Title page with All Author Information

Title: Mechanisms of personality-targeted intervention effects on adolescent alcohol misuse, internalising and externalising symptoms

Author list (listed in order of contribution) and contact information:

1) Maeve O'Leary-Barrett, B.A. (corresponding author).
Affiliation: McGill University, Department of Psychology
Address: McGill University, Department of Psychology
Stewart Biology Building
1205 Dr. Penfield Avenue
Montreal, Quebec, H3A 1B1
Email: maeve.oleary-barrett@mail.mcgill.ca. Tel: 514-632-0329

2) Natalie Castellanos-Ryan, Ph.D.
Affiliation: Université de Montréal, École de Psychoéducation,
Address: École de Psychoéducation, Université de Montréal
Pavillon Marie-Victorin, Bureau C-414
90, av. Vincent-d'Indy,
Outremont, QC H2V 2S9
Email: natalie.castellanos.ryan@umontreal.ca .Tel: 514-343-6111 ext. 28511

3) Robert O. Pihl, Ph.D.
Affiliation: McGill University, Department of Psychology (address above)
Email: robert.pihl@mcgill.ca. Tel: 514-398-6096

4) Patricia J. Conrod, Ph.D.
Affiliations: Department of Psychiatry, Université de Montréal, CHU Hôpital Ste Justine and Addictions Department, Institute of Psychiatry, King's College London.
Address: Centre de recherche du CHU Ste-Justine, Université de Montréal,
3175 Chemin de la Côte Sainte-Catherine, Bureau 1551
Montréal, Québec, H3T 1C5.
Email: patricia.conrod@umontreal.ca. Tel: 514-345-4931 ext. 4051

Acknowledgements: This investigation was supported by a research grant and fellowship (2003-2008) from Action on Addiction, registered charity number 1007308. Ms. O'Leary-Barrett is supported by an Aides a la Formation-Recherche (AFR) grant from the Fonds National de Recherche (FNR) du Luxembourg. Dr. Conrod is supported by a Senior Research Scientist award from the Fondation de Recherche en Santé du Québec (FRSQ; 2010-2015) and a Canadian Institute of Health Research (CIHR) grant (no. 114887). Dr. Castellanos-Ryan is supported by fellowships from the Ministère de l'Éducation, du Loisir et du Sport du Québec (no. 149169), and the Fonds de Recherche en Santé du Québec (no. 22530). We would like to thank all the schools, facilitators and students who took part in this study. We also wish to thank Nadia Al-Khudhairy and Kim Hayward (both previously at the Institute of Psychiatry, King's College London) for their invaluable contribution to this project, and Alain Girard (Université de Montréal) for his much-appreciated assistance with statistical analyses.

Clinical Trial registered on www.ClinicalTrials.gov, "Adventure: The Efficacy of Personality-Targeted Interventions for Substance Misuse and Other Risky Behaviours as Delivered by Educational Professionals", study NCT00776685.

Abstract

Objective: This study aims to explore the mechanisms of personality-targeted intervention effects on problematic drinking, internalising and externalising symptoms.

Method: As part of a cluster-randomised trial, 1210 high-risk students (mean age 13.7 years) in 19 London high schools (42.6% white, 54% male) were identified using the Substance Use Risk Profile Scale. Intervention school participants were invited to participate in personality-matched interventions by trained school staff. MacKinnon's products of coefficients method was used to compare three complementary mechanism hypotheses, namely, whether early changes in i) alcohol use, ii) internalising and externalising symptoms or iii) personality during the 6 months post-intervention accounted for intervention effects over 2 years.

Results: Early intervention effects on drinking behaviours during the 6 months post-intervention partially accounted for longer term intervention effects on the onset of binge drinking (95% CI -.349 to -.062) and drinking problems (95% CI -.206 to -.016) over 2 years. Intervention effects on anxiety symptoms and conduct problems were partially mediated by early reductions in depressive symptoms (95% CI -.013 to -.001; 95% CI -.047 to -.001), and intervention effects on internalising symptoms were also partially mediated by reductions in anxiety sensitivity (95% CI -.003 to 0).

Conclusions: 2 year intervention effects on problematic drinking were largely accounted for by early changes in drinking behaviours, and were not mediated by changes in mental health symptoms or personality risk factors. Early improvements in mood and anxiety sensitivity partially mediated longer term reductions in mental health problems.

Keywords: prevention, mechanisms, early-onset alcohol use, adolescence

Public health significance: This study suggests that long term personality-targeted intervention effects on problematic drinking in youth are largely accounted for by early changes in drinking behaviours, and are not mediated by changes in mental health symptoms or personality risk factors. Short-term intervention effects on early-onset alcohol use may serve as proximal markers of longer-term intervention effects on both substance and non-substance related problems.

Introduction

Substance use and mental disorders are identified as the third leading contributor of global burden of disease (Ferrari et al., 2014). Comorbidity of substance use disorders (SUDs) with other forms of psychopathology is the norm, rather than the exception, both in adult and youth populations, and patients with SUDs and comorbid mental health problems have poorer outcomes in treatment studies (Couwenbergh et al., 2006). Namely, comorbidity is associated with poorer treatment compliance, higher levels of psychopathology, suicidal ideation and attempts, higher treatment cost, and poorer functioning and prognosis (Clark et al., 1997; Deas, 2006; Faggiano et al., 2008; Grella, Hser, Joshi, & Rounds-Bryant, 2001; King, Gaines, Lambert, Summerfelt, & Bickman, 2000). Indeed, it is widely acknowledged that prevention and treatment programs are under-developed for populations with dual diagnoses (Salvo, 2012). Simultaneous attention to SUDs and comorbid psychopathology is thought to be more effective than interventions targeting either disorder alone; specifically, an intervention focus on risk factors for comorbid problems is recommended to enhance efficacy (Stice, Shaw, Bohon, Marti, & Rohde, 2009). There is thus a great need for preventive interventions targeting

risk factors for the development both of SUDs and other forms of psychopathology, in order to address commonalities in the pathways to mental disorders and to avoid treatment response difficulties in adulthood. Moreover, it is important to understand the mechanisms of effective programs, in order to identify appropriate intervention targets and further enhance treatment effects. Randomised prevention trials provide a unique opportunity to evaluate whether changes in a putative risk factor translate into changes in future pathology (Hinshaw, 2002), and analyses of mediator variables can enhance our understanding of intervention mechanisms, and allow us to further refine treatment strategies.

It is increasingly suggested that personality factors may partially account for the relationship between other risk factors (e.g., internalising and externalising symptoms) and substance misuse (Davis, Cohen, Davids, & Rabindranath, 2015; Kotov, Gamez, Schmidt, & Watson, 2010). Indeed, some studies suggest that personality factors may mediate the relationship between genetic factors and substance misuse (Laucht, Becker, Blomeyer, & Schmidt, 2007; McGue & Bouchard, 1998). Targeting personality risk factors for addiction offers a promising prevention approach in that personality traits are differentially associated with motives for substance use (Cooper, Frone, Russell, & Mudar, 1995), drugs of choice (Conrod, Pihl, Stewart, & Dongier, 2000), patterns of coping (Connor-Smith & Flachsbart, 2007), and sensitivity to the effects of drugs (Conrod, Pihl, & Vassileva, 1998; Leyton et al., 2002). Personality-targeted interventions can thus address the specific motivations for use and vulnerability factors associated with a particular personality profile, enhancing the individual relevance and impact of an intervention."

Personality-targeted interventions have demonstrated their efficacy in three separate randomised controlled trials (Conrod, Castellanos-Ryan, & Mackie, 2011; Conrod, O'Leary-Barrett, Newton et al, 2013; Conrod, Stewart, Comeau, & Maclean, 2006). This brief program has resulted in two-year intervention effects on alcohol and drug misuse (Conrod et al., 2011, 2013; Conrod, Castellanos-Ryan, & Strang, 2010), as well as internalising and externalising symptoms (O'Leary-Barrett et al., 2013). The aim of the current paper is to explore the mechanisms of personality-targeted interventions on indicators of problematic drinking (namely, the initiation and growth of binge drinking and alcohol-related problems rates and frequency), and severity of depression, anxiety and conduct problems over 2 years. Comorbidity models suggest that the intervention mechanisms can be understood in one of three ways. Namely, i) decreases in mental health symptoms may lead to subsequent decreases in alcohol use or improvements in associated internalising or externalising symptoms, ii) delays in early-onset drinking or decreased early alcohol consumption may lead to decreased hazardous drinking and mental health symptoms over the longer term, through protecting the adolescent brain from the detrimental consequences of early alcohol use and iii) intervention effects on both alcohol misuse and mental health symptoms may operate through a common factor, *i.e.*, personality. This study will examine these three complementary hypotheses. The following section will explain these three pathways in more details.

The affect regulation model suggests that alcohol use can be understood as an attempt to "self-medicate" negative mood states (*e.g.,* sadness, anxiety or anger) or mental health symptoms (Cooper, Frone, Russell, & Mudar, 1995; Lazareck et al., 2012). This model is

supported by a recent meta-analysis on twelve studies for combined cognitive behavioural therapy and motivational interviewing to treat comorbid major depression and alcohol use disorders showing that treatment effects on depression were achieved earlier than those on alcohol use (Riper et al., 2014). Similarly, interventions targeting depressive symptoms in adolescence have resulted in secondary intervention effects on substance use escalation (Rohde, Stice, Gau, & Marti, 2012; Stice, Rohde, Gau, & Wade, 2010). In the realm of externalising disorders, several interventions targeting disruptive behaviours in childhood and early adolescence have resulted in lower substance use in mid-adolescence (van Lier, Huizink, & Crijnen, 2009; Zonnevylle-Bender, Matthys, van de Wiel, & Lochman, 2007). This suggests that substance misuse may be associated with externalising symptoms through an underlying externalising profile (as opposed to being a behaviour related to self-medication, as when associated with internalising symptoms). The hypothesis to be examined in this study, henceforth referred to as the "psychopathology reduction mechanism", expands on the affect regulation hypothesis in that it assesses a temporal sequence in which a reduction in internalising or externalising symptoms in the first 6 months post-intervention may account for longer term reductions in substance misuse. In addition, this hypothesis will examine whether early reductions in internalising or externalising symptoms could account for subsequent improvements in mental health, which may potentially occur through a global mood-enhancing effect or a reduction in overall distress.

A second potential intervention mechanism is through the delay of early onset and escalation of alcohol use, both of which have been associated with "developmental harm" in adolescence (Lubman, Hides, Yucel, & Toumbourou, 2007). This includes an

increased risk for mental health problems (Ferrari et al., 2014; McGue, Iacono, Legrand, Malone, & Elkins, 2001) and addiction in adulthood. Rates of adult alcohol dependence in individuals whose onset of alcohol use was below 14 years are estimated at 40% (Grant & Dawson, 1997). The harmful impact of early onset alcohol use may be explained by neurobiological processes, namely neurotoxic effects of ethanol on the adolescent brain (Lubman et al, 2007). Adult alcoholics have been shown to be impaired on cognitive tasks (Miller & Orr, 1980), and these deficits have been replicated in adolescents with substance use disorders, though on a smaller scale (Brown, Tapert, Granholm, & Delis, 2000). Cognitive deficits have also been recognized in the non-problematic, social drinking population (Parsons, 1998), with the suggestion that there is a continuum of deficits related to quantity of alcohol consumption (Squeglia, Spadoni, Infante, Myers, & Tapert, 2009). Studies on the mechanisms of long-term intervention effects of family-focused universal prevention programmes such "Guiding Good Choices" and the "Strengthening Families Program for Parents and Youth: 10-14" (Spoth, Trudeau, Guyll, Shin, & Redmond, 2009), as well as a combination of the Strengthening Families Program with the universal school-based Life Skills Training Program (Spoth, Trudeau, Redmond, & Shin, 2014) suggest that intervention effects on problematic substance use in young adulthood occurred indirectly through intervention effects on substance use initiation and growth in adolescence. This study's design would allow us to test whether a similar mechanism may operate during a 2-year period following participation in a personality-targeted intervention.

A third potential intervention mechanism for both substance misuse and other mental symptoms is through a decrease in common risk factors. Personality-targeted

interventions target individuals with high levels of four personality traits, namely sensation seeking, impulsivity, anxiety sensitivity and hopelessness (Conrod et al., 2013). These personality profiles are correlates and risk factors of substance misuse and psychopathology in adolescence, and are associated with distinct motivational pathways (Castellanos-Ryan & Conrod, 2012). Anxiety sensitivity and hopelessness are risk factors for addiction through the use of substances to dampen fears of the physical sensations of anxiety, or to numb depressive symptoms, respectively. These internalising traits are also risk factors for anxiety and depressive disorders, in turn (Woicik, Stewart, Pihl, & Conrod, 2009). Impulsivity is associated with a multitude of disinhibited behaviours, including conduct disorders (Urben, Suter, Pihet, Straccia, & Stephan, 2014) and polysubstance use (Conrod, Pihl, Stewart, & Dongier, 2000). Lastly, sensation seeking is associated with risk-taking behaviours for thrill-seeking or enhancement purposes, including binge drinking, but no other psychopathology (Castellanos-Ryan, O'Leary-Barrett, Sully, & Conrod, 2013). Evidence for common risk factors for addiction and psychopathology is supported by genome-wide linkage (Gizer et al., 2012) and factor analytic studies (Kotov et al., 2011). It is therefore possible that intervention effects on both substance misuse and other forms of psychopathology could be explained by decreases in the personality traits common to both problems. The potential for personality change across adolescence (and beyond) is supported by contemporary theories of personality and development (*e.g.*, Roberts, Walton, & Viechtbauer, 2006). Whilst no research to date has specifically tested whether personality risk factors for substance misuse are similarly subject to developmental influences, it is feasible to believe that they could be. Externalising traits (*e.g.*, sensations seeking and impulsivity) and alcohol use

have been shown to mutually influence and exacerbate one another across adolescence and young adulthood (MacPherson, Magidson, Reynolds, Kahler, & Lejuez, 2010; Quinn, Stappenbeck, & Fromme, 2011). Anxiety sensitivity levels have also been found to decrease subsequent to a targeted intervention (Watt, Stewart, Lefaivre, & Uman, 2006). However, whilst personality-targeted interventions select individuals that exhibit high levels of personality risk factors, the goal of the intervention is not to change personality. The interventions target coping behaviours and risky motives for substance use that are specific to each personality profile. It is thus possible that intervention effects may be mediated by personality-specific changes in problematic coping as opposed to changes in personality itself (*e.g.*, Conrod, Castellanos-Ryan, & Mackie, 2011). However, no study to date has tested whether changes in personality risk factors themselves may account for subsequent intervention effects on problematic outcomes.

Please see Figure 1 for a visual illustration of the three complementary mechanism hypotheses (psychopathology reduction, developmental harm and common factors) to be tested. This study will examine the mechanisms of the personality-targeted intervention effects on measures of problematic alcohol misuse (binge drinking and alcohol-related problems), internalising and externalising symptoms over a two-year period by examining each of the three hypotheses presented.

Method

Participants and procedure: This cluster-randomised study randomly assigned 19 schools from 9 randomly-selected London boroughs to control (n=8) or intervention (n=11) conditions. All year-9 students (mean age 13.7 years) were invited to participate.

Students completed self-report questionnaires during school hours at 6-month intervals for 2 years. Participation was informed by passive consent from parents and active assent from students, following approval from the King's College London Research Ethics Committee (CREC/06/07-192). High-risk students were defined as those scoring one standard deviation above the school mean on one of the four subscales of the Substance Use Risk Profile Scale (Castellanos-Ryan et al., 2013). High-risk participants in intervention schools were invited to participate in personality-matched intervention sessions by trained school staff. If a student had elevated scores on more than one subscale, they were assigned to the personality group in which they showed the most statistical deviance according to z-scores. 574 (82.7%) high-risk participants received an intervention, but high-risk students were included in the intent-to-treat follow-up analysis regardless of whether or not they attended the sessions. The sample was ethnically diverse (42.6% white, 26.5% South Asian, 17.2% black, 8.6% mixed origins and 5.1% other), and was 54% male. Follow-up assessments were conducted for all students who took part at baseline, including low-risk youth (N=2643), but this study reports on intervention mechanisms using only the high-risk sample. Please see Figure 2.

Measures

Demographic characteristics: Adolescents provided information on gender and ethnicity using a forced choice answering procedure following Conrod et al (2006).

Personality risk: The Substance Use Risk Profile Scale (SURPS) was used to assess variation in personality risk for substance dependence along 4 dimensions: sensation seeking, impulsivity, anxiety sensitivity and hopelessness. This scale has good concurrent, predictive and incremental validity (relative to other personality measures)

with regards to differentiating individuals prone to reinforcement-specific patterns of substance-use in multiple samples (Conrod et al., 2010; Conrod, Castellanos, & Mackie, 2008; Krank et al., 2011; Woicik et al., 2009), including the sample described in the current study (Castellanos-Ryan et al., 2013). SURPS traits are concurrently and prospectively associated with substance misuse and non substance-related externalising behaviours and internalising symptoms (Castellanos-Ryan et al., 2013). Each subscale had good internal reliability for short scales in the current study (Swailes & McIntyre-Bhatty, 2002), with Cronbach alpha coefficients ranging from .67-.82 [α=.67 for sensation seeking (6 items); α=.67 for anxiety sensitivity (5 items), α=.68 for impulsivity (5 items); α=.82 for hopelessness (7 items)]. Averaged inter-item correlations for each subscale were as follows: sensation seeking: .24, impulsivity and anxiety sensitivity:.29, hopelessness: .41, which are considered acceptable (Clark et al., 1997). Personality subscales had good test-retest reliability over 2 years ($p<.001$ for each subscale).

Alcohol use: Participants self-reported their frequency and quantity of alcohol consumption in the past 6 months using two 6-point scales. Binge drinking was assessed by asking students the frequency at which they had consumed 5 or more alcoholic beverages (4 or more for girls) on one occasion in the past 6 months. Frequency of alcohol problems in the past 6 months was assessed using an abbreviated version of the Rutgers Alcohol Problem Index (RAPI; White & Labouvie, 1989), based on the 8 most frequently endorsed items by 14 to 16 years old adolescents living in London (Conrod, Castellanos, & Mackie, 2008) in a community sample with very similar demographic characteristics to the current study participants. Participants' self-report drinking behaviour was reliable across the five 6-month assessments during 2 years (assessed

using Chronbach's alpha), with respect to their reported age when they first tried alcohol (α=0.95) and age when they first consumed a full alcoholic drink (α=0.92).

Internalising symptoms: Depression and anxiety symptom severity over the past 6 months were measured using the Depression and Anxiety subscales from the Brief Symptoms Inventory (Derogatis, 1993).

Externalising symptoms: Conduct problems were assessed according to the conduct subscale of the Strengths and Difficulties Questionnaire (Goodman, 1997).

Calculating change scores: Change scores reflecting the differences in mediator variables between baseline and 6 months-follow up were calculated in order to test the three hypotheses of interest (see Figure 1). Namely: 1) The psychopathology reduction hypothesis was examined using change scores reflecting the difference in depressive and anxiety symptoms and conduct problems from baseline to 6 months-follow up as mediator variables. 2) The developmental harm hypothesis was tested using change scores reflecting the difference in quantity and frequency of alcohol consumption and alcohol-related problems from baseline to 6 months follow-up as mediator variables. As changes in the quantity and frequency of alcohol use were strongly correlated (*r*=.79), analyses including both variables used the residual drinking frequency scores in order to remove the covariance between the two variables. 3) The common factors hypothesis was tested using change scores reflecting differences in the four personality variables between baseline and 6 months-follow up as mediators.

Intervention

Personality-targeted interventions involved two 90-minute group sessions led by a trained school-based facilitator and co-facilitator, with an average of 6 personality-

matched adolescents per group. The interventions were manualised, and incorporated cognitive-behavioural therapy (CBT), psycho-educational and motivational enhancement therapy (MET; Carroll et al., 1998) components. Manuals included real life "scenarios" shared by London youth in specifically-organised focus groups. In the first session, participants were guided in a goal-setting exercise designed to enhance motivation to change behaviour. Psychoeducational strategies were used to teach participants about the target personality variable and associated problematic coping behaviours. Substance misuse was referred to as a problematic coping behaviour across all groups, and the groups discussed personality-specific motives for use (*e.g.,* to cope with feelings of sadness in the hopelessness-prone group). Other personality-specific maladaptive coping behaviours were discussed in each group, *e.g.,* avoidance (anxiety sensitivity and impulsivity groups), interpersonal dependence (hopelessness group), aggression (impulsivity groups) and risky behaviours (sensation seeking groups). Participants were then introduced to the CBT model and guided in breaking down personal experiences according to the physical, cognitive, and behavioural components of an emotional response. A novel component to this intervention approach is that all exercises discussed thoughts, emotions, and behaviours in a personality-specific way, *e.g,* identifying situational triggers and cognitive distortions related to impulsivity specifically. In the second session, participants were encouraged to identify and challenge personality-specific cognitive distortions (*e.g.,* negative, global, self-referent thinking for hopelessness) that can lead to problematic behaviours.

Training and supervision: Intervention facilitators and co-facilitators included school counsellors, student support team members, teachers and special educational needs staff.

As reported in the supplementary materials of O'Leary-Barrett, Mackie, Castellanos-Ryan, Al-Khudhairy, & Conrod (2010), all staff attended a 3-day training workshop, followed by a minimum of 4-hours supervision in running through a full, 2-session intervention with the trial therapist. Supervised interventions were run with groups of year-10 students who were not involved in the trial. An 18-point checklist was devised to measure whether facilitators demonstrated sufficient mastery of CBT, MET and general counselling skills. 31 staff members (84%) successfully qualified as facilitators of the intervention. 2 individuals did not reach a sufficient standard of program delivery, so acted as co-facilitators of the intervention, but did not lead the group sessions.

Treatment integrity: 182 intervention sessions took place with high-risk youth over a 4-month period. Trained research staff observed 76 (41.7%) of these sessions to assess adherence to the treatment protocol (fidelity) and intervention quality, and each facilitator was observed running at least one intervention session.

Treatment fidelity: A scale was developed by the principal investigator (P.C.) and trial therapist to evaluate adherence to 12 core treatment components of the personality-targeted intervention program (*e.g.*, goal setting, identifying and challenging automatic thoughts). Facilitators were evaluated as having "achieved", "partly achieved", or "not achieved" each component. 88.2% of rated sessions were evaluated as having "achieved" or "partly achieved" these 12 core treatment components, and 64.5% of rated sessions were evaluated as having "achieved" most components. Facilitators were also rated on 5 core counselling skills (*e.g.,* involving the entire group, being empathic) considered essential for successful program delivery. 98.4% of sessions were rated as having

"achieved" or "partly achieved" these core counselling skills, and 65.6% of sessions were rated as having "achieved" all core counselling skills (O'Leary-Barrett et al., 2010).

Treatment quality: Facilitators were evaluated using Young and Beck's Cognitive Therapy Scale (Young & Beck, 1980) on 11 key therapeutic skills, *e.g.*, interpersonal effectiveness or application of cognitive-behavioural techniques. Independent ratings by a clinical psychologist not involved in the study showed that 100% of rated sessions achieved a mean score of at least 3 ("satisfactory"). The mean rating in response to the question, "How would you rate the clinician in this session, as a cognitive therapist?" was 3.6 (between "satisfactory" and "good"). The mean rating in response to the question, "If you were conducting an outcome study in cognitive therapy, do you think you would select this therapist to participate at this time?" was 2.4 (between "uncertain/borderline" and "probably yes". These scores suggest the intervention facilitators achieved many of the goals of a CBT intervention in practice but did not perform at a therapeutic level equivalent to a trained clinical psychologist. Comparisons of the efficacy of personality-targeted interventions as delivered by trained psychologists and school-based staff nevertheless revealed similar effect sizes across programs (O'Leary-Barrett et al., 2010).

Control schools did not deliver the personality-targeted interventions to youth to trial participants, and received training in intervention delivery at the end of the trial, as an incentive for participation.

Attrition: Follow-up rates appear in Figure 2, and show significantly higher retention rates in intervention than control schools at 2-years post-baseline (p=.02) in the high-risk sample, due to one control school having insufficient resources to organise a systematic follow-up at the final follow-up point. Attrition at the end of the 2-year follow-up period

was predicted by higher levels of conduct problems (p=.01) and hopelessness (p=.05). However, severe levels of conduct problems did not predict attrition, and there were no interactions between treatment condition and baseline levels of hopelessness or conduct problems on follow-up rates. Attrition was not predicted by gender, ethnicity, alcohol use, depression, anxiety, or personality traits other than hopelessness. Missing data was replaced using full information maximum likelihood estimation in SPSS which enabled the use of all available data. As data was Missing Not At Random, missing data were computed separately according to intervention condition and personality risk status (high vs. low), using demographic and outcome data from previous time-points as covariates. This procedure was considered adequate as the data estimation strategy was conceived according to the model for missingness, and attrition was not strongly associated with outcome measures (Schafer & Graham, 2002). This procedure is determined valid when less than 25% of a dataset is missing (Kenward & Carpenter, 2007).

Statistical analyses

Intervention effects over 2 years

Problematic alcohol use variables: Latent growth models in MPlus (Muthén & Muthén, 2010) were used to examine intervention effects on dichotomous drinking outcomes (onset of binge drinking and alcohol related problems). This allowed us to model data with a preponderance of zero observations, following Conrod et al (2013), which reported primary study outcomes on the same sample. Additionally we ran latent growth models on the continuous drinking outcomes for the sub-samples who had reported the onset of binge drinking or problem drinking at baseline, respectively. In our sample at baseline, 270 (22.3%) reported binge drinking and 201 (16.6%) reported having experienced

problems relating to alcohol use in the preceding 6 months. These latent growth models allowed us to examine the effects of the intervention on the probability of engaging in a particular behaviour (the dichotomous parts of the model, *i.e.*, binge drinking and drinking problems onset) and its effects on frequency of the behaviour when present (the continuous parts of the model, *i.e.*, frequency of binge drinking and drinking problems). These models also allowed for the observation of main effects of the intervention across time (reflected in the intercept centered at 6 months) and time-dependent effects of the intervention (reflected in the slope from 6-24 months). All continuous outcome variables revealed inter-class (cluster) correlations (ICCs) that were below .10, meaning that there was little variance at the school level across time. Some effects of cluster were observed for dichotomous outcomes (ICC=.10). The authors have previously reported having conducted additional analyses in the same sample using multilevel latent growth models whilst controlling for cluster in STATA, which did not impact the results (Conrod et al., 2013). Therefore, cluster was not accounted for in the latent growth models.

In order to attest to the real life impact of the interventions on problematic drinking outcomes, the binge drinking and drinking problem variables were dichotomised using cut-off points that were determined by considering the potential public health impact of these behaviours, following Spoth et al (2009, 2014). Namely, participants who, at 2 years post-intervention, reported binge drinking on a weekly basis, and those who reported having experienced 1-2 negative consequences of alcohol use over the past 6 months were considered as cases that would be more likely to be using alcohol at a level that could have public health consequences. Relative reduction rates (RRRs) were then computed based on the relative number of cases in each condition that reported

experiencing this predefined negative outcome at 2 years post-intervention. RRRs correspond to the proportion of control condition cases that would have been prevented had those individuals been in the experimental condition.

Internalising and externalising symptoms: Intervention effects on depression, anxiety and conduct problems were analysed using linear generalised estimating equations (GEE), using an autoregressive correlation structure, following O'Leary-Barrett et al (2013), which reported secondary study outcomes on the same sample. The models used outcomes from 6, 12, 18 and 24 months follow-up, and accounted for correlations within outcomes across multiple time points. All GEE analyses were conducted using IBM SPSS Statistics 20 and significance levels were set at $p<0.05$. Inter-cluster correlations indicated that 1-12% of the variance in outcomes was explained by school. Average design effects ranged from 0.6 to 8. According to recommendations by Muthén and Satorra (1995), school clusters were accounted for in all analyses and considered as the repeated measure in the generalised estimating equation models. The distribution of depression and anxiety symptoms was highly positively skewed, so data were log transformed before analysis.

Intervention mechanisms: Linear regressions in STATA 13 (StataCorp, College Station, TX) examined whether treatment conditions predicted changes in mediator variables (change scores), accounting for gender, ethnicity and controlling for school cluster (a pathway; Baron & Kenny, 1986). Non-independence observations were adjusted for using tests based on the Huber-White sandwich estimate of variance (White, 1980). This method provides standard errors which are robust within cluster correlations.

Relationships between the mediator variables (change scores) and alcohol use outcomes (b pathways; Baron & Kenny, 1986), were examined in latent growth models, accounting for gender and ethnicity. Latent growth models of the dichotomous problematic drinking outcomes (onset of binge drinking and alcohol-related problems) also controlled for baseline levels of the corresponding drinking variable. Relationships between mediator variables and internalising and externalising symptoms (b pathways) were examined using linear regressions in STATA. Analyses accounted for baseline measures of the outcome variables, as well as demographics and school cluster.

For all outcomes, the indirect effect of the intervention-mediator-dependent variable pathway was examined using MacKinnon's products of coefficients method (MacKinnon, Fritz, Williams, & Lockwood, 2007), using the prodclin program (Tofighi & MacKinnon, 2011). For outcomes for which intervention effects were present, mediation effects were examined; where no intervention effects were detected, indirect effects of the intervention were explored using the same procedure as described above.

Mediation of intervention effects on 2 year outcomes examined three complementary hypotheses, namely whether intervention effects were accounted for by early changes in personality (the common factors hypothesis), alcohol use (the developmental harm hypothesis) or internalising and externalising symptoms (the psychopathology reduction hypothesis) from baseline to 6 months follow-up. Changes in personality risk factors from baseline to 6 months follow-up were explored as mediators for the mental health symptoms to which they were theoretically relevant. For example, the change in levels of anxiety sensitivity was not explored as a potential mediator of intervention effects on conduct problems as there is no established relationship between these variables.

Results

See table 1 for intervention effects on mediator variables (a pathways), accounting for gender, ethnicity and school cluster. Table 1 shows that there are statistically and trend-level significant a pathways relating to each of the three complementary hypotheses; developmental harm, psychopathology reduction and common factors. Specifically, there were trend level intervention effects on drinking frequency and drinking problems over 6 months, significant decreases in depressive symptoms and trend-level decreases in anxiety symptoms and conduct problems, and significant decreases in anxiety sensitivity and impulsivity. Post-hoc analyses were conducted to investigate intervention effects on relative rankings on personality traits using standardised scores (in addition to mean levels, as reported in table 1). There were no changes in relative ranking on hopelessness, sensation seeking and anxiety sensitivity from baseline to 6 months follow-up. There was a relative increase in impulsivity ranking that was specific to the control condition. Impulsivity rankings in the intervention condition did not change over time. The relative stability in mean levels and ranking across most of the personality traits across adolescence is consistent with results from a meta-analysis on the development and stability of mean and rank-order personality traits across the lifetime (Caspi, Roberts, & Shiner, 2005)

Mediation or indirect pathways for the three complementary hypotheses were examined only for mediator variables with significant or trend-level associations with the outcome variable (*i.e.,* b pathways). Tables 2 and 3 reports indirect estimates for each mediator variable examined. The tables also report intervention effects on the outcome variables

without mediators, and controlling for mediator variables with significant partial mediation or indirect pathways (c and c' pathways, respectively; Baron & Kenny, 1986).

Mechanisms of intervention effects on measures of problematic drinking (table 2)

Binge drinking

Binge drinking onset (dichotomous model): The intervention was associated with reduced rates of binge drinking at 6 months follow-up (intercept), $p<.001$, but was not significantly associated with growth in binge drinking rates (slope) from 6-24 months. This is equivalent to a main intervention effect but no intervention by time interaction, with binge drinking in the intervention group being maintained at a lower rate than the control group from 6-24 months. The intervention effect on the intercept of binge drinking rates was partially mediated through changes in drinking quantity, drinking frequency and drinking problems from baseline to 6 months post-intervention, as reported in table 2. When all mediators were entered into the model together (using the residual drinking frequency score due to the strong correlation between drinking quantity and frequency), the partial mediation effects through both drinking quantity and drinking problems remained significant, whereas the partial mediation through drinking frequency did not. The mediation pathway accounted for 56.8% of the variance in binge drinking onset over 2 years. 27.6% of the variance was accounted for by early changes in drinking behaviours.

There was an indirect effect on growth in binge drinking rates (slope) from 6-24 months follow-up through early post-intervention changes in drinking quantity, drinking frequency and drinking problems. When all mediators were entered into the model (using the residual drinking frequency score), only the partial mediation effects through early

changes in drinking quantity remained significant. The indirect pathway accounted for 16.5% of the variance in the growth of binge drinking rates from 6-24 months.

These findings provide support for the developmental harm hypothesis, as the maintenance of lower binge drinking rates over 2 years in the intervention group was accounted for by early changes in drinking behaviours, and not by changes in mental health symptoms or personality factors.

Binge drinking frequency (continuous model): There were no intervention effects on the intercept or slope of the continuous part of the binge drinking model in the sub-sample who had reported binge drinking at baseline (n=270). There was an indirect effect on binge drinking frequency at 6 months follow-up (intercept) through early changes in drinking quantity, drinking frequency and depressive symptoms, as reported in table 2. When all indirect effects were entered into the model (using the residual drinking frequency score), indirect effects through early changes in both drinking quantity and depressive symptoms remained significant. Together, the indirect pathway accounted for 16.7% of the variance in binge drinking frequency intercept at 6 months. 6.2% of the variance was accounted for by early changes in drinking behaviours and 4.4% was accounted for by early changes in depressive symptoms.

There was an indirect effect on the binge drinking frequency slope from 6-24 months follow-up (intercept) through early changes in drinking quantity, frequency and depressive symptoms. All indirect effects remained significant when entered into the model together. The indirect pathway accounted for 15.9% of the variance in the growth in binge drinking frequency from 6-24 months (slope). 6.2% of the variance was accounted for by changes in drinking behaviours, and 1.3% by changes in depressive

symptoms. These findings provide support for both the developmental harm and, to a lesser extent, the psychopathology reduction hypotheses in accounting for binge drinking frequency over 2 years in baseline binge drinkers.

Drinking problems

Drinking problem onset (dichotomous model): There was a trend-level reduction in drinking problem onset at 6 months follow-up (intercept) in the intervention relative to the control condition, p=.09, but no intervention effects on the growth of onset of drinking problems (slope) from 6-24 months. This is equivalent to a trend-level main intervention effect but no intervention by time interaction on the intervention group's rate of drinking problem onset, with trend-level treatment gains being maintained from 6-24 months. There were indirect effects through early changes in drinking quantity and frequency from baseline to 6 months follow-up, as reported in table 2. When both mediator variables were entered into the model together (using the residual drinking frequency score), only the indirect effect through drinking quantity remained significant. Together, the indirect pathway accounted for 46.2% of the variance in drinking problem onset over 2 years. 5.8% of the variance was accounted for by in early changes in drinking behaviours. These findings support the developmental harm hypothesis.

Indirect effects on the growth in drinking problem rates from 6-24 months (slope) were not explained by early changes in drinking behaviours, mental health symptoms or personality risk factors.

Drinking problem frequency (continuous model): There were no intervention effects on the intercept or slope of the continuous part of the drinking problem frequency in the sub-sample who had reported experiencing drinking problems at baseline (n=201). There

were indirect effects on the frequency of drinking problems at 6 months (intercept) through early changes in drinking quantity and frequency. Only the indirect effect through drinking quantity remained significant when the change scores were entered into the model together. Similarly, indirect effects on the growth in drinking problem frequency from 6-24 months (slope) occurred through early changes in drinking quantity. The indirect pathway accounted for 12.4% of the variance in the drinking problem intercept over 2 years in participants who reported drinking problems at baseline. 5.3% of the variance was accounted for by changes in drinking quantity. These findings provide support for the developmental harm hypothesis in accounting for drinking problem frequency over 2 years in baseline problem drinkers.

Relative reduction rates

In order to assist in the interpretation of the real life impact of the interventions from a public health perspective, relative reduction rates (RRRs) were calculated to approximate the percentage of those in an intervention school who could avoid a problematic drinking outcome that they would otherwise likely develop if they were a member of a control school. The RRR for weekly binge drinking 2 year post-intervention was 19.9%, and the RRR for experiencing 1-2 weekly problems related to alcohol use in the previous 6 months was 15.4%.

Mechanisms of intervention effects on internalising and externalising symptoms (table 3)

Depressive symptoms. The intervention was associated with a significant reduction in depressive symptoms over 2 years (p=.05). Intervention effects were partially mediated by early changes in drinking problems and anxiety sensitivity from baseline to 6 months follow-up (as shown in table 3). Both partial mediation effects remained significant when

the two mediators were entered into the model together. The mediation pathway accounted for 33% of the variance in depressive symptoms over 2 years. 1% of the variance was accounted for by changes in drinking problems and anxiety sensitivity over the first 6 months post-intervention. These findings lent support to both the developmental harm and common factors hypotheses, as long term intervention effects on depressive symptoms were partially mediated by early changes in both drinking-related behaviours and personality risk factors.

Anxiety symptoms. The intervention was associated with a significant reduction in anxiety symptoms over 2 years (p=.01). Intervention effects were partially mediated by changes in anxiety sensitivity, depression, and drinking frequency, quantity and alcohol-related problems from baseline to 6 months follow-up. When all mediators were entered into the model together (using the residual drinking frequency score), all remained significant except the partial mediation effect through early changes in drinking quantity. Together, the mediation pathway accounted for 33% of the variance in anxiety over 2 years, and 6% of the variance was accounted for by early changes in depressive symptoms. Changes in anxiety sensitivity, drinking frequency and drinking problems accounted for 1% of the variance each. These findings suggest that intervention effects on anxiety symptoms over 2 years were largely accounted for by global improvements in mood. In addition, these findings provided some support for the developmental harm and common factors hypotheses, although the variance accounted for by these mechanisms was small.

Conduct problems. The intervention was associated with a significant reduction in conduct problems over 2 years (p=.001). This intervention effect was partially mediated by early changes in depressive symptoms and drinking problems. When both mediators

were entered into the model together, only the partial mediation effect through changes in depressive symptoms remained significant. Together, the mediation pathway accounted for 20% of the variance in conduct problems over 2 years. Less than 1% of the variance was accounted for by early changes in depressive symptoms. Similarly to above, these findings suggest that intervention effects on conduct problems over 2 years were accounted for by global improvements in mood, and not early changes in drinking behaviours or personality risk factors.

All analyses were rerun accounting for baseline levels of the mediator variable and using residual scores, and results did not differ.

Discussion

This study suggests that personality-targeted intervention effects on binge drinking onset over 2 years are partially mediated by early changes in drinking behaviours in the initial 6 months following the intervention. There were also indirect effects on the intercept and growth from 6-24 months (slope) in binge drinking frequency in the sub-sample reporting binge drinking at baseline through early changes in drinking behaviours. Similarly, there were significant indirect pathways on the onset of drinking problems over 2 years through early changes in alcohol use, and indirect effects on the intercept and growth from 6-24 months (slope) in the frequency of drinking problems through early changes in alcohol use in the sub-sample reporting having experienced problems relating to alcohol consumption at baseline. These findings are largely supportive of the developmental harm hypothesis, and suggest that early post-intervention changes in alcohol use play an important role in accounting for longer term intervention effects on problematic drinking outcomes.

2–year intervention effects on problematic drinking were largely not accounted for by changes in mental health symptoms (in contrast with the psychopathology reduction hypothesis). There was, however, an indirect effect on the frequency and growth of binge drinking over 2 years through early reductions in depressive symptoms in the sub-sample having reported binge drinking at baseline, suggesting that early improvements in mood may help to temper the escalation of binge drinking from 14-16 years, particularly in early-onset binge drinkers. However, this indirect effect was relatively smaller than that through early changes in alcohol use. Whilst there were reductions in mental health symptoms subsequent to the intervention, these changes largely did not appear to mediate long-term intervention effects on drinking. The minimal support for the psychopathology reduction mechanism with regards to intervention effects on alcohol misuse is consistent with some other studies in community samples (*e.g,*. Adrian, McCarty, King, McCauley, & Stoep, 2014), which do not show a direct relationship between internalising and externalising symptoms and substance use in mentally healthy participants. Indeed, the associations between internalising and externalising symptoms with substance use are not consistently demonstrated in community adolescent samples (Colder et al., 2013; McCarty et al., 2013). The fact that early decreases in conduct problems did not mediate intervention effects on alcohol misuse in our study is consistent with studies showing that conduct problems are not causally linked to substance use behaviours, but rather that these behaviours are concurrently related as part of a spectrum of externalising behaviours (Castellanos-Ryan & Conrod, 2011, Urben et al, 2014). The psychopathology reduction (or affect regulation) mechanism of substance use appears to be more established in individual experiencing harmful alcohol use, or problematic internalising

or externalising symptoms (Edwards et al., 2014). This is supported by results from several indicated intervention approaches, demonstrating that targeting early depressive symptoms or conduct problems led to subsequent decreases in substance use (Rohde et al, 2012; Zonnevylle-Bender et al, 2007). In contrast, our study participants were not selected based on indicators of high-risk behaviours; most participants did not drink at baseline and did not report problematic internalising or externalising symptoms (see O'Leary-Barrett et al, 2013). However, our results show that early post-intervention changes in depressive symptoms partially mediated longer term intervention effects on anxiety symptoms and conduct problems. Early changes in drinking accounted for a relatively smaller portion of the variance in mental health symptoms over 2 years. These findings suggest that early improvements in mood may lead to broader improvements in long term well-being, and support the psychopathology reduction mechanism with regards to long term intervention effects on mental health symptoms.

The current findings largely do not support the hypothesis that changes in personality account for long term intervention effects on mental health or alcohol misuse (the common factors hypothesis). Our findings revealed that there were reductions in some personality risk factors in the intervention condition (particularly those that have been shown to be less stable over time), and that reductions in anxiety sensitivity accounted for a small portion of the intervention effects on both depressive and anxiety symptoms over 2 years. The relationship between anxiety sensitivity and both depressive and anxiety symptoms is supported by other studies (Olthuis, Watt, & Stewart, 2014). However, 2-year intervention effects on drinking behaviours were not accounted for by changes in personality. As outlined in our hypotheses, this selective intervention model involves

targeting problematic coping specific to each personality trait (*e.g.*, avoidance in anxiety sensitive youth), but does not try to change youth's personalities. The interventions discuss how youth can maintain their sense of individuality without their personality leading to problems. Youth were taught personality-specific coping strategies to enable them to better cope in situations where they misuse alcohol or drugs (*e.g.*, thinking before acting in the impulsivity group, and evaluating potential short and long-term negative consequences of using substances to cope with feelings of frustration). The findings that 6-month intervention effects on drinking behaviours mediated most of the longer term outcomes of the intervention support this interpretation.

The clinical implications of these findings are that it is of crucial importance to intervene on early onset alcohol use behaviours, as delaying onset and tempering the quantity of drinking when it begins in early adolescence accounts for reductions in subsequent problematic drinking. Early intervention effects on alcohol use behaviours (*i.e.*, over the first 6 months) may in fact serve as a marker of longer-term intervention effects on both substance and non-substance related problems. Whilst the current results are specific to the mechanisms of the personality-targeted approach, one could hypothesise that they may also apply more widely to other evidence-based intervention approaches in community samples. Indeed, studies examining mechanisms of universal family-focused substance use prevention programmes found that intervention effects on substance misuse in young adulthood occurred indirectly through substance use initiation and growth factors in adolescence (Spoth et al., 2009; Spoth et al., 2014). These results suggest that, despite notable differences in the format and delivery of personality-targeted interventions relative to universal family focused interventions, reductions in early onset

substance use behaviours may be key to longer term intervention efficacy on problematic alcohol use (either directly or indirectly) across various programs. We are currently investigating whether delays in early onset alcohol use result in benefits in cognitive domains through protecting the developing brain from the neurotoxic effects of ethanol (Lubman et al, 2007). However, until we have a more detailed understanding of intermediate processes, the proximal mechanisms by which early changes in alcohol use account for later intervention effects on substance use remains unclear.

In addition to reductions in substance use, personality-targeted interventions also result in global improvements in mood, anxiety and conduct problems across all personality groups (in addition to some personality-specific intervention effects on more severe levels of mental health symptoms; O'Leary-Barrett et al, 2013), which partially mediate longer term intervention effects on both internalising and externalising symptoms that are often comorbid with substance use disorders in clinical populations. The process through which the intervention effects came about in each personality group was not examined in the current study. It is possible, for example, that individuals learned personality-specific coping skills that enabled them to better manage their personality traits. Tentative support for this idea is provided by research demonstrating that personality-targeted interventions reduce coping motives for substance use (Conrod et al., 2011). Personality-specific intervention effects and mechanisms were, however, beyond the scope of the current study, and will be further investigated in subsequent studies in our lab and others (*e.g.*, Olthuis, Watt, Mackinnon, & Stewart, 2015).

This study suggests that personality-targeted interventions impact alcohol misuse and psychopathology through two relatively independent processes. Specifically, 2-year

intervention effects on problematic alcohol use appear to operate through the "developmental harm" mechanism (*i.e.,* early reductions in drinking behaviours), whereas intervention effects on mental health symptoms appear to operate through reductions in psychopathology (specifically, depressive symptoms) and, to a certain extent, reductions in personality risk factors (the common factors hypothesis), with short term reductions in anxiety sensitivity partially mediating intervention effects on internalising symptoms. This has implications for both mental health and substance use prevention. Namely, the current results suggest that, in a preventive context at least, intervention effects on alcohol misuse may not be dependent on improvements in mental health symptoms, and vice versa. These findings also inform models of substance use and psychiatric comorbidity in that common risk factors (*i.e.,* high risk personality profiles) may confer risk to different sets of problems that might not be causally related in youth. As discussed above, the causal relationship between substance misuse and mental health symptoms may become more evident when levels of substance use and psychopathology are greater than in the current sample (as suggested by several studies in clinical samples, *e.g.,* Edwards et al., 2014).

The strengths of this study include its cluster-randomised design, large sample size and methodological rigour. The examination of mechanisms of effective interventions is crucially important in guiding treatment strategies, and targeting risk factors for addiction and comorbid problems is an innovative approach that is much needed due to the difficulties faced treating substance use comorbidity in clinical populations.

One limitation of these results is that the mediators examined accounted for only a small portion of the variance in intervention effects on internalising and externalising

symptoms. This suggests that the mechanism of intervention effects on mental health symptoms is largely not captured by the variables examined. The variance in problematic drinking accounted for by the current models is larger (up to 57% for binge drinking rates), but there is still a significant portion of variance in intervention effects that is not explained by the variables examined. One reason for this may be that the study was designed to provide insights into the mechanisms of long-term intervention effects, but not to test the process through which these changes are achieved (which may explain more of the variance). A second limitation is that we did not include additional measures of personality risk factors with which to supplement our investigation of the common factors hypothesis, such as cognitive measures of disinhibition or behavioural measures of personality traits. A subsequent trial in our lab is investigating cognitive measures associated with each personality risk factor and will be able to shed further light on this question. Thirdly, whilst the current findings largely contrast with the psychopathology reduction hypothesis, they do not necessarily disprove the hypothesis as the sample in question is relatively healthy. A recent study suggests that, although there may not be a direct psychopathology reduction, or affect regulation, pathway to substance use in adolescence, the internalising pathway to adolescent substance use may be mediated by individual's rumination style (Adrian et al, 2014). This suggests that more proximal mechanisms of intervention effects such as emotional and cognitive processing would provide greater insight into the relationship between substance use and internalising and externalising symptoms, and an even richer understanding of the process through which participants responded to the intervention. Intervention process is being examined in a subsequent study. Lastly, personality-targeted interventions were compared with drug

education and psychological services as usual in control schools, as opposed to an active comparison intervention, thus control participants had less contact with school-based intervention facilitators. However, there was no difference in the amount of contact with research project staff across treatment conditions, as the interventions were delivered by school-based professionals only. Two previous studies have demonstrated that personality-matched interventions are significantly more effective in reducing substance-related outcomes than personality-mismatched or motivational control interventions (Conrod, Pihl, Stewart, & Dongier, 2000), or non-specific treatments controlling for effects of group and therapist exposure (Watt, Stewart, Birch, & Bernier, 2006). This suggests that personality matching is key to intervention efficacy and reduces the likelihood that the reported intervention results are due to a placebo effect. In addition, the use of intent-to-treat analyses was a conservative data analysis procedure, as 120 (17.3%) of high-risk participants did not receive an intervention. The true impact of the intervention may therefore be stronger than what is reported here.

In conclusion, these findings suggest that long term personality-targeted intervention effects on problematic drinking in youth are largely accounted for by early changes in drinking behaviours, and not by changes in mental health symptoms or personality risk factors. Intervention effects on internalising and externalising symptoms are largely accounted for by reductions in depressive symptoms and reductions in anxiety-sensitivity (in the case of internalising symptoms). Thus, targeting personality risk factors leads to intervention effects on substance- and non substance-related behaviours which appear to operate through distinct mechanisms.

References

Adrian, M., McCarty, C., King, K., McCauley, E., & Stoep, A. V. (2014). The internalizing pathway to adolescent substance use disorders: Mediation by ruminative reflection and ruminative brooding. *Journal of adolescence, 37*(7), 983-991.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol, 51*(6), 1173-1182.

Brown, S. A., Tapert, S. F., Granholm, E., & Delis, D. C. (2000). Neurocognitive functioning of adolescents: Effects of protracted alcohol use. *Alcoholism: Clinical and Experimental Research, 24*(2), 164-171.

Carroll, K. M., Connors, G. J., Cooney, N. L., DiClemente, C. C., Donovan, D. M., Kadden, R. R., Longabaugh, R. L., Rounsaville, B. J., Wirtz, P.W., & Zweben, A.

(1998). Internal validity of Project MATCH treatments: discriminability and integrity. *J Consult Clin Psychol, 66*(2), 290-303.

Caspi, A., Roberts, B. W., & Shiner, R. L. (2005). Personality development: stability and change. *Annu Rev Psychol*, 56, 453-484.Castellanos-Ryan, N., & Conrod, P. J. (2011). Personality correlates of the common and unique variance across conduct disorder and substance misuse symptoms in adolescence. *J Abnorm Child Psychol, 39*(4), 563-576.

Castellanos-Ryan, N., & Conrod, P. J. (2012). Personality and substance misuse: Evidence for a four factor model of vulnerability. In B. K. Vester J, Strain E, Galanter M., Conrod PJ (Ed.), *Drug Abuse and Addiction in Medical Illness* (Vol. 1 & 2): Humana/Spring Press.

Castellanos-Ryan, N., O'Leary-Barrett, M., Sully, L., & Conrod, P. (2013). Sensitivity and specificity of a brief personality screening instrument in predicting future substance use, emotional, and behavioral problems: 18-month predictive validity of the substance use risk profile scale. *Alcohol Clin Exp Res, 37 Suppl 1*, E281-290.

Clark, D. B., Pollock, N., Bukstein, O. G., Mezzich, A. C., Bromberger, J. T., & Donovan, J. E. (1997). Gender and comorbid psychopathology in adolescents with alcohol dependence. *J Am Acad Child Adolesc Psychiatry, 36*(9), 1195-1203.

Colder, C. R., Scalco, M., Trucco, E. M., Read, J. P., Lengua, L. J., Wieczorek, W. F., & Hawk, L. W., Jr. (2013). Prospective associations of internalizing and externalizing problems and their co-occurrence with early adolescent substance use. *J Abnorm Child Psychol, 41*(4), 667-677.

Connor-Smith, J. K., & Flachsbart, C. (2007). Relations between personality and coping: a meta-analysis. *J Pers Soc Psychol, 93*(6), 1080-1107.

Conrod, P. J., Castellanos-Ryan, N., & Mackie, C. J. (2011). Long-term effects of a personality-targeted interventions to reduce alcohol use in adolescents. *J Cons Clin Psychol, 79*(3), 296-306.

Conrod, P. J., Castellanos-Ryan, N., & Strang, J. (2010). Brief, personality-targeted coping skills interventions and survival as a non-drug user over a 2-year period during adolescence. *Archives of General Psychiatry, 67*(1), 85-93.

Conrod, P. J., Castellanos, N., & Mackie, C. (2008). Personality-targeted interventions delay the growth of adolescent drinking and binge drinking. *J Child Psychol Psychiatry, 49*(2), 181-190.

Conrod, P. J., O'Leary-Barrett, M., Newton, N., Topper, L., Castellanos-Ryan, N., Mackie, C., & Girard, A. (2013). Effectiveness of a selective, personality-targeted prevention program for adolescent alcohol use and misuse: a cluster randomized controlled trial. *JAMA Psychiatry, 70*(3), 334-342.

Conrod, P. J., Pihl, R. O., Stewart, S. H., & Dongier, M. (2000). Validation of a system of classifying female substance abusers on the basis of personality and motivational risk factors for substance abuse. *Psychol Addict Behav, 14*(3), 243-256.

Conrod, P. J., Pihl, R. O., & Vassileva, J. (1998). Differential sensitivity to alcohol reinforcement in groups of men at risk for distinct alcoholism subtypes. *Alcohol Clin Exp Res, 22*(3), 585-597.

Conrod, P. J., Stewart, S. H., Comeau, N., & Maclean, A. M. (2006). Efficacy of cognitive-behavioral interventions targeting personality risk factors for youth alcohol misuse. *J Clin Child Adolesc Psychol, 35*(4), 550-563.

Conrod, P. J., Stewart, S. H., Pihl, R. O., Cote, S., Fontaine, V., & Dongier, M. (2000). Efficacy of brief coping skills interventions that match different personality profiles of female substance abusers. *Psychol Addict Behav, 14*(3), 231-242.

Cooper, M. L., Frone, M. R., Russell, M., & Mudar, P. (1995). Drinking to regulate positive and negative emotions: a motivational model of alcohol use. *J Pers Soc Psychol, 69*(5), 990-1005.

Couwenbergh, C., van den Brink, W., Zwart, K., Vreugdenhil, C., van Wijngaarden-Cremers, P., & van der Gaag, R. J. (2006). Comorbid psychopathology in adolescents and young adults treated for substance use disorders: a review. *Eur Child Adolesc Psychiatry, 15*(6), 319-328.

Davis, C., Cohen, A., Davids, M., & Rabindranath, A. (2015). Attention-deficit/hyperactivity disorder in relation to addictive behaviors: a moderated-mediation analysis of personality-risk factors and sex. *Front Psychiatry, 6*, 47.

Deas, D. (2006). Adolescent substance abuse and psychiatric comorbidities. *J Clin Psychiatry, 67 Suppl 7*, 18-23.

Derogatis, L. R. (1993). *Brief Symptom Inventory*. Mineapolis, MN: NCS Pearson Inc.

Edwards, A. C., Joinson, C., Dick, D. M., Kendler, K. S., Macleod, J., Munafo, M., Hickman. M, Lewis, G., & Heron, J. (2014). The association between depressive symptoms from early to late adolescence and later use and harmful use of alcohol. *Eur Child Adolesc Psychiatry, 23*(12), 1219-1230.

Faggiano, F., Vigna-Taglianti, F. D., Versino, E., Zambon, A., Borraccino, A., & Lemma, P. (2008). School-based prevention for illicit drugs use: a systematic review. *Prev Med, 46*(5), 385-396.

Ferrari, A. J., Norman, R. E., Freedman, G., Baxter, A. J., Pirkis, J. E., Harris, M. G., Page, A., Carnahan, E., Degenhardt, L., Vos, T., & Whiteford, H. A. (2014). The burden attributable to mental and substance use disorders as risk factors for suicide: Findings from the Global Burden of Disease Study 2010. *PLoS One, 9*(4).

Gizer, I. R., Ehlers, C. L., Vieten, C., Feiler, H. S., Gilder, D. A., & Wilhelmsen, K. C. (2012). Genome-wide linkage scan of antisocial behavior, depression, and impulsive substance use in the UCSF family alcoholism study. *Psychiatric genetics, 22*(5), 235-244.

Goodman, R. (1997). The Strengths and Difficulties Questionnaire: a research note. *J Child Psychol Psychiatry, 38*(5), 581-586.

Grant, B. F., & Dawson, D. A. (1997). Age at onset of alcohol use and its association with DSM-IV alcohol abuse and dependence: Results from the national longitudinal alcohol epidemiologic survey. *Journal of Substance Abuse, 9*(1), 103-110.

Grella, C. E., Hser, Y. I., Joshi, V., & Rounds-Bryant, J. (2001). Drug treatment outcomes for adolescents with comorbid mental and substance use disorders. *J Nerv Ment Dis, 189*(6), 384-392.

Hinshaw, S. P. (2002). Intervention research, theoretical mechanisms, and causal processes related to externalizing behavior patterns. *Dev Psychopathol, 14*(4), 789-818.

Kenward, M. G., & Carpenter, J. (2007). Multiple imputation: current perspectives. *Stat Methods Med Res, 16*(3), 199-218.

King, R. D., Gaines, L. S., Lambert, E. W., Summerfelt, W. T., & Bickman, L. (2000). The co-occurrence of psychiatric and substance use diagnoses in adolescents in different service systems: frequency, recognition, cost, and outcomes. *J Behav Health Serv Res, 27*(4), 417-430.

Kotov, R., Gamez, W., Schmidt, F., & Watson, D. (2010). Linking "big" personality traits to anxiety, depressive, and substance use disorders: a meta-analysis. *Psychol Bull, 136*(5), 768-821.

Kotov, R., Ruggero, C. J., Krueger, R. F., Watson, D., Yuan, Q., & Zimmerman, M. (2011). New dimensions in the quantitative classification of mental illness. *Arch Gen Psychiatry, 68*(10), 1003-1011.

Laucht, M., Becker, K., Blomeyer, D., & Schmidt, M. H. (2007). Novelty seeking involved in mediating the association between the dopamine D4 receptor gene exon III polymorphism and heavy drinking in male adolescents: results from a high-risk community sample. *Biol Psychiatry, 61*(1), 87-92.

Lazareck, S., Robinson, J. A., Crum, R. M., Mojtabai, R., Sareen, J., & Bolton, J. M. (2012). A longitudinal investigation of the role of self-medication in the development of comorbid mood and drug use disorders: findings from the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). *J Clin Psychiatry, 73*(5), e588-593.

Leyton, M., Boileau, I., Benkelfat, C., Diksic, M., Baker, G., & Dagher, A. (2002). Amphetamine-induced increases in extracellular dopamine, drug wanting, and

novelty seeking: a PET/[11C]raclopride study in healthy men. *Neuropsychopharmacology, 27*(6), 1027-1035.

Lubman, D. I., Hides, L., Yucel, M., & Toumbourou, J. W. (2007). Intervening early to reduce developmentally harmful substance use among youth populations. *Med J Aust, 187*(7 Suppl), S22-25.

MacKinnon, D. P., Fritz, M. S., Williams, J., & Lockwood, C. M. (2007). Distribution of the product confidence limits for the indirect effect: program PRODCLIN. *Behavior Research Methods, 39*, 384-389.

MacPherson, L., Magidson, J. F., Reynolds, E. K., Kahler, C. W., & Lejuez, C. W. (2010). Changes in sensation seeking and risk-taking propensity predict increases in alcohol use among early adolescents. *Alcoholism, clinical and experimental research, 34*(8), 1400-1408.

McCarty, C. A., Wymbs, B. T., Mason, W. A., King, K. M., McCauley, E., Baer, J., & Vander Stoep, A. (2013). Early adolescent growth in depression and conduct problem symptoms as predictors of later substance use impairment. *Journal of Abnormal Child Psychology, 41*(7), 1041-1051.

McGue, M., & Bouchard, T. J., Jr. (1998). Genetic and environmental influences on human behavioral differences. *Annu Rev Neurosci, 21*, 1-24.

McGue, M., Iacono, W. G., Legrand, L. N., Malone, S., & Elkins, I. (2001). Origins and consequences of age at first drink. I. Associations with substance-use disorders, disinhibitory behavior and psychopathology, and P3 amplitude. *Alcohol Clin Exp Res, 25*(8), 1156-1165.

Miller, W. R., & Orr, J. (1980). Nature and sequence of neuropsychological deficits in alcoholics. *J Stud Alcohol, 41*(3), 325-337.

Muthén, B., & Satorra, A. (1995). Complex sample data in structural equation modeling. In P. V. Marsden (Ed.), *Sociological methodology* (pp. 267-316). Washington, DC: American Sociological Association.

Muthén, L. K., & Muthén, B. O. (2010). *Mplus User's Guide* (6 ed.). Los Angeles: Muthén & Muthén.

O'Leary-Barrett, M., Mackie, C. J., Castellanos-Ryan, N., Al-Khudhairy, N., & Conrod, P. J. (2010). Personality-targeted interventions delay uptake of drinking and decrease risk of alcohol-related problems when delivered by teachers. *J Amer Acad Child Adol Psychiatry, 49*(9), 954-963.e951.

O'Leary-Barrett, M., Topper, L., Al-Khudhairy, N., Pihl, R. O., Castellanos-Ryan, N., Mackie, C. J., & Conrod, P. J. (2013). Two-year impact of personality-targeted, teacher-delivered interventions on youth internalizing and externalizing problems: a cluster-randomized trial. *J Am Acad Child Adolesc Psychiatry, 52*(9), 911-920.

Olthuis, J. V., Watt, M. C., Mackinnon, S. P., & Stewart, S. H. (2015). CBT for high anxiety sensitivity: Alcohol outcomes. *Addict Behav, 46C*, 19-24.

Olthuis, J. V., Watt, M. C., & Stewart, S. H. (2014). Anxiety Sensitivity Index (ASI-3) subscales predict unique variance in anxiety and depressive symptoms. *J Anxiety Disord, 28*(2), 115-124.

Parsons, O. A. (1998). Neurocognitive deficits in alcoholics and social drinkers: A continuum? *Alcoholism: Clinical and Experimental Research, 22*(4), 954-961.

Quinn, P. D., Stappenbeck, C. A., & Fromme, K. (2011). Collegiate heavy drinking prospectively predicts change in sensation seeking and impulsivity. *Journal of Abnormal Psychology, 120*(3), 543-556.

Riper, H., Andersson, G., Hunter, S. B., de Wit, J., Berking, M., & Cuijpers, P. (2014). Treatment of comorbid alcohol use disorders and depression with cognitive-behavioural therapy and motivational interviewing: A meta-analysis. *Addiction, 109*(3), 394-406.

Roberts, B. W., Walton, K. E., & Viechtbauer, W. (2006). Patterns of mean-level change in personality traits across the life course: a meta-analysis of longitudinal studies. *Psychol Bull, 132*(1), 1-25.

Rohde, P., Stice, E., Gau, J. M., & Marti, C. N. (2012). Reduced substance use as a secondary benefit of an indicated cognitive-behavioral adolescent depression prevention program. *Psychol Addict Behav, 26*(3), 599-608.

Salvo, N., et al. (2012). Prevention of substance use in children/adolescents with mental disorders: a systematic review. *J Can Acad Child Adolesc Psychiatry., 21*(4), 245-252.

Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods, 7*(2), 147-177.

Spoth, R., Trudeau, L., Guyll, M., Shin, C., & Redmond, C. (2009). Universal intervention effects on substance use among young adults mediated by delayed adolescent substance initiation. *J Consult Clin Psychol, 77*(4), 620-632.

Spoth, R., Trudeau, L., Redmond, C., & Shin, C. (2014). Replication RCT of early universal prevention effects on young adult substance misuse. *J Consult Clin Psychol, 82*(6), 949-963.

Squeglia, L. M., Spadoni, A. D., Infante, M. A., Myers, M. G., & Tapert, S. F. (2009). Initiating moderate to heavy alcohol use predicts changes in neuropsychological functioning for adolescent girls and boys. *Psychol Addict Behav, 23*(4), 715-722.

Stice, E., Rohde, P., Gau, J. M., & Wade, E. (2010). Efficacy trial of a brief cognitive–behavioral depression prevention program for high-risk adolescents: Effects at 1- and 2-year follow-up. *Journal of Consulting and Clinical Psychology, 78*(6), 856-867.

Stice, E., Shaw, H., Bohon, C., Marti, C. N., & Rohde, P. (2009). A meta-analytic review of depression prevention programs for children and adolescents: factors that predict magnitude of intervention effects. *J Consult Clin Psychol, 77*(3), 486-503.

Swailes, S., & McIntyre-Bhatty, Y. T. (2002). The 'Belbin' team role inventory: Reinterpreting reliability estimates. *Journal of Managerial Psychology, 17*(6), 529-536.

Tofighi, D., & MacKinnon, D. P. (2011). RMediation: an R package for mediation analysis confidence intervals. *Behav Res Methods, 43*(3), 692-700.

Urben, S., Suter, M., Pihet, S., Straccia, C., & Stephan, P. (2014). Constructive thinking skills and iImpulsivity dimensions in conduct and substance use disorders: differences and relationships in an adolescents' sample. *Psychiatr Q*.

van Lier, P. A. C., Huizink, A., & Crijnen, A. (2009). Impact of a preventive intervention targeting childhood disruptive behavior problems on tobacco and alcohol

initiation from age 10 to 13 years. *Drug and Alcohol Dependence, 100*(3), 228-233.

Watt, M., Stewart, S. H., Birch, C., & Bernier, D. (2006). Brief CBT for high anxiety sensitivity decreases drinking problems, relief alcohol outcome expectancies, and conformity drinking motives: Evidence from a randomized controlled trial. *J Ment Health, 15*(6), 683-695.

Watt, M. C., Stewart, S. H., Lefaivre, M. J., & Uman, L. S. (2006). A brief cognitive-behavioral approach to reducing anxiety sensitivity decreases pain-related anxiety. *Cogn Behav Ther, 35*(4), 248-256.

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica, 48*(817-838).

White, H., & Labouvie, E. W. (1989). Towards the assessment of adolescent problem drinking. *J Stud Alcohol, 50*, 30-37.

Woicik, P. A., Stewart, S. H., Pihl, R. O., & Conrod, P. J. (2009). The Substance Use Risk Profile Scale: a scale measuring traits linked to reinforcement-specific substance use profiles. *Addict Behav, 34*(12), 1042-1055.

Young, J. E., & Beck, A. T. (1980). *Cognitive Therapy Scale*. University of Pennsylvania. Philadelphia.

Zonnevylle-Bender, M. J., Matthys, W., van de Wiel, N. M., & Lochman, J. E. (2007). Preventive effects of treatment of disruptive behavior disorder in middle childhood on substance use and delinquent behavior. *J Am Acad Child Adolesc Psychiatry, 46*(1), 33-39.

Figure 1

Figure 1: Three complementary mechanism hypotheses

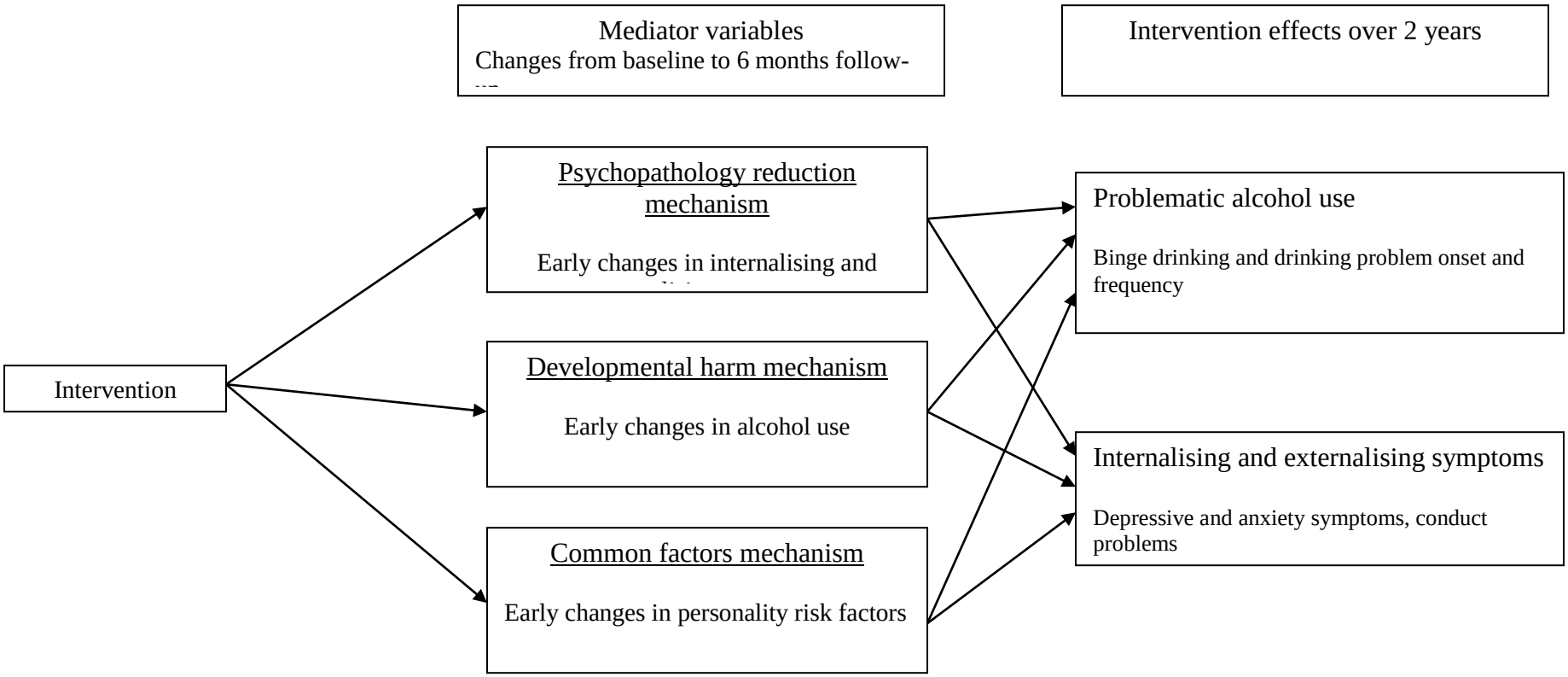

Figure 2

Figure 2: CONSORT diagram

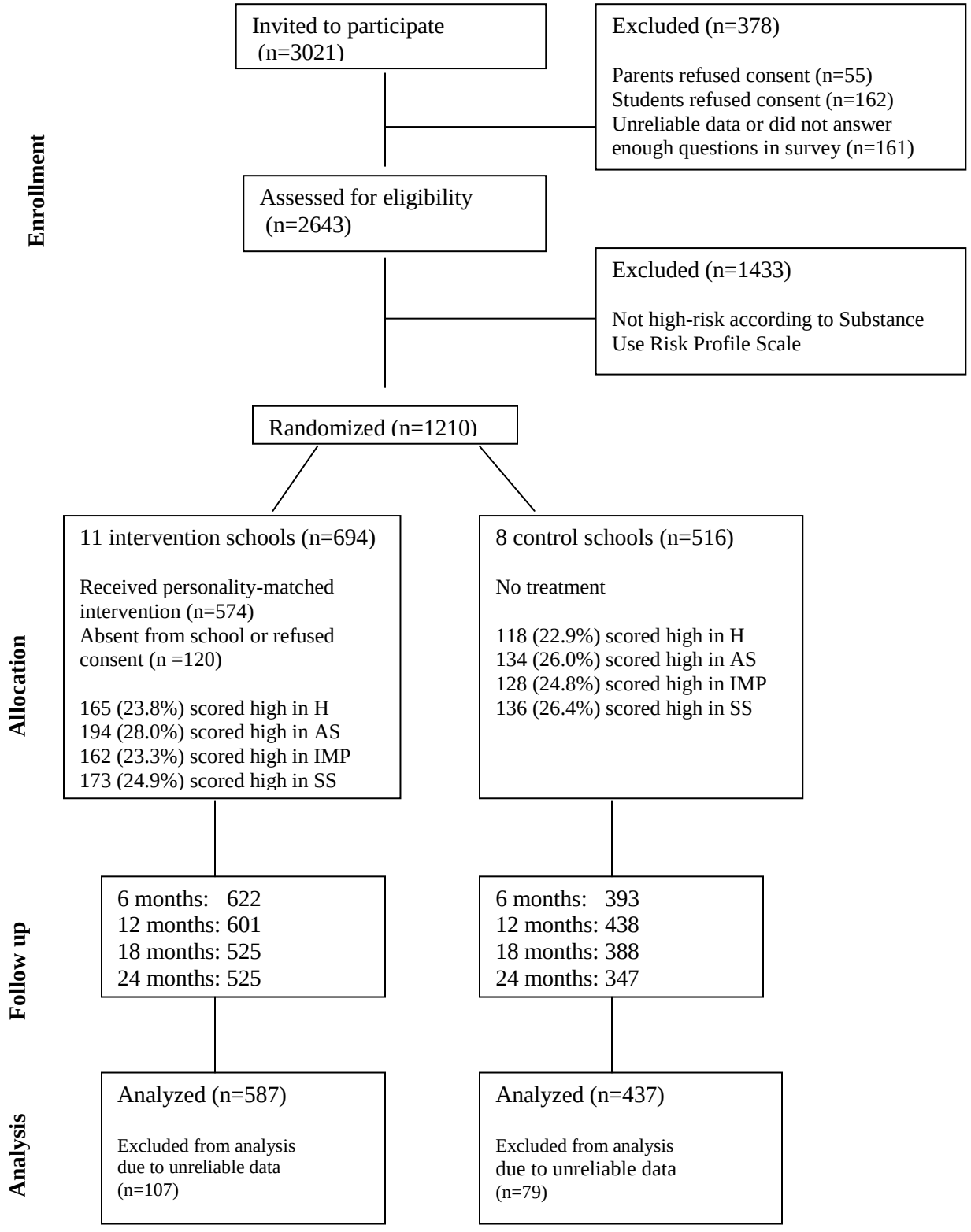

Table 1: Intervention effects on mediator variables from baseline to 6 months follow-up[a]

Mechanism	Mediators	B (S.E.)	β
Developmental harm mechanism	**Drinking behaviours**		
	Drinking quantity	-.12 (.08)	-.11
	Drinking frequency	-.17 (.10)[t]	-.15
	Drinking problems (total)	-.53 (.27)[t]	-.12
Psychopathology reduction mechanism	**Mental health symptoms**		
	Depression	-.85 (.39)*	.16
	Anxiety	-.54 (.29)[t]	.14
	Conduct problems	-.18 (.10)[t]	-.10
Common factors mechanism	**Personality**		
	Hopelessness	.07 (.20)	.02
	Anxiety sensitivity	-.31 (.15)*	-.11
	Impulsivity	-.52 (.20)*	-.18
	Sensation seeking	-.15 (.18)	-.04

Notes: [a]All models include demographic variables (gender and ethnicity), and account for school cluster;
^Mediator variables: change in score from baseline to 6 months follow-up;
B= Unstandardised coefficient, S.E. = robust standard error, β = Standardised beta;
*$p < .05$, [t]$\leq .10$.

Table 2: Mechanisms of intervention effects on measures of problematic drinking[a]

Outcome variables over 2 years *Mediator variables^ (b†)*	Estimate (S.E.), [Standardised Estimate]	Indirect estimate (S.E.), [95% CI][b]
Binge drinking onset (intercept) [D][1]		
Intervention effect without mediators (c†)	-.79 (.21)***, [-.15]	
Intervention effect with mediators (c'†)	-.49 (.20)*, [-.10]	
Drinking quantity	.92 (.16)***, [.37]	**-.19 (.07) [-.349, -.062]**[c]
Drinking frequency	.66 (.13)***, [.28]	**-.13 (.06) [-.257, -.032]**
Drinking problems	.18 (.05)***, [.29]	**-.12 (.06) [-.255, -.016]**[c]
*Hopelessness^*	.09 (.03)**, [.15]	-.002 (.03) [-.061, .055]
Binge drinking onset (slope) [D][1]		
Intervention effect without mediators (c†)	.12 (.10), [.10]	
Intervention effect with mediators (c'†)	.04 (.10), [.04]	
Drinking quantity	-.19 (.07)**, [-.31]	**.04 (.02) [.007, .083]**[c]
Drinking frequency	-.21 (.05)***, [-.37]	**.04 (.02) [.009, .085]**
Drinking problems	-.05 (.02)**, [-.32]	**.03 (.02) [.003, .069]**
Binge drinking frequency (intercept) [C][2]		
Intervention effect without mediators (c†)	-.01 (.03), [-.04]	
Intervention effect with mediators (c'†)	-.01 (.02), [.05]	
Drinking quantity	.02 (.01)*, [.14]	**-.003 (.002) [-.009, 0]**[c]
Drinking frequency	.04 (.01)***, [.27]	**-.01 (.003) [-.013, -.001]**
Depression	-.01 (.002)*, [-.23]	**.005 (.003) [0, .013]**[c]
Anxiety	-0.01 (.002)*, [-.16]	.002 (.002) [-.002, .007]

Binge drinking frequency (slope) [C][2]		
Intervention effect without mediators (c†)	.001 (.01), [.01]	
Intervention effect with mediators (c'†)	.003 (.01), [.02]	
Drinking quantity	-0.01 (.004)*, [-.12]	**.001 (.001) [0, .004]**[c]
Drinking frequency	-.01 (.004)*, [-.16]	**.002 (.001) [0, .004]**[c]
Depression	.003 (.001)**, [.26]	**-.003 (.002) [-.007, 0]**[c]
Anxiety	.003 (.001)*, [.20]	-.001 (.001) [-.004, .001]
Drinking problems onset (intercept) [D][3]		
Intervention effect without mediators (c†)	-.46 (.27)[t],[-.07]	
Intervention effect with mediators (c'†)	-.26 (.26), [-.04]	
Drinking quantity	.54 (.17)***, [.54]	**-.10 (.05) [-.206, -.016]**[c]
Drinking frequency	.64 (.14)***, [.22]	**-.10(.06) [-.222, -.008]**
Hopelessness	.09 (.04)**, [.12]	0 (.03) [-.056, .057]
Impulsivity	-.04 (.03)[t], [-.08]	.02 (.02) [-.007, .059]
Drinking problems onset (slope) [D][3]		
Intervention effect without mediators (c†)	.004 (.14), [.002]	
Intervention effect with mediators (c'†)	-.05 (.14), [-.03]	
Drinking frequency	-.13 (.07)*, [-.15]	.02 (.02) [-.002, .057]
Hopelessness	-.04 (.02)*, [-.17]	0 (.01). [-.026, .025]
Impulsivity	.04 (.02)[t], [.13]	-.02 (.02) [-.055, .003]
Anxiety	-.03 (.02)[t], [-.16]	.01 (.02) [-.014, .047]

Drinking problem frequency (intercept) [C][4]		
Intervention effect without mediators (c†)	.001(.04),[.002]	
Intervention effect with mediators (c'†)	.03 (.04), [.05]	
Drinking quantity	.07 (.02) ***, [.25]	**-.01 (.01) [-.025, -.002][c]**
Drinking frequency	.05 (.02)**, [.19]	**-.01 (.01) [-.019, -.001]**
Drinking problem frequency (slope) [C][4]		
Intervention effect without mediators (c†)	-.01 (.02), [-.14]	
Intervention effect with mediators (c'†)	-.02 (.02),[-.29]	
Drinking quantity	-.03 (.01)***, [-.81]	**.004 (.002) [.001, .009]**

Notes:
[D]: Dichotomous model of the probability of engaging in a particular behaviour (*i.e.* binge drinking and drinking problems onset);
[C]: Continuous model of the frequency of binge drinking or drinking problems in the sub-samples having reported binge drinking or drinking problems at baseline (n=270 and n=201, respectively);
[a]All models include gender and ethnicity as covariates. Dichotomous models also controlled for baseline levels of the corresponding drinking variable. Intercept of the outcome measure reflects the mean constant in frequency for any individual across time (6-24 months); slope of the outcome measure reflects any mean deviance from the intercept over time;
Model fit : [1]: Akaike (AIC)= 4221.022, Bayesian (BIC)= 4285.132, Sample-Size Adjusted BIC= 4243.842 (n* = (n + 2) / 24);
[2]: Akaike (AIC)= - -476.989 , Bayesian (BIC)= - 419.206 , Sample-Size Adjusted BIC = -466.791 (n* = (n + 2) / 24);
[3] Akaike (AIC)= 2947.468, Bayesian (BIC)= 3010.241, Sample-Size Adjusted BIC = 2968.955 (n* = (n + 2) / 24);
[4] Akaike (AIC)= 1032.197, Bayesian (BIC)= 1083.312, Sample-Size Adjusted BIC= 1045.221 (n* = (n + 2) / 24);
^Mediator variables: Mediation/ indirect effects were examined only when mediators had significant or trend-level b pathways;
†Mediation pathway according to Baron & Kenny (1986);
S.E. = standard error, CI: Confidence Intervals, ***p <= .001, **p <= .01, *p < .05, [t]$\leq$ .10.
[b]MacKinnon's products of coefficients method referring to the impact of each mediator individually;
Indirect estimates in bold font: Significant indirect pathway according to MacKinnon's products of coefficient method;
[c]: significant mediation pathways remain when taking others mediators into account.

Table 3: Mechanisms of intervention effects on internalising and externalising symptoms[a]

Outcome variables over 2 years	B (S.E.), β	Indirect estimate (S.E.), [95% CI][b]
Mediator variables^ (b†)		
Depressive symptoms		
Intervention effect without mediators (c†)	-.02 (.01)*, [-.09]	
Intervention effect with mediators (c'†)	-.01 (.01), [-.08]	
Drinking quantity	.01 (.005)[t], [.05]	-.001 (.001) [-.004, .001]
Drinking problems	.003 (.001)***, [.08]	**-.002 (.001) [-.004, 0]**[c]
Anxiety	.01 (.001)***, [.22]	-.006(.003) [-.012, .002]
Hopelessness	.005 (.001)**, [.09]	.0003 (.001) [-.002, .002]
Anxiety sensitivity	.003 (.002)[t], [.05]	**-.001 (.001) [-.003, 0]**[c]
Anxiety symptoms		
Intervention effect without mediators (c†)	-.02(.01),[-.12]**	
Intervention effect with mediators (c'†)	-.01 (.01)[t], [-.07]	
Drinking frequency	.01 (.003)*, [.05]	**-.001 (.001) [-.004, 0]**[c]
Drinking quantity	.01 (.003)*, [.05]	**-.001 (.001) [-.003, 0]**
Drinking problems	.003 (.001)*, [.08]	**.002 (.001) [-.004, 0]**[c]
Depression	.01 (.001)***, [.27]	**-.007(.003)[-.013, -.001]**[c]
Anxiety sensitivity	.003 (.001)*, [.06]	**-.001 (.001) [-.003, 0]**[c]
Conduct problems		
Intervention effect without mediators (c†)	-.19 (.06) **, [-.10]	

Intervention effect with mediators (c'†)	-.16 (.06)**, [-.09]	
Drinking quantity	.10 (.05)*, [.05]	.012 (.011) [-.037, .005]
Drinking problems	.03 (.01)***, [.07]	**-.02 (.01) [-.038, 0]**
Depression	.02 (.01)*, [.07]	**-.02 (.01) [-.047, -.001]**[c]
Hopelessness	.02 (.01)*, [.05]	.002 (.005) [-.008, .012]
Sensation seeking	.02 (.01)[t], [.03]	-.003 (.004) [-.012, .004]
Impulsivity	.02 (.01)[t], [.04]	-.011 (.008) [-.029, .002]

Notes :

[a]Intervention effects reported in O'Leary-Barrett et al (2013), without mediators in the model. All models include gender, ethnicity, and the corresponding baseline mental health symptom scores as covariates, and account for school cluster;

^Mediator variables: change in score from baseline to 6 months follow-up. Mediation or indirect pathways were examined only for mediator variables with significant or trend-level associations with the outcome variable (b pathways);

†Mediation pathway according to Baron & Kenny (1986);

B= Unstandardised coefficient, S.E. = standard error, β = Standardised beta; CI: Confidence Intervals;

***p <= .001, **p <= .01, *p < .05, [t]≤.10;

[b]MacKinnon's products of coefficients method referring to the impact of each mediator individually when controlling for gender, ethnicity and corresponding baseline symptoms;

Indirect estimates in bold font: Significant indirect pathway according to MacKinnon's products of coefficient method;

[c]: significant mediation pathways remain when taking others mediators into account.