Additive effectiveness of mindfulness meditation to a school-based brief cognitive-behavioral alcohol intervention for adolescents

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Public Health Significance Statements

- This study supports targeting cognitive risk factors for adolescent alcohol use through Cognitive Behavioral Therapy to reduce the growth of alcohol consumption in adolescents.
- The addition of Mindfulness Meditation to existing Cognitive Behavioral Therapy did not improve alcohol use outcomes when compared to an active control.

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Abstract

Objective: This randomized controlled trial is the first study to evaluate the additive efficacy of mindfulness meditation to brief school-based universal Cognitive Behavior Therapy (CBT+MM) for adolescent alcohol consumption. Previous studies have lacked strong controls for non-specific effects and treatment mechanisms remain unclear. The present study compared a CBT+MM condition to an active control CBT intervention with Progressive Muscle Relaxation (CBT+PMR) for non-specific effects, and an assessment-only control (AoC). **Method**: Cluster sampling was used to recruit Australian adolescents (*N* = 404, 62% female) aged 13-17 years (Mean age = 14.99 years, *SD* = .66 years) of mostly Australian/New Zealand or European descent. School classes were randomized to three intervention conditions (CBT+PMR=8 classes, CBT+MM=7, AoC=7) and adolescents completed pre-intervention, post-intervention, 3-month and 6-month follow-up assessments, including measures of alcohol consumption, mindfulness, impulsivity, and the alcohol-related cognitions of alcohol expectancies and drinking refusal self-efficacy. **Results**: Multi-level modelling analyses revealed that both intervention conditions reduced the growth of alcohol consumption compared to the AoC (B=-0.18, p=.014), although CBT+MM was no more effective than CBT+PMR, B=-0.06, p=.484. Negative alcohol expectancies increased for adolescents in the intervention conditions compared to the AoC (B=1.09, p=.012), as did positive alcohol expectancies, B=1.30, p=.008. There was no effect of interventions on mindfulness, drinking refusal self-efficacy, or impulsivity. **Conclusions**: There was no evidence of mindfulness-specific effects beyond existing effects of CBT within a brief universal school-based CBT intervention. Hypothesized mechanisms of change were largely unsupported.

Keywords: adolescent, cognitive behavior therapy, mindfulness, alcohol, prevention

Introduction

According to the World Health Organization (2014), 46.1% of 15-19 year-olds identify as current or former drinkers. Further, the pattern of use for this age group includes higher rates of monthly heavy episodic drinking compared to older alcohol users (World Health Organization, 2014). Adolescent alcohol use has been associated with decreased cognitive abilities (Nguyen-Louie et al., 2015), increased social problems, such as criminal offenses and employment issues (Jennings, Piquero, Rocque, & Farrington, 2015), high school non-completion (Kelly et al., 2015), and social anxiety (Spear, 2014), and reduced brain matter volume (Luciana, Collins, Muetzel, & Lim, 2014) and subsequent neurocognitive effects, including reduced memory, attention, and executive functioning (Lisdahl, Gilbart, Wright, & Shollenbarger, 2013). Due to the high prevalence of adolescent alcohol use and the associated consequences, prevention approaches have been proposed to ameliorate harms (Tripodi, Bender, Litschge, & Vaughn, 2010).

The meta-analysis of adolescent alcohol treatments by Tripoli and colleagues (2010) concluded that individual and several family-based adolescent alcohol treatment programs have shown large effects in reducing alcohol use for adolescents aged 12-19 years. Intervention effect sizes decrease over time (Tripodi et al., 2010). Interestingly, brief interventions also showed large effect sizes for a number of studies delivered in a variety of settings including clinics, school (one study only), and community centres (Tripodi et al., 2010). Despite this, brief school-based interventions have low-to-mixed evidence of effectiveness in the short-term (1-3 months) (Carney, Myers, Louw, & Okwundu, 2016). As schools provide an opportunity for maximum breadth of intervention targets (McLellan & Meyers, 2004), improving the effects of school-based interventions may provide an avenue for high impact.

The focus on mechanisms of change within interventions has been widely recommended to pinpoint areas of maximum impact and to identify the causal pathways of intervention effects within existing programs (Gaume, McCambridge, Bertholet, & Daeppen, 2014; O'Leary-Barrett, Castellanos-Ryan, Pihl, & Conrod, 2016). Further, there is evidence that intervention targets may produce differential effects according to the age of the intervention group (Onrust, Otten, Lammers, & Smit, 2016). A model of risk that can elucidate the inter-relationships between risk factors may assist intervention effort through identifying unique mechanisms by which to target these factors.

Within adult alcohol use treatment interventions, drinking refusal self-efficacy and alcohol expectancies are considered to be key factors in explaining onset and maintenance of alcohol use disorders as well as mechanisms of treatment outcomes (Coates et al., 2018; Connor, Haber, & Hall, 2016; Magill, Kiluk, McCrady, Tonigan, & Longabaugh, 2015). Drinking refusal self-efficacy refers to one's belief in their ability to refuse alcohol and alcohol expectancies encompass positive and negative beliefs regarding likely outcomes of alcohol consumption (Connor et al., 2016; Magill et al., 2015). Despite their importance in adult treatment and their prospective association with adolescent alcohol use (Connor, George, Gullo, Kelly, & Young, 2011), there has been little research into whether these factors influence adolescent intervention outcomes (Black & Chung, 2014). Adults drink more frequently while adolescents have higher single occasion consumption, and adolescent use is associated with higher rates of mood, conduct disorders, and future alcohol-related problems (Deas, Riggs, Langenbucher, Goldman, & Brown, 2000). Due to the differing clinical profiles, it cannot be assumed that adults and adolescents will respond similarly to treatments and hypothesized treatment mechanisms (Deas et al., 2000). Developmental differences could be substantial. Indeed, targeting refusal skills can actually increase alcohol use in middle adolescence, rather than decrease it (Onrust et al., 2016).

If targeting drinking refusal self-efficacy is important, but addressing it directly can be detrimental during adolescence, interventions could improve efficacy through targeting related factors. Adolescence is a unique risk period for the development of alcohol use and dependence due, in part, to neurodevelopmental changes involving reduced executive functioning (especially impulse control) within the context of increased sensitivity to reward (Robert & Schumann, 2017). It is no surprise then, that while other personality factors such as neuroticism, agreeableness, and openness (Chassin, Flora, & King, 2004), as well as individual differences in depression, stress, and emotion regulation (Gigsby, Forster, Unger, & Sussman, 2016) contribute to adolescent alcohol use, impulsivity is consistently found to be a large predictor of alcohol consumption and problems, especially amongst adolescents (Gigsby et al., 2016; Stautz & Cooper, 2013). Additionally, adolescents are particularly influenced by social dynamics, which influence appraisals and perceived drinking norms (Colder et al., 2017).

Elevated reward drive (also referred to as trait Reward Drive, Approach Motivation, or Sensation Seeking) has been hypothesized to facilitate the formation of positive alcohol expectancies, which in turn increase alcohol use (Gullo, Dawe, Kambouropoulos, Staiger, & Jackson, 2010). On the other hand, high rash impulsivity (trait Rash Impulsiveness, Disinhibition, or Lack of Premeditation) undermines drinking refusal self-efficacy, predicting increased use (Gullo et al., 2010). Additionally, high positive expectancies and low negative expectancies are thought to decrease drinking refusal self-efficacy, which in turn predicts higher consumption (Gullo et al., 2010). This bioSocial Cognitive Theory (bSCT) of substance use has been supported in community samples (Gullo et al., 2010; Harnett, Lynch, Gullo, Dawe, &

Loxton, 2013; Kabbani & Kambouropoulos, 2013), and treatment-seeking cannabis and alcohol dependent adults (Gullo et al., 2014; Papinczak, Connor, Harnett, & Gullo, 2018), as well as adolescent populations (Patton, Gullo, et al., 2018).

It is clear from this research that alcohol-related cognitions impact alcohol use and that these cognitions are influenced by individual differences in appetitive and inhibitory processes. Cognitive Behavioral Therapy (CBT) is uniquely placed to target alcohol-related cognitions directly and perhaps interrupt the link between impulsivity and cognitions (Loree, Lundahl, & Ledgerwood, 2015), as well as indirectly impacting drinking refusal self-efficacy through altering alcohol expectancies (Connor et al., 2016; Patton, Gullo, et al., 2018). Current promising interventions have utilized CBT to target individual personality risk factors for adolescent alcohol use, including impulsivity traits (Conrod et al., 2013). For example, previous interventions have targeted boredom-susceptibility and reward-seeking cognitions in adolescents identified to have high sensation seeking (Conrod, Castellanos, & Mackie, 2008). It is possible that the effectiveness of these programs is driven by targeting these general cognitions regarding alcohol (such as expectancies and self-efficacy) as well as personality-risk specific cognitions. However, the effect of these interventions appears to be more robust for reward drive-related impulsivity and may not be equally effective in targeting rash impulsiveness-related traits (Conrod et al., 2008; Conrod, Stewart, Comeau, & Maclean, 2006). This could explain the comparable effectiveness of universal cognitive-based alcohol programs (Teesson et al., 2017).

Therefore there may be room for increased effectiveness in CBT methods of targeting rash impulsiveness in school-based interventions. This may help to explain the mixed evidence for the effectiveness of school-based alcohol use intervention programs (Carney et al., 2016; Onrust et al., 2016). The findings that the effects of CBT for adolescent alcohol prevention interventions are strongest for high impulsivity adolescents and that impulsivity impacts a major cognitive mechanism of CBT (drinking refusal self-efficacy) lends support to the theory that targeting impulsivity directly may improve intervention effectiveness. We hypothesize that mindfulness meditation may be a more appropriate strategy to target rash impulsiveness. Mindfulness meditation involves deliberate attention on the present with non-judgmental acceptance of present moment experiences, which is theoretically consistent with managing rash, inattentive impulses (Papies, Barsalou, & Custers, 2012). Brief meditation has been shown to improve attention and self-regulation (Tang et al., 2007) and increase brain white matter (Tang, Lu, Fan, Yang, & Posner, 2012). As adolescence is a period of both reward sensitivity and reduced impulse control (Stautz, Dinc, & Cooper, 2017) and each imparts unique risks for alcohol use (Gullo et al., 2010), finding effective strategies to target both factors of impulsivity could improve the efficacy of current intervention approaches.

Mindfulness is a complementary technique to CBT (Beck & Haigh, 2014). Mindfulness interventions have gained empirical support for their efficacy as a treatment for adult and adolescent mental health problems (Khoury et al., 2013; Zoogman, Goldberg, Hoyt, & Miller, 2015). Further, there is preliminary support for the addition of mindfulness training to adolescent alcohol misuse interventions (Harris, Stewart, & Stanton, 2017). Previous studies investigating mindfulness often utilize a waitlist control group or do not include an active treatment comparison group in their design (Khoury et al., 2013; Zoogman et al., 2015). This lack of active comparison results in uncertainty as to the specific vs non-specific (e.g., relaxation) effects of mindfulness (Davidson, 2010; Goyal et al., 2014), especially when it is combined with a previously validated treatment approach, such as CBT. Therefore, a procedure such as Progressive Muscle Relaxation, which invokes relaxation but not increased objectivity regarding one's internal experience, known as decentering, which is considered a key component of mindfulness (Feldman, Greeson, & Senville, 2010), would be an appropriate active control.

The present study aimed to investigate the effect of a CBT-based adolescent alcohol use prevention intervention. Further, we aimed to identify whether Mindfulness Meditation (MM) would produce additional effectiveness to the CBT approach. To investigate this thoroughly, we utilized PMR as an active control for non-specific relaxation effects where adolescents received CBT (i.e., CBT+PMR). Both of these active conditions (CBT+MM and CBT+PMR) were compared to an assessment-only control group. We hypothesized that both interventions would reduce the growth in alcohol use over a six-month period post-intervention compared to the assessment-only control and that the CBT+MM condition would be superior to the CBT+PMR intervention. We also aimed to investigate possible mechanisms of effect of the intervention by conducting secondary analyses on other outcome variables including drinking refusal self-efficacy, positive and negative alcohol expectancies, and mindfulness ability. We predicted that both CBT interventions would decrease positive alcohol expectancies and increase negative alcohol expectancies and drinking refusal self-efficacy compared to the assessment-only control, but that mindfulness would increase only for the CBT+MM condition.

Methods

Ethical clearance, trial registration and reporting

The trial was granted ethical clearance by the University of Queensland Behavioural and Social Sciences Ethical Review Committee (#2015000875), Brisbane Catholic Education (#196), and was registered with the Australian New Zealand Trials Registry (ACTRN12616000077460). The Journal Article Reporting Standards (JARS; American Psychological Association, 2008) have been used to guide the current report.

Power

Originally the analysis was planned as Structural Equation Modelling (SEM) (ACTRN12616000077460). The sample size was determined assuming intra-class variance of 0.4 (Heo & Leon, 2010). The meta-analysis by Sedlmeier et al. (2012) found moderate psychological effect sizes for meditation compared to relaxation ($\bar{r}$ = .21). However, a systematic review of mindfulness for adult substance use treatment found effect sizes ranged from small to moderate (Zgierska et al., 2009). Due to these findings and the robust active control in the present study a small effect size was assumed (β = .14). Based on these estimates, number of time points, degrees of freedom and analysis requirements and assuming a 20% attrition rate over time, a baseline sample of 441 students was sought (Kim, 2005; Muthén & Curran, 1997). Multi-Level Modelling (MLM) was considered more appropriate for the data after data collection (see analytical procedure section). Using the approach for MLM (Hox, 2002; Snijders, 2005), post hoc power analysis indicates that the study had power of .80 (α = .05) to detect a β = .12 effect size of CBT+MM vs CBT+PMR within the current sample.

Participants and anonymized matching procedure

Four-hundred and ninety-nine students in Grade 9 or 10 (typically 13–15 years of age) from 6 schools were approached to participate in the study, of which 468 provided informed consent and were randomized. Grade 9 and 10 students were sought in order to deliver the prevention intervention earlier than the average age of onset of 15.7 years for Australian adolescents (Australian Institute of Health and Welfare, 2014). Twenty-five schools in urban South-East Queensland were initially contacted for possible inclusion in the study, out of which, six schools agreed to participate. Informed consent was gained from participants and their parent or guardian. A cluster randomization procedure was utilized with an intention-to-treat approach, and 468 students were randomized by KP using an online random number generator to CBT+PMR, CBT+MM, or Control conditions within class clusters in each school (see Figure 1 for CONSORT flow diagram). That each school participated in all three conditions allowed for greater certainty that variation between conditions was not due to randomization artifacts. Participants were not incentivized to complete the intervention. However, all but one school opted for their students to receive skills reminder SMS. Students went into a pool to receive a gift voucher to a local electronics store and replies to these messages resulted in more chances to receive a voucher.

Participants were anonymized using a nine-item code per the procedure of Schnell and colleagues (2010). The codes were manually matched across time points using Levenshtein string distance function in Microsoft Excel and cross-checking with mobile phone numbers, if provided (Schnell, Bachteler, & Reiher, 2010). The majority of participants (75%) were matched to at least one other time point (see Table S01 in supplementary materials), which was considered a high matching rate given that losses of up to 50% can be reported for two time-point anonymized matching (Schnell et al., 2010). However, the total number of participants at the completion of data collection (N = 542) was greater than the number of allocated participants at Time 1 (total N allocated = 468). This was interpreted as a) possible failures in matching resulting in a single participant present at several time points appearing as several individuals or b) collection of data from participants who were not consented to participate (e.g., due to change in class or newly enrolled students during follow-up period). To correct for the latter possibility, data were restricted to participants present at Time 1 and all cases across Times 2, 3, and 4 who were not matched to a case at Time 1 were removed to conform to study ethics approval (final sample N = 404, 74.54% of all data initially collected).

Participants were aged 13-17 years (Mean age = 14.99, *SD* = .66 years), and 62% were female (*N* = 251). In the final analyses, there were 130 adolescents in the CBT+MM condition (8 classes), 141 in the CBT+PMR condition (7 classes), and 133 in the AoC condition (7 classes). There were no significant pre-intervention differences between participants in each condition for demographic, predictor, and outcome measures. Most participants lived within medium affluence families and had Australian or European backgrounds (see Table S03 for baseline characteristics). Sixty-five percent of participants provided data at 6-month follow-up (Time 4). However, 75% provided data at 3 or more of the 4 assessment occasions.

Interventions

The intervention involved a universal Cognitive Behavioral Therapy (CBT) program. The interventions were delivered by one or two facilitators in class groups of 8-23 students. The facilitators were not blinded to condition. Adolescents in the two intervention conditions were introduced to the cognitive model of the interplay between thoughts, emotions, and behaviors (Beck, 1976) and were taught techniques to identify, challenge, and change “unhelpful” cognitions. The techniques were first applied to general stress and negative emotions before then being applied to alcohol use. Specifically, class-generated cognitions regarding possible alcohol use at a hypothetical party. The adolescents were also taught either Progressive Muscle Relaxation (CBT+PMR condition; Creed, Reisweber, & Beck, 2011) or mindful breathing exercises (CBT+MM; Harris, 2009; Williams and Penman, 2011). The CBT+PMR condition participants were introduced to PMR as a technique to reduce stress through recognizing and relaxing tension. The CBT+MM condition was taught MM as a technique to reduce inattention and to increase present-moment awareness. Both intervention conditions were given access to condition-specific websites with resources on the CBT and PMR/MM techniques, including recordings of PMR/MM exercises used in sessions. See Table S02 in supplementary materials for session outlines.

Procedure

The intervention was designed to be 110 minutes in total (plus 80 minutes for completing assessments), delivered over 3 sessions. Due to practical considerations within each school, total intervention time differed between schools. The 6 schools ranged in intervention time from 110-220 minutes with an average intervention time of 173 minutes. The intervention was delivered by students completing masters or doctorate-level psychology programs who were trained in the intervention by a doctoral-level instructor. Assessment measures were completed prior to the intervention (Time 1), immediately post-intervention (Time 2), 3-months post-intervention (Time 3), and 6-months post-intervention (Time 4). The control group completed the measures only.

Measures

Alcohol use. Alcohol use was measured using the 10-item Alcohol Use Disorders Identification Test (AUDIT; Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). The first three items of the AUDIT assess frequency of alcohol use (0 = 'Never'; 4 = '4 or more times a week'), typical quantity of drinks in a single occasion (0 = '1 or 2'; 4 = '10 or more'), and frequency of binge use (6+ standard drinks; 0 = 'Never'; 4 = 'Daily or almost daily'). These three items are widely used as a stand-alone scale of alcohol consumption, known as the AUDIT-C (Bush, Kivlahan, McDonell, Fihn, & Bradley, 1998). The average Cronbach's alpha over the four time-points for the AUDIT-C was .38. Cronbach's alpha can be impacted by non-normal distributions (Sheng & Sheng, 2012), so the positive skew in the current sample may have impacted this score. Non-parametric correlations to assess test-retest reliability showed significant moderate to strong associations between all assessment occasions at $p < .001$. Effect sizes ranged between $_{s}r(259) = .54$ (Time 1 with Time 3) to $_{s}r(304) = .65$ (Time 1 with Time 2).

Alcohol-related cognitions. Positive and Negative Alcohol Expectancies were measured using the 21-item Drinking Expectancy Questionnaire – Adolescent version (DEQ-A; Connor et al., 2011; Patton et al., 2017). The scale comprises two positive expectancy subscales (*increased confidence*, 6-items; and *tension reduction*, 5-items) and two negative expectancy subscales (*cognitive and motor impairment,* 5-items; and *negative mood,* 4-items). Items are measured on a 5-point Likert scale (1 = 'Strongly Disagree'; 5 = 'Strongly Agree'). The average Cronbach's alphas over the four time-points for the two positive subscales combined and the two negative subscales combined were both .97.

Drinking Refusal Self-Efficacy (DRSEQ) was measured using the 19-item Drinking Refusal Self-Efficacy Questionnaire–Revised Adolescent version (DRSEQ-RA), which is measured using a 6-point Likert scale (1 = 'I am very sure I could NOT resist drinking'; 6 = 'I am very sure I could resist drinking'; Patton et al., 2018; Young, Hasking, Oei, & Loveday, 2007). The subscales of the DRSEQ-RA relate to *opportunistic* (7-items), *social pressure* (5-items), and *emotional relief* (7-items) drinking refusal self-efficacy contexts. The average Cronbach's alpha over the four time-points was .98.

Impulsivity. Reward Drive (RD) was measured using the 10-item shortened Sensitivity to Reward Scale (SR-S), which is measured using binary response options (1 = 'YES', 2 = 'NO') (Cooper & Gomez, 2008). The average Cronbach's alpha over the four time-points was .78. Rash Impulsiveness was measured using the 8-item Barratt Impulsiveness Scale–Brief (BIS-B), which allows 4 response options (1 = 'Rarely/Never'; 4 = 'Almost always/Always'; Steinberg, Sharp, Stanford, & Tharp, 2013). The average Cronbach's alpha over the four time-points was .77.

Family Affluence. Socio-economic background was measured using the Family Affluence Scale–II (FAS-II), which is a 4-item scale developed for the WHO Health Behavior in School-Aged Children survey (Boyce, Torsheim, Currie, & Zambon, 2006). Family Affluence was included as a covariate because of the regional and SES diversity among recruited schools. A significant difference in FAS-II scores was found among recruited schools (F [5, 396] = 3.03, p = .01). An example item from the FAS-II is "How many computers does your family own" (0 = 'None'; 3 = 'Two or more'). The FAS was validated by the WHO across 35 countries, achieving good criterion validity when compared to country Gross Domestic Product (Boyce et al., 2006). Reliability has also been established through comparison with parent responses to items (Currie et al., 2008). The scale is recommended for use in research evaluating adolescent health and Socio-Economic Status (Boyce et al., 2006).

Mindfulness. The 14 item Mindful Attention Awareness Scale-Adolescent (MAAS-A; Brown, West, Loverich, & Biegel, 2011) was used to assess change in mindfulness over time. Items, e.g. "I rush through activities without being really attentive to them" are measured on a 6-point Likert scale (1 = 'Almost always'; 6 = 'Almost never). The average Cronbach's alpha over the four time-points was .95. Participants were also asked about their previous mindfulness experience (1="No, never"; 2="Only a few times"; 3="Many times but not anymore"; 4="I currently practice mindfulness meditation").

Analytical procedure

Multilevel modelling (MLM) was conducted in MLwiN (version 2.30). Those analyzing the data were not masked to intervention conditions. Originally Structural Equation Modelling (SEM) was planned (ACTRN12616000077460). However, MLM was considered more appropriate due to the variability observed between recruited schools in intervention length, follow-up times and SMS reminder support. This is supported by the variance partition coefficient (VPC) for the AUDIT-C MLM analysis, which showed that 8% of the variance in alcohol consumption was explained by school-level variation, VPC = .08. SEM analyses revealed similar outcomes to those presented in the current paper. The SEM outcomes can be made available upon request.

Three-level models were built with assessment time-points (level 1) nested within participants (level 2), nested within schools (level 3). Gender, age, and family affluence were included as level 2 covariates with the latter two being grand mean-centred (see Table S04 in supplementary materials for covariate correlations with outcome variables). Full iterative generalized least squares (IGLS) was used to estimate the models. Two-condition contrasts per outcome measure were calculated using contrast codes (Cohen, Cohen, West, & Aiken, 2003). These comparisons were based on the hypothesised outcomes for the outcome measures. For alcohol, impulsivity, and cognition outcomes, Contrast 1 compared both intervention conditions to the control and Contrast 2 compared the intervention conditions, as predicted. For the mindfulness outcome variable, Contrast 1 compared the CBT+MM condition to the other two conditions and Contrast 2 compared CBT+PMR to assessment-only control (see Tables S05, S06, and S07 in supplementary materials for contrast codes used). The contrasts were entered into the MLM models as level 2 predictors, along with Time (coded 0, 1, 2, 3) as a level 1 predictor, and cross-level interaction terms between Time and the Contrasts were calculated and added to the model. Random intercepts were specified. Plots of residuals at each level were examined to check assumptions and outliers. The tested models were specified as follows:

$$\text{Outcome}_{ijk} = \beta_{0jk} + \beta_1\,\text{Male}_{jk} + \beta_2\,\text{Age}_{jk} + \beta_3\,\text{FamilyAffluence}_{jk} + \beta_4\,\text{TimePoint}_{ijk} + \beta_5\,\text{Contrast1}_{jk} + \beta_6\,\text{Contrast2}_{jk} + \beta_7\,\text{TimePoint.Contrast1}_{ijk} + \beta_8\,\text{TimePoint.Contrast2}_{ijk} + e_{ijk}$$

Results

Missing data. The majority of the sample (73.7%) provided responses at three or all four time-points (see Table S01). A fewer number of participants (15.4%) were present at only two time-points and 10.6% attended Time 1 only. The descriptives for the outcome variables are given in Table 1. Little's Missing Completely at Random (MCAR; Little, 1988) test was significant in an analysis including all outcome and covariate variables, $\chi^2(2303) = 2608.59$, $p < .001$. Separate variance t-tests showed that participants with missing data at Time 2-4 were, in general, reporting at Time 1 higher alcohol consumption and rash impulsiveness, and lower drinking refusal self-efficacy and mindfulness. Including these as auxiliary variables did not affect model parameter estimates and, thus, were not retained. MLM provides an optimal means of reducing potential bias from attrition due to its ability to chart individual growth trajectories and use of full information maximisation likelihood (FIML) estimation (Graham, 2009; Hallgren & Witkiewitz, 2013; Witkiewitz, Falk, Kranzler, Litten, & Hallgren, 2014). Multiple imputation (MI) and FIML are both considered "gold standard" methods for handling missing data and are found to be generally equivalent, including simulations performed on alcohol treatment trial data (Graham, 2009; Hallgren & Witkiewitz, 2013; Witkiewitz et al., 2014). However, FIML is less computationally intensive and there is some evidence it may provide less biased estimates than MI in smaller samples and non-normal distributions (Demirtas, Freels, & Yucel, 2008; Witkiewitz et al., 2014; Yuan, Yang-Wallentin, & Bentler, 2012).

Covariates. There was a significant positive effect of Age on the AUDIT-C, indicating that older adolescents had higher consumption rates at Time 1. Older adolescents also had significantly higher positive and negative alcohol expectancies at Time 1. Male adolescents had significantly lower positive and negative alcohol expectancies as well as higher drinking refusal self-efficacy at Time 1 compared to female adolescents. However, male adolescents also showed significantly higher Reward Drive compared to female adolescents at Time 1. There was a significant difference between schools in family affluence (F [5, 396] = 3.03, p = .01). Family affluence can directly influence alcohol use, especially for young males (Currie et al., 2008; Richter et al., 2009). In the present study, it was negatively associated with Reward Drive at Time 2. Reward Drive has been consistently associated with positive alcohol expectancies and alcohol use (Gullo et al., 2010, 2017; Patton et al., 2018).

Alcohol use. The multilevel models analyzed the growth of the outcome measures over time and whether this growth was impacted by intervention condition, age, gender or family affluence. The results of each MLM analysis (unstandardized regression coefficients) are outlined in Table 2 and represented visually in Figure 2.

As expected due to the age of the population, AUDIT-C scores were low, but there was a significant interaction between Time and Contrast 1, such that participating in either intervention significantly decreased the growth in AUDIT-C scores compared to assessment-only control. The treatment effect size was standardized by comparing the hypothesized model's deviance (-*2*Log-Likelihood*) to that of a model in which the treatment Contrast parameter was constrained to zero. This difference in model fit is equivalent to a chi-square value, which was then converted a Cohen's d of -.14. Contrary to hypothesis, CBT+MM did not produce a significantly larger effect on alcohol growth compared to CBT+PMR, as indicated by the non-significant Time x Contrast 2 interaction (see Table 2).

Alcohol-related cognitions. There was a significant interaction between Time and Contrast 1 for both positive and negative alcohol expectancies, indicating that adolescents in the intervention conditions had significantly higher growth in these expectancies compared to those in the assessment-only control condition. Examination of the residuals plots for drinking refusal self-efficacy total revealed severe deviation from normality. The social pressure subscale of DRSEQ was analysed instead because the distribution of residuals met normality assumptions and was the more relevant subscale for this population (Aas, Klepp, Laberg, & Aarø, 1995; Jester et al., 2015; Jones, Will, & Fromme, 2001; Tomlinson & Brown, 2012; Young-Wolff et al., 2015). Social pressure refusal self-efficacy subscale scores correlated highly with the DRSE total score at each time-point (correlations ranges from r = .84 for Time 1 to r = .88 for Time 4, ps < .001). The results revealed that adolescents in the intervention conditions had significantly higher social pressure drinking refusal self-efficacy than the control group at Time 1, but that the growth over time was not impacted by condition. This may be partly due to the finding that social pressure drinking refusal self-efficacy did not significantly change, on average, across the 4 time-points. Correlations were run and significant moderately sized associations were found between social pressure drinking refusal self-efficacy and alcohol consumption at each time-point, Time 1 $r(381) = -.42$, $p < .001$, Time 2 $r(303) = -.49$, $p < .001$, Time 3 $r(264) = -.48$, $p < .001$, Time 4 $r(247) = -.44$, $p < .001$. There was also evidence of a prospective association after controlling for Time 1 alcohol consumption with Time 1 social pressure drinking refusal self-efficacy explained 5% of unique variance in Time 2 alcohol consumptions ($sr^2 = .05$; $p < .001$), 8% of unique variance in Time 3 alcohol consumption ($sr^2 = 08$; $p < .001$), and 5% of unique variance in Time 4 alcohol consumption ($sr^2 = .05$; $p < .001$).

Impulsivity. The results indicated that the intervention groups had significantly higher Reward Drive at Time 1 compared to the control group, but it did not significantly change over time overall and this was not moderated by condition. While Rash Impulsivity significantly increased over the four time-points, growth was not moderated by intervention condition.

Mindfulness. There were no significant effects of condition, time, or the covariates on the MAAS-A. Including previous mindfulness experience in the model did not alter effects. However, greater previous mindfulness experience was significantly related to increased mindfulness over time on the MAAS-A. Despite this, associations between mindfulness and alcohol consumption were small. Nonparametric correlations showed very weak concurrent correlations between these factors at Time 1, ${}_{s}r(365) = -.13$, $p = .011$, and Time 2, ${}_{s}r(296) = -.13$, $p = .021$, but non-significant associations at Times 3 and 4. Prospective associations were also non-significant or very weak. Regressions showed that only Time 2 mindfulness predicted Time 4 alcohol consumption, $\beta = -.14$, $t(212) = -2.03$, $p = .043$, and that it accounted for 1% of variance, ${}_{adj}R^2 = .01$, $F(1, 212) = 4.13$, $p = .043$. The small variance suggests that even if mindfulness had increased due to intervention efforts, it may not have impacted alcohol use.

Discussion

This study is the first test of the additive effectiveness of Mindfulness Meditation to a brief universal Cognitive Behavior Therapy (CBT+MM) intervention for adolescent alcohol use using a robust active control. The bioSocial Cognitive Theory (bSCT; Gullo et al., 2010) was utilized to identify evidence-based risk factors for intervention. It was theorized that CBT may directly target alcohol expectancies and, in doing so, indirectly affect refusal self-efficacy and also address the risk conveyed by the impulsivity factor of Reward Drive (theoretically, expectancies mediate the effect of Reward Drive, and expectancy effects on alcohol use are mediated by refusal self-efficacy). The addition of MM was proposed to directly target Rash Impulsiveness-related risk, which is theorized to have a direct effect on alcohol use and an indirect effect through lowering refusal self-efficacy. The effect of CBT+MM condition on adolescent alcohol use outcomes was compared with an active control of CBT combined with Progressive Muscle Relaxation (CBT+PMR) and an assessment-only control group. The effects of these interventions on possible mechanisms of change were also investigated, including drinking refusal self-efficacy, positive and negative alcohol expectancies, Reward Drive, Rash Impulsiveness, and mindfulness. The results showed that CBT reduced the growth in alcohol use and increased both positive and negative alcohol expectancies but that there was no evidence that mindfulness had an additive effect beyond the effects of relaxation.

Previous research has found encouraging evidence for mindfulness as an effective treatment for adolescent mental health problems (Zoogman et al., 2015). However, the meta-analysis by Khoury and colleagues (2013) found that only 35 (approximately 17%) of their 209 included studies included an active psychological control condition, with most studies utilizing a pre-post design or comparing a mindfulness-based therapy to a waitlist control. A second meta-analysis by Zoogman at al. (2015) considered that 60% of the 20 included studies had an active treatment. However, their definition of active control included the health and other school classes taken by the students, which could be interpreted as treatment-as-usual. These consistent methodological issues leave ambiguity as to benefit of mindfulness compared to existing treatments (Sedlmeier et al., 2012) and prompted the use of a robust active comparison condition to control for the non-specific effects of mindfulness in the present study.

The finding that there was no difference between the CBT+MM and the CBT+PMR condition is consistent with previous research concluding that mindfulness-based treatments do not provide benefits above CBT with relaxation approaches for broader mental health diagnoses including depression and anxiety (Farias et al., 2016; Khoury et al., 2013). However, this is the first evidence of no additional benefit in youth alcohol use prevention. While the lack of change in mindfulness over time could mean that the adolescents were not trained in or applying mindfulness effectively, previous interventions have shown effects with only a few mindfulness sessions (Sedlmeier et al., 2012). Further, a recent RCT found that a school-based mindfulness intervention did not improve depression, anxiety, or eating disorder symptoms and that adolescent home practice of mindfulness did not moderate these effects (Johnson, Burke, Brinkman, & Wade, 2017). It is also possible that the effects are smaller due to the non-clinical nature of the sample (Zoogman et al., 2015). Accordingly, the present results suggest that the addition of mindfulness may not improve adolescent substance use outcomes beyond existing CBT and relaxation treatments.

Mindfulness meditation also did not have a significant impact on adolescent impulsivity. There was an increase in both reward drive and rash impulsiveness across the 6-months included in the present study and there was no effect of CBT+MM or CBT+PMR on this growth. The finding that impulsivity increases across adolescence replicates previous research (Littlefield, Stevens, Ellingson, King, & Jackson, 2016). That neither intervention condition decreased the growth in impulsivity may seem counterintuitive given previous success targeting these personality factors (Conrod et al., 2013). However, it is unclear whether previous interventions are altering the impulsivity personality traits themselves or changing the way in which individuals act on their impulses (e.g., to express them in more adaptive ways). Indeed, there are divergent theoretical perspectives on whether the traits themselves can be altered (Harkness & Lilienfeld, 1997; Magidson, Roberts, Collado-Rodriguez, & Lejuez, 2014). Therefore, future research could investigate whether CBT and mindfulness interventions moderate the pathways by which impulsivity imparts risk for alcohol use, e.g., through drinking refusal self-efficacy and alcohol expectancies (Gullo et al., 2017, 2010). Additionally, the use of self-report instruments may have affected the ability to detect treatment effects. Future studies should seek to employ teacher- and parent-rated scales, and behavioral measures of impulsivity, if practical (Fernie et al., 2013). What these findings confirm is that adolescence is a period of increasing elevated impulsivity and therefore elevated risk for alcohol use (Stautz et al., 2017).

Both intervention conditions produced a reduction in the growth of alcohol consumption over the 6-month period compared to the assessment-only control. These findings are noteworthy, considering that reduction in adolescent alcohol use due to early intervention is a greater predictor of reduced future problematic drinking than personality and mental health risk factors (O'Leary-Barrett et al., 2016). Promisingly, our effect size is greater than recent meta-analytic estimates of the effect sizes for CBT-based universal alcohol use programs for similarly-aged adolescents, which were non-significant (Onrust et al., 2016). Despite this, the role of social cognitive factors as potential mechanisms of change received mixed support. Alcohol expectancies did change over time, dependent on treatment condition. Both CBT interventions showed an increase in positive and negative expectancies compared to the assessment-only control group. There was also a trending effect ($p = .06$) of a larger increase in negative alcohol expectancies over time for the CBT+MM condition. Increased negative expectancies are associated with reduced adolescent drinking (Colder et al., 2017) and therefore may have contributed to the reduced consumption outcomes in the intervention conditions. However, the increase in positive expectancies was unexpected. Despite their increased positive expectancies, the intervention conditions had reduced the growth of alcohol consumption compared to the control. One possible explanation is that the increase in expectations of positive outcomes is that reduced consumption and, therefore, less hazardous consumption, may have produced more positive alcohol experiences. Further research into the dynamic effect of initial positive treatment response on psychological risk factors like expectancies is required to support this.

Drinking refusal self-efficacy, which is a robust predictor of CBT alcohol outcomes in adult populations (Connor et al., 2016; Magill et al., 2015), did not increase or decrease across the 6-months, even for adolescents in the intervention conditions. The average social pressure drinking refusal self-efficacy scores at each time-point in the sample ranged from 25.50 to 27.26 of a possible total of 30, showing possible evidence of a ceiling effect. While it was expected that drinking refusal self-efficacy would decrease over time and with exposure to alcohol use, it is possible that 6-months was not sufficient to capture this effect, especially with the low levels of alcohol consumption within the present sample. Prospective relationships between drinking refusal self-efficacy and alcohol consumption at each time-point show drinking refusal self-efficacy was associated with higher consumption. Due to the importance of this factor indicated by previous research (Black & Chung, 2014; Connor et al., 2011, 2016; Magill et al., 2015), it is plausible that with increased exposure to alcohol contexts, the high self-efficacy of these adolescents will reduce their risk of future misuse.

Another possibility regarding the current drinking refusal self-efficacy findings is that the present study potentially intervened too early to see an impact. Drinking refusal self-efficacy was associated with future drinking in this study; however, previous research shows that targeting this factor in late adolescence produces greater effects (Onrust et al., 2016). This may be due to the phenomenon seen in the present study that drinking refusal self-efficacy is high prior to experience with alcohol. In this age-group it may be more effective to target related constructs such as rash impulsiveness and alcohol expectancies, as in the present study, as improvements in these factors may have future “knock on” effects on drinking refusal self-efficacy. This shows the benefit of a theoretically driven model of biosocial cognitive risk (such as the bSCT) which can provide a deeper understanding of the dynamic interplay between adolescent alcohol use and risk factors to inform treatment targets and the age of optimal effect.

The present study had limitations. Firstly, although a post-hoc MLM power analysis indicated that the current study had adequate power to detect effects, the study had a moderately sized sample. Due to the robust control and small-to-medium effects, a larger sample may be beneficial in future studies to further evaluate effects and group comparisons. As effects of alcohol-interventions often reduce over time (Tripodi et al., 2010), future studies could also evaluate the effects of the addition of mindfulness to CBT over a longer follow-up period. There was also variation in the delivery of the interventions due to practical considerations and one school opted not to include SMS follow-up skills reminders. While the current study attempted to incorporate this variation into the analysis through the use of multi-level modelling, a more standardized approach would be recommended in future trials. While facilitators were trained to deliver interventions in a standardised manner, and received regular supervision by a clinical psychologist (MJG), video recording of sessions for independent fidelity rating was beyond the scope of the study.

Future research may also wish to consider the content of chosen active controls. The inclusion of PMR as an active control for mindfulness is considered a strength of the current study. This is due to the hypotheses that impulsivity would be impacted by the mindfulness-specific effects of decentering (Bernstein et al., 2015; Feldman et al., 2010). However, mindfulness mechanisms are also thought to include attention regulation, body awareness, emotional regulation and perspective alteration (Hölzel et al., 2011). While PMR and mindfulness have differential impacts on stress (Gao, Curtiss, Liu, & Hofmann, 2017), anxiety, and depression (Lancaster, Klein, & Knightly, 2016), both involve directed attention and can therefore increase constructs considered to be components of mindfulness (Gao et al., 2017). Therefore, active controls in mindfulness interventions should be chosen based on the aspect of mindfulness considered central to the intervention effects.

This study is the first to compare a mindfulness-enhanced CBT intervention for adolescent alcohol use to CBT with an active relaxation control. The findings support the use of CBT as an effective universal intervention to reduce the growth in adolescent alcohol consumption. The addition of mindfulness meditation to the brief CBT intervention was not found to have a benefit beyond that of the active CBT control (progressive muscle relaxation). An investigation of associated outcomes found support for the theory that alcohol expectancies may be an important precursor to alcohol consumption but that drinking refusal self-efficacy may gain increasing importance in predicting misuse as contact with alcohol increases. Both Rash Impulsiveness and Reward Drive increased over time, supporting theories of increasing risk for substance use in mid-adolescence. Our findings highlight the need for robust, well-controlled studies of alcohol interventions that are guided by strong theory to elucidate the complex mechanisms of action (and inaction; (Magill & Longabaugh, 2013)).

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Tables and Figures

Table 1. *Descriptive statistics for the outcome variables at each time-point and for each condition.*

		All conditions				CBT+PMR		CBT+MM		AoC	
Outcome variable	Time-point	Minimum	Maximum	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Alcohol consumption (AUDIT-C)	Time 1	0	8	0.94	1.66	0.97	1.67	0.88	1.64	0.97	1.68
	Time 2	0	7	0.81	1.58	0.80	1.60	0.73	1.54	0.90	1.60
	Time 3	0	11	0.76	1.7	0.88	2.12	0.33	0.97	1.04	1.67
	Time 4	0	11	0.93	1.85	0.90	1.97	0.61	1.37	1.24	2.05
Drinking Refusal Self-Efficacy Social Pressure Subscale (DRSEQ-RA SP)	Time 1	5	30	25.79	6.47	26.45	5.92	26.52	6.07	24.36	7.18
	Time 2	5	30	25.5	6.58	25.04	7.04	25.98	6.28	25.54	6.37
	Time 3	5	30	27.26	5.37	27.05	5.62	28.42	3.02	26.41	6.54
	Time 4	5	30	26.25	6.76	26.15	7.35	27.17	5.39	25.54	7.18
Positive Alcohol Expectancies (DEQ-A Pos)	Time 1	11	55	23.99	11.14	22.24	10.99	24.37	11.21	25.48	11.05
	Time 2	11	46	23.54	10.89	24.40	11.13	22.94	10.62	23.19	10.92
	Time 3	11	55	22.15	11.44	22.07	11.37	23.35	10.80	21.15	12.09
	Time 4	11	55	23.33	11.36	22.82	11.77	24.92	10.60	22.48	11.56

Negative Alcohol Expectancies (DEQ-A Neg)	Time 1	10	50	21.33	10	20.08	9.98	21.57	10.19	22.41	9.76
	Time 2	10	41	20.8	9.59	21.48	9.71	20.58	9.80	20.28	9.31
	Time 3	10	50	20.02	10.37	19.78	10.28	21.04	9.98	19.35	10.83
	Time 4	10	50	20.8	10.01	20.20	10.23	22.50	9.38	19.93	10.24
Reward Drive (SR-S)	Time 1	0	10	4.46	2.47	4.73	2.62	4.44	2.41	4.21	2.36
	Time 2	0	10	4.49	2.68	4.69	2.91	4.76	2.79	4.03	2.24
	Time 3	0	10	4.45	2.97	4.79	2.91	4.92	3.08	3.73	2.81
	Time 4	0	10	4.37	3.11	4.55	3.38	3.98	2.85	4.53	3.08
Rash Impulsiveness (BIS-B)	Time 1	8	30	16.96	4.29	17.14	4.22	16.70	4.18	17.03	4.49
	Time 2	8	30	16.92	4.29	16.75	4.45	16.91	4.07	17.10	4.36
	Time 3	8	32	16.75	3.89	16.75	4.20	16.81	3.72	16.70	3.75
	Time 4	8	30	17.22	3.89	17.28	3.89	17.26	3.80	17.11	4.01
Mindfulness (MAAS-A)	Time 1	14	84	58.7	14.27	57.45	14.72	59.30	14.43	59.37	13.69
	Time 2	14	84	58.05	15.9	59.63	16.69	56.75	15.17	57.61	15.72
	Time 3	14	84	61.31	17.57	60.70	18.08	62.25	15.60	61.10	18.75
	Time 4	14	84	56.38	17.84	56.83	19.16	55.38	16.95	56.83	17.32

Table 2.

Multilevel Modelling results for alcohol use, alcohol-related cognitions, impulsivity factors, and mindfulness with condition contrasts^

(N = 404).

Outcome	Estimate	Intercept β_{0jk}	$Male_{jk}$	Age_{jk}	Family $Affluence_{jk}$	$Contrast1_{jk}$	$Contrast2_{jk}$	$Time_{ijk}$	Time. $Contrast1_{ijk}$	Time. $Contrast2_{ijk}$	σ^2_e	σ^2_{v0}	σ^2_{u0}	-2*log likelihood
Alcohol Consumption (AUDIT-C)	Unstandardised coefficient	0.94	-0.17	0.28^+	0.05	-0.11	-0.14	0.03	-0.18^+	-0.06				
	SE	0.10	0.14	0.11	0.07	0.17	0.19	0.03	0.07	0.08	1.52	0.33	1.98	4438.86
	z	-	-1.19	2.48	0.76	-0.62	-0.72	0.97	-2.46	-0.70				
	p	-	0.234	**0.013**	0.447	0.535	0.472	0.332	**0.014**	0.484				
Negative Alcohol Expectancies (DEQ-A Negative)	Unstandardised coefficient	21.91	-1.91^+	1.50^+	0.56	-1.48	-0.09	-0.17	1.09^+	-0.94				
	SE	0.56	0.82	0.62	0.41	1.01	1.14	0.20	0.44	0.50	57.46	0	39.40	8583.09
	z	-	-2.33	2.43	1.38	-1.47	-0.08	-0.84	2.50	-1.88				
	p	-	**0.020**	**0.015**	0.168	0.142	0.936	0.401	**0.012**	0.060				
Positive Alcohol Expectancies (DEQ-A Positive)	Unstandardised coefficient	24.54	-1.84^+	1.67^+	0.76	-1.97	-0.28	-0.22	1.30^+	-0.85				
	SE	0.63	0.92	0.69	0.46	1.14	1.28	0.23	0.49	0.56	72.00	0	50.21	8832.96
	z	-	-2.00	2.41	1.66	-1.73	-0.22	-0.94	2.67	-1.50				
	p	-	**0.046**	**0.016**	0.097	0.084	0.826	0.347	**0.008**	0.134				
Social Pressure Drinking Refusal Self-Efficacy (DRSEQ-RA SP)	Unstandardised coefficient	25.30	1.22^+	-1.01^+	0.05	1.57^+	-0.71	0.12	-0.05	-0.19				
	SE	0.36	0.53	0.40	0.27	0.65	0.73	0.13	0.27	0.31				
	z	-	2.29	-2.52	0.20	2.43	-0.97	0.93	-0.18	-0.62	22.59	0.84	16.58	7671.30
	p	-	**0.022**	**0.012**	0.841	**0.015**	0.332	0.352	0.857	0.535				

Reward Drive (SR-S)	Unstandardised coefficient	4.32	0.55^{+}	0.28	-0.08	0.58^{+}	-0.20	0.01	0.01	0.06				
	SE	0.16	0.23	0.18	0.12	0.28	0.31	0.06	0.12	0.14	3.73	0	3.64	5064.13
	z	-	2.37	1.59	-0.70	2.07	-0.65	0.09	0.07	0.42				
	p	-	**0.018**	0.112	0.484	**0.038**	0.516	0.928	0.944	0.674				
Rash Impulsivenes s (BIS-B)	Unstandardised coefficient	16.09	-0.05	-0.03	0.20	-0.03	-0.38	0.15^{+}	-0.03	0.11				
	SE	0.25	0.39	0.30	0.20	0.44	0.49	0.06	0.13	0.15	5.02	1.12	10.91	6178.33
	z	-	-0.11	-0.08	1.04	-0.06	-0.78	2.38	-0.20	0.71				
	p	-	0.912	0.936	0.298	0.952	0.435	**0.017**	0.841	0.478				
Mindfulness (MAAS-A)	Unstandardised coefficient	59.30	-1.17	-1.62	-0.20	0.45	-0.99	-0.49	-0.21	0.54				
	SE	0.92	1.33	1.01	0.67	1.66	1.88	0.36	0.77	0.86	166.25	0.37	95.66	9414.58
	z	-	-0.88	-1.60	-0.30	0.27	-0.52	-1.37	-0.28	0.63				
	p	-	0.379	0.110	0.764	0.787	0.603	0.171	0.779	0.529				

Note. Boldface indicates $p < .05$, $^{+}$ indicates significant unstandardized coefficient at $p < .05$. ^Contrast 1 compared CBT+MM and CBT+PMR to AoC (except for the mindfulness outcome where Contrast 1 compared CBT+MM to CBT+PMR and AoC) and Contrast 2 compared all three conditions. See supplementary materials for contrasts directions.

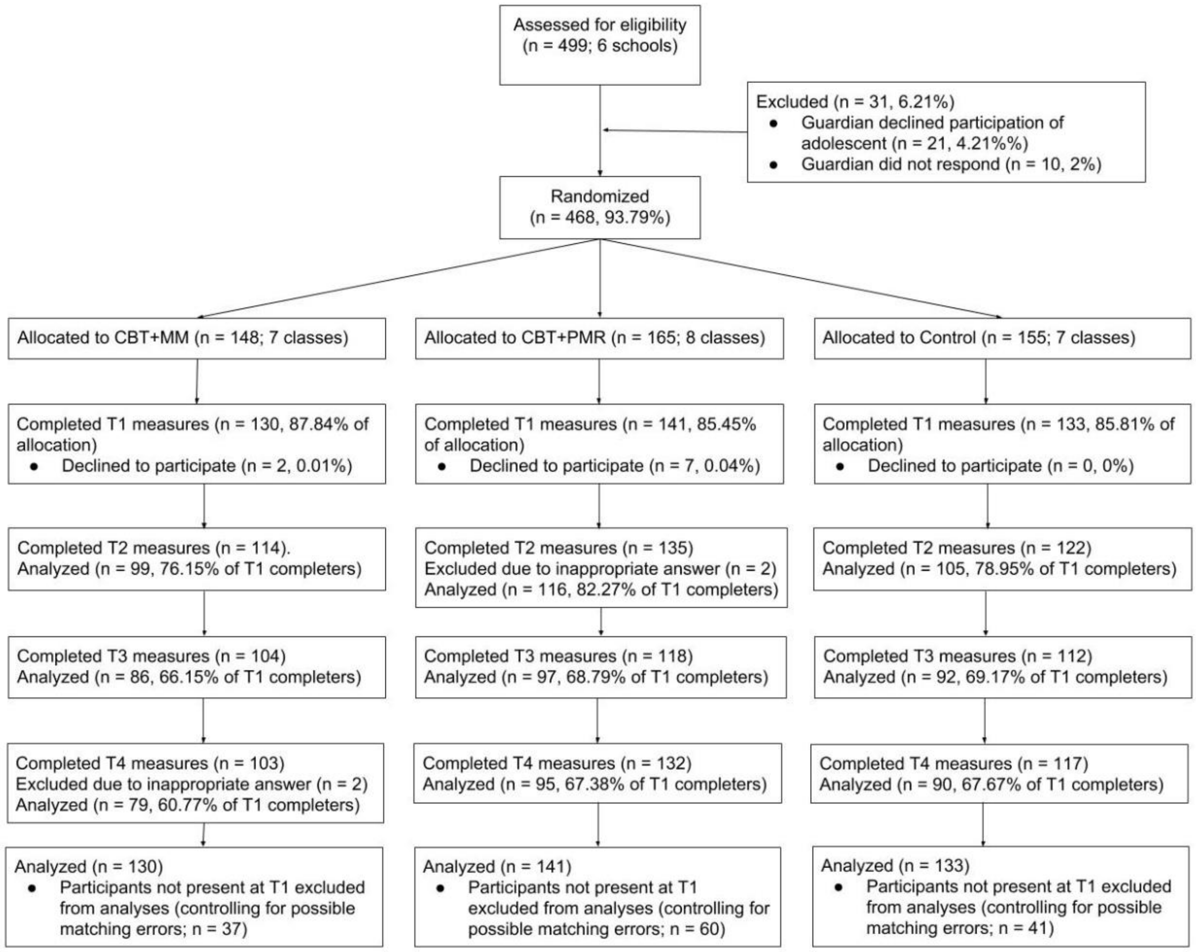

Figure 1. Participant flow across assessment occasions.

Note. "Inappropriate answers" refers to identifiably false or nonsensical responses, e.g., "Hrdifjekgr". Exclusions to control for possible matching errors are described in the method section.

Supplementary materials

Table S01.

Participant matching outcomes (N = 404).

Present	Time point	*N*	Percent	Overall *N*	Overall Percent
One time point	T1	43	10.6	43	10.6
Two time points	T1 and T2	46	11.4	63	15.6
	T1 and T3	7	1.7		
	T1 and T4	10	2.5		
Three time points	T1, T2, and T3	44	10.9	98	24.2
	T1, T2, T4	30	7.4		
	T1, T3, T4	24	5.9		
Four time points	T1, T2, T3, T4	200	49.5	200	49.5

Table S02.

Intervention content for universal Cognitive Behavioral Therapy (CBT) program with Progressive Muscle Relaxation (CBT+PMR) or Mindfulness Meditation (CBT+MM)

3 sessions	Content
Session 1	• Introduction of facilitators and parental consent. • Questionnaires, information sheet, and participant consent.
	• Psychoeducation. • Introduction to mindfulness (CBT+MM)/ Introduction to PMR (CBT+PMR) • Mindful eating. (CBT+MM)/ Stress and the body exercise. (CBT+PMR) • Mindfulness of the breath and body (CBT+MM)/ Progressive Muscle Relaxation exercise (CBT+PMR) • Summary and home practice 1.
Session 2	• Welcome back and home practice review 1. • Introducing the cognitive model of the interplay between thoughts, emotions, and behavior. • Cognitive model example.
	• Challenging unhelpful cognitions. • Introduction to and practice identifying cognitive distortions. • Sitting Mindfulness of Thoughts practice (CBT+MM) / Sitting PMR Practice (CBT+PMR) • Summary and home practice 2.
Session 3	• Welcome back and home practice review 2 • Review of cognitive model • Cognitive model applied to thoughts about alcohol • Exercise: Hypothetical Party
	• Summary and explanation of follow-ups and SMS. • Post intervention questionnaires.

Table S03.

Participant demographic variables (N = 404).

Demographic variable		*N*	%
Parental Background	Australian/New Zealander	77	19.06
	Aboriginal/Torres Strait Islander	8	1.98
	European	130	32.18
	Asian	33	8.17
	Polynesian/Melanesian	7	1.73
	North American	3	0.74
	African	6	1.49
	Mixed nationality parentage	20	4.95
	Unsure/did not respond	120	29.70
Where participant was born	Australia/New Zealand	357	88.37
	Europe	16	3.96
	Asia	23	5.69
	Polynesia/Melanesia	2	0.50
	North America	2	0.50
	Africa	4	0.99
Language mostly spoken at home	English	369	91.34
	Other	33	8.17
	Missing	2	0.50
Family Affluence	Low affluence	25	6.19
	Medium affluence	334	82.67
	High affluence	43	10.64
	Missing	2	0.50
Who participants live with	Mother	30	7.43
	Father	12	2.97
	Both mother and father	338	83.66
	Other	22	5.45
	Missing	2	0.50

Table S04.

Pearson correlations between covariates and outcome variables.

		Gender	T1_Age	T1_Family Affluence Scale
T1_DRSEQ_Soc	Pearson Correlation	.169**	-.125*	0.027
	Sig. (2-tailed)	0.001	0.014	0.597
T1_DEQA_Pos	Pearson Correlation	-0.027	0.029	0.088
	Sig. (2-tailed)	0.601	0.575	0.085
T1_DEQA_Neg	Pearson Correlation	-0.031	0.024	0.071
	Sig. (2-tailed)	0.542	0.643	0.166
T1 MAAS-A total	Pearson Correlation	0.046	-0.068	-0.031
	Sig. (2-tailed)	0.374	0.19	0.549
T1 SR-S total	Pearson Correlation	0.034	0.069	0.034
	Sig. (2-tailed)	0.503	0.18	0.5
T1 BIS-Brief Total	Pearson Correlation	-0.009	0.025	0.093
	Sig. (2-tailed)	0.861	0.628	0.068
T1_AUDIT_C	Pearson Correlation	-0.024	.139**	0.054
	Sig. (2-tailed)	0.635	0.006	0.292
T2_DRSEQ_Soc	Pearson Correlation	.123*	-0.104	0.028
	Sig. (2-tailed)	0.03	0.067	0.621
T2_DEQA_Pos	Pearson Correlation	-.195**	.124*	0.013
	Sig. (2-tailed)	0.001	0.031	0.828
T2_DEQA_Neg	Pearson Correlation	-.214**	.131*	-0.011
	Sig. (2-tailed)	0	0.022	0.851
T2 MAAS-A total	Pearson Correlation	-0.073	-0.094	-0.033
	Sig. (2-tailed)	0.202	0.101	0.565
T2 SR-S total	Pearson Correlation	.113*	0.102	-.116*
	Sig. (2-tailed)	0.046	0.072	0.041
T2 BIS-Brief Total	Pearson Correlation	0.042	-0.02	0.03
	Sig. (2-tailed)	0.454	0.725	0.593
T2_AUDIT_C	Pearson Correlation	-.135*	0.064	0.082
	Sig. (2-tailed)	0.017	0.265	0.151
T3_DRSEQ_Soc	Pearson Correlation	0.061	-0.096	-0.015
	Sig. (2-tailed)	0.316	0.116	0.801
T3_DEQA_Pos	Pearson Correlation	0.016	0.097	-0.05
	Sig. (2-tailed)	0.802	0.123	0.426
T3_DEQA_Neg	Pearson Correlation	-0.035	0.117	-0.038
	Sig. (2-tailed)	0.576	0.06	0.541
T3 MAAS-A total	Pearson Correlation	-0.054	-0.03	0.031
	Sig. (2-tailed)	0.404	0.646	0.636
T3 SR-S total	Pearson Correlation	.208**	-0.061	-0.011
	Sig. (2-tailed)	0.001	0.343	0.86
T3 BIS-Brief Total	Pearson Correlation	0.025	-0.012	0.036
	Sig. (2-tailed)	0.683	0.845	0.562
T3_AUDIT_C	Pearson Correlation	-0.037	0.106	0.001
	Sig. (2-tailed)	0.546	0.082	0.983

T4_DRSEQ_Soc	Pearson Correlation	0.018	-0.068	0.055
	Sig. (2-tailed)	0.778	0.282	0.389
T4_DEQA_Pos	Pearson Correlation	-0.1	.243**	-0.011
	Sig. (2-tailed)	0.119	0	0.86
T4_DEQA_Neg	Pearson Correlation	-0.102	.221**	-0.032
	Sig. (2-tailed)	0.111	0.001	0.619
T4 MAAS-A total	Pearson Correlation	-.150*	-0.035	0.043
	Sig. (2-tailed)	0.023	0.599	0.521
T4 SR-S total	Pearson Correlation	-0.013	-0.067	-0.047
	Sig. (2-tailed)	0.871	0.384	0.543
T4 BIS-Brief Total	Pearson Correlation	0.022	0.017	0.032
	Sig. (2-tailed)	0.732	0.784	0.613
T4_AUDIT_C	Pearson Correlation	-0.011	0.037	-0.112
	Sig. (2-tailed)	0.86	0.554	0.073

Note. *$p < .05$ **$p < .001$

Table S05.

Contrast codes for alcohol consumption and impulsivity models

Condition	**Contrast 1a**	**Contrast 2a**
CBT+MM	0.33	0.5
Ax only	-0.66	0
CBT+PMR	0.33	-0.5

Table S06.

Contrast codes for social cognition models

Condition	**Contrast 1b**	**Contrast 2b**
CBT+MM	0.33	-0.5
Ax only	-0.66	0
CBT+PMR	0.33	0.5

Table S07.

Contrast codes for mindfulness models

Condition	**Contrast 1c**	**Contrast 2c**
CBT+MM	0.66	0
Ax only	-0.33	-0.5
CBT+PMR	-0.33	0.5

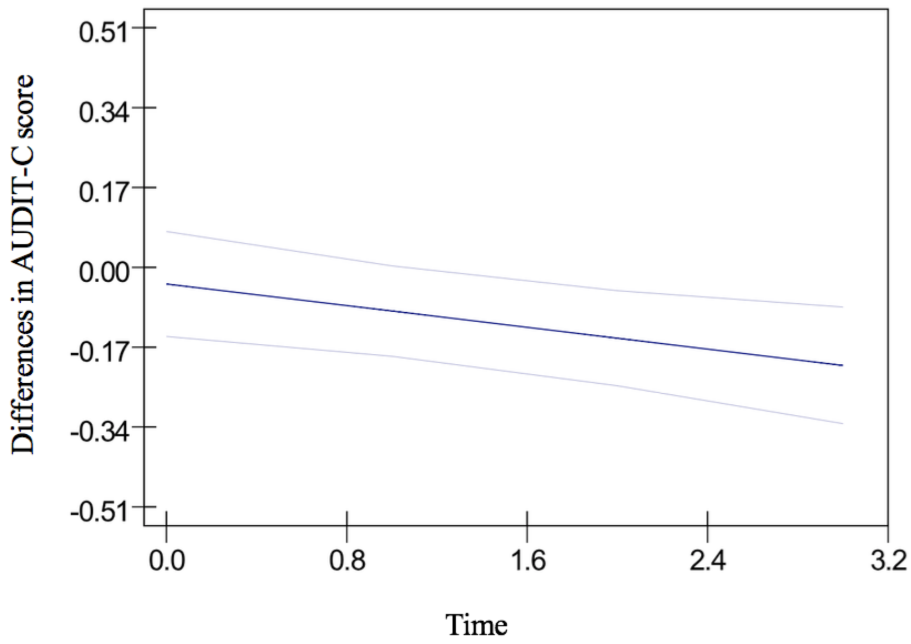

Figure S01. Multilevel Model plots of Contrast 1 (CBT+PMR and CBT+MM vs. AoC) for Alcohol Consumption across time. *Note*. Model included age, gender, and family affluence as level 2 covariates.

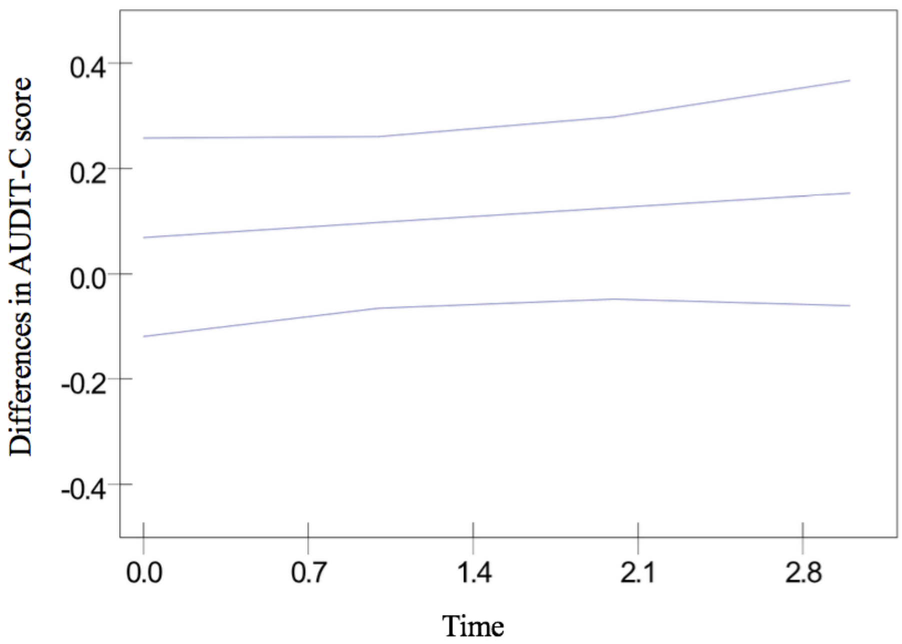

Figure S02. Multilevel Model plots of Contrast 2 (CBT+PMR vs CBT+MM) for Alcohol Consumption across time. *Note*. Model included age, gender, and family affluence as level 2 covariates.