

Article

Does Alcohol Hangover Affect Emotion Regulation Capacity? Evidence From a Naturalistic Cross-Over Study Design

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Abstract

Aims: The aim of this study was to investigate the effects of alcohol hangover on emotion regulation.

Methods: Forty-five non-smoking, healthy participants aged between 18 and 30 years completed a lab-based emotion regulation task assessing cognitive reappraisal and an emotion regulation questionnaire (State-Difficulties in Emotion Regulation Scale [S-DERS]) when hungover (morning following a night of heavy drinking) and under a no-hangover condition in a naturalistic, within-subjects design study.

Results: Participants reported poorer emotion regulation overall ($P < 0.001$, $d = 0.75$), and for the subscales ‘Non-Acceptance’, ‘Modulation’ and ‘Clarity’ ($P_s \leq 0.001$, $d_s \geq 0.62$), but not ‘Awareness’ on the S-DERS, in the hangover versus the no-hangover condition. Hangover did not impair emotion regulation ability as assessed using the lab-based task ($P_s \geq 0.21$, $d_s \leq 0.40$), but there was a general negative shift in valence ratings (i.e. all images were rated more negatively) in the hangover relative to the no-hangover condition ($P < 0.001$, $d = 1.16$).

Conclusion: These results suggest that emotion regulation in everyday life and emotional reactivity may be adversely affected by alcohol hangover, but some emotion regulation strategies (e.g. deliberate cognitive reappraisal) may be unaffected.

INTRODUCTION

Alcohol hangover refers to the combination of mental and physical symptoms, experienced the day after a single episode of heavy drinking, starting when blood alcohol concentration (BAC) approaches zero (van Schrojenstein Lantman *et al.*, 2017a). Alcohol hangover can impair core cognitive processes, such as short- and long-term memory, sustained attention and psychomotor speed (Gunn *et al.*, 2018), as well as ‘higher-order’ executive functions

(Heffernan *et al.*, 2019). These impairments may contribute towards the negative effects of hangover on productivity in the workplace that were recently estimated to cost the UK economy £1.4 billion per annum (Bhattacharya, 2019). However, alcohol hangover can also negatively influence mood and emotion. Self-report measures have indicated that participants experience increased anxiety (Collins and Chiles, 1978; Marsh *et al.*, 2019; McKinney and Coyle, 2006) and reduced ‘tranquillity’, which includes items such as

happy–sad (Gunn *et al.*, 2019; McKinney and Coyle, 2006), during a hangover relative to a no-hangover control condition. Furthermore, symptoms of a hangover include negative emotions such as ‘anxiety’ and ‘depression’, albeit these are not as commonly reported as other symptoms such as headache or fatigue (van Schrojenstein Lantman *et al.*, 2017b). Considered together, these results suggest that negative affect is increased during hangover. Increased negative affect could have a detrimental influence on workplace performance. For example, employees who reported being hungover at work at least once in the past year were more likely to report conflict with colleagues and criticisms from supervisors than those who did not go to work hungover (Ames *et al.*, 1997). However, the cognitive mechanisms that contribute towards negative affect in the hangover state are unclear. One process that may be influenced by hangover and is typically utilised to maintain emotional equilibrium is emotion regulation.

Emotion regulation is a multidimensional construct that refers to the way people control the experience and expression of emotions (Gross, 1998; Gross *et al.*, 2006). Emotion regulation involves being aware of one’s emotions and why they are experienced, being willing to tolerate temporary emotional distress to achieve one’s aims or pursue meaningful activities, and engaging in effortful cognitive processes to attenuate (or *amplify*) emotional responses to stimuli or situations (Gratz and Roemer, 2004). These cognitive processes include inhibitory control, goal-directed behaviours and emotion modulation strategies such as cognitive reappraisal or suppression. Cognitive reappraisal can be defined as reframing the way one thinks about potentially emotion-eliciting situations or stimuli to alter their emotional impact and meaning. This aspect of emotion regulation has received the majority of attention in the empirical literature (Ochsner *et al.*, 2012). Reappraising the meaning of a stimulus can increase positive affect and reduce negative affect, and frequent use of this emotion regulation strategy is associated with healthier social relationships and greater well-being (Gross and John, 2003). However, reappraisal is a cognitively complex emotion regulation strategy as it utilises a number of executive functions (e.g. inhibiting the initial response and other interfering thoughts, and cognitive switching from the initial appraisal to alternative appraisals (Ochsner *et al.*, 2012; Ochsner and Gross, 2005)).

During hangover, cognitive resources that are utilised when engaging in effortful cognitions are reduced (Scholey *et al.*, 2019; Wolff *et al.*, 2016). This may contribute towards impairments in processes needed for efficient emotion regulation during a hangover, such as inhibitory control (Devenney *et al.*, 2019; Gunn *et al.*, 2019; McKinney *et al.*, 2012) and executive function (Heffernan *et al.*, 2019; Howland *et al.*, 2010). These results imply that some dimensions of emotion regulation (e.g. deliberate modulation of emotions) could be negatively affected by alcohol hangover, and regulation strategies that are effortful may become less effective. Furthermore, although participants are aware of their current emotions during a hangover (Howland *et al.*, 2010), the social and psychological isolation they feel when hungover could indicate impairments in the ability to regulate emotions (Griffin *et al.*, 2018).

The aim of the current study was therefore to investigate the effect of alcohol hangover on emotion regulation using a widely-used laboratory task that measures cognitive reappraisal. We also used a self-report questionnaire measuring state emotion regulation to investigate the effect of hangover on additional dimensions of emotion regulation and assess emotion regulation in real-life situations. We hypothesised that participants would show impaired emotion regulation whilst hungover compared with a no-hangover control

condition. We also hypothesised that engaging in deliberate cognitive reappraisal would be perceived as more effortful during hangover compared with a no-hangover control, and that emotion regulation would negatively correlate with hangover severity.

MATERIALS AND METHODS

Participants

Participants were recruited via the ‘harvesting’ method (Crandall *et al.*, 1997). Individuals were approached on campus and in popular general public areas (e.g. cafes) by the researcher and asked if they would like to participate in the study. Participants ($n = 45$, 24 male and 21 female) consumed ≥ 6 (female) or ≥ 8 (male) units of alcohol on a typical night of heavy drinking, were non-smokers aged between 18 and 30 years, and reported themselves as being generally in good mental and physical health. To exclude the potential confound of hangover resistance, participants were required to have experienced a hangover in the past month. Participants were excluded if they were pregnant/breast-feeding, taking medication or using recreational drugs, reported consuming > 400 mg caffeine per day (equivalent to four large coffees), had a current or past personal or family history of drug dependency, or had a diagnosed sleep disorder. Participants consumed an average of 13.9 (standard deviation [SD] = 5.8; range = 6–26.5) units of alcohol, reaching an estimated blood alcohol concentration (eBAC) of 0.15% (SD = 0.07; range = 0.03–0.32; male = 0.15%, female = 0.16%), on the night before the hangover testing session. Four participants consumed small amounts of alcohol the night before the no-hangover condition, despite instructions to refrain from alcohol consumption at least 24-h prior to testing, and were therefore excluded from analysis. Upon completion of both conditions, participants were paid £10 and received a full debrief. The University of Bath Psychology Research Ethics Committee approved this research, ethics code: 18-086.

Design

The study was an experimental ‘naturalistic’ design, with a within-subjects factor of condition (hangover and no-hangover). Hangover researchers have argued that the naturalistic design has some advantages over the experimental approach (in which a set amount of alcohol is administered under controlled conditions) when exploring the real-world cognitive effects of alcohol hangover (Verster *et al.*, 2019). Participants refrained from alcohol consumption for at least 24 h prior to testing in the no-hangover condition, whilst the hangover condition took place the morning following an evening of heavy alcohol consumption. Both sessions took place in a similar location (e.g. lab, café, etc.) and time to when participants completed the first session. Participants completed the hangover condition first, or the no-hangover condition first, depending on the state that they were in when first recruited. Therefore no formal randomisation was conducted, however, order of condition was counterbalanced during recruitment so that $\sim 50\%$ of participants completed the no-hangover condition first.

Materials and measures

Participants reported alcohol consumption for the previous night and eBAC was calculated using the Widmark formula (National Highway Traffic Safety Administration, 1994). Participants completed a one-item hangover severity scale, the modified Alcohol Hangover Severity

Scale (mAHS; Hogewoning *et al.*, 2016), the Groningen Sleep Quality Scale (GSQS; Mulder-Hajonides *et al.*, 1980) and the Karolinska Sleepiness Scale (KSS; Åkerstedt and Gillberg, 1990). Participants also completed a VAS mood scale (Bond and Lader, 1974) comprising of the two factors 'tranquillity' and 'alertness' (Herbert *et al.*, 1976), reported any events from the previous night that may affect their emotions (e.g. argument with partner), and completed a rating scale of mental effort (RSME; Zijlstra and Van Doorn, 1985).

The State-Difficulties in Emotion Regulation Scale (S-DERS) was used to measure state changes in emotion regulation (Lavender *et al.*, 2015). The S-DERS is a 21-item questionnaire that provides a total score and four subscale scores that reflect different dimensions of emotion regulation. The 'Non-Acceptance' subscale is comprised of six items that reflect a negative response to current emotions (e.g. 'I feel ashamed with myself for feeling this way'). The 'Modulate' subscale is comprised of seven items that reflect difficulties with modulating emotional and behavioural response (e.g. 'I am having difficulty controlling my behaviours'). The 'Awareness' subscale is comprised of five items that reflect a limited attention to and awareness of current emotions (e.g. 'I am acknowledging my emotions'), and the subscale 'Clarity' is comprised of two items reflecting problems identifying current emotions (e.g. 'I am confused about how I feel'). Participants were asked to indicate how much each item applied to their emotions at that moment in time (from 1 = not at all to 5 = completely).

Participants also completed an emotion regulation task assessing cognitive reappraisal (McRae *et al.*, 2012; Ochsner and Gross, 2005; Urry, 2006). Participants viewed images from the International Affective Picture System (IAPS; Lang *et al.*, 1993), which depicted either positive or negative emotional content (e.g. puppies or a dead body), or were neutral images (e.g. a chair). IAPS numbers are given in the supplementary materials. Prior to presentation of an image, participants were instructed to either up-regulate their emotions ('INCREASE'), down-regulate their emotions ('DECREASE'), or look at the image without initiating any emotion regulation strategy ('LOOK'). Decrease instructions were given for negative images, increase instructions for positive and look instructions for negative, positive and neutral images. There were therefore five trial types: Decrease-Negative, Look-Negative, Increase-Positive, Look-Positive and Look-Neutral.

Prior to the task, participants were given suggestions of strategies they could use to regulate their emotions (e.g. 'Imagine it is just a scene from a movie') and completed 10-practise trials, after which participants described their regulation techniques and corrective instructions were given if necessary. Trials began with an instruction (1 s), followed by a positive, negative or neutral image (5 s) with the instruction below. Images were presented in a random order. After the presentation of the image, participants rated their emotions on two dimensions; Arousal (level of excitement in response to stimuli) and Valence (pleasantness of stimuli), using the self-assessment manikin (SAM; Lang, 1980). The SAM is a rating system using graphical figures that provides a quick, non-verbal method of quantifying Valence (with one the most negative score possible, indicated by selection of the unhappy manikin on the left, and nine the most positive score indicated by selection of the happy manikin on the right) and Arousal responses (with one the lowest arousal rating, indicated by the sleeping figure on the left, and nine the highest possible arousal rating, indicated by the figure with a fast-beating heart). There were 100 experimental trials (20 for each trial type) presented in a single block, with each image shown once (thus 110 images were presented including practice trials). To ensure that the comparison of affective ratings in the regulate and look

conditions was valid, the images were also matched for Valence and Arousal scores across instruction-stimuli pairs (e.g. Look-Negative and Decrease-Negative). A schematic representation of the task is presented in Fig. 1.

Procedure

Participants were given information about the study when they were approached and invited to take part and they provided written informed consent before testing began. No participants were intoxicated when they were approached to take part in the study. Participants reported on their previous night's alcohol consumption, caffeine consumption and potential emotional events that may have occurred prior to testing. Participants were breathalysed and completed the sleep, hangover, mood and emotion regulation questionnaires before completing the cognitive reappraisal task. This was followed by the rating scale for mental effort. The second testing session was then arranged for at least 36 h after the first to prevent crossover effects.

Statistical analysis

Four subjects were excluded from the statistical analysis as they reported consuming alcohol the night before the no-hangover testing session. Outliers were removed from data if they were $>1.5 \times$ interquartile range and >2 SD from the mean. Statistical analysis was performed using SPSS (IBM SPSS Statistics for Windows, version 24) and where data were non-normally distributed, bootstrapping of 5000 samples was performed (Field, 2018). Where multiple comparisons were conducted, a Bonferroni correction was applied. As acute intoxication effects on cognition have been observed at BAC $>0.02\%$ (Holloway, 1994), the statistical analysis was also repeated excluding participants with a BAC $>0.02\%$ at testing.

RESULTS

Effects of hangover on emotion regulation

As the S-DERS is a measure of emotion dysregulation, higher scores indicate greater emotion dysregulation (i.e. 'poorer emotion regulation'). A paired sample *t*-test indicated that total S-DERS scores were greater ($t(41) = 4.863$, $P < 0.001$, $d = 0.75$) in the hangover condition than the no-hangover condition. The subscales 'Non-Acceptance', 'Modulation', 'Awareness' and 'Clarity' were calculated as per Lavender *et al.* (2015) and compared between conditions using a series of paired-sample *t*-tests (with a Bonferroni corrected alpha of 0.007). As with total scores, higher scores for each subscale indicate poorer emotion regulation. Non-Acceptance ($t(37) = 5.244$, $P = 0.001$, $d = 0.85$), Modulation ($t(40) = 5.465$, $P < 0.001$, $d = 0.85$) and Clarity scores ($t(40) = 3.974$, $P = 0.001$, $d = 0.62$) were all greater in the hangover than the no-hangover control condition. However, awareness scores did not differ between conditions ($P = 0.672$). Mean and SD scores for each factor are presented in Table 1.

Emotion regulation task

Regulation scores for negative stimuli were calculated by subtracting affect rating scores on Look-Negative trials from scores on Decrease-Negative trials, and regulation scores for positive stimuli were calculated by subtracting affect rating scores on Look-Positive trials from Increase-Positive trials. In both cases, a higher score indicates greater emotion regulation. We investigated the effect of hangover on regulation scores for Valence and Arousal using a 2 (Condition: Hangover,

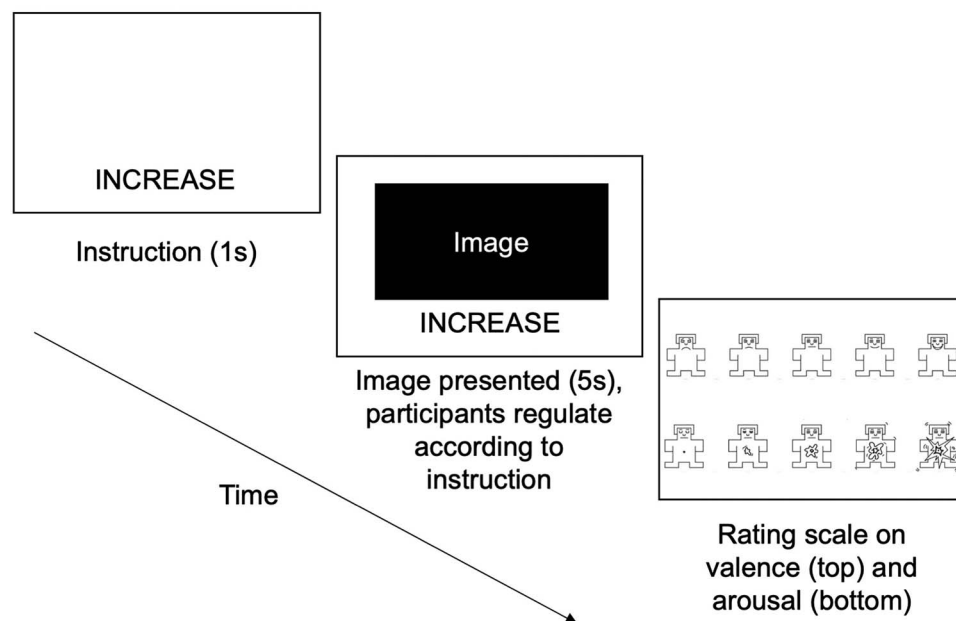


Fig. 1 Schematic representation of the emotion regulation task. Participants were presented with an instruction (INCREASE, DECREASE or LOOK) for 1 s before an image (Negative, Positive or Neutral) was presented for 5 s. During this time participants regulated their emotions according to the instructions or simply viewed the images (in the 'LOOK' condition). Participants then rated their emotions in terms of Valence and Arousal on a one to nine scale using the Self-Assessment Manikin (Lang, 1980).

Table 1. Means, standard deviations and group comparisons for each self-report variable

Variable	Hangover		No-hangover		<i>P</i>	<i>Effect size</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
<i>State emotion regulation questionnaire (S-DERS)^a</i>						
Total	39.64	10.92	32.62	7.20	<0.001	<i>d</i> = 0.75
Non-Acceptance	9.08	2.94	7.66	2.45	0.001	<i>d</i> = 0.85
Modulation	11.78	4.89	8.44	2.63	<0.001	<i>d</i> = 0.85
Awareness	13.85	4.16	13.61	4.44	0.694	<i>d</i> = 0.06
Clarity	3.68	1.79	2.66	1.15	0.001	<i>d</i> = 0.62
<i>Mood</i>						
Tranquillity factor	44.16	4.72	46.92	4.92	0.016 ^b	<i>d</i> = 0.39
Alertness factor	47.90	4.92	56.26	4.83	<0.001	<i>d</i> = 1.53
<i>Hangover severity</i>						
mAHSS	2.95	1.57	0.23	0.29	<0.001	<i>d</i> = 1.96
One-item hangover scale	4.71	1.92	0.14	0.93	<0.001	<i>d</i> = 2.33
<i>Sleep</i>						
GSQS (Quality) ^a	6.14	1.52	5.57	1.21	0.070	<i>d</i> = 0.29
KSS (Sleepiness) ^a	6.68	1.53	3.15	1.27	<0.001	<i>d</i> = 2.27
<i>Mental effort</i>						
RSME	71.36	26.90	44.36	21.28	<0.001	<i>d</i> = 1.02

Notes: M, mean; S-DERS—a higher scores indicate poorer performance or greater difficulties regulating emotion.

No-Hangover) \times 2 (Stimulus type: Negative, Positive) repeated-measures analysis of variance (ANOVA). For Valence scores there were no main effects or interactions ($P_s \geq 0.214$), and for Arousal there was a main effect of stimulus type only ($F(1, 41) = 27.296$, $P < 0.001$, $d = 1.63$), whereby regulation scores for Arousal were lower for negative than positive stimuli.

Although not part of our original analysis plan, we found there were differences between the hangover and no-hangover conditions in overall affect ratings. We therefore explored the influence of

hangover on affective ratings of Valence and Arousal using a 2 (Condition) \times 5 (Instruction-Stimuli pair) repeated-measures ANOVA. For raw valence scores (rather than the difference scores between Look and Regulate trials, which specifically index emotion regulation), there was a main effect of Condition ($F(1, 35) = 11.926$, $P < 0.001$, $d = 1.16$), whereby participants rated the images as being lower in Valence overall (i.e. less positive) in the hangover condition than the no-hangover condition. No such effects were seen for Arousal ratings ($P = 0.168$). Means and SD scores for the emotion regulation task

Table 2. Means, standard deviations, and group comparisons for the emotion regulation task

Variable	Hangover		No-hangover		<i>P</i>	<i>Effect size</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
<i>Emotion regulation task:</i>						
Regulation scores: Valence	0.35	0.38	0.42	0.40	0.214	<i>d</i> = 0.40
Regulation scores: Arousal	−0.05	0.41	−0.12	0.40	0.609	<i>d</i> = 0.16
Affect ratings: Valence	4.90	0.33	5.07	0.28	<0.001	<i>d</i> = 1.16
Affect ratings: Arousal	3.93	1.51	3.80	1.43	0.168	<i>d</i> = 0.47

Notes: *M*, mean; Regulation scores were calculated by subtracting Look trials from Regulate trials in the Emotion Regulation task.

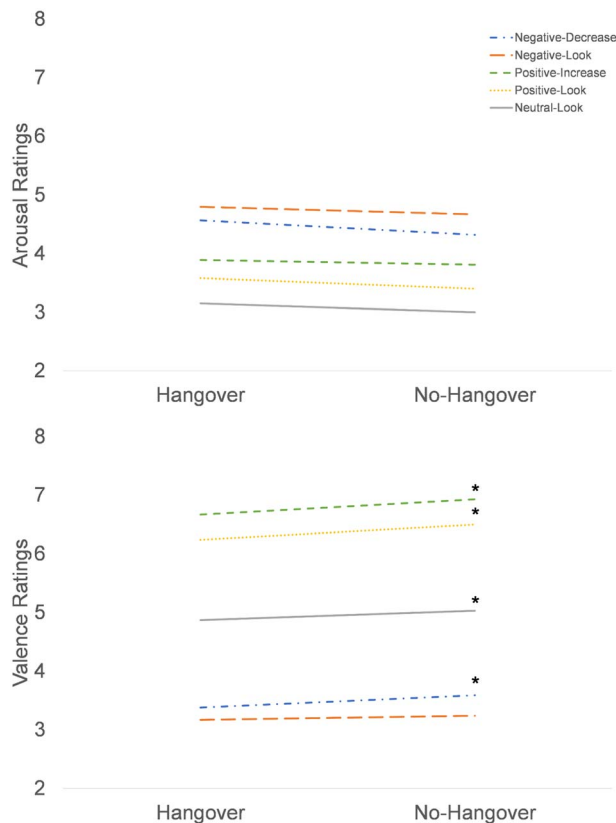


Fig. 2 Graphical representation of mean ratings for stimuli on the emotion regulation task. Participants rated the visual stimuli as significantly lower in Valence overall (i.e. more negative) in the hangover versus the no-hangover condition (*bottom panel*). There were also clear effects of emotion regulation instruction, with positive stimuli being rated as higher in Valence in the Increase-Positive compared with the Look-Positive condition, and lower in Valence for the Look-Negative than the Decrease-Negative instructions. There was no evidence that hangover condition influenced ratings of Arousal (*top panel*), but there was a main effect of stimuli-instruction pairs, which indicated that stimuli in the Look-Neutral condition were rated as being lowest in Arousal and those in the Look-Negative condition were highest in Arousal.

are presented in Table 2 and the findings are presented graphically in Fig. 2.

Subjective mood

The two factors ‘tranquillity’ and ‘alertness’ were calculated from VAS mood questionnaire scores as per (Herbert *et al.*, 1976) and analysed separately. A paired sample *t*-test indicated that tranquillity

scores were reduced ($t(41) = 2.502$, $P = 0.016$, $d = 0.39$) in the hangover compared with the no-hangover condition. Alertness scores were also reduced ($t(39) = 9.652$, $P < 0.001$, $d = 1.53$) in the hangover compared with the no-hangover condition.

Separate paired sample *t*-tests indicated sleepiness scores were greater ($t(39) = 14.362$, $P < 0.001$, $d = 2.27$) in the hangover condition than the no-hangover condition, but GSQS scores differed at a trend level only ($P = 0.07$). A paired-samples *t*-test also indicated that perceived mental effort (as measured using the RSME) was greater ($t(41) = 6.616$, $P < 0.001$, $d = 1.02$) in the hangover than no-hangover condition.

CORRELATIONAL ANALYSIS

To address our third hypothesis, we performed Bivariate correlations testing for relationships between hangover severity (as measured by the mAHSS) and emotion regulation (with a Bonferroni adjusted alpha of 0.007). These showed that hangover severity was strongly positively correlated with emotion dysregulation, as measured with the S-DERS ($r = 0.651$, $P < 0.001$). This was also the case for the Modulation ($r = 0.662$, $P < 0.001$) and Clarity subscale ($r = 0.609$, $P < 0.001$), but not Non-Acceptance ($r = 0.359$, $P = 0.025$) or Awareness ($r = 0.235$, $P = 0.139$). However, there were no significant associations between hangover severity and regulation for positive or negative stimuli in the emotion regulation task ($P_s \geq 0.329$). There was a negative association between affect ratings (valence) and hangover severity for Look-Negative stimuli only ($r = -0.350$, $P = 0.021$) and a positive association between arousal ratings and hangover severity for all instruction-stimuli pairs except Increase-Positive ($r_s \geq 0.305$, $P_s \leq 0.047$).

Results obtained when excluding subjects with a BAC >0.02% All results remained the same when excluding five participants with a BAC >0.02% at testing, with the exception of the hangover effects on tranquillity which were reduced to trend significance ($P = 0.08$).

Results of an exploratory analysis testing for sex differences A 2 (condition) \times 2 (sex) repeated-measures ANOVA for S-DERS total scores indicated a main effect of condition only ($F(1, 43) = 16.831$, $P < 0.001$, $d = 1.25$), whereby scores were greater in the hangover relative to the no-hangover condition. Sex differences in the emotion regulation task were explored using 2 (condition) \times 2 (stimuli) \times 2 (sex) repeated-measures ANOVAs for valence and arousal regulation scores in the emotion regulation task. There were no main effects or interactions with sex ($P_s \geq 0.21$). Furthermore, independent *t*-tests indicated no sex differences for hangover severity ($P = 0.974$) or alcohol consumption ($P = 0.687$).

DISCUSSION

In line with our first hypothesis, subjective emotion regulation ability was impaired in the hangover compared with the no-hangover condition. This was reflected by greater total emotion dysregulation scores on the S-DERS—a questionnaire covering a variety of emotion regulation strategies used in daily life. When analysing each subscale of the S-DERS, participants reported a greater negative response to their emotional state (Non-Acceptance), had greater difficulties with emotional and behavioural responses (Modulation), and had greater problems identifying emotional states (Clarity) when hungover. However, there was no difference in awareness of current emotional state (the amount of attention given to emotions, i.e. Awareness) when hungover compared with a no-hangover control condition. It should be noted that a recent study of the psychometric properties of the DERS questionnaire suggests the Awareness subscale has relatively poor psychometric properties compared with the other subscales (Hallion *et al.*, 2018). However, the remaining subscales maintained good internal consistency. In contrast, there was no difference between hangover and no-hangover conditions in performance on a more objective measure of emotion regulation ability (differences in affective ratings between regulate and look trials during the emotion regulation task). However, the participants did rate emotional stimuli as being lower in Valence (more negative) in the hangover compared with the no-hangover condition—and this was true for both the Look and Regulate trials of the emotion regulation task. Therefore, these results appear to reflect a tonic effect on emotional reactivity (as even positive stimuli were evaluated as being less positive) rather than a specific effect on *emotion regulation* or regulation of negative affect. Results from our correlational analyses lent partial support to our hypothesis, whereby hangover severity was positively associated with emotion dysregulation, but there were no associations between hangover severity and regulatory capacity in the emotion regulation task.

Although results from the self-report questionnaire measure indicated poorer emotion regulation during hangover, the results of the cognitive task indicated that cognitive reappraisal (a deliberate emotion regulation strategy) was unaffected by hangover. However, the design of the cognitive task, which instructed participants to deliberately engage in cognitive reappraisal as part of the study, may have prevented us from observing significant effects. As reappraisal is cognitively demanding (Urry, 2006; Urry *et al.*, 2009), it is possible that fewer available cognitive resources during a hangover (Scholey *et al.*, 2019; Wolff *et al.*, 2016) would shift motivation away from effortful processes, and participants would be less likely to spontaneously use cognitive reappraisal strategies in real-life. Our findings of greater perceived difficulties with modulating emotions and behaviour when hungover compared with a no-hangover control may reflect a difficulty in engaging in cognitively demanding regulation strategies. This is further supported by our finding of greater perceived mental effort to complete the lab-based task, as they may be less motivated to engage in effortful emotion regulation strategies—the *efficiency* of such processes may be reduced, even while the *effectiveness* is unaffected. In other words, the participants could regulate their emotions when explicitly asked to do so (and when there were few other competing demands), but they may find it much harder to do this in the flow of everyday life. Therefore, future research could use experience-sampling methods to investigate which emotion regulation strategies are typically adopted in hangover, if these are different to those which are regularly used, and how effective these strategies are when used spontaneously (in response to frustrating or rewarding events experienced in everyday life). Furthermore, future

research should investigate whether hangover shifts an individual's emotion regulation strategy towards less effortful (and less healthy) strategies, such as emotional suppression (Gross, 2015).

In line with our third a-priori hypothesis, our results highlight a positive association between hangover severity and emotion dysregulation. Although underlying mechanisms cannot be established in the current study, it is possible that symptoms, such as headache (Attridge *et al.*, 2017), consume cognitive resources leaving fewer available to allocate to effective emotion regulation. Fatigue can also impair the ability to effectively allocate cognitive resources during goal-directed behaviours (Boksem *et al.*, 2005). Alternatively, engaging in emotion regulation can reduce cognitive resources (Schmeichel, 2007), leaving fewer resources available to process symptoms of a hangover (e.g. reducing feelings of nausea). Further research is warranted to investigate the underlying mechanisms of the relationship between hangover severity and emotion regulation and to understand its possible mediating role in the low mood experienced during hangover.

The current findings should be viewed in light of the following strengths and limitations. The within-subject naturalistic design of the current study should be viewed as a strength, as each participant serves as their own control. However, the participant harvesting method design could be seen as a limitation as participants were tested in potentially noisy environments (e.g. cafés). Furthermore, given that a small-to-medium effect size was observed for valence ratings ($d = 0.40$), the current study may have been underpowered to observe effects in the lab-based emotion regulation task. The use of the Widmark formula does account for factors such as sex, weight, alcohol consumed and drinking period. However, as it retrospectively estimates peak blood alcohol concentration (cBAC) (as opposed to direct measurement of BAC), it should be viewed as a rough estimate of alcohol consumption.

Emotion regulation is important for everyday behaviours, such as maintaining relationships and engaging in meaningful goal-directed activities (Gross, 2015). Our results suggest that hangover may negatively influence the ability to effectively regulate emotions in everyday life. As emotion regulation is positively associated with the quality of interpersonal interactions (Lopes *et al.*, 2005), poor emotion regulation and low mood in hangover may contribute towards problems in workplace activities that require interaction with others, such as participating in meetings or teaching (Buvik *et al.*, 2018).

In conclusion, our results highlight poorer emotion regulation in hangover as assessed using a self-report measure, but not a lab-based task measuring a core aspect of emotion regulation (cognitive reappraisal). However, results from the cognitive task did suggest that there is a general negative shift in the emotional appraisal of visual stimuli during hangover, suggesting hangover caused participants to react more negatively to stimuli (even positive images). This finding merits further investigation and needs to be replicated in larger samples, alongside different aspects of emotion regulation (e.g. emotional acceptance) or other emotion regulation strategies (e.g. suppression).

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Alcohol and Alcoholism* online.

DATA AVAILABILITY STATEMENT

The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

FUNDING

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CONFLICTS OF INTEREST STATEMENT

Over the past 3 years, Joris Verster has received grants/research support from the Dutch Ministry of Infrastructure and the Environment, Janssen, Nutricia and Sequential, and acted as a consultant/advisor for Clinilabs, More Labs, Red Bull, Sen-Jam Pharmaceutical, Toast!, and ZBiotics. The other authors have no conflicts of interest to declare.

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