# A novel concurrent pictorial choice model of mood-induced relapse in hazardous drinkers

## Lorna Hardy MSc & Lee Hogarth PhD

School of Psychology, University of Exeter, Washington Singer Building, Perry Road, Exeter EX4 4QG, UK.

Author for correspondence: Lee Hogarth, School of Psychology, University of Exeter, Washington Singer Building, Perry Road, Exeter EX4 4QG, UK. *Email address*: L.Hogarth@exeter.ac.uk. Phone: 01392724613.

Word count (excluding abstract and bibliography) = 3816

1 figure and 1 table.

Running header: Mood-induced alcohol-seeking in hazardous drinkers

## Abstract

This study tested whether a novel concurrent pictorial choice procedure, inspired by animal self-administration models, is sensitive to the motivational effect of negative mood induction on alcohol-seeking in hazardous drinkers. Forty eight hazardous drinkers (scoring ≥ 7 on the Alcohol Use Disorders Inventory) recruited from the community completed measures of alcohol dependence, depression and drinking coping motives. Baseline alcohol-seeking was measured by percent choice to enlarge alcohol versus food related thumbnail images in two-alternative forced-choice trials. Negative and positive mood was then induced in succession by means of self-referential affective statements and music, and percent alcohol choice was measured after each induction in the same way as baseline. Baseline alcohol choice correlated with alcohol dependence severity (*r*=.42, *p*=.003), drinking coping motives (in two questionnaires, *r*=.33, *p*=.02 and *r*=.46, *p*=.001) and depression symptoms (*r*=.31, *p*=.03). Alcohol choice was increased by negative mood over baseline (*p*<.001, ηp2 = .280), and matched baseline following positive mood (*p*=.54, ηp2=.008). The negative mood-induced increase in alcohol choice was not related to gender, alcohol dependence, drinking to cope or depression symptoms (*p*s≥.37). The concurrent pictorial choice measure is a sensitive index of the relative value of alcohol, and provides an accessible experimental model to study negative mood-induced relapse mechanisms in hazardous drinkers.

**Keywords**: Alcohol; Mood-induced relapse; Hazardous drinkers; Depression; Coping motives.

**Public Significance Statement**: Negative mood is a key trigger for relapse to alcohol. This study validated a new and highly accessible laboratory method for studying negative mood-induced relapse in hazardous drinkers, which can be used to test novel behavioural and pharmacological treatments.

Author Note

The data and narrative interpretation contained within the manuscript have not appeared before, either at a conference or meeting, posted on a listserv, or shared on a website including academic social networks.

## Introduction

Negative reinforcement models of addiction propose that negative states, such as withdrawal and negative affect, strongly motivate drug-seeking behaviour to remove or ameliorate these states (Koob, 2013). The significance of negative affect as a motivator of alcohol use is borne out by the finding that alcohol dependent individuals retrospectively attribute negative mood as their reason for relapsing more frequently than any other (Brown et al., 1990; Hodgins, el-Guebaly, & Armstrong, 1995; Marlatt, 1996; Strowig, 2000). Furthermore, experimental studies have shown that induction of acute negative mood reliably promotes alcohol-seeking behaviour, as indexed by increased subjective craving, preferential choice, willingness to spend, consumption and cognitive bias (Birch et al., 2004; Cooney, Litt, Morse, Bauer, & Gaupp, 1997; Cyders et al., 2016; Kelly, Masterman, & Young, 2011; Litt, Cooney, Kadden, & Gaupp, 1990; Rousseau, Irons, & Correia, 2011; Rubonis et al., 1994; Willner, Field, Pitts, & Reeve, 1998; Zack, Poulos, Fragopoulos, & MacLeod, 2003; Zack, Poulos, Fragopoulos, Woodford, & MacLeod, 2006; Zack, Toneatto, & MacLeod, 1999). Critically, sensitivity to negative mood-induced alcohol craving predicts relapse in dependent drinkers even after controlling other relevant predictor variables (Brady et al., 2006; Cooney, et al., 1997; Higley et al., 2011; Sinha et al., 2011). Therefore, treatments that reduce negative-mood induced alcohol-seeking may promote abstinence after quitting.

Various negative mood induction procedures have been used to motivate alcohol-seeking behaviour including sad music (Birch, et al., 2004; Kelly, et al., 2011; Willner, et al., 1998), the presentation of negative words or phrases (Zack, et al., 2003; Zack, et al., 2006; Zack, et al., 1999), guided imagery where participants describe a key negative-affect related drinking triggers (Cooney, et al., 1997; Rubonis, et al., 1994) or negative autobiographical memories (Cyders, et al., 2016; Litt, et al., 1990; Rousseau, et al., 2011) which are scripted for re-reading at test. The current study used a combination of self-referential negative statements (Velten, 1968), such as ‘I don’t think things are ever going to get better’, plus musical mood induction (Martin, 1990) because this combination is more effective than either alone (Zhang, Yu, & Barrett, 2014), and this method is more time efficient than guided imagery.

Various methods have also been used to measure the increase in alcohol-seeking prompted by negative mood induction, including intra-nasal alcohol self-administration (Cyders, et al., 2016), free alcohol consumption (Cyders, et al., 2016; Magrys & Olmstead, 2015; McGrath, Jones, & Field, 2016; Pratt & Davidson, 2009; Zack, et al., 2006), economic demand/willingness to pay (Amlung & MacKillop, 2014; Owens, Ray, & MacKillop, 2014; Rousseau, et al., 2011) and willingness to work for alcohol (Willner & Jones, 1996), alcohol relief expectancies (Birch, et al., 2004), alcohol craving (Brady, et al., 2006; Cooney, et al., 1997; Field & Powell, 2007; Litt, et al., 1990; Pratt & Davidson, 2009; Rubonis, et al., 1994; Willner & Jones, 1996), and alcohol cognitive bias (Austin & Smith, 2008; Field & Powell, 2007; Field & Quigley, 2009; Grant, Stewart, & Birch, 2007; Kelly, et al., 2011; Potthast, Neuner, & Catani, 2015; Woud, Becker, Rinck, & Salemink, 2015; Zack, et al., 2003; Zack, et al., 2006; Zack, et al., 1999).

The key innovation of the current study was to test a novel concurrent pictorial choice procedure in which participants chose to enlarge alcohol versus food related thumbnail images in two-alternative forced-choice trials. This method was chosen because previous studies have shown that preferential choice to enlarge cocaine versus control images is associated with cocaine use frequency (Moeller et al., 2013; Moeller et al., 2009), and preference to enlarge tobacco over food images is increased by mood induction and withdrawal (Hogarth, Mathew, & Hitsman, 2017). Furthermore, related choice procedures have demonstrated the sensitivity of alcohol choice to taste aversion learning (Rose, Brown, Field, & Hogarth, 2013), and the sensitivity of tobacco choice to mood induction (Hogarth et al., 2015), alternative reinforcer value (Stoops, Poole, Vansickel, & Rush, 2011), acute satiety (Hogarth & Chase, 2011), nicotine replacement pharmacotherapy (Hogarth, 2012) and tobacco dependence severity (Hogarth, 2012; Hogarth & Chase, 2011, 2012). Finally, in animals, two-alternative self-administration models have revealed the sensitivity of drug choice to a wide range of manipulations of drug value (Ahmed, 2010; Moeller & Stoops, 2015; Nader & Woolverton, 1991; Nader & Woolverton, 1992; Panlilio, Hogarth, & Shoaib, 2015).

The current study tested whether a negative mood induction procedure combining self-referential negative statements and sad music would augment percent alcohol choice in a concurrent pictorial choice procedure in hazardous drinkers. Forty eight hazardous drinkers completed questionnaires of alcohol dependence, drinking coping motives and depression symptoms. Baseline alcohol-seeking was measured by percent choice to enlarge alcohol versus food related thumbnail images in two-alternative forced choice trials. Negative and then positive moods were induced by affective statements and music, and concurrent pictorial alcohol choice was measured after each induction procedure. Subjective mood was measured to validate each induction procedure. The key prediction was that percent alcohol choice would increase following negative mood induction and decrease following positive mood induction, validating this method as a model of negative mood-induced relapse in hazardous drinkers. Secondary analysis examined whether baseline alcohol choice, and negative mood-induced alcohol choice differed between males and females (Cyders, et al., 2016; Rubonis, et al., 1994; Willner, et al., 1998), or varied with drinking coping motives (e.g. Field & Quigley, 2009) or depression symptoms (Hogarth, et al., 2017), as suggested by previous studies.

## Method

### Participants

Participants were 48 adults from the community who responded to online adverts. All participants answered yes when asked if they regularly drank more alcohol per week than specified by UK guidelines (21 units for men, 14 for women), and reported an Alcohol Use Disorders Inventory (AUDIT) total score above the hazardous threshold of ≥ 7 (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). Participants were recompensed with £15. Ethical approval was obtained from the University of Exeter Research Ethics Committee.

### Questionnaires

Breath alcohol was recorded with an AlcoSense Lite before questionnaires were administered. Questionnaires were as follows. (1) the Alcohol Use Disorders Inventory Test (AUDIT: (Babor, et al., 2001). The total score (range 0-40) was used to index alcohol use and associated problems. Questions one to three were used to quantify alcohol consumption: drinking days per week, drinks per drinking day and binge drinking frequency, respectively. (2) The Reasons for Drinking Questionnaire (RFDQ: (Zywiak, Connors, Maisto, & Westerberg, 1996) from which the negative coping subscale was examined. This subscale includes 7 items which ask participants to assess how important different reasons for drinking are for their own consumption, including sadness, anger, frustration, anxiety, tension, illness and relationship difficulties, measured on a 0-10 scale ranging from ‘not at all important’ to ‘very important’. (3) The Drinking Motives Questionnaire Revised (DMQ-R (Cooper, 1994) from which the negative coping subscale was examined. This subscale contains 5 items which ask participants to assess how frequently their drinking is motived by each listed reason – including worries, depression/nervousness, bad mood, to build confidence and to forget problems – rated on a 1-5 scale ranging from ‘almost never’ to ‘almost always’. (4) Beck’s Depression Inventory IA was used to record depression symptoms (BDI: (Beck, Steer, Ball, & Ranieri, 1996).

### Baseline alcohol choice

Instructions stated: ‘In this task you can choose to view images of alcohol and food using the left and right arrow keys. Press the space bar to begin’. As shown in Figure 1A, each trial presented a pair of thumbnail images, one alcohol and one food related randomly in the left and right position, which remained until the left or right arrow key was chosen. This enlarged the chosen image, which remained alone on screen for 2 seconds. Thirty two baseline trials randomly sampled from a set of 28 alcohol images (including beer, wine and spirits) and 28 food images (all typical UK dinners).

### Negative mood induction

Instructions then requested careful attention to statements and sad music (Barber’s Adagio for Strings) began playing through headphones (Morrison & O'Connor, 2008). There followed 16 trials in which 16 Velten self-referential negative statements (e.g. ‘I don’t think things are ever going to get better’ – for a full list see Hogarth, et al., 2015) were presented in random order for 10 seconds each.

### Negative test phase

Instructions stated: ‘You can now view alcohol and food pictures in the same way as before. Press the space bar to continue’. There were 64 test trials each containing a negative statement randomly sampled from the set of 16 and presented for 3 seconds, before an alcohol/food image choice was made in identical fashion to baseline.

### Positive mood induction

Instructions requested careful attention to statements, then happy music (Mozart’s Eine Kleine Nachtmusik) began playing through headphones (Morrison & O'Connor, 2008). There followed 16 trials in which 16 positive statements (e.g. ‘I feel cheerful and lively’ – for a full list see Hogarth, et al., 2015) were presented once each in random order for 10 seconds.

### Positive test phase

Instructions stated: ‘You can now view alcohol and food pictures in the same way as before. Press the space bar to continue’. There were 64 test trials, identical to the negative test phase, except that each trial contained a positive statement randomly sampled from the set of 16.

### Subjective mood measures

Subjective mood was measured by the on-screen question ‘How do you currently feel?’, and a 9 point Likert scale ranging from 1=‘happy’, 5=‘neutral’, 9=‘sad’. This measure was obtained after each phase of the design as shown in Figure 1. The mood scores after the induction and test phases were averaged for negative and positive phases, to create three scores reflecting mood at baseline, in the negative induction/test phase, and in the positive induction/test phase.

### Analytical plan

Subjective mood scores were entered into a mixed ANOVA with the within-subjects variable block (baseline, negative, positive) and the between-subjects variable gender (male, female) to validate the induction procedures. Percent choice of alcohol over food was also calculated from baseline, negative and positive trials (>50%=preference for alcohol, <50%=preference for food) and entered into a mixed ANOVA with the within-subjects variable block (baseline, negative, positive) and the between-subjects variable gender to determine whether alcohol choice was sensitive to mood induction. Pearson correlations were used to examine the association between baseline percent alcohol choice, the negative mood-induced increase in alcohol choice (from baseline to negative block), and the questionnaire variables AUDIT, RFDQ and DMQ-R negative coping, and BDI.

## Results

### Participants

Table 1 shows the characteristics of participants, divided by gender. There were no significant differences between males and females in these measures. AUDIT questions one to three were used to characterise level of alcohol consumption. The sample means of 3.3 for AUDIT Q1, 2.1 for Q2 and 2.7 for Q3 indicate that the sample, on average, drank two or three times a week, drank five to six drinks on these occasions, and had a binge drinking session between monthly and weekly.

### Subjective mood

ANOVA with subjective mood data shown in Figure 1B produced a significant main effect of block, *F*(2,92) = 37.61, *p* < .001, ηp2 = .450, no main effect of gender, *F*(1,46) = .45, *p* = .51, ηp2 = .010, and no interaction between block and gender, *F*(2,92) =.62, *p* = .54, ηp2 = .013. Pairwise comparison of the three blocks revealed a significant difference between baseline and negative, *F*(1,47) = 29.63, *p* < .001, ηp2 = .387, baseline and positive, *F*(1,47) = 17.84, *p* < .001, ηp2 = .275, and negative and positive, *F*(1,47) = 54.43, *p* < .001, ηp2 = .537. Finally, t-tests comparing each mood score against the ‘neutral’ value of 5 indicated that baseline was not significantly different, *t*(47)=-.97, *p*=.34, whereas mood in the negative block was significantly greater than 5 (i.e. towards the ‘sad’ end of the scale), *t*(47)=4.49, *p*<.001, and mood in the positive block was significantly less than 5 (i.e. towards the ‘happy’ end of the scale), *t*(47)=-4.56, *p*<.001. Thus, the mood induction procedures produced the expected shift in subjective mood state, and there were no differences in this effect between males and females.

### Alcohol choice

ANOVA with the alcohol choice scores shown in Figure 1C produced a significant main effect of block, *F*(2,92) = 10.84, *p* < .001, ηp2 = .191, no main effect of gender, *F*(1,46) = 1.96, *p* = .17, ηp2 = .041, and no interaction between block and gender, *F*(2,92) =1.01, *p* = .37, ηp2 = .021. Pairwise comparison of the three blocks revealed a significant difference between baseline and negative, *F*(1,47) = 18.26, *p* < .001, ηp2 = .280, negative and positive, *F*(1,47) = 11.38, *p* = .001, ηp2 = .195, but not between baseline and positive, *F*(1,47) =.38, *p* = .54, ηp2 = .008. Thus, negative mood induction increased alcohol choice relative to baseline, and positive mood induction returned alcohol choice to baseline.

To determine whether the changes in alcohol choice across blocks were driven by time order effects or mood induction, each block was segmented into quarters. Percent alcohol choice remained stable across quarters of the baseline block (44.5, 44.0, 40.6, and 43.5, respectively), increased step-wise and remained stable across quarters of the negative test (56.1, 52.6, 51.8, and 53.9, respectively), and then decreased step-wise and remained stable across quarters of the positive test (41.4, 42.1, 43.1, and 40.1, respectively). ANOVA on these data with the variables block (baseline, negative, positive) and quarter (4) yielded a main effect of block, *F*(2,282) = 10.43, *p* < .001, ηp2 = .182, and no main effect of quarter, *F*<1, or block by quarter interaction, *F*(6,282) = 1.06, *p* = .39, ηp2 = .022. Furthermore, the main effect of quarter was not significant in either baseline, *F*<1, negative, *F*(3,141) = 1.76, *p* = .16, ηp2 = .036, or positive block, *F*<1. Overall, these findings suggest that changes in alcohol choice were driven by mood induction rather than time.

### Correlations between alcohol choice and questionnaire scales

Table 2 shows the correlation coefficients between baseline alcohol choice, negative mood-induced alcohol choice (increase in alcohol choice from the baseline and negative block), questionnaire scales and subjective negative mood reactivity (increase in sadness from baseline to negative block). Baseline alcohol choice was significantly correlated with AUDIT, RFDQ and DMQ-R negative coping scales, and BDI. Negative mood-induced alcohol choice did not correlate with any variable. Finally, neither percent alcohol choice measured in the positive mood induction block, nor the decreases in alcohol choice between positive versus negative blocks correlated significantly with any of the questionnaire measures, *r*s<.25, *p*s>.08 (not shown in Table 2).

## Discussion

The first key finding of the study was that greater choice of alcohol versus food images in the baseline block correlated with AUDIT, drinking coping motives and depression symptoms. One interpretation of these relationships is that the concurrent pictorial choice procedure indexes of the relative value of alcohol (Murphy, Correia, Colby, & Vuchinich, 2005), and that hazardous drinkers who report higher AUDIT, drinking coping motives or depression symptoms ascribe greater relative value to alcohol over alternative rewards. In support of this claim, two earlier studies have similarly found that cocaine choice in the concurrent pictorial choice procedure was associated with cocaine use frequency (Moeller, et al., 2013; Moeller, et al., 2009), suggesting that the measure provides a valid index of drug value in different drug user group. The second key finding was that the negative and positive mood induction procedures were effective in shifting subjective mood state towards sadness and happiness respectively, as anticipated. However, the most important finding was that alcohol choice increased following negative mood induction and retuned to baseline following positive mood induction, suggesting that the concurrent pictorial choice measure is sensitive to the motivational effect of negative mood induction on the relative value of alcohol. What is more, the effect of negative mood induction on alcohol choice relative to baseline was large (ηp2 = .280). Smokers with diagnosed current major depression have shown an even larger effect (ηp2 = .782) of negative mood induction on tobacco choice in the concurrent pictorial choice task (Hogarth, et al., 2017). Thus, the concurrent pictorial choice measure offers a sensitive, accessible and clinically useful method for studying negative mood-induced relapse processes in hazardous drinkers, and is considerably simpler than existing models designed for this purpose (Brady, et al., 2006; Cooney, et al., 1997; Higley, et al., 2011; Sinha, et al., 2011).

The negative mood-induced increase in alcohol choice was comparable in magnitude, and not statistically different, in males and females, suggesting that published mixed findings of this sort might be discounted (Cyders, et al., 2016; Rubonis, et al., 1994; Willner, et al., 1998). More troubling is that negative mood-induced alcohol choice did not correlate with drinking coping motives, in contrast to several studies which have reported this association. It is important to note, however, that all these studies used undergraduate student samples (Austin & Smith, 2008; Birch, et al., 2004; Field & Powell, 2007; Field & Quigley, 2009; Grant, et al., 2007; Rousseau, et al., 2011; Woud, et al., 2015; Zack, et al., 2003), apart from one which used alcoholic males (Cooney, et al., 1997). One possible explanation is that the relationship between negative mood-induced alcohol choice and drinking coping motives is nonlinear, and approaches asymptote at higher levels of coping, making a correlation harder to detect in hazardous drinkers compared to students. Finally, negative mood-induced alcohol choice did not correlate with depression symptoms. This contradicts our previous finding that smokers with major depression (compared to smokers without) were more sensitive to negative mood-induced tobacco choice in a procedure similar to the present (Hogarth, et al., 2017). Given the existing weak evidence that negative mood-induced alcohol choice increases with depression symptoms (Cooney, et al., 1997; Owens, et al., 2014), a study is needed to sample drinkers across the depression continuum to achieve sufficient power to determine if such an association does exist.

One limitation of the study was that negative and positive blocks were experienced in the same sequential order by all participants, rather than counterbalanced. This means that changes in alcohol choice could have been driven by mood induction procedures or by time variables such as sensitization or habituation to stimuli, or task disengagement. Additional analyses, however, revealed that alcohol choice changed as a step-function immediately following negative and positive mood induction, and did not change significantly across quarters within each block. This suggests that changes in alcohol choice were driven by the mood induction procedures rather than time variables. One uncertain interpretation remains, however. It is not clear whether positive mood induction actively returned alcohol choice to baseline, or whether the return to baseline was due to the termination of the negative mood induction procedure. However, the majority of mood induction studies are designed such that there is a gap between negative mood induction and the test of alcohol self-administration, consumption, demand or craving, indicating that negative mood induction effect persists for some time. It seems likely, therefore, that the positive mood induction actively opposed negative mood induction to return alcohol choice to baseline rapidly. If this interpretation is correct, the current model could be used to test mood management interventions or antidepressant pharmacotherapy as protective agents against negative mood induced alcohol relapse (Hesse, 2009). However, further studies are needed in which positive, negative and neutral induction procedures are counterbalanced to determine whether positive mood induction can in fact oppose negative mood induction, and whether positive mood induction can reduce alcohol choice below baseline when tested in isolation.

There also remains uncertainty about whether the changes in alcohol choice were driven by the self-referential mood relevant statements, the music, or both. Previous studies have shown that sad music alone (Birch, et al., 2004; Kelly, et al., 2011; Willner, et al., 1998) and negative statements alone (Zack, et al., 2003; Zack, et al., 2006; Zack, et al., 1999) can produce changes in alcohol-seeking and subjective mood. However, the specific musical pieces and textual statements employed in the current study (derived from Morrison & O'Connor, 2008) have not been tested in isolation, and therefore their independent effects on alcohol choice remains unclear. More generally, future studies should explore different induction procedures that evoke specific emotional states so as to better isolate the affective states that most effectively drive alcohol choice, so these might be modelled and targeted therapeutically.

Finally, the magnitude of the mood induction effects is worthy of note. Compared to baseline, negative mood induction increased subjective negative mood by an average of 1.4 points on a 1-9 scale, which is comparable to previous publications (e.g. Morrison & O'Connor, 2008) and suggests that the negative mood induction procedure was mild, conforming to ethical requirements. The negative mood induction procedure increased alcohol choice by an average of 10.4% on a 0-100% scale. Although this effect size was large, the numerical change observed may have been limited by the high value of food (baseline alcohol choice was 43% overall) and the possibility of a negative mood-induced increase in food choice in restrained eaters (Cardi, Leppanen, & Treasure, 2015). Consequently, the negative mood induction effect might be increased in future studies by using lower value non-food images as the alternative choice.

To conclude, this study found in hazardous drinkers, that a novel concurrent pictorial choice measure was sensitive to individual differences in the relative value of alcohol, and to the motivational effect of negative mood induction. This concurrent pictorial choice measure offers a sensitive and accessible method for studying the mechanisms of negative mood-induced relapse processes in hazardous drinkers, and may be useful in the development of new targeted treatments.

## References

Ahmed, S. H. (2010). Validation crisis in animal models of drug addiction: Beyond non-disordered drug use toward drug addiction. *Neuroscience & Biobehavioral Reviews, 35*(2), 172-184. doi: doi:10.1016/j.neubiorev.2010.04.005

Amlung, M., & MacKillop, J. (2014). Understanding the effects of stress and alcohol cues on motivation for alcohol via behavioral economics. *Alcoholism: Clinical and Experimental Research, 38*(6), 1780-1789. doi: 10.1111/acer.12423

Austin, J. L., & Smith, J. E. (2008). Drinking for negative reinforcement: The semantic priming of alcohol concepts. *Addictive Behaviors, 33*(12), 1572-1580. doi: <http://dx.doi.org/10.1016/j.addbeh.2008.07.016>

Babor, T. F., Higgins-Biddle, J. C., Saunders, J. B., & Monteiro, M. G. (2001). AUDIT: The alcohol use disorders identification test guidelines for use in primary care. Second edition. Retrieved from

Beck, A. T., Steer, R. A., Ball, R., & Ranieri, W. F. (1996). Comparison of Beck Depression Inventories-IA and-II in psychiatric outpatients. *Journal of Personality Assessment, 67*(3), 588-597. doi: 10.1207/s15327752jpa6703\_13

Birch, C. D., Stewart, S. H., Wall, A., McKee, S. A., Eisnor, S. J., & Theakston, J. A. (2004). Mood-induced increases in alcohol expectancy strength in internally motivated drinkers. *Psychology of Addictive Behaviors, 18*(3), 231-238. doi: 10.1037/0893-164X.18.3.231

Brady, K. T., Back, S. E., Waldrop, A. E., McRae, A. L., Anton, R. F., Upadhyaya, H. P., . . . Randall, P. K. (2006). Cold pressor task reactivity: Predictors of alcohol use among alcohol-dependent individuals with and without comorbid posttraumatic stress disorder. *Alcoholism: Clinical and Experimental Research, 30*(6), 938-946. doi: 10.1111/j.1530-0277.2006.00097.x

Brown, S. A., Vik, P. W., McQuaid, J. R., Patterson, T. L., Irwin, M. R., & Grant, I. (1990). Severity of psychosocial stress and outcome of alcoholism treatment. *Journal of Abnormal Psychology, 99*(4), 344-348. doi: 10.1037/0021-843X.99.4.344

Cardi, V., Leppanen, J., & Treasure, J. (2015). The effects of negative and positive mood induction on eating behaviour: A meta-analysis of laboratory studies in the healthy population and eating and weight disorders. *Neuroscience & Biobehavioral Reviews, 57*, 299-309. doi: <http://dx.doi.org/10.1016/j.neubiorev.2015.08.011>

Cooney, N. L., Litt, M. D., Morse, P. A., Bauer, L. O., & Gaupp, L. (1997). Alcohol cue reactivity, negative-mood reactivity, and relapse in treated alcoholic men. *Journal of Abnormal Psychology, 106*(2), 243-250.

Cooper, M. L. (1994). Motivations for alcohol use among adolescents: Development and validation of a four-factor model. *Psychological Assessment, 6*(2), 117-128. doi: 10.1037/1040-3590.6.2.117

Cyders, M. A., VanderVeen, J. D., Plawecki, M., Millward, J. B., Hays, J., Kareken, D. A., & O'Connor, S. (2016). Gender-specific effects of mood on alcohol-seeking behaviors: Preliminary findings using intravenous alcohol self-administration. *Alcoholism: Clinical and Experimental Research, 40*(2), 393-400. doi: 10.1111/acer.12955

Field, M., & Powell, H. (2007). Stress increases attentional bias for alcohol cues in social drinkers who drink to cope. *Alcohol and Alcoholism, 42*(6), 560-566. doi: 10.1093/alcalc/agm064

Field, M., & Quigley, M. (2009). Mild stress increases attentional bias in social drinkers who drink to cope: A replication and extension. *Experimental and Clinical Psychopharmacology, 17*(5), 312-319. doi: 10.1037/a0017090

Grant, V. V., Stewart, S. H., & Birch, C. D. (2007). Impact of positive and anxious mood on implicit alcohol-related cognitions in internally motivated undergraduate drinkers. *Addictive Behaviors, 32*(10), 2226-2237. doi: <http://dx.doi.org/10.1016/j.addbeh.2007.02.012>

Hesse, M. (2009). Integrated psychological treatment for substance use and co-morbid anxiety or depression vs. treatment for substance use alone. A systematic review of the published literature. *BMC Psychiatry, 9*, 6-6. doi: 10.1186/1471-244X-9-6

Higley, A., Crane, N., Spadoni, A., Quello, S., Goodell, V., & Mason, B. (2011). Craving in response to stress induction in a human laboratory paradigm predicts treatment outcome in alcohol-dependent individuals. *Psychopharmacology, 218*(1), 121-129. doi: 10.1007/s00213-011-2355-8

Hodgins, D. C., el-Guebaly, N., & Armstrong, S. (1995). Prospective and retrospective reports of mood states before relapse to substance use. *Journal of Consulting and Clinical Psychology, 63*(3), 400-407. doi: 10.1037/0022-006X.63.3.400

Hogarth, L. (2012). Goal-directed and transfer-cue-elicited drug-seeking are dissociated by pharmacotherapy: Evidence for independent additive controllers. *Journal of Experimental Psychology: Animal Behavior Processes, 38*(3), 266-278. doi: 10.1037/a0028914

Hogarth, L., & Chase, H. W. (2011). Parallel goal-directed and habitual control of human drug-seeking: implications for dependence vulnerability. *J Exp Psychol Anim Behav Process, 37*(3), 261-276. doi: 10.1037/a0022913

Hogarth, L., & Chase, H. W. (2012). Evaluating psychological markers for human nicotine dependence: Tobacco choice, extinction, and Pavlovian-to-instrumental transfer. *Experimental and Clinical Psychopharmacology, 20*(3), 213-224. doi: 10.1037/a0027203

Hogarth, L., He, Z., Chase, H. W., Wills, A. J., Troisi, J., II, Leventhal, A. M., . . . Hitsman, B. (2015). Negative mood reverses devaluation of goal-directed drug-seeking favouring an incentive learning account of drug dependence. *Psychopharmacology, 232*(17), 3235-3247. doi: 10.1007/s00213-015-3977-z

Hogarth, L., Mathew, A. R., & Hitsman, B. (2017). Current major depression is associated with greater sensitivity to the motivational effect of both negative mood induction and abstinence on tobacco-seeking behavior. *Drug and Alcohol Dependence, 176*, 1-6. doi: <https://doi.org/10.1016/j.drugalcdep.2017.02.009>

Kelly, A. B., Masterman, P. W., & Young, R. M. (2011). Negative mood, implicit alcohol-related memory, and alcohol use in young adults: The moderating effect of alcohol expectancy. *Addictive Behaviors, 36*(1–2), 148-151. doi: <http://dx.doi.org/10.1016/j.addbeh.2010.08.025>

Koob, G. F. (2013). Negative reinforcement in drug addiction: the darkness within. *Curr Opin Neurobiol, 23*(4), 559-563. doi: 10.1016/j.conb.2013.03.011

Litt, M. D., Cooney, N. L., Kadden, R. M., & Gaupp, L. (1990). Reactivity to alcohol cues and induced moods in alcoholics. *Addictive Behaviors, 15*(2), 137-146. doi: [http://dx.doi.org/10.1016/0306-4603(90)90017-R](http://dx.doi.org/10.1016/0306-4603%2890%2990017-R)

Magrys, S. A., & Olmstead, M. C. (2015). Acute stress increases voluntary consumption of alcohol in undergraduates. *Alcohol and Alcoholism*. doi: 10.1093/alcalc/agu101

Marlatt, G. A. (1996). Taxonomy of high-risk situations for alcohol relapse: Evolution and development of a cognitive-behavioral model. *Addiction, 91*, 37-49.

Martin, M. (1990). On the induction of mood. *Clinical Psychology Review, 10*(6), 669-697. doi: [http://dx.doi.org/10.1016/0272-7358(90)90075-L](http://dx.doi.org/10.1016/0272-7358%2890%2990075-L)

McGrath, E., Jones, A., & Field, M. (2016). Acute stress increases ad-libitum alcohol consumption in heavy drinkers, but not through impaired inhibitory control. *Psychopharmacology, in press*.

Moeller, S. J., Beebe-Wang, N., Woicik, P. A., Konova, A. B., Maloney, T., & Goldstein, R. Z. (2013). Choice to view cocaine images predicts concurrent and prospective drug use in cocaine addiction. *Drug and Alcohol Dependence, 130*(1–3), 178-185. doi: <http://dx.doi.org/10.1016/j.drugalcdep.2012.11.001>

Moeller, S. J., Maloney, T., Parvaz, M. A., Dunning, J. P., Alia-Klein, N., Woicik, P. A., . . . Goldstein, R. Z. (2009). Enhanced choice for viewing cocaine pictures in cocaine addiction. *Biological Psychiatry, 66*(2), 169-176. doi: 10.1016/j.biopsych.2009.02.015

Moeller, S. J., & Stoops, W. W. (2015). Cocaine choice procedures in animals, humans, and treatment-seekers: Can we bridge the divide? *Pharmacology Biochemistry and Behavior, 138*, 133-141. doi: <http://dx.doi.org/10.1016/j.pbb.2015.09.020>

Morrison, R., & O'Connor, R. C. (2008). The role of rumination, attentional biases and stress in psychological distress. *British Journal of Psychology, 99*(2), 191-209. doi: 10.1348/000712607x216080

Murphy, J. G., Correia, C. J., Colby, S. M., & Vuchinich, R. E. (2005). Using behavioral theories of choice to predict drinking outcomes following a brief intervention. *Experimental and Clinical Psychopharmacology, 13*(2), 93-101. doi: 10.1037/1064-1297.13.2.93

Nader, M. A., & Woolverton, W. L. (1991). Effects of increasing the magnitude of an alternative reinforcer on drug choice in a discrete-trials choice procedure. *Psychopharmacology, 105*(2), 169-174.

Nader, M. A., & Woolverton, W. L. (1992). Effects of increasing response requirement on choice between cocaine and food in rhesus monkeys. *Psychopharmacology, 108*(3), 295-300. doi: 10.1007/BF02245115

Owens, M. M., Ray, L. A., & MacKillop, J. (2014). Behavioral economic analysis of stress effects on acute motivation for alcohol. *Journal of the Experimental Analysis of Behavior, 103*, 77-86. doi: 10.1002/jeab.114

Panlilio, L. V., Hogarth, L., & Shoaib, M. (2015). Concurrent access to nicotine and sucrose in rats. *Psychopharmacology, 232*(8), 1451-1460. doi: 10.1007/s00213-014-3787-8

Potthast, N., Neuner, F., & Catani, C. (2015). When abuse primes addiction — Automatic activation of alcohol concepts by child maltreatment related cues in emotionally abused alcoholics. *Addictive Behaviors, 48*, 62-70. doi: <http://dx.doi.org/10.1016/j.addbeh.2015.05.004>

Pratt, W. M., & Davidson, D. (2009). Role of the HPA axis and the A118G polymorphism of the μ-opioid receptor in stress-induced drinking behavior. *Alcohol and Alcoholism, 44*(4), 358-365. doi: 10.1093/alcalc/agp007

Rose, A. K., Brown, K., Field, M., & Hogarth, L. (2013). The contributions of value-based decision-making and attentional bias to alcohol-seeking following devaluation. *Addiction, 108*(7), 1241-1249. doi: 10.1111/add.12152

Rousseau, G. S., Irons, J. G., & Correia, C. J. (2011). The reinforcing value of alcohol in a drinking to cope paradigm. *Drug and Alcohol Dependence, 118*(1), 1-4. doi: <http://dx.doi.org/10.1016/j.drugalcdep.2011.02.010>

Rubonis, A. V., Colby, S. M., Monti, P. M., Rohsenow, D. J., Gulliver, S. B., & Sirota, A. D. (1994). Alcohol cue reactivity and mood induction in male and female alcoholics. *Journal of Studies on Alcohol, 55*(4), 487-494.

Sinha, R., Fox, H. C., Hong, K., Hansen, J., Tuit, K., & Kreek, M. (2011). Effects of adrenal sensitivity, stress- and cue-induced craving, and anxiety on subsequent alcohol relapse and treatment outcomes. *Archives of General Psychiatry, 68*(9), 942-952. doi: 10.1001/archgenpsychiatry.2011.49

Stoops, W. W., Poole, M. M., Vansickel, A. R., & Rush, C. R. (2011). Influence of escalating alternative reinforcer values on cigarette choice. *Behavioural Processes, 87*(3), 302-305. doi: 10.1016/j.beproc.2011.05.002

Strowig, A. B. (2000). Relapse determinants reported by men treated for alcohol addiction. *Journal of Substance Abuse Treatment, 19*(4), 469-474. doi: [http://dx.doi.org/10.1016/S0740-5472(00)00122-7](http://dx.doi.org/10.1016/S0740-5472%2800%2900122-7)

Velten, E. (1968). A laboratory task for induction of mood states. *Behaviour Research and Therapy, 6*(4), 473-482. doi: 10.1016/0005-7967(68)90028-4

Willner, P., Field, M., Pitts, K., & Reeve, G. (1998). Mood, cue and gender influences on motivation, craving and liking for alcohol in recreational drinkers. *Behavioural Pharmacology, 9*(7), 631-642.

Willner, P., & Jones, C. (1996). Effects of mood manipulation on subjective and behavioural measures of cigarette craving. *Behavioural Pharmacology, 7*(4), 355-363.

Woud, M. L., Becker, E. S., Rinck, M., & Salemink, E. (2015). The relationship between drinking motives and alcohol-related interpretation biases. *Journal of Behavior Therapy and Experimental Psychiatry, 47*, 102-110. doi: <http://dx.doi.org/10.1016/j.jbtep.2014.11.012>

Zack, M., Poulos, C. X., Fragopoulos, F., & MacLeod, C. M. (2003). Effects of negative and positive mood phrases on priming of alcohol words in young drinkers with high and low anxiety sensitivity. *Experimental and Clinical Psychopharmacology, 11*(2), 176-185. doi: 10.1037/1064-1297.11.2.176

Zack, M., Poulos, C. X., Fragopoulos, F., Woodford, T. M., & MacLeod, C. M. (2006). Negative affect words prime beer consumption in young drinkers. *Addictive Behaviors, 31*(1), 169-173. doi: <http://dx.doi.org/10.1016/j.addbeh.2005.04.016>

Zack, M., Toneatto, T., & MacLeod, C. M. (1999). Implicit activation of alcohol concepts by negative affective cues distinguishes between problem drinkers with high and low psychiatric distress. *Journal of Abnormal Psychology, 108*(3), 518-531. doi: 10.1037/0021-843X.108.3.518

Zhang, X., Yu, H. W., & Barrett, L. F. (2014). How does this make you feel? A comparison of four affect induction procedures. *Frontiers in Psychology, 5*, 689. doi: 10.3389/fpsyg.2014.00689

Zywiak, W. H., Connors, G. J., Maisto, S. A., & Westerberg, V. S. (1996). Relapse research and the Reasons for Drinking Questionnaire: a factor analysis of Marlatt's relapse taxonomy. *Addiction, 91*(12s1), 121-130. doi: 10.1046/j.1360-0443.91.12s1.2.x

##

|  |  |  |
| --- | --- | --- |
|  | Group |  |
|  | Males(n=22)M (SD, range) | Females(n=26)M (SD, range) | *p* |
| Age | 28.8 (10.7, 19- 63) | 25.2 (10.0, 19-51) | .23 |
| Breath alcohol (mg/l) | 0 (0, 0-0) | 0 (.1, 0-.3) | .36 |
| AUDIT total score | 18.4 (5.7, 8-33) | 16.8 (4.9, 7-26) | .32 |
| AUDIT Q1 | 3.5 (.6, 2-4) | 3.2 (.5, 2-4) | .17 |
| AUDIT Q2 | 2.2 (1.2, 0-4) | 2.0 (.8, 1-3) | .43 |
| AUDIT Q3 | 2.7 (.5, 2-3) | 2.7 (.5, 2-3) | .84 |
| RDFQ negative coping | 3.4 (2.4, 0-7.1) | 3.3 (2.3, 0-8.1) | .79 |
| DMQ-R negative coping | 3.0 (1.1, 1.2-4.6) | 2.7 (.8, 1.0-4.2) | .24 |
| BDI | 11.7 (9.5, 0-35) | 9.2 (6.8, 1-26) | .28 |

Table 1: Characteristics of the male and female group. Breath alcohol mg/l = milligrams per litre. AUDIT = Alcohol Use Disorders Inventory Test. AUDIT Q1-Q3 = drinking days per week, drinks per drinking day, and binge drinking frequency, respectively (see results for interpretation of these numbers). RFDQ = Reasons for Drinking Questionnaire. DMQ-R = Drinking Motives Questionnaire Revised. BDI = Beck’s Depression Inventory.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Negative mood-induced alcohol-seeking | AUDIT | RFDQ negativecoping | DMQ-R negativecoping | BDI | Subjective negative mood reactivity |
| Percent alcohol choice baseline | *r*=-.08,*p*=.55 | ***r*=.42,*****p*=.003** | ***r*=.33,*****p*=.02** | ***r*=.46,*****p*=.001** | ***r*=.31,*****p*=.03** | *r*=.22,*p*=.12 |
| Negative mood-induced alcohol-seeking |  | *r*=-.03*p*=.84 | *r*=.09*p*=.53 | *r*=.13*p*=.37 | *r*=.03*p*=.85 | *r*=.07*p*=.62 |
| AUDIT |  |  | *r*=.22*p*=.14 | ***r*=.36*****p*=.01** | *r*=.26*p*=.08 | *r*=-.01*p*=.95 |
| RFDQ negativecoping |  |  |  | ***r*=.77*****p*<.001** | ***r*=.67*****p*<.001** | *r*=-.09*p*=.55 |
| DMQ-R negativecoping |  |  |  |  | ***r*=.60*****p*<.001** | *r*=-.07*p*=.649 |
| BDI |  |  |  |  |  | *r*=-.25*p*=.09 |

Table 2: Correlation matrix between alcohol choice measures and questionnaires. Negative mood induced alcohol-seeking scores reflect the increase in percent alcohol choice between the baseline and negative conditions. AUDIT = Alcohol Use Disorders Inventory; RFDQ = Reasons for Drinking Questionnaire; DMQ-R = Drinking Motives Questionnaire Revised; BDI = Beck’s Depression Inventory. Bold text highlights significant correlations.



### Figure 1

A: Procedure used to test the impact of negative and positive mood induction on alcohol choice. At baseline, alcohol choice was measured by preference to select for enlargement alcohol versus food related thumbnail images in two-alternative forced choice trials. Negative mood was then induced by depressive statements and music (Barber’s Adagio for Strings) before alcohol choice was tested again in the same way. Positive mood was then induced by positive statements and music (Mozart’s Eine Kleine Nachtmusik) before alcohol choice was tested again in the same way. Subjective mood was reported on a 1-9 scale from 1=‘happy’, 5=‘neutral’, 9=‘sad’ between each successive stage of the procedure. The key question was whether negative mood would increase percent alcohol choice relative to baseline and the positive condition, validating this experimental model of mood-induced alcohol-seeking in hazardous drinkers. B: Subjective mood during the baseline, negative and positive mood induction blocks, separated by gender. Results indicate that negative mood increased sadness and positive mood induction increased happiness, relative to baseline, and there were no gender effects or interactions. C: Percent alcohol versus food choice in the baseline, negative and positive mood induction blocks separated by gender. Results indicated that negative mood induction increased alcohol choice relative to the baseline, positive mood induction returned alcohol choice to baseline, and there were no gender effects or interactions.