-.29	.85**	-			
7.TMT A	.09	-.09	-.12	-.06	.19	.20	-		
8.TMT B	.07	-.29	-.04	-.11	-.02	-.12	.62**	-	
9.Volume of alcohol	-.11	.17	.42*	.40*	-.11	-.17	.14	.28	-

*Note *p<0.05 ;** p<0.01.*

Physiological measures of stress EDA and HR have a significant positive correlation from at rest to during the MIST based task. A significant negative correlation is also observed between EDA average during MIST and subjective stress at rest. TMT part A and B positivly correlate to each other. There is also a significant correlation for student's volume of alcohol consumed and EDA average for at rest and during the MIST based task. There is no correlation between the volume of alcohol consumed by first year students in an average month and the time taken to complete the TMT part A and B in seconds (table 3). Therefore the hypothesis is not supported.

The data set was then split using gender and correlations analysed again. Female correlations are summarised in a correlation matrix see (table 4) and Male correlations summarised in a correlation matrix see (table 5).

Table 4.

Summary of Correlation Coefficients for females (N=22).

Variables	1	2	3	4	5	6	7	8	9
1.Subjective stress at rest	-								
2.Subjective stress in MIST	.39	-							
3.EDA average at rest	-.15	.16	-						
4.EDA average in MIST	-.48*	.15	.83**	-					
5.HR average at rest	.32	-.13	-.05	-.34	-				
6.HR average in MIST	.21	-.15	-.29	-.43*	.81**	-			
7.TMT A	.17	.02	-.10	-.04*	.20	.20	-		
8.TMT B	.10	-.17	.10	-.01	-.02	-.14	.66**	-	
9.Volume of alcohol	.02	.22	.63**	.57**	-.01	-.09	.08	.18	-

*Note *p<0.05 ;** p<0.01.*

Table 5.
Summary of Correlation Coefficients for males (N=8).

Variables	1	2	3	4	5	6	7	8	9
1.Subjective stress at rest	-								
2.Subjective stress in MIST	-.38	-							
3.EDA average at rest	-.41	.22	-						
4.EDA average in MIST	-.41	.22	1.00**	-					
5.HR average at rest	.08	.11	.10	.10	-				
6.HR average in MIST	-.25	.11	.57	.57	.43	-			
7.TMT A	-.25	-.33	.21	.21	-.07	.02	-		
8.TMT B	.08	-.66	-.55	-.55	-.38	-.26	.38	-	

9.Volume of alcohol	-.25	-.11	-.21	-.21	-.14	-.05	.52	.71*	-

*Note *p<0.05;** p<0.01.*

Correlations from the whole sample are still present within the female only sample. A new negative correlation emerged between the TMT part A and EDA average during the MIST based task. There is no correlation between the volume of alcohol consumed by female first year students in an average month and the time taken to complete the TMT part A or B in seconds. These results do not support the hypothesis in the female

Male participant's scores show a positive correlation between EDA at rest to during the MIST based task. There is also a significant positive relationship observed in male first year student's volume of alcohol consumed on an average month and time taken to complete the TMT part B, suggesting that the more alcohol male first year students consume, the less executive function performance they exhibit under stress (see table 5)

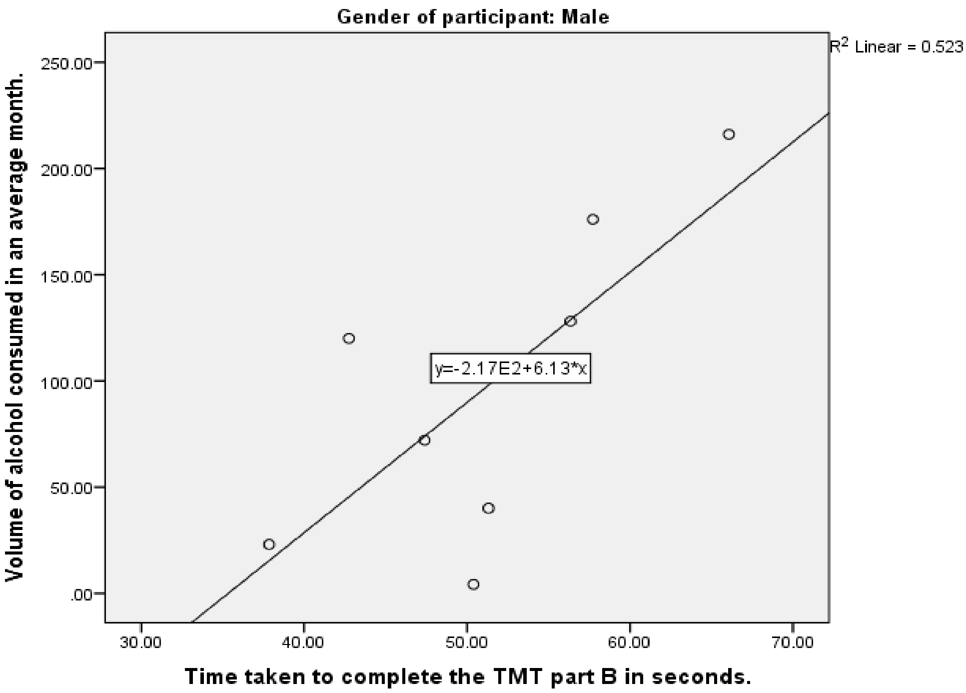

Figure 1. Scatter plot to represents a significant positive relationship (p=.047) between volume of alcohol consumed in an average month and time taken to complete the TMT part B in seconds under stress.

Multiple Linear Regression (MLR).

Correlations revealed a significant positive relationship between alcohol consumption in an average month and time taken to complete TMT part B in seconds during stress in males. A MLR was then run to predict time taken on the TMT part B in seconds from volume of alcohol consumed in an average month and stress measured by subjective scores and average EDA during the MIST based task. HR was not included in this analysis as it did not significantly correlate to the other variables within the model, see table 6 for unstandardised coefficients (B), standard errors (SE) and standardised coefficients (β) for both male and females.

Table 6.

Summary of Multiple Regression Analysis.

	Females (N=22)			Males (N=8)		
Variable	*B*	*SEs*	*β*	*B*	*SEs*	*β*
Intercept	61.33	14.64		80.42	13.06	
Volume of Alcohol	.04	.05	.21	.07	.02	.63*
Subjective Stress in MIST	-2.50	3.30	-.17	-6.99	2.88	-.42
EDA average in MIST	-.31	.61	-.13	-.58	.28	-.35

*Note *p<0.05.*

For females, the MLR model did not significantly predict time taken to complete TMT part B. For males the MLR model significantly predicted time taken to complete TMT part B, $F(3, 4) = 10.979$, $p = .021$, adj. $R^2 = .810$. The main predictor in males is volume of alcohol consumed which is significant at $p<0.05$. Higher scores in these predictor variables equate to more time taken by the participant to complete the TMT part B in seconds during stress.

Discussion

The current study aimed to investigate the relationship between alcohol drinking behaviour and stress, and scores on an EF test measuring aspects of WM and cognitive fluidity in first year psychology students. Stress was induced using the MIST based task and the stress response measured using both a subjective measure and physiological measures EDA and HR. The results confirmed stress was induced in all participants as indicated by significantly higher scores from at rest to during the task.

The hypothesis that higher levels of drinking behaviour reported by students will relate to reduced performance on an EF task measured under stress is not supported in the whole sample. A significant positive correlation emerged in male students for alcohol consumption and longer time taken to complete the TMT part B in seconds, which equates to a reduced performance of EF components WM and cognitive fluidity. This suggests that increased alcohol drinking behaviour is related to reduced EF after stress was induced, but only in male students. Correlations also emerged between the physiological measures of stress at rest and during the MIST based task, and between average EDA measured at rest and in during the MIST based task with volume of alcohol consumed. This relationship suggests stress related drinking might occur in students.

Further to preliminary analysis a multiple regression analysis illustrates how higher scores in measures of subjective stress and EDA during the MIST based task, plus volume of alcohol consumed in an average month by the student significantly predict longer time taken to complete the TMT part B in males. This indicates reduced EF ability of the male participants. HR was not included in this model as it did not correlate to any of the measures signifying it may be a poor measure of stress as an indicator of reduced EF performance.

The hypothesis that increased alcohol consumption would relate to reduced performance in EF task while stressed is not supported by the present results. Acute stress was indicated by previous literature to reduce EF (Qin et al., 2009; Gartner et al., 2014; Plessow et al., 2011) as was elevated alcohol consumption in the student population (Weissenborn & Duka, 2003; Piechatzek et al., 2009; Parada et al., 2012; Gil-Hernandez & Garcia-Moreno, 2016) therefore when these variables are combined it was predicted to adversely impact upon EF performance yet the results did not meet this prediction.

Previous combined research looked at the impact of daily stressors and alcohol consumption (Goldstein et al., 2016) finding a significant relationship between elevated scores of stress, alcohol consumption and depression equating to impairments on a WM task in both genders. The present findings do not support this as no significant correlation was found within the whole sample. Differences in results between the present study and Goldstein et al.'s (2016) research could be due to the type of stress measured. The daily long term exposure to stress measured by Goldstein et al. (2016) may have caused more damage to the structure of the PFC and therefore EF ability whereas a short term acute stressor although creating loss of ability would not damage the PFC to the same extent (Arnsten, 2009). The results of both of these studies could therefore reflect this difference in stressor type measured.

Differences in results may also be due to the sampling exclusions made. The present study limited the sample to that of first year students for homogeneity, controlling for stress experienced in other years of study. Goldstein et al. (2016) used a sample of 86 university students, ages ranging from 17-26 yet no details were provided of the year of study. Research demonstrates that although first year students show heaviest alcohol drinking behaviour (Bewick et al., 2008), prolonged use of alcohol can cause damaging effects to cognitive ability compared to those who do not have long term alcohol related disorders (Brown et al., 2000). Future research could therefore aim to investigate this further by grouping participants by year of study to assess the long-term impact of continued alcohol drinking behaviour on EF.

As the present findings did not support the hypothesis, results will now be discussed in relation to the literature looking at the individual impact of stress. Previous research looking at the impact of stress on the EF WM has found a significant reduction in both males (Gartner et al., 2014) and females (Qin et al., 2009). The present research tested EF WM alongside the EF cognitive fluidity. Research on the EF cognitive fluidity found stress did not immediately impair cognitive fluidity however impairments were observed in the last trail where a negative impact upon cognitive function of the participant was observed (Plessow et al., 2011). In measuring cortisol Plessow et al. (2011) found higher cortisol indicated increased goal shielding and reduced cognitive fluidity, suggesting that impairments parallel the release of cortisol in the HPA axis stress response, observed at longer time periods after stress was induced. The present study did not test EF at multiple time points after stress was induced; thus the effect of cortisol on EF was not measured, which may explain the different outcomes. Future research could investigate this further to see if impairments of EF due to alcohol consumption and acute psychological stress increase in parallel to the HPA axis activation and cortisol release.

Cognitive fluidity as tested in this research is suggested to be impaired by stress by taking the PFC ‘offline’ in a habitual response to the stressor (Arnsten and Goldman-Rakic, 1998). This finding is implied in this research, as it is assumed elevated stress combined with alcohol drinking behaviour will equate to decreased EF, a function of the PFC. However, a non-significant result was obtained in the whole sample. This result may be clarified by Goldfarb et al.’s (2017) recent research. They propose that EF cognitive fluidity is not a modular function; rather it can be divided into two main components: flexibility, a function of the PFC dampened by stress, and adjustment, a function of the dorsal striatum (part of the forebrain suggested to be enhanced by stress). In relation to the current study, the TMT was given to participants in two parts which had different instructions; although flexibility was used mostly in part B it could be suggested that adjustment was used by participants to quickly adapt to the different rules in part B compared to part A. Therefore, although stress could have dampened the EF cognitive fluidity it could have also increased function of the adjustment component.

As previously stated, WM, a function of the PFC, is found to be reduced by stress (Gartner et al., 2014; Qin et al., 2009) therefore it could be assumed that acute psychological stress could have in some part impaired WM performance on this test and concomitantly, as suggested by Goldfarb et al. (2017), increased adjustment as part of cognitive fluidity resulting in conflict in the performance outcomes with WM results being mitigated by adjustment. Nevertheless, as the TMT measured aspects of both of these functions the individual performance outcomes could not be determined, therefore future research should consider including a battery of tests to determine the individual performance of each EF.

Despite the non-significant relationship observed in the main sample, significant results were obtained for male students. Alcohol was the strongest factor in this model therefore the results in the male sample will now be discussed in relation to research looking solely at the effects of alcohol drinking behaviour on EF. Previous research from Rodgers (2005) looking at the effects of elevated alcohol consumption on EF found men who were classed as harmful/hazardous drinkers performed significantly worse on a series of cognitive tasks that measured cognitive ability and specifically WM, than females in the same category. A similar result was obtained in the present research. The significant results in males from Rodgers (2005) study was removed after adjustments were made for education, as the men in their sample of harmful/hazardous drinkers were of low education yet in the present sample all participants were of university level of education, demonstrating the significant impact of alcohol drinking behaviour. However, the number of males in the current research is low with 8 participants. The lack of male participants is therefore a limitation to the research, as we cannot effectively generalise the results to a wider population with lack of power from the sample size. Future research should aim to increase the sample size in male participants, allowing results to be generalised to the student population.

Although not an aim of the research, a significant positive correlation emerged between student EDA average for at rest and during the MIST based task and the volume of alcohol consumed in an average month. This suggests that the more physiologically aroused an individual is at rest and while stressed, the more likely they are to engage in stress related drinking. However, it should be noted that for the participants at rest EDA will be above their normal arousal states due to their awareness of being assessed. As previously discussed animal research using adolescent rats also supports this result (Siegmund et al., 2005; Füllgrabe et al., 2007; Fernández et al., 2016). Human based research also supports the positive correlation observed; Zvorsky (2012) found participants were more likely to perceive implicit alcohol cues after they were stressed, suggesting that stress heightens our perception of alcohol associations. When combined with reduced EF this could lead to increased alcohol consumption.

Limitations

Limitations arose from the design of the experiment as a comparison sample without having been subjected to the stress procedure was not included, meaning performance of EF with or without acute psychological stress could not be investigated.

In the measurement of alcohol, the quantity and frequency measure, though found to be a reliable measure of alcohol consumption (Rehm, 1998), does not capture binge drinking behaviour in students nor the onset of drinking behaviour. Goldstein et al. (2016) suggest these factors are linked to broader cognitive deficits in EF, therefore their inclusion would have provided a more comprehensive assessment of the affect of alcohol drinking behaviour on EF.

Implications and Future directions

Typically, University lifestyle incorporates high levels of stress and alcohol drinking behaviour which is evident to have adverse impacts on EF performance. Therefore, healthy lifestyle choices which may mitigate the impacts of stress and alcohol drinking behaviour suggested in animal research (Leasure and Nixon, 2010; Hutton et al., 2015) need to be promoted. As the present study found significant results in male students only, it is possible that males may be more at risk of the adverse impacts of the university lifestyle, suggesting that increased efforts could be made to target the education of male students about the risks of stress and alcohol drinking behaviour.

Future research investigating the combined impact of stress and alcohol drinking behaviour on EF could be improved by a) using a larger sample size to effectively investigate gender differences; b) incorporating a control condition for stress; and c) using a battery of EF tests. Additionally, whilst it has been suggested that first year of university is the heaviest year for alcohol consumption, binge drinking behaviour is continued into later years of study combined with increasing levels of academic pressure creating stress, so further impairments to EF may be observed if the experiment was extended to cover all years of study.

Conclusion

In conclusion, the present study has explored the relationship between alcohol drinking behaviour, stress and EF. The current findings from the whole sample contradict that of previous research, yet a significant result was observed in male participants. This suggests alcohol and stress combine to adversely impact upon EF in males, yet due to the low number of male participants this result lacks power. In order to enhance our understanding of the combined effects of alcohol drinking behaviour and stress on EF in a student population recommendations have been made for the direction of future research.

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