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Ultra-brief breath counting (mindfulness) training promotes recovery from stress-induced alcohol-seeking in student drinkers

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HIGHLIGHTS

- Breath counting promoted recovery from stress induced alcohol-seeking.
- Breath counting attenuated stress induced changes in subjective negative affect.
- Breath counting might treat stress induced relapse.
- Mindfulness therapy may work via resilience to negative drinking triggers.

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ABSTRACT

The therapeutic effect of mindfulness interventions on problematic drinking is thought to be driven by increased resilience to the impact of stress on negative mood and alcohol-seeking behaviour, but this claim needs empirical support. To address this hypothesis, the current study tested whether brief training of one component of mindfulness – breath counting – would reduce drinkers' sensitivity to the effect of noise stress on subjective mood and alcohol-seeking behaviour. Baseline alcohol-seeking was measured by choice to view alcohol versus food thumbnail pictures in 192 student drinkers. Participants then received a 6-minute audio file which either trained breath counting or recited a popular science extract, in separate groups. All participants were then stressed by a loud industrial noise and alcohol-seeking was measured again simultaneously to quantify the change from baseline. Subjective mood was measured after all three stages (baseline, post intervention, post stress test). The breath counting group were instructed to deploy this technique during the stress test. Results showed that the breath counting versus control intervention improved subjective mood relative to baseline, attenuated the worsening of subjective mood produced by stress induction, and accelerated recovery from a stress induced increase in alcohol-seeking behaviour. Exploratory moderation analysis showed that this accelerated recovery from stress induced alcohol-seeking by breath counting was weaker in more alcohol dependent participants. Mindfulness therapies may improve problematic drinking by increasing resilience to stress induced negative mood and alcohol-seeking, as observed in this study. The weaker therapeutic effect of breath counting in more dependent drinkers may reveal limitations to this intervention strategy.

1. Introduction

Negative affective states play a major role in triggering problematic drinking and relapse (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004). Prospective studies show that anxiety, depression, and self-reported drinking to cope with negative affect (coping motives) are prospective risk factors for the development/persistence of alcohol dependence and propensity to relapse (Boschloo et al., 2013; Bruce et al., 2005; Crum et al., 2008; Crum, La Flair, et al., 2013; Crum, Mojtabai, et al., 2013; Crum & Pratt, 2001; Gilman & Abraham, 2001; Holahan, Moos, Holahan, Cronkite, & Randall, 2001; Hussong, Ennett, Cox, & Haroon, 2017; King, Iacono, & McGue, 2004; Kushner et al., 2005; Samet et al., 2013; Sihvola et al., 2008; Vernig & Orsillo, 2015; Zimmermann et al., 2003). Furthermore, the experimental induction of negative mood or stress increases alcohol motivation, and this effect is greater in those who report coping motives or depression symptoms (literature reviewed in: Hogarth, Hardy, Mathew, & Hitsman, 2018; Hogarth, Mathew, & Hitsman, 2017). Finally, individual sensitivity to stress induced alcohol craving is associated with greater risk of relapse (Brady et al., 2006; Cooney, Litt, Morse, Bauer, & Gaupp, 1997; Higley et al.,

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2011; Sinha et al., 2011). Consequently, therapies have sought to build resilience to negative affect triggered alcohol motivation (Marlatt & Donovan, 2005; Stasiewicz, Bradizza, & Slosman, 2018).

Mindfulness therapies which train awareness and acceptance of negative emotions have reduced drinking frequency and relapse (Bowen et al., 2014; Garland & Howard, 2018; Li, Howard, Garland, McGovern, & Lazar, 2017; Sancho et al., 2018; Stasiewicz et al., 2013; Zgierska et al., 2008; but see Grant et al., 2017), even if mindfulness training is relatively brief (Kamboj et al., 2017; Mermelstein & Garske, 2015; see also Tang, Tang, & Posner, 2013). Evidence that these therapeutic effects are mediated by increased resilience to negative affective drinking triggers comes from three studies. Witkiewitz, Bowen, Douglas, and Hsu (2013) found that the impact of mindfulness versus treatment as usual (TAU) on reduced alcohol craving was mediated by a latent variable that included acceptance of negative affect, but also included acting with awareness and nonjudgment, suggesting the mediator may be a complex construct. Hsu, Collins, and Marlatt (2013) found that the impact of mindfulness versus TAU on reduced alcohol use days was moderated such that individuals with lower distress tolerance benefited more, suggesting mindfulness may attenuate affective reactivity. Finally, Witkiewitz and Bowen (2010) reported a moderated mediation, wherein mindfulness therapy attenuated the mediational pathway between depression, craving and substance use, relative to TAU. These three studies support the claim that mindfulness interventions reduce drinking by building resilience to negative affective drinking triggers.

Trait mindfulness is similarly associated with resilience to negative affective drinking triggers in cross sectional studies with student drinkers. Bravo, Pearson, Stevens, and Henson (2016) reported a moderated mediation, wherein trait mindfulness predicted a weaker mediational pathway between depression and alcohol problems via self-reported drinking to cope with negative affect. Similar results have been reported by others (Roos, Pearson, & Brown, 2015; Bodenlos, Noonan, & Wells, 2013; Tull, Bardeen, DiLillo, Messman-Moore, & Gratz, 2015). Collectively, the foregoing studies suggest that experimentally trained (i.e. state) and trait mindfulness confer resilience to negative triggers for alcohol motivation, although the precise link between state and trait mindfulness remains unclear (Bravo, Pearson, Wilson, & Witkiewitz, 2018).

Importantly, emotional reactivity to negative mood and stress induction can be attenuated by extended mindfulness training (Basso, McHale, Ende, Oberlin, & Suzuki, 2019; Brewer et al., 2009; Carroll & Lustyk, 2018; Crosswell et al., 2017; Hoge et al., 2013; Kral et al., 2018; Lillis, Hayes, Bunting, & Masuda, 2009; Ortner, Kilner, & Zelazo, 2007; Tang et al., 2007), and ultra-brief mindfulness training (8 and 20 min audio files or verbal script) (Adams et al., 2012; Carpenter, Sanford, & Hofmann, 2019; Liu, Wang, Chang, Chen, & Si, 2013; Masedo & Rosa Esteve, 2007; Sauer & Baer, 2012), although four ultra-brief studies have reported null effects (Evans, Eisenlohr-Moul, Button, Baer, & Segerstrom, 2014; Luberto & McLeish, 2018; Paz, Zvielli, Goldstein, & Bernstein, 2017; Vernig & Orsillo, 2009). It is worth noting that trait mindfulness also predicts reduced emotional reactivity to stress induction (Arch & Craske, 2010; Bullis, Bøe, Asnaani, & Hofmann, 2014), and greater self-reported distress tolerance/emotion regulation (Feldman, Dunn, Stemke, Bell, & Greeson, 2014; Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007; Hsu et al., 2013; Luberto et al., 2014). In sum, emotional reactivity is clearly attenuated by longer mindfulness programs and trait mindfulness, but the effectiveness of ultra-brief mindfulness training remains equivocal.

The most important question is whether mindfulness interventions attenuate negative mood induced craving. There are three nominally positive studies. The first positive study found that 8 weeks of mindfulness based relapse prevention (MBRP) attenuated stress-induced alcohol/drug craving, compared to TAU, in substance dependent individuals (Carroll & Lustyk, 2018). The problem is that standard relapse prevention produced the same effect. Furthermore, in a separate study, cognitive-behavioral stress management also attenuated stress induced craving (Back, Gentilin, & Brady, 2007), so this effect is not specific to mindfulness interventions. The second positive study found, in treatment-seeking smokers, that mindfulness training versus psychoeducation attenuated neural stress reactivity measured by fMRI, and this predicted reduced smoking at follow up (Kober, Brewer, Height, & Sinha, 2017). However, the study did not test for an attenuation of stress-induced craving per se, so interpretation of the effect is ambiguous. The third positive study found in student drinkers that alcohol craving measured after stress induction was reduced by a subsequent 8-minute mindfulness versus educational audio, suggesting mindfulness promoted recovery from stress-induced craving (Bravo, Prince, O'Donnell, & Pearson, submitted for publication). However, because craving was not measured before stress induction, it is unclear whether mindfulness attenuated stress-induced craving as opposed to background craving.

These three studies need to be set against four null results. The first null study found in alcohol/cocaine abusers that although mindfulness versus CBT attenuated stress induced emotional reactivity, it did not attenuate stress-induced craving (Brewer et al., 2009). The second null study found in risky college drinkers that 10-min mindfulness versus relaxation training did not attenuate stress-induced changes in subjective mood or craving (Vinci et al., 2014). The third null study found in a group of daily smokers that 10-min guided mindful mediation versus popular science audio did not attenuate tobacco craving following stress induction (Luberto & McLeish, 2018). However, there was no stress induced increase in craving either, so the design was not optimal to test for an attenuation of this effect. The fourth null study produced a very similar pattern of results in female smokers (Adams et al., 2012). In sum, available studies are equivocal as to whether mindfulness training attenuates craving responses to negative triggers, and there is no obvious methodological parameter that distinguishes the positive from the negative findings.

To address these uncertainties, the current study tested whether one specific element of mindfulness therapy – breath counting (attention directed to breathing) – would attenuate stress-induced increases in alcohol-seeking behaviour, and subjective negative affect, measured in the lab. Breath counting was selected as the training manipulation because it is a core component of larger mindfulness packages, quickly engages attention to interoceptive states blocking out external distraction, it can be easily deployed in daily life by a wide range of groups making it practically useful, and breath counting accuracy correlates with trait mindfulness (Levinson, Stoll, Kindy, Merry, & Davidson, 2014; Wong, Massar, Chee, & Lim, 2018). Importantly, briefly trained breath counting or mindful breathing techniques have been shown to attenuate or accelerate recovery from mood and stress induction effects on subjective mood (Arch & Craske, 2006; Goldin & Gross, 2010; Keng & Tan, 2018; see also: Feldman, Greeson, & Senville, 2010), improve cognitive performance (Gorman & Green, 2016; McHugh, Simpson, & Reed, 2010; Mrazek, Smallwood, & Schooler, 2012), and improve learning and problem solving (Kiken & Shook, 2011; McHugh, Procter, Herzog, Schock, & Reed, 2012; McHugh et al., 2010; Ramsburg & Youmans, 2012, 2014).

The current study tested whether breath counting would attenuate stress-induced increases in alcohol-seeking in undergraduate drinkers (n = 192). Baseline alcohol-seeking was first measured by preference to view alcohol versus food thumbnail pictures in a series of two-alternative forced choice trials. The pictorial choice measure has been well validated as an index of the relative value ascribed to drug versus food, and as a robust correlate of dependence symptom severity, drug use frequency, and other vulnerability markers such as coping motives and psychiatric symptoms in clinical and subclinical samples (Hardy, Parker, Hartley, & Hogarth, 2018; Hogarth & Hardy, 2018a; Moeller & Stoops, 2015). Participants then listened to a 6-minute audio file which either trained breath counting (the breath counting group), or recited an extract from a popular science book – Bill Bryson's A Short History of

Nearly Everything (the control group). All participants were then stressed by listening to a loud and unpleasant industrial noise (70 dB), during which alcohol choice was measured again, as at baseline, to measure the increase in alcohol-seeking (Cherek, 1985). The breath counting group were told to deploy the breath counting technique in the stress test. Subjective annoyance and happiness were measured at baseline, post intervention, and post stress test. It was predicted that in the control group stress induction would increase alcohol choice and annoyance and decrease happiness, and that these induction effects would be attenuated in the breath counting group. These data would support the hypothesis that mindfulness interventions achieve therapeutic impact on substance use outcomes by building resilience to acute stress triggers, and that brief breath counting training may have therapeutic potential in its own right.

2. Methods

2.1. Participants

192 participants, who had drunk at least once in the past month and were therefore not teetotal, were recruited from the University of Exeter student population (age range: 18–52 years) and were randomly assigned to either the breath counting group or control group. Participants provided informed consent, were debriefed and received a chocolate bar as the reimbursement for participation. The study was approved by the School of Psychology Research Ethics Committee.

2.2. Questionnaires

Participants completed the following questionnaires. The adult Patient-Reported Outcomes Measurement Information System Alcohol Use Short Form (PROMIS; Pilkonis et al., 2016) which contains 7 items assessing loss of control over drinking in the past 30 days (e.g., “I drank more than I planned”), endorsed on a 1–5 scale ranging from “Never” to “Always” (we report the average scale scores). The Alcohol Use Disorder Identification Test (AUDIT; Babor, Higgins-Biddle, Saunders, & Monteiro, 2001) which contains 10 items assessing the frequency of alcohol use and alcohol-related problems experienced in the past 12 months. Total scores can range from 0 to 40 split into categories: low-risk (0–7), hazardous (8–15), harmful (16–19) and possibly dependent (20–40). The modified five factor Drinking Motives Questionnaire Revised (DMQR; Grant, Stewart, O'Connor, Blackwell, & Conrod, 2007), which measures how frequently drinking is motived by each listed reason, on a 1–10 scale ranging from “Never” to “Almost always”. It has five subscales: drinking to cope with anxiety and depression, conformity, enhancement and socialising (the two coping subscales were collapsed). The Generalised Anxiety Disorder (GAD; Spitzer, Kroenke, Williams, & Lowe, 2006) scale which contains 7 items assessing generalised anxiety disorder in the past two weeks (e.g., “feeling nervous, anxious or on edge”). The score on each item ranges from 0 (“Not at all”) to 3 (“Nearly every day”). The total score can range from 0 to 21, with a score of 5, 10, and 15 as the cut-off points for mild, moderate and severe anxiety, respectively. The Patient Health Questionnaire depression scale (PHQ; Kroenke et al., 2009) which contains 8 items assessing depressive symptoms in the past two weeks (e.g., “little interest or pleasure in doing things”). The score on each item ranges from 0 (“Not at all”) to 3 (“Nearly every day”). The total score can range from 0 to 24, with a score of 5, 10, 15 and 20 as the cut-off points for mild, moderately severe and severe depression, respectively.

2.3. Procedure

2.3.1. Baseline alcohol choice

As shown in Fig. 1, alcohol pictorial choice was measured at baseline by participants completing 24 two-alternative forced-choice trials in which they freely chose to enlarge thumbnail pictures of either alcohol or food by pressing a left or right arrow key (Hardy & Hogarth, 2017). Instructions were: ‘In this task, you can view alcohol and food pictures by pressing the left or right arrow key’. In each trial, the alcohol and food thumbnail stimuli presented were each sampled from a set of 28 pictures, and presented randomly in the left or right screen position. The dependent variable was the percentage choice of alcohol across all choice trials. Following baseline alcohol choice, subjective mood was measured, at the baseline timepoint, by asking participants to what extent they currently felt happy and annoyed, in random order, on a 5-point scale ranging from 1 (“not at all”) to 5 (“extremely”).

2.3.2. Breath counting versus control intervention

The half of participants who were assigned to the breath counting group listened to a 6-minute audio file (inspired by Ramsburg & Youmans, 2014) in which they were instructed (via a female voice) to relax and concentrate on their breath sensations, then count each out-breath, at normal pace, from one to ten, and then start again from one (see Supplementary material for full transcript and the audio file). The half of participants who were assigned to the control group received a 6-minute audio file in which was recited (by the same female voice as the breath counting audio) an extract from the popular science book A Short History of Nearly Everything by Bill Bryson (see Supplementary material). For both groups, after the audio file, participants were asked how much attention they had paid to the recording on a scale ranging from 1 (‘a little’) to 5 (‘a lot’), and how pleasant they had found to the experience on a scale ranging from 1 (‘Unpleasant’) to 5 (‘Pleasant’). Finally, all participants had their subjective happiness and annoyance measured at this post-intervention timepoint (identical to the baseline timepoint).

2.3.3. The stress-induced alcohol choice test

All participants then completed an alcohol pictorial choice task identical to baseline, except a loud and unpleasant industrial noise (70 dB; file: airsander.mp3 from www.freesfx.co.uk) was played continuously through headphones over 36 trials, to induce mild stress and augment alcohol choice (Cherek, 1985). The 36 trials of the test phase were broken into three time bins of 12 trials each to examine changes over time. The breath counting group were instructed to deploy the breath counting technique during the stress test, whereas the control group received no comparable instruction. All participants reported their subjective happiness and annoyance identical to the baseline and post intervention timepoints. Finally, the breath counting group reported their attention to and pleasantness of the breath technique deployed during the stress test, identical to the post-intervention timepoint. In the end, all participants completed a mood repair procedure (Hardy & Hogarth, 2017) to normalise mood prior to departure (for ethical reasons).

2.3.4. Analytical plan

ANOVAs were performed with the between subjects variable intervention group (breath counting, control) and the within subjects variable timepoint, which differed according to which dependent variable was considered. Percent alcohol choice was calculated from the baseline phase and the three time bins of the test phase, so progressive recovery from stress could be tested. Consequently, the block variable in this analysis had four levels: baseline and stress test bin 1–3. ANOVAs with subjective happiness and sadness included a timepoint variable with 3 levels (baseline, post intervention, post stress test). Pearson correlations were used to explore the relationship between questionnaire indices and behavioural/subjective measures in the task.

3. Results

The data that forms the basis of the results presented here are available from the University of Exeter Research Data Repository

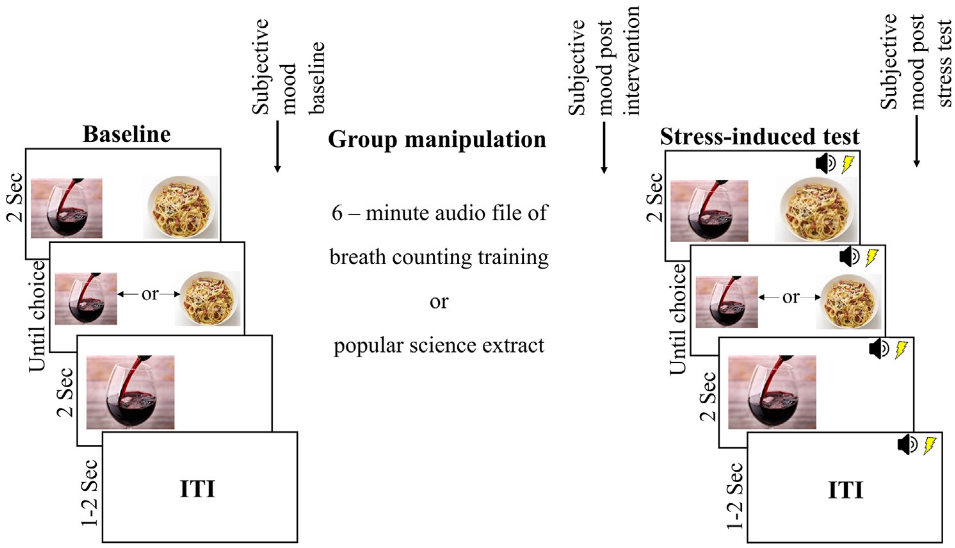

Fig. 1. Task used to test whether breath counting promotes resilience to stress induced alcohol-seeking in student drinkers. Baseline alcohol choice was measured by preference to view alcohol versus food thumbnail pictures in two-alternative forced choice trials. Participants then listened to a six minute audio file which either trained breath counting or recited a popular audio book (control group). Alcohol choice was then measured again but with noise stress induction added. The breath counting group were told to deploy this technique during the stress test. Subjective happiness and annoyance were measured at the three timepoints denoted.

(https://ore.exeter.ac.uk/repository/), doi: TBC.

3.1. Participants

Four participants were excluded due to the extreme change in their percent alcohol picture choices from baseline to test that were greater than three times the interquartile range of the sample, leaving 188 participants for analysis. This did not change the pattern of significance of the results. As shown in Table 1, the breath counting and control groups were matched with respect to questionnaire measures. The breath counting group reported paying more attention to, and greater pleasantness of, the intervention at the post-intervention timepoint. Characterising the severity of alcohol use disorder symptoms in the sample as whole, the proportion of participants that fell into each AUDIT category were: low-risk (26%), hazardous (46%), harmful (18%), and possibly dependent (11%).

3.2. Subjective happiness

Fig. 2A shows subjective happiness reported by the breath counting and control group at three timepoints of the experiment (baseline, post intervention, post stress test). ANOVA on these data yielded a significant main effect of timepoint, $F(2,372) = 65.30$, $p < .000$, $\eta_p^2 = 0.260$, suggesting that subjective happiness changed over time. There was also a significant interaction between intervention group and timepoint, $F(2,372) = 12.98$, $p < .001$, $\eta_p^2 = 0.065$, and a significant main effect of intervention group, $F(1,186) = 13.39$, $p < .001$, $\eta_p^2 = 0.067$, suggesting the intervention manipulation affected subjective happiness. Contrasts of the intervention groups indicated that their subjective happiness did not differ significantly at baseline, $F(1,186) = 1.95$, $p = .16$, $\eta_p^2 = 0.010$, but did differ significantly at post intervention, $F(1,186) = 30.60$, $p < .001$, $\eta_p^2 = 0.141$, and at post stress test, $F(1,186) = 7.79$, $p = .006$, $\eta_p^2 = 0.040$. Furthermore, contrasts of baseline versus post intervention timepoints indicated that breath counting significantly increased happiness, $F(1,92) = 13.76$, $p < .001$, $\eta_p^2 = 0.130$, whereas the control intervention decreased happiness, $F(1,94) = 20.73$, $p < .001$, $\eta_p^2 = 0.181$. These analyses suggest that breath counting compared to the control intervention increased happiness after the intervention, and protected from a stress induced decrease in happiness in the stress test.

3.3. Subjective annoyance

Fig. 2B shows subjective annoyance reported by the breath counting and control group at three timepoints of the experiment (baseline, post intervention, post stress test). ANOVA on these data yielded a significant main effect of timepoint, $F(2,372) = 126.73p < .001$, $\eta_p^2 = 0.405$, suggesting that subjective annoyance changed over time.

Table 1
Mean (SD, range) of questionnaire data reported by the breath counting and control groups. PROMIS = Patient-Reported Outcomes Measurement Information System Alcohol Use Short Form. AUDIT = Alcohol Use Disorder Identification Test. DMQR = modified Drinking Motives Questionnaire Revised. GAD = The Generalised Anxiety Disorder test. PHQ = Patient Health Questionnaire depression scale. *p* = significance level of the group contrast. – = test not possible.

	Group		*p*
	Breath counting (n = 93)	Control (n = 95)	
Age	21.51 (3.91, 18–52)	21.05 (2.09, 18–32)	0.32
Gender ratio (M/F)	47/46	48/47	1.00
PROMIS alcohol use	2.3 (0.8, 1–4.7)	2.4 (0.7, 1–4.1)	0.27
AUDIT score	11.44 (5.69, 2–28)	12.75 (6.16, 2–31)	0.13
DMQR coping	2.8 (1.8, 0–8.3)	3.2 (2.1, 0–9.2)	0.17
DMQR enhancement	4.9 (2.2, 0–9)	5.4 (2.2, 0–10)	0.11
DMQR socialising	6.7 (1.6, 1.4–9.8)	6.9 (1.8, 1.8–10)	0.43
DMQR conformity	1.6 (2.0, 0–9.2)	2.1 (1.9, 0–6.8)	0.10
GAD score	5.77 (4.51, 0–20)	6.79 (4.39, 0–21)	0.12
PHQ score	6.12 (4.74, 0–22)	6.65 (5.14, 0–24)	0.46
Attention to intervention (post-intervention)	3.98 (0.91, 1–5)	2.85 (1.15, 1–5)	< 0.001
Pleasantness of intervention (post-intervention)	4.02 (0.92, 2–5)	3.01 (1.13, 1–5)	< 0.001
Attention to intervention (post-test)	2.80 (1.15, 1–5)		–
Pleasantness of intervention (post-test)	2.98 (1.04, 1–5)		–

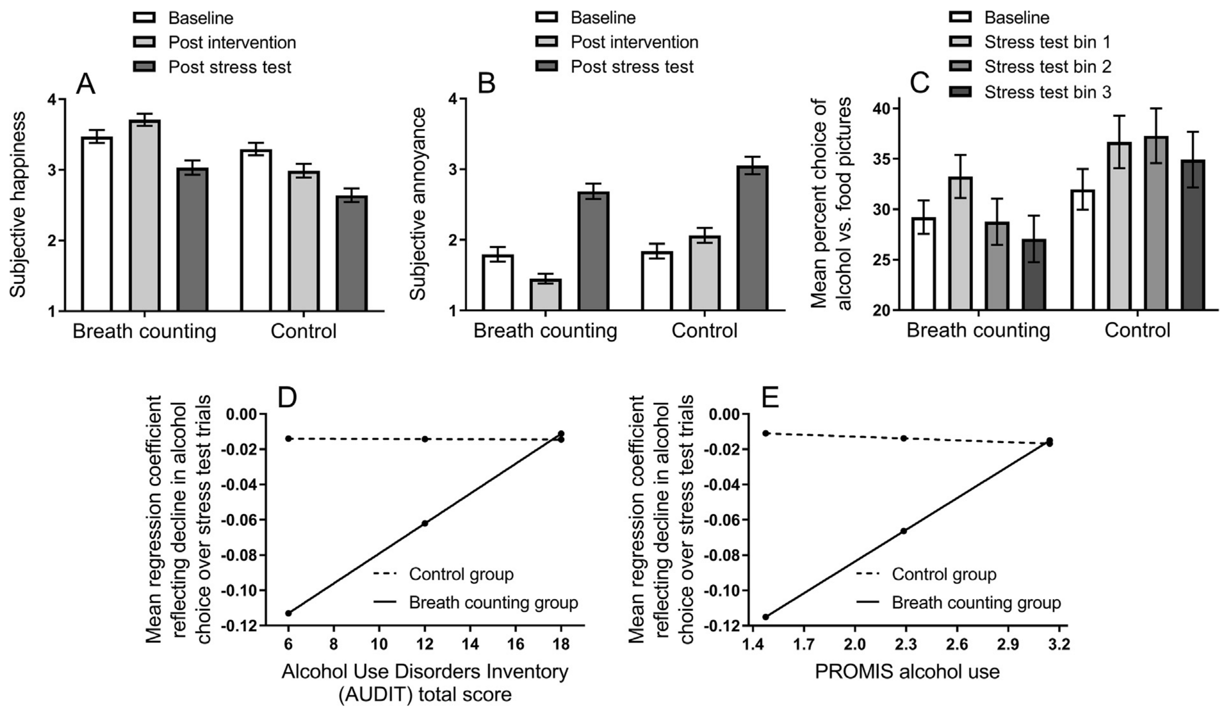

Fig. 2. (A) Mean (and SEM) subjective happiness measured at three timepoints (baseline, post intervention and post stress test) in the two groups. The breath counting group relative to the control group showed greater happiness post intervention, and an attenuated stress induced decrease in happiness post stress test. (B) Mean subjective annoyance measured at three timepoints in the two groups. The breath counting group relative to the control group showed reduced annoyance post intervention, and an attenuated stress induced increase in annoyance post stress test. (C) Mean percent choice of alcohol versus food pictures at baseline and across three time bins of the stress test, in the breath counting and control group. Both groups showed an increase in alcohol choice at stress test bin 1 vs. baseline. The groups differed thereafter. In the breath counting group, alcohol choice declined linearly back to baseline across test bins 2 and 3. In the control group, alcohol choice was stable above baseline across the stress test. (D) Moderation analysis: the effect of breath counting versus control intervention on recovery from stress induced alcohol-seeking (i.e. decline in alcohol choice across stress test trials indexed by a regression coefficient), was moderated by AUDIT scores, such that breath counting produced steeper recovery in participants with low and intermediate, but not high, AUDIT scores. (E) Equivalent moderation analysis with PROMIS alcohol use scores. Breath counting produced steeper recovery from stress induced alcohol-seeking in participants with low and intermediate, but not high, PROMIS alcohol use scores.

There was also a significant interaction between intervention group and timepoint, $F(2,372) = 6.50$, $p = .002$, $\eta_p^2 = 0.034$, $p < .000$, $\eta_p^2 = 0.405$, and a significant main effect of intervention group, $F(1,186) = 8.67$, $p = .004$, $\eta_p^2 = 0.045$, suggesting the intervention manipulation affected subjective annoyance. Contrasts of the two intervention groups indicated that their subjective annoyance did not differ significantly at baseline, $F(1,186) = 0.10$, $p = .73$, $\eta_p^2 = 0.001$, but did differ significantly at the post intervention, $F(1,186) = 23.24$, $p < .001$, $\eta_p^2 = 0.111$, and at post stress test timepoints, $F(1,186) = 4.91$, $p = .028$, $\eta_p^2 = 0.026$. Furthermore, contrasts of baseline versus post intervention timepoints indicated that the breath counting intervention significantly decreased annoyance, $F(1,92) = 17.78$, $p < .001$, $\eta_p^2 = 0.162$, whereas the control intervention increased annoyance, $F(1,94) = 5.05$, $p = .03$, $\eta_p^2 = 0.051$. These analyses suggest that breath counting compared to the control intervention decreased annoyance after the intervention, and protected from a stress induced increase in annoyance in the stress test.

3.4. Percent alcohol picture choice

Fig. 2C shows percent alcohol picture choice measured at baseline and three time bins of the stress test for the breath counting and control group. ANOVA on these data yielded a significant interaction between intervention (2) and block (4), $F(3,588) = 3.09$, $p = .027$, $\eta_p^2 = 0.016$, suggesting that the breath counting group recovered more quickly from the stress induced alcohol-seeking effect. There was also a significant main effect of block, $F(3,558) = 5.71$, $p = .001$, $\eta_p^2 = 0.030$, but no effect of group, $F(1,186) = 3.61$, $p = .059$, $\eta_p^2 = 0.019$. Breakdown of the significant 2x4 interaction was achieved with a series of 2x2 ANOVAs. Analysis of baseline and test bin 1 yielded a significant main effect of block, $F(1,186) = 13.88$, $p < .001$, $\eta_p^2 = 0.069$, and no interaction between intervention group and block, $F(1,186) = 0.08$, $p = .778$, $\eta_p^2 = 0.000$, suggesting that stress increased alcohol choice at test bin 1 relative to baseline, and groups were matched in sensitivity to this effect (i.e. there was no immediate protective effect of breath counting). By contrast, analysis of baseline and test bin 2 again yielded a significant effect of block, $F(1,186) = 4.59$, $p = .033$, $\eta_p^2 = 0.024$, but also a significant interaction between intervention group and block, $F(1,186) = 6.44$, $p = .012$, $\eta_p^2 = 0.033$, suggesting that breath counting protected from stress induced alcohol-seeking at test bin 2. Similarly, analysis of baseline and test bin 3 yielded no significant effect of block, $F(1,186) = 0.11$, $p = .741$, $\eta_p^2 = 0.001$, and a significant interaction between intervention group by block, $F(1,186) = 4.57$, $p = .034$, $\eta_p^2 = 0.024$, again suggesting that breath counting protected from stress induced alcohol-seeking at test bin 3. One way ANOVAs comparing groups at each time bin found no significant difference at baseline, $F(1,186) = 1.12$, $p = .292$, $\eta_p^2 = 0.006$, or test bin 1, $F(1,186) = 1.03$, $p = .311$, $\eta_p^2 = 0.006$, but a significant difference at test bin 2, $F(1,186) = 5.74$, $p = .018$, $\eta_p^2 = 0.030$, and test bin 3, $F(1,186) = 4.77$, $p = .030$, $\eta_p^2 = 0.025$. Finally, examination of the three test bins indicated that there was a significant linear decline for the breath counting group, $F(1,92) = 12.95$, $p = .001$, $\eta_p^2 = 0.123$, but not the control group, $F(1,94) = 1.04$, $p = .311$, $\eta_p^2 = 0.011$. These analyses suggest that breath counting, compared to the control intervention, promoted recovery from a stress-induced increase in alcohol choice.

3.5. Exploratory correlations

Correlations tested whether, in the sample as a whole, baseline alcohol choice and the stress induced increase in alcohol choice were associated with questionnaire scales. Percent alcohol choice at baseline correlated significantly with AUDIT, $r = 0.43$, $p < .001$, PROMIS alcohol use, $r = 0.34$, $p < .001$, DMQR enhancement, $r = 0.31$, $p < .001$, DMQR social, $r = 0.29$, $p < .001$, and DMQR coping, $r = 0.37$, $p < .001$, but not DMQR conformity, $r = 0.06$, $p = .34$, GAD anxiety, $r = 0.05$, $p = .52$, or PHQ depression, $r = 0.14$, $p = .06$. The stress induced increase in alcohol choice from baseline to test (over all time bins) correlated positively with AUDIT, $r = 0.16$, $p = .03$, PROMIS alcohol use, $r = 0.19$, $p = .008$, and DMQR coping, $r = 0.19$, $p = .007$, but not with DMQR enhancement, $r = 0.14$, $p = .06$, DMQR social, $r = 0.13$, $p = .08$, DMQR conformity, $r = 0.11$, $p = .14$, GAD anxiety, $r = 0.03$, $p = .69$, or PHQ depression, $r = 0.00$, $p = .99$. These correlations suggest that baseline alcohol-seeking and stress induced alcohol-seeking are linked to a range of vulnerability factors.

3.6. Exploratory moderation analysis

Moderation analysis was used to test whether the beneficial effect of breath counting differed between individuals. Recovery from stress induced alcohol-seeking was quantified by calculating a regression slope for each participant relating the probability of choosing the alcohol picture over successive test trials. This recovery score was entered as the outcome variable, intervention group was entered as the predictor variable and each questionnaire was entered as the moderator, in separate moderation models using Hayes Process Software for SPSS (https://processmacro.org/index.html). A significant moderation effect was found for AUDIT, $b = -0.01$, $p = .03$, shown in Fig. 2D. The breath counting versus control intervention produced steeper recovery from stress induced alcohol-seeking in those with low, $b = 0.09$, $p < .005$, and intermediate AUDIT scores, $b = 0.04$, $p < .05$, but not those with high AUDIT scores, $b = -0.00$, $p = .92$. A significant moderation effect was also found with PROMIS alcohol use scores, $b = -0.06$, $p = .04$, shown in Fig. 2E. The breath counting versus control intervention produced steeper recovery from stress induced alcohol-seeking in those with low, $b = 0.10$, $p < .005$, and intermediate PROMIS alcohol use scores, $b = 0.05$, $p = .03$, but not those with high PROMIS alcohol use scores, $b = -0.00$, $p = .95$. Finally, there were no moderation effects with DMQR coping, $b = 0.00$, $p = .97$, DMQR social, $b = -0.02$, $p = .09$, DMQR enhancement, $b = -0.01$, $p = .61$, DMQR conformity, $b = -0.00$, $p = .73$, GAD anxiety, $b = -0.00$, $p = .96$, or PHQ depression, $b = -0.00$, $p = .26$. Finally, there were no significant moderation effects when the change in happiness or annoyance from baseline to test was entered as the outcome variable. The overall implication of these analyses is that breath counting produced less recovery from stress induced alcohol-seeking in those with greater alcohol dependence.

4. Discussion

The study found that following training of a breath counting technique (versus control), happiness increased and annoyance decreased, relative to baseline. Participants also rated the breath counting intervention as more pleasant and attention demanding, indicating this practice was pleasant and acceptable. Deployment of the breath counting technique during noise stress induction resulted in a smaller decrease in happiness and smaller increase in annoyance, relative to the control group, suggesting that breath counting attenuated stress induced negative mood. Finally, deployment of the breath counting technique during noise stress promoted more rapid recovery from the stress induced increase in alcohol-seeking over bins of the test block. These findings indicate that ultra-brief breath counting training can improve mood, and attenuate stress induced negative mood and alcohol motivation. The therapeutic impact of mindfulness interventions on problematic drinking could be driven by such stress resilience effects, and ultra-brief breath counting training could have therapeutic potential in its own right.

Breath counting attenuated stress induced negative mood, corroborating studies showing attenuation of mood/stress induced subjective/physiological responses by (a) mindfulness or meditation training (Basso et al., 2019; Brewer et al., 2009; Carroll & Lustyk, 2018; Hoge et al., 2013; Kral et al., 2018; Lillis et al., 2009; Ortner et al., 2007; Tang et al., 2007); (b) ultra-brief mindfulness interventions (Adams et al., 2012; Carpenter et al., 2019; Liu et al., 2013; Masedo & Rosa Esteve, 2007; Sauer & Baer, 2012); and (c) ultra-brief breath counting training similar to the one used here (Arch & Craske, 2006; Goldin & Gross, 2010; Keng & Tan, 2018). However, several mindfulness training studies have failed to demonstrate attenuation of emotional reactivity (Evans et al., 2014; Luberto & McLeish, 2018; Paz et al., 2017; Vernig & Orsillo, 2009). Nevertheless, the weight of evidence supports the idea that mindfulness/breath counting engenders resilience to mood/stress induced emotional responses. It remains unknown whether this mechanism plays a role in the therapeutic impact of mindfulness on drinking outcomes.

The novel contribution of the current study was to demonstrate that deployment of the briefly trained breath counting technique promoted recovery from a stress induced increase in alcohol choice across time bins of the stress test, compared to the control group. This finding corroborates three studies which have reported attenuation of mood/stress induced craving by mindfulness based relapse prevention (Carroll & Lustyk, 2018), cognitive-behavioral stress management (Back et al., 2007), and ultra-brief mindfulness training (Bravo et al., submitted for publication); for a potentially related fMRI effect see Kober et al. (2017). However, there remain four studies which have reported no impact of extended (Brewer et al., 2009) or ultra-brief mindfulness training (Adams et al., 2012; Luberto & McLeish, 2018; Vinci et al., 2014) on mood/stress induced craving. There are multiple methodological differences between the positive and negative studies. Therefore, the boundary conditions necessary to demonstrate attenuation of mood/stress induced drug motivation remain obscure. We can conclude that the current model is sensitive to this effect, making it attractive as an assay in future studies.

The current study cannot isolate the mechanism(s) by which the breath counting intervention created resilience to stress induced mood and alcohol-seeking. A wide range of behavioural manipulations have been shown to attenuate mood/stress induced effects on subjective mood or physiological reactivity. These include brief instructions about accepting emotions (Campbell-Sills, Barlow, Brown, & Hofmann, 2006; Keogh, Bond, Hanmer, & Tilston, 2005; Levitt, Brown, Orsillo, & Barlow, 2004; McMullen et al., 2008; Schartau, Dalgleish, & Dunn, 2009; Singer & Dobson, 2007; Singer & Dobson, 2009; Vieten, Astin, Buscemi, & Galloway, 2010), guided imagery of the stressor prior to testing (Yaremko & Butler, 1975; Yaremko, Glanville, & Leckart, 1972), guided positive mental imagery (Jacob et al., 2011), guided neutral mental imagery (Joormann & Siemer, 2004; Joormann, Siemer, & Gotlib, 2007), attentional capture by happy faces (Sanchez, Vazquez, Gomez, & Joormann, 2014), occupancy of working memory by secondary tasks (Erber & Tesser, 1992; Kron, Schul, Cohen, & Hassin, 2010; Trask & Sigmon, 1999; Van Dillen, Heslenfeld, & Koole, 2009; Van Dillen & Koole, 2007, 2009), distress tolerance training (Bornovalova, Gratz, Daughters, Hunt, & Lejuez, 2012), acute exercise (Bernstein & McNally, 2017a, 2017b; Mata, Hogan, Joormann, Waugh, & Gotlib, 2013; Rejeski, Thompson, Brubaker, & Miller, 1992), exposure to green environments (Jiang, Li, Larsen, & Sullivan, 2014) and drawing pleasant pictures (Dalebroux, Goldstein, & Winner, 2008; Drake, Coleman, & Winner, 2011; Drake & Winner, 2012; Smolarski, Leone, & Robbins, 2015). Although any of these processes could be responsible for the effects found in the present study, occupancy of working memory resources is perhaps the most plausible mechanism

(Tapper, 2018). If, over the stress test, participants became more skilled in attending to the breath counting exercise, diverting attention from the noise, this would explain the progressive recovery from stress induced alcohol-seeking. Future studies need to isolate the effective mechanism by including an active control group (e.g. number counting, relaxation training), and by inserting measures (e.g. state mindfulness, breath counting accuracy) to test mediation of the therapeutic outcome.

There were also individual differences in the observed effects. First, baseline alcohol choice was associated with multiple indices of vulnerability to alcohol dependence (AUDIT, PROMIS alcohol use, DMQR subscales), as has been reported previously in clinical and subclinical samples (Hardy & Hogarth, 2017; Hardy et al., 2018; Hogarth & Hardy, 2018b; Hogarth et al., 2018), consistent with the relative value of alcohol playing a role in dependence risk. Interestingly, percent alcohol choice did not correlate with anxiety and depression, confirming similar null associations with student drinkers (Hogarth & Hardy, 2018b; Hogarth et al., 2018), and contradicting studies with more severe drinker samples (Hardy & Hogarth, 2017; Hardy et al., 2018). The implication is that psychiatric symptoms play a more powerful role in alcohol valuation in more severe drinkers.

Second, the magnitude of the stress induced increase in alcohol-seeking from baseline to test, in the sample as a whole, increased with AUDIT and PROMIS alcohol use measures. By contrast, three previous studies found that AUDIT was not associated with negative mood induced alcohol-seeking (Hardy & Hogarth, 2017; Hogarth & Hardy, 2018b; Hogarth et al., 2018), suggesting stress induction may favour this association. However, in the wider literature, the association between dependence and mood/stress induced craving is inconsistent (Austin & Smith, 2008; Cooney et al., 1997; Field & Powell, 2007; Field & Quigley, 2009; Randall & Cox, 2001; Sinha et al., 2009; Woud, Becker, Rinck, & Salemink, 2015; Zack, Poulos, Fragopoulos, & MacLeod, 2003; Zack, Poulos, Fragopoulos, Woodford, & MacLeod, 2006; Zack, Toneatto, & MacLeod, 1999), although the link to relapse risk is more reliable (Brady et al., 2006; Cooney et al., 1997; Higley et al., 2011; Sinha et al., 2011). The implication is that stress/mood induced drug motivation may increase with only particular dimensions of dependence, yet to be clarified.

Third, the stress induced increase in alcohol-seeking correlated with DMQR coping, but not other DMQR subscales. Similar selective associations have been reported in other studies (Austin & Smith, 2008; Birch et al., 2004; Field & Powell, 2007; Field & Quigley, 2009; Grant, Stewart, & Birch, 2007; Hogarth & Hardy, 2018b; Hogarth, Hardy, et al., 2019; Hogarth et al., 2018; Rousseau, Irons, & Correia, 2011; Woud et al., 2015). By contrast, stress induced alcohol-seeking did not correlate with anxiety or depression symptoms, which contradicts findings from both student and clinical samples (Cooney et al., 1997; Fucito & Juliano, 2009; Hogarth et al., 2018; Hogarth et al., 2017). One explanation is that although psychiatric symptoms confer sensitivity to negative affect drug use triggers, this relationship is proximally mediated by coping motives (Cox & Klinger, 1988; Hogarth, Martin, & Seedat, 2019), such that the correlation between psychiatric symptoms and mood/stress induced drug-seeking is weaker and more unreliable. However, this model requires empirical confirmation.

Finally, the moderation analyses showed that breath counting produced less recovery from stress induced alcohol-seeking as dependence severity increased, and produced no recovery in more dependent drinkers. It is possible that this resistance to recovery was a corollary of more dependent drinkers showing a greater stress induced alcohol-seeking effect overall. In any case, the implication is that breath counting (and by extension mindfulness training) may be less effective for more dependent drug users. However, this claim contradicts a moderation analysis of clinical trials data which showed that mindfulness based relapse prevention versus control interventions produced a bigger effect on substance use outcomes as dependence symptom severity increased (Roos, Bowen, & Witkiewitz, 2017), i.e. greater efficacy for more dependent individuals. It is difficult to resolve the discrepancy between these findings. It is possible that more dependent individuals benefit more from extended interventions, and less from brief interventions, or there may be unique facets of mindfulness training not encompassed by breath counting. Regardless, the findings from the present study demand that the effect of breath counting on recovery from stress induced alcohol-seeking is tested in more severe drinkers to assess whether this approach has therapeutic potential in a non-student sample.

To conclude, the study found that a briefly trained breath counting technique improved mood, attenuated stress induced worsening of mood, and promoted recovery from stress induced alcohol-seeking in student drinkers. Mindfulness therapies may improve drinking outcomes via these effects. This possibility could be evaluated in a mindfulness clinical trial by testing whether the treatment effect on drinking outcomes is mediated by an effect on stress induced subjective mood and alcohol-seeking (Hsu et al., 2013; Magill & Longabaugh, 2013; Witkiewitz & Bowen, 2010; Witkiewitz et al., 2013). The second conclusion is that brief breath counting training might have therapeutic potential in its own right. However, this claim is limited because breath counting did not promote recovery from stress induced alcohol-seeking in more dependent drinkers. The clinical potential of breath counting needs to be evaluated in a more severe drinker sample. Finally, the finding that stress induced alcohol-seeking was sensitive to the breath counting intervention suggests this model could be used to screen other candidate interventions designed to mitigate this effect, such as anxiolytic pharmacotherapy (Mantsch, Baker, Funk, Le, & Shaham, 2016; Schwandt et al., 2016; Spanagel, Noori, & Heilig, 2014).

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Contributors

Hogarth, Hardy and Bakou designed the study. Bakou implemented the design and created materials. Shuai ran the study and wrote the first draft of the paper. Hogarth conducted the analysis. All authors contributed to the final article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2019.106141.

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