Testing an online, theory-based intervention to reduce pre-drinking alcohol consumption and alcohol-related harm in undergraduates: A randomised controlled trial

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Full citation: Caudwell, K. M., Mullan, B. A., & Hagger, M. S. (2018). Testing an online, theory-based intervention to reduce pre-drinking alcohol consumption and alcohol-related harm in undergraduates: A randomised controlled trial. *International Journal of Behavioral Medicine*. doi: 10.1007/s12529-018-9736-x

Abstract

Purpose: The present study tested the efficacy of a theory-based online intervention comprising motivational (autonomy support) and volitional (implementation intention) components to reduce pre-drinking alcohol consumption and alcohol-related harm.

Methods: Undergraduate students (N=202) completed self-report measures of constructs from psychological theories, pre-drinking alcohol consumption, and alcohol-related harm at baseline, and were randomly assigned to one of four intervention conditions in a 2 (autonomy support: present/absent) x 2 (implementation intention: present/absent) design. Participants completed follow-up measures of all variables at four weeks post-intervention. All participants received national guidelines on alcohol consumption and an email summary of intervention content at its conclusion. Participants also received weekly SMS messages in the four-week post-intervention period restating content relevant to their intervention condition.

Results: No statistically significant main effect for either the autonomy support or implementation intention intervention components, nor an interaction effect, was found on the outcome measures. However, statistically significant reductions in pre-drinking alcohol consumption and alcohol-related harm were observed across all groups at follow-up, when compared to baseline.

Conclusions: Reductions in outcome measures were likely related to elements common to each condition (i.e., provision of national guidelines, assessment of outcome measures, email summary, and SMS messages), rather than motivational and volitional components.

Keywords: alcohol consumption; pre-drinking; alcohol-related harm; self-determination theory; autonomy support; action phase model; implementation intention

Introduction

Pre-drinking refers to the practice of consuming alcohol prior to attending an event, where alcohol consumption often continues [1-3]. Pre-drinkers consume more alcohol, and are more likely to experience alcohol-related harm, relative to those who do not pre-drink on a drinking occasion [4, 5]. Pre-drinking is common in university and college populations, where students tend to consume alcohol at hazardous levels, and consider excessive alcohol consumption as integral to the ‘university experience’ [6-10]. Students tend to engage in pre-drinking in an attempt to reduce their overall expenditure on alcohol by purchasing alcohol at lower prices from retailers (e.g., supermarkets, grocery stores) to consume in a private setting, as opposed to at a bar or nightclub, and to maximize intoxication prior to attending a subsequent event [7, 11]. Given the inherent risks associated with pre-drinking, there is a need to develop pre-drinking interventions that seek to reduce excessive alcohol consumption and the associated risk of alcohol-related harm [12].

Several alcohol interventions have been developed to reduce excessive alcohol consumption behaviors among university and college students [13, 14]. Many of these interventions draw from psychological theories of social cognition and motivation that include constructs known to influence alcohol consumption (e.g., normative feedback and planning approaches) [15-17]. Such interventions work by attempting to target these motivational and social cognitive constructs in an attempt to elicit concomitant behavior change [18]. Two theories that have been applied to alcohol consumption, and received considerable attention in the literature on health behavior change, are self-determination theory [19] and the theory of planned behavior [20]. The following sections explain the fundamental elements of these theoretical approaches in relation to behavior change, and the basis for the development of the intervention.

25 Self-Determination Theory and the Theory of Planned Behavior

26 Self-determination theory is an organismic theory of motivation, which makes the
27 distinction between different forms of motivation. Specifically, motivation is proposed to
28 exist on a continuum ranging from *controlled* to *autonomous*. *Controlled motivation* refers to
29 engaging in a behavior for mostly extrinsic or externally regulated reasons that are not
30 entirely self-determined. For example, an individual may wish to reduce their alcohol
31 consumption because others will be disappointed with them if they do not, or because the
32 individual will feel embarrassed if they fail to do so. Conversely, *autonomous motivation*
33 reflects engaging in behavior for intrinsic or personally-relevant reasons. For example, an
34 individual might reduce their alcohol consumption because it carries personally-endorsed
35 benefits (e.g., to health and wellbeing). Self-determination theory has been applied to predict
36 individuals' motivation in relation to pre-drinking [21], following research finding
37 autonomous motivation is a key component in relation to individuals' keeping alcohol
38 consumption within recommended guidelines [16]. The theory has also been adopted as a
39 basis for interventions aimed at changing health behavior with autonomy-supportive
40 interpersonal styles as a key means to promote autonomous motivation and subsequent health
41 behavior change [22, 23].

42 In contrast to self-determination theory, the theory of planned behavior is a social
43 cognitive theory that posits *intentions* as the most proximal antecedent of behavior [20].
44 Intentions are motivational in nature and reflect an individual's assessment of how much
45 effort they are prepared to invest in pursuing the behavior. Intentions are a function of three
46 sets of belief-based variables: *attitude* (i.e., the individual's positive or negative evaluation of
47 behavior engagement), *subjective norm* (i.e., perceived social influence surrounding
48 behavioral engagement), and *perceived behavioral control* (i.e., control over behavioral
49 engagement). These three sets of beliefs influence behavior indirectly via the mediation of

intention. Perceived behavioral control is also conceptualized as predicting behavior directly, in instances where an individual's perceptions of control over the behavior match reality. The theory has demonstrated efficacy in predicting intentions and behavior across multiple health behaviors, with meta-analyses demonstrating that attitudes and perceived behavioral control have the strongest effects on behavior through intentions [24]. There is also evidence to suggest that interventions targeting constructs in the theory, particularly attitudes and perceived behavioral control are effective in changing behavior [25].

Self-determination theory and the theory of planned behavior have been integrated to form a comprehensive account of how individuals' motivational orientations lead them to form consistent belief-based evaluations, and intentions to engage in behavior [26]. The integrated account suggests that self-determined motives serve as distal predictors of behavior through the belief-based constructs in the theory. The process involved is likely due to individuals strategically aligning their sets of beliefs with respect to future participation in the health behavior (e.g., attitudes, perceived behavioral control) with their motives. For example, an individual might be autonomously motivated to reduce their pre-drinking alcohol consumption because it is consistent with their internalized sense of self (e.g., reducing alcohol consumption services personally-relevant internalized long-term goals, such as studying for an exam), which leads them to align their attitudes to be consistent with their autonomous motives and hold positive attitudes toward making such reductions in the future, which influences their intentions and subsequent behavior with respect to alcohol. Research has supported the motivational sequence proposed in the integrated model [27], and also demonstrated its efficacy as a basis for intervention [23].

Self-determination theory and the theory of planned behavior are theories that aim to explain motivation across multiple behaviors, contexts, and populations, and they have been applied to many health behaviors [28-30] including alcohol consumption [31-33]. Parallels

can be drawn between these perspectives and specific motivational models that have been developed to explain alcohol consumption. Prominent among these models is Cox and Klinger's [34] motivational account of alcohol consumption. The model proposes that the consumption of alcohol leads individuals to form expectations of the affective and instrumental effects of alcohol consumption, which influence that individual's decisions to approach alcohol use in the future. These affective and instrumental effects are analogous to the belief-based evaluations that form the basis of an individual's intentions to engage in alcohol consumption (i.e., attitude, subjective norm), and decision on whether or not to drink (i.e., intention), from the theory of planned behavior. However, there are also clear distinctions and unique components to the approaches adopted in the current research. For example, the theory of planned behavior also identifies on facilitating factors or barriers with respect to future alcohol consumption, similar to self-efficacy. In addition, self-determination theory focuses on the quality, rather than absolute quantity, of motivation with respect to engaging in, or reducing, alcohol consumption (e.g., controlled or autonomous). In summary, the integration of these theories in the current research offer comprehensive account of alcohol consumption and a basis for intervention that are likely to be effective in changing behavior [35].

Volitional Approaches to Behavior Change

Although the theory of planned behavior, self-determination theory, and integrated approaches based on both have demonstrated efficacy in predicting and changing health behavior [16, 24, 35, 36] a substantial shortfall in the relation between intention and behavior has been noted [37, 38]. This suggests that individuals do not always act in accordance with their intentions, termed *inclined abstainers* [39] or *unsuccessful intenders* [38]. The intention-behavior 'gap' has been an important area of inquiry, and may depend in part on factors such as the individual's level of self-control, or ability to plan [40, 41], leading researchers to

conclude that intention is a necessary, yet not sufficient, requirement for behavior change [42]. Gollwitzer and Brandstätter [43] proposed *implementation intentions* as a means to overcome limitations in self-regulation that impede enacting intentions. According to Gollwitzer [44], simply forming an intention (e.g., “I intend to consume less alcohol when pre-drinking”) is not sufficient to enact the stated behavior. An implementation intention prompts individuals to augment their intentions to include ‘if-then’ plans, that require individuals to identify a cue in the environment and explicitly link it with the intended action (e.g., “If I finish a drink, I will then have a non-alcoholic drink to consume less alcohol when pre-drinking”). Implementation intentions have been successful in facilitating health behavior change in a range of contexts [42], and given environmental influences that relate to alcohol consumption (e.g., being offered an alcoholic beverage at a party), may have particular relevance for reducing pre-drinking excessive alcohol consumption [45]. If individuals can identify relevant cues in the pre-drinking environment, these can be used to call the individual to the intended action, resulting in reduced alcohol consumption and risk of experiencing alcohol-related harm.

Implementation intentions are proposed to work by intervening in the post-intentional phase of decision making. Specifically, Heckhausen [46] proposed a model of *action phases* that distinguishes between motivational and volitional phases in the processes that lead to behavior enactment. The motivational phase includes constructs leading up to and including *intention* (e.g., autonomous motivation, belief-based evaluations such as attitudes), preceding a volitional stage where that intention may or may not lead to concomitant behavior. Therefore, the generating of implementation intentions may facilitate the attainment of intended behaviors in the volitional stage by specifying important cue-based responses that are consistent with the target behavior (e.g., reductions in pre-drinking alcohol consumption). Research from a self-determination theory perspective has demonstrated that implementation

intentions appear more effective when an individual's reasons for forming them are more autonomously motivated [47, 48]. Individuals who show high self-regulation – the ability to exert control over behavior – tend to exhibit autonomous motivation, likely because the enactment of the intended behavior brings about a personally meaningful or relevant outcome, as opposed to behaviors that are enacted due to external contingencies [49]. Drawing from these theoretical perspectives, targeting the motivational and volitional phases of behavior through the facilitation of autonomous motivation and the formation of consistent implementation intentions may lead individuals to reduce their pre-drinking alcohol consumption than either approach in isolation.

The Present Study

Given the importance of motivational and volitional factors in behavior change consistent with dual-phase models, interventions that include components that target motivation and planning are likely to maximize behavioral engagement, and may be appropriate for individuals with low intentions, or who lack the self-regulatory capacity to enact these intentions. In the present study, we aimed to test an intervention that targets both motivational and volitional phases, consistent with previous integrative approaches applied to alcohol consumption and goal pursuit [47, 50]. The intervention was developed based on previous developmental work from component theories, and recent research conducted with the target population of pre-drinking university students [7, 21, 51]. To target the motivational phase, we provided participants with an autonomy-supportive exercise in which they were instructed to reflect on reducing pre-drinking alcohol consumption in terms of key concepts related to autonomy, that would facilitate autonomous motivation [52]. To target the volitional stage, we informed participants that goals were more likely attained when individuals form 'if-then' plans to enact these goals, and instructed participants to form implementation intentions following recent best practice recommendations in the literature

[42]. The intervention therefore consisted of four groups: an autonomy support-only group that received only the autonomy support component of the intervention; an implementation intention-only group that received only the implementation intention component of the intervention; a combined group that received both autonomy support and implementation intention components, and; a control group that received neither intervention component. The intervention was delivered online, as this was considered a preferable medium for university students engaging in health behavioral interventions, that could be implemented with high reach at low cost, and was likely to benefit at-risk populations who may not seek health services in relation to their alcohol consumption [53-55].

We hypothesized main effects for the intervention in reducing pre-drinking alcohol consumption and alcohol-related harm in the autonomy support-only and implementation intention-only groups compared to the control group. In addition, based on previous research which found that individuals were more likely to adhere to implementation intentions when they are autonomously motivated to perform the target behavior [47], we hypothesized that the group receiving both the autonomy support and implementation intention intervention components would experience greater reductions in pre-drinking alcohol consumption than the groups receiving either of the components alone, and the control group.

Methods

Design and Procedure

The study used a 2 (autonomy support: present vs. absent) x 2 (implementation intention: present vs. absent) randomized controlled design, with students completing a questionnaire and receiving the intervention at baseline, and a follow-up questionnaire, four weeks later. Students were directed to the online study as displayed through Qualtrics™, which comprised an information sheet detailing the study and an instruction to click 'next' if

they consented to participate, or otherwise close their browser window. Participants completed baseline measures of alcohol consumption and alcohol-related harm, as well as theory-based measures. Next, participants were randomly assigned to an experimental condition through use of a Qualtrics™ randomisation tool that assigned a condition number at random to each participant. The program then proceeded to display elements relevant to that condition based on the number (1 = control; 2 = autonomy support-only; 3 = implementation intention-only; 4 = combined). The study was approved by the university [omitted for blind review] Ethics Committee (Approval Number [omitted for blind review] and pre-registered with the [omitted for blind review] registry.

Participants in all conditions were initially shown the Australian National Health and Medical Research Council (NHMRC) guidelines on alcohol consumption to reduce the per-occasion and lifetime risk of harm [56]. Participants assigned to the intervention conditions were then presented with the autonomy support intervention content (i.e., the autonomy support-only) or the implementation intention intervention content (i.e., the implementation intention-only), or both the autonomy support and implementation intention components (i.e., the combined condition). The content of the autonomy support condition consisted of an exercise in which the participant was instructed to respond to five autonomy-supportive text prompts, presented one at a time, on successive pages (e.g., “Identifying some of the negative consequences of pre-drinking can be a good first step in forming your plan to reduce your pre-drinking alcohol consumption. Reducing your pre-drinking alcohol consumption will help you to avoid some of these negative consequences you may experience when pre-drinking excessively”). These prompts were developed following guidelines regarding autonomy-supportive communication [52]. The content of the implementation intention condition provided participants with a general definition of an implementation intention, and an example specific to reducing pre-drinking alcohol consumption (e.g., “If I finish an

alcoholic beverage during a pre-drinking session, I will then drink a glass of water to help reduce my pre-drinking alcohol consumption”). Participants were then asked either to select implementation intentions from the examples provided, or form their own implementation intentions following the *if-then* format, or both. Participants in the combined condition completed the autonomy support component, followed by the implementation intention component, according to their order in terms of action phases [46].

An automated e-mail was sent to all participants on completion of the intervention thanking them for their participation, restating the NHMRC guidelines, providing them with a summary of their responses and, if applicable, their statements from the autonomy support exercise, and/or their implementation intentions, and providing them with a reminder to monitor their email inbox for the invitation to complete the follow-up questionnaire in four weeks’ time. Prior to follow-up, participants were sent an automated SMS message relevant to their condition each week over four weeks (i.e., participants assigned to the control group received restated NHMRC guidelines, participants assigned to the autonomy-support, implementation-only, and combined conditions, received SMS messages related to the respective content received), consistent with previous research [57]. At follow-up, participants completed the same measures of pre-drinking alcohol consumption and alcohol-related harm, the theory-based measures, and a measure of goal progress.

Recruitment Procedures

The recruitment strategy involved printed posters and messages advertising the study, which directed eligible students to a URL to the intervention questionnaire hosted on the Qualtrics platform. Posters were placed around university campuses, in Facebook advertisements targeting university students with an interest in alcohol, and through an online system to a university-based participant pool. Participants were eligible if they were over 18

years of age, and had engaged in pre-drinking (defined as “the practice of consuming alcohol prior to attending a subsequent social event, where alcohol consumption often continues”) in the previous 12 months. Participants were informed that they would be taking part in an intervention to reduce pre-drinking alcohol consumption, however they were blinded as to the purpose of the intervention components and the content of other conditions.

Figure 1 shows the progression of participants through the intervention from baseline to follow-up. Thirteen participants did not complete the intervention at baseline, leaving a sample of a 202 participants ($M_{\text{age}} = 20.95$ years; $SD_{\text{age}} = 4.02$ years; 147 [72.77%] female). A total of 117 (57.92%) participants completed the four-week follow-up questionnaire ($M_{\text{age}} = 20.86$ years; $SD_{\text{age}} = 3.89$ years; 87 [74.36%] female). Table 1 includes age and gender information for each condition, at baseline and follow-up. The majority of participants at baseline (86.63%) and follow-up (91.45%) reported that they were pursuing degrees in health-related faculties¹. Participants in the final sample completed the intervention between August 2015 and June 2016, coinciding with the beginning of second semester, and first semester, respectively. Recruitment and enrolment for the intervention occurred over two semesters; however, there was no effect of month of enrolment in the intervention on pre-drinking alcohol consumption or alcohol-related harm at baseline, nor follow-up, evidenced by one-way ANOVA ($ps > .232$) and non-parametric Kruskal-Wallis tests ($ps > .150$).

Measures

Hazardous alcohol consumption. We used the Alcohol Use Disorders Identification Test (AUDIT-C) [58] as an indication of hazardous alcohol consumption. The AUDIT-C

¹At baseline, students were coded as belonging to arts (n = 6; 2.97%), business (n = 8; 3.96%), education (n = 4; 1.98%), science (n = 7; 3.47%), health (n = 175; 86.63%), and humanities n = 2; (0.99%) faculties. At follow-up, students were coded as belonging to arts (n = 3; 2.56%), business (n = 3; 2.56%), education (n = 1; 0.85%), science (n = 1; 0.85%), health (n = 107; 91.45%), and humanities (n = 3; 1.71%) faculties. Participants' scores on outcome measures did not differ as a function of their university, nor between pool and non-pool members; analyses are included in Electronic Supplementary Material 1.

comprises four statements regarding hazardous alcohol consumption behavior and outcomes (e.g., “How often did you have a drink containing alcohol in the past year?”), with responses scored from 0 (e.g., “never”) to 4 (e.g., “6 or more times a week”), and is summed to derive a total score ranging from 0 to 12, with higher scores indicative of hazardous alcohol consumption.

Outcome measures. Participants reported their pre-drinking alcohol consumption for each of the previous four weeks in standard drink equivalents, with the aid of a pictorial guide detailing common beverage containers and their respective standard drink totals [56]. Weekly pre-drinking alcohol consumption was summed to create a monthly score, consistent with previous research [16].

Alcohol-related harm was measured using the Brief Young Adult Alcohol Consequences Scale (B-YAACQ) [59], comprising 24 statements related to the experience of alcohol-related harm (e.g., “I have done something I have later regretted because of drinking”), with participants responding “yes” or “no” via radio button whether each statement is true of them. Although the B-YAACQ was developed for use over a 12-month period, we amended the time-frame to refer to the four-week period at baseline and follow-up, to ascertain an effect of the intervention, consistent with previous research [60].

Theory of planned behavior measures. We measured participants’ attitude, subjective norm, perceived behavioral control, and intentions, regarding reducing pre-drinking alcohol consumption between baseline and follow-up, based on previous research [21]. For attitude, we used a six-point bipolar adjective scale with a common stem (“reducing my pre-drinking alcohol consumption over the next four weeks would be... bad/good”; Cronbach’s $\alpha = .87$ [baseline]; $.89$ [follow-up]). Subjective norm was assessed using three statements (e.g., “people who are important to me would want me to reduce my alcohol

consumption during pre-drinking sessions”) with participants responding on a scale from 1 (“strongly disagree”) to 6 (“strongly agree”). Unfortunately, participant scores for subjective norm were unavailable, due to a programming error in the online questionnaire. Perceived behavioral control was also assessed using three statements (e.g., “If I wanted to, I could reduce my pre-drinking alcohol consumption”) and a similar response scale from 1 (“strongly disagree”) to 6 (“strongly agree”; Cronbach’s $\alpha = .77$ [baseline]; $.84$ [follow-up]). Intention was measured using three items (e.g., “I intend to reduce my pre-drinking alcohol consumption over the next four weeks”) and a similar response scale from 1 (“strongly disagree”) to 6 (“strongly agree”). Item scores were averaged (Cronbach’s $\alpha = .98$ [baseline]; $.98$ [follow-up]).

Self-determined goals. A measure of goal self-concordance [47] was used to reflect the extent to which participants pursued the goal of reducing their pre-drinking alcohol consumption for autonomous or controlled reasons. Participants provided responses to four statements reflecting controlled (e.g., “because somebody wants me to, or because I’ll get something from somebody if I do”) and autonomous (e.g., “because you really believe that it’s an important goal to have. You endorse it freely and value it wholeheartedly”) reasons, on a Likert-type response scale from 1 (“not at all for this reason”) to 9 (“completely because of this reason”). Consistent with Ryan and Connell’s [61] work on the relative autonomy index, which has been supported in a recent meta-analysis [62], we adopted the approach of Koestner et al., [47] to compute our measure of self-concordance by subtracting scores on controlled items from those on autonomous items (Cronbach’s $\alpha = .51$ [baseline]; $.45$ [follow-up]).

Planning ability. We included a measure of planning from the self-regulation questionnaire [63] to assess the planning ability of participants at baseline and follow-up. This measure consisted of nine items reflecting planning (e.g. “I have trouble making plans to

help me reach my goals”), with response scales ranging from 1 (“strongly disagree”) to 5 (“strongly agree”). Item scores were averaged (Cronbach’s $\alpha = .81$ [baseline]; $.85$ [follow-up]).

Results

Preliminary analyses

Intervention condition variables. We developed two dichotomous variables to represent the intervention conditions for subsequent analyses. The variables denoted whether or not the participant received the autonomy support component (coded 0 or 1), or the implementation intention component (coded 0 or 1).

Alcohol-related variables. At baseline, the average AUDIT-C score for the sample was 4.52 ($SD = 2.16$), and the average pre-drinking alcohol consumption for the four weeks prior to was 16.07 standard drinks ($SD = 17.14$, $mdn = 11.00$). Participant B-YAACQ average scores at baseline were 6.31 ($SD = 3.85$). These scores were largely consistent with previous research [64-66]. Participants reported engaging in an average of 2.97 pre-drinking sessions per month ($SD = 1.94$, $mdn = 3$), spending \$27.92 ($SD = \16.72, $mdn = \$25.00$) on pre-drinking alcohol, and AUD \$42.54 ($SD = \31.18, $mdn = \$40.00$) on alcohol consumed following a pre-drinking (i.e., at the subsequent event).

Randomization checks. To ascertain whether random allocation to conditions was successful, a MANOVA was conducted with intervention components (i.e., autonomy support: 0 or 1; implementation intention: 0 or 1) as the independent variables, and age, AUDIT-C score, attitude, perceived behavioral control, planning, intention, goal self-concordance, baseline pre-drinking alcohol consumption and alcohol-related harm as the dependent variables. The MANOVA showed no statistically significant main effect for the autonomy support ($F(9,170) = 1.51$, $p = .150$; Wilk’s $\Lambda = .93$; partial $\eta_p^2 = .07$) or

implementation intention ($F(9,170) = .32, p = .968$; Wilk's $\Lambda = .98$; partial $\eta_p^2 = .02$) components, nor a statistically significant interaction effect ($F(9,170) = 1.52, p = .144$; Wilk's $\Lambda = .93$; partial $\eta_p^2 = .07$). A χ^2 test of contingencies showed no statistically significant difference in gender proportion between conditions: $\chi^2(3) = 2.04, p = .565$, Cramer's $V = .10$.

Attrition checks. To check for any bias related to attrition, a multivariate analysis of variance (MANOVA) was conducted with completion status (baseline-only, $n = 61$; baseline and follow-up, $n = 109$) as the independent variable, and age, AUDIT-C score, attitude, perceived behavioral control, planning, intention, goal self-concordance, baseline pre-drinking alcohol consumption and alcohol-related harm, as the dependent variables. The MANOVA was not statistically significant ($F(9,160) = .64, p = .762$, Wilk's $\Lambda = .97$; partial $\eta_p^2 = .04$) indicating that participants who completed baseline-only did not significantly differ to those who went on to complete the follow-up in terms of their responses. Chi-square tests showed participant attrition was not related to gender ($p = .820$, Cramer's $V = .02$), nor condition ($p = .565$, Cramer's $V = .10$).

Manipulation checks. We compared mean scores on goal self-congruence between participants who received the autonomy support component of the intervention (i.e., those in the autonomy support and combined conditions) and those who did not (i.e., those in the control and implementation intention conditions), using a one-way analysis of covariance (ANCOVA) with a variable indicating whether participants received the autonomy support component of the intervention (coded 0 or 1), controlling for baseline self-congruence scores. The test was not statistically significant: $F(1,115) = 1.97, p = .163, \eta_p^2 = .02$, indicating goal self-concordance did not differ significantly between those who received an autonomy support manipulation ($M = 3.87$; $SE = .60$) and those who did not ($M = 2.66$; $SE = .63$). Participant responses to autonomy support prompts were coded for consistency, with 33

(61.10%) participants providing responses consistent with all four prompts, and the majority (n = 48 [88.90%]) providing responses consistent with at least three prompts.

Fifty-six participants selected and/or formed one or more implementation intentions, with the majority selecting or forming one (n = 24 [42.86 %]), followed by two (n = 20 [35.71 %]), three (n = 8 [14.29 %]), four (n = 3 [5.36 %]) and five (n = 1 [1.79 %]). Kruskal-Wallis tests indicated no statistically significant differences between the total number of implementation intentions selected or formed, for pre-drinking alcohol consumption ($\chi^2(5) = 2.47, p = .649$) and alcohol-related harm ($\chi^2(5) = 1.68, p = .794$). A total of 38 participants selected one or more experimenter-provided implementation intentions only, with 18 generating at least one implementation intention either in conjunction with an experimenter-provided (12), or outright (8). The self-generated implementation intentions were assessed for compliance with instructions, scored using a dichotomous scale as to whether the content complied (1) or not (0). Six of the self-generated implementation intentions were deemed non-compliant, and twelve were deemed compliant. Mann-Whitney U-tests indicated no difference between compliers and non-compliers in terms of pre-drinking alcohol consumption (compliers *mdn* = 7.00, non-compliers *mdn* = 3.50; *U* = 31.50, *z* = -1.38, *p* = .169) nor alcohol-related harm (compliers *mdn* = 3.00, non-compliers *mdn* = 1.00; *U* = 25.00, *z* = -1.85, *p* = .065).

Main analyses

We conducted mixed-model analyses of variance (ANOVA) with the dummy-coded variables for the autonomy support (absent = 0, present = 1) and implementation intention (absent = 0, present = 1) intervention components as between-participants factors, and time (i.e., baseline, follow-up) as the within-participants factor. Separate analyses were conducted with pre-drinking alcohol consumption (total standard drinks consumed during pre-drinking

sessions), and alcohol-related harm (B-YAACQ scores) as the dependent variables. This way, main effects of the control, autonomy support only, implementation intention only, and combined intervention conditions on the outcomes, along with the main effect of time and interaction effects, could be compared. Both complete-case and intention-to-treat with the last observation carried forward analyses were conducted.² Assumptions of sphericity and equality of error variances were met ($ps > .05$) prior to conducting the main analyses.

Effects of the intervention on pre-drinking alcohol consumption. ANOVAs

revealed no statistically significant three-way interaction effect of time, autonomy support, and implementation intention ($F(1,197) = 2.02, p = .157, \eta_p^2 = .01$). There were also no statistically significant two-way interaction effects of time and autonomy support ($F(1,197) = .08, p = .772, \eta_p^2 < .01$), and time and implementation intention ($F(1,197) = .48, p = .489, \eta_p^2 < .01$), on pre-drinking alcohol consumption. A statistically significant main effect of time on pre-drinking alcohol consumption was found, with a large effect size ($F(1,197) = 26.65, p < .001, \eta_p^2 = .12$). Participant pre-drinking alcohol consumption at baseline ($M = 17.76, SE = 1.35$) was significantly different from that at follow-up ($M = 13.95, SE = 1.20$); a difference of 3.81 standard drinks. Finally, there were no statistically significant two-way interactions for the autonomy support and implementation intention conditions on pre-drinking consumption.

Effects of the intervention on alcohol-related harm. We found no statistically

significant three-way interaction effect of time, autonomy support, and implementation intention ($F(1,198) = 1.66, p = .199, \eta_p^2 = .01$), and no statistically significant two-way interaction effects of time and autonomy support ($F(1,198) = .05, p = .823, \eta_p^2 < .01$) and time and implementation intention ($F(1,198) = .36, p = .551, \eta_p^2 < .01$), on alcohol-related

²Results from complete case analyses are included in Electronic Supplementary Material 2.

harm. We also found the statistically significant main effect of time with a large effect size: ($F(1,198) = 80.22, p < .001, \eta_p^2 = .29$). Participant B-YAACQ scores at baseline ($M = 6.62, SE = .29$) were significantly reduced at follow-up ($M = 4.66, SE = .30$), a difference of 1.96. There were no statistically significant two-way interactions for the autonomy support and implementation intention conditions on pre-drinking consumption³.

Effects of the intervention on psychological variables. To check for an effect of the intervention on psychological variables, a MANCOVA was conducted with the intervention components (autonomy support and implementation intention) as independent variables, and attitude, perceived behavioral control, planning, intention, and goal self-concordance as the dependent variables with the baseline measurements for each variable included as covariates. Results revealed no main multivariate effect of the autonomy support ($F(5,105) = 1.40, p = .231$, Wilk's $\Lambda = .93, \eta_p^2 = .07$) or implementation intention ($F(5,105) = 1.76, p = .129$, Wilk's $\Lambda = .91, \eta_p^2 = .09$) conditions, nor any interaction effect ($F(5,105) = 1.66, p = .152$, Wilk's $\Lambda = .92, \eta_p^2 = .08$), on the dependent variables. Baseline-adjusted averaged-item means for each psychological variable by intervention condition are included in Table 2.

Discussion

The aim of the present study was to test the efficacy of an online intervention based on psychological theory in reducing pre-drinking alcohol consumption in undergraduate students. The intervention targeted the motivational and volitional phases proposed in the model of action phases [46] using the techniques of autonomy support and prompting the formation of implementation intentions. While the main study hypotheses were not supported (i.e., there was no statistically significant interaction effect nor main effect of the intervention

³We also conducted our main analyses using hierarchical linear multiple regression. The analyses revealed an identical pattern of relations.

components), we found a strong, statistically significant effect of time independent of intervention components. That is, participants reduced their pre-drinking alcohol consumption by 3.81 standard drinks, and experienced 1.96 fewer instances of alcohol-related harm, in the month following the intervention.

Although the main study hypotheses were not supported, the reductions in participant pre-drinking alcohol consumption and experience of alcohol-related harm independent of condition represent a finding warranting further discussion, given that university students experience a range of negative academic and personal outcomes associated with theirs and others' alcohol consumption [7, 67], and recent meta-analytic evidence suggesting that computer-delivered college and university alcohol interventions show modest effects [68]. The lack of effects of the autonomy support and implementation intention components raise questions over the importance of these theory-based motivational and volitional strategies in changing pre-drinking behavior. The observed reductions in pre-drinking alcohol consumption and alcohol-related harm over time implicates elements that were common to all conditions contributed to behavior change (i.e., assessment of pre-drinking alcohol consumption and alcohol-related harm, provision of alcohol consumption guidelines to reduce the risk of alcohol-related harm, and sending of email summary and SMS reminders), and that the inclusion of additional theory-based components had no significant effect.

Research indicates that Australians are generally unaware of alcohol consumption guidelines, especially young adult Australians and heavy drinkers [69], similar to research from the USA [70]. There is some indication that the administration of outcome measures at baseline leads to *assessment reactivity* among control group participants, and that 'attenuated' versions of university and college alcohol consumption interventions can confer treatment effects [71, 72]. Given that participants were required to quantify their alcohol consumption in standard drink equivalents prior to assignment to intervention conditions, it is likely that

this assessment contributed to behavior change [71]. Similarly, participants' completion of theory-based measures that were phrased in terms of behavior change may have led to a *question-behavior effect* [73]. Reflecting on personal alcohol consumption in relation to national guidelines (i.e., during the intervention, and upon receiving the summary email and weekly SMS messages) may have also contributed to reductions in participants' alcohol consumption. This is likely as SMS messages are thought to improve the efficacy of health behavior interventions through enhancing participant engagement [57, 74]. Although these SMS messages were structured in order to complement the intervention content (e.g., participants receiving the autonomy support component received congruently-framed messages), the lack of condition effect suggests these messages served a prompting function as opposed to a complementary one. In summary, the assessment of pre-drinking alcohol consumption and alcohol-related harm, provision of information on alcohol consumption limits that would reduce the risk of alcohol-related harm, and the receiving of an email summary and four once-weekly SMS reminders following the intervention, were sufficient in eliciting reductions in these outcome variables at follow-up.

A potential issue that may partly account for the lack of effects of the motivational or volitional intervention components may be participant compliance. Participants appeared to comply more with the autonomy support component than the implementation intention component, potentially due to the autonomy support component requiring more engagement and introspection, as opposed to the planning task. However, groups receiving the autonomy support component did not score significantly higher on goal self-concordance, suggesting that the manipulation may not have been sufficient in facilitating autonomous motivation to reduce pre-drinking alcohol consumption. Previous research on online motivational interviewing has suggested that increased engagement in the intervention influences their perceptions of an online motivational interviewing intervention [75]. Specifically,

participants prompted to reflect on their open-ended answers reported higher perceived relevance of the intervention, higher perceived ability to express and elaborate on their answers, and higher overall appreciation, than participants who did not have the opportunity to reflect [75]. Self-determination theory-based interventions have also been more intensive, delivered ‘face-to-face’, often involving repeated interactions with practitioners [76]. Means to optimise participant engagement in online self-determination interventions may be an important consideration in future research.

Similarly, compliance with the implementation intention intervention was generally limited, with many participants failing to generate statements that complied with instructions and examples provided, or providing responses that were not congruent with the goal of reducing pre-drinking alcohol consumption. Given that the implementation intention component was developed following many of the recommendations of planning intervention components as outlined by Hagger et al. [42], this may raise questions over the use of online implementation intention interventions to reduce pre-drinking behavior. It is likely that prompting participants to consider specific contingencies in implementation intentions (i.e., to address barriers or obstacles to successful goal attainment), or increasing the emphasis on the formation of simple and specific plans, may be useful, as some participants’ plans alluded to naïve or overly-optimistic strategies that may not have been successful over the intervention period (e.g., “If I feel tipsy, then I will stop drinking”). This may be especially relevant in the university student population, where alcohol consumption is synonymous with identity and socialisation, and attempts to moderate or refuse to drink excessively may be especially challenging [77, 78]. Armitage [79] found that experimenter-provided implementation intentions were more effective in reducing alcohol consumption than those that were self-generated. Other possible factors regarding the lack of effect of implementation intentions on behavior change could be that participants who opted for one or both of the

experimenter-provided implementation intentions may have simply selected these options as they were easier than generating their own, or to expedite progression through the intervention. It is likely that the cues outlined in the experimenter-provided implementation intentions did not arise following the intervention (e.g., the participant was not offered a drink). Future research may measure participant commitment to, and perceived success of, their implementation intentions, and assess plan recall, to ascertain whether these factors influence behavior change and goal attainment.

It is important to raise the issue of the lack of power of the intervention to detect statistically significant effects. We have included a post hoc analysis indicating statistical power required to detect the effects of time, autonomy support, and implementation intentions, and their interactions, in Electronic Supplementary Material 3. A meta-analysis of health behavior interventions using autonomy support strategies report small-to-medium sized effects on behavioral outcomes ($\rho = .33$ or $\eta_p^2 = .11$; [36]). However, the effect for the current intervention is more than ten times smaller than this effect ($\eta_p^2 < .01$); accordingly, we had very low power to detect such a small effect. Put differently, to have adequate statistical power ($\beta = .80$) to find a small effect of the autonomy support intervention on behavior would have required a substantially larger sample size ($n = 592$). Similarly, the effect size of the implementation intention intervention component in the present study are small ($\eta_p^2 < .01$) in comparison to the small-to-medium sized meta-analytic effect of that observed in meta-analyses of implementation intentions ($d = .48$ or $\eta_p^2 = .06$), based on averaged effect sizes [80, 81].

So what can be deduced from these data regarding interventions to reduce pre-drinking? Certainly, our study was insufficiently powered to detect main effects of the autonomy support or implementation intention effects on pre-drinking alcohol consumption and alcohol-related harm, but considering the size of the effect and the sample size required

to detect it, conducting a sufficiently-powered study would require substantial resources. Furthermore, the impact of the interaction of the two components on pre-drinking, also seems to be trivial in size. Nevertheless, it is important to acknowledge that such small effects may have clinical significance if implemented at the population level. This notwithstanding, the substantive effect of time, for which we had sufficient statistical power, suggest that one or more of the components common to both conditions (e.g., measurement, provision of NHMRC guidelines, email summary, SMS reminders) were effective in reducing pre-drinking alcohol consumption and alcohol-related harm, providing an avenue for further investigation. A more viable endeavour may be to isolate these components, and design an intervention trial that evaluates their effectiveness.

Strengths, limitations, and future directions

The present study has several strengths and limitations that should be considered in light of the findings. The design of the study allowed for an online intervention to be delivered to a large proportion of university students in a preferred medium, as well as a means of testing an online autonomy supportive intervention [53, 75]. The use of a randomized controlled design, testing the motivational and volitional approaches in isolation and combination, has contributed to research in this area [47]. However, several major limitations that may influence the interpretation and application of the present findings must be discussed.

An important consideration in interpreting the findings of the present study relates to the measures used. The accuracy of participants in retrospectively recalling their alcohol consumption accurately is limited, however there is some evidence to suggest participant recall may at least be underestimated [70, 82]. Further, the alteration of the B-YAACQ to refer to a four-week period may have influenced the sensitivity of the measure in terms of

accounting for short-term change (e.g., it may be more likely that students would encounter certain instances of alcohol-related harm over a longer period of time). Similarly related to measures, a necessary part of the evaluation of this intervention was to ascertain whether or not it had any effect on participants' scores on the measures of motivational and volitional constructs. Although we were unable to test this on all theory measures due to the problem with the subjective norm measure, the lack of significant differences between groups on the psychological and outcome measures suggest the intervention did not influence participants' beliefs nor motivation, and this may in part explain the lack of concomitant behaviour change.

Although the use of email summary and SMS reminders were implemented to enhance the efficacy of the intervention components, we are unable to ascertain if these methods complemented the intervention techniques as intended. It may be that SMS reminders that are more aligned with participant responses (e.g., that reiterate or summarize their content), and measurement of their influence from the perspectives of participants, would elucidate this issue. Isolating the impact of these messages in future studies adopting a factorial design including message and no message conditions would elucidate the independent and interactive effects of messaging on behavioral outcomes. Future research may also consider allowing participants to compose their own SMS reminders, or opt for goal (e.g., reducing pre-drinking alcohol consumption) or plan (e.g., implementation intention) reminders [83, 84]. The relatively short intervention length, or the low 'dosage', may have limited the efficacy of the intervention in eliciting behavior change through the autonomy support and/or implementation intention components. Increased researcher or health practitioner involvement (e.g., assessing the suitability of participant responses to intervention prompts) and 'booster doses' could be used to maintain autonomous motivation, or allow for alternative implementation intentions to be adopted.

Compliance issues also limit the extent to which the lack of implementation intention effect can be attributed to the technique itself, or failure to form suitable implementation intentions that led to the reduction in outcome measures. The length of follow-up also precludes any speculation of the effectiveness of the component over longer periods of time, as opportunities to enact plans become evident, or the decision to reduce pre-drinking alcohol consumption becomes more internalized and autonomously-motivated [85]. Given the absence of a significant effect at the follow-up period, a lagged time effect may be minimal.

Conclusion

The present study used motivational and volitional techniques (i.e., autonomy support and implementation intentions) from psychological theories of health behavior to reduce pre-drinking alcohol consumption and alcohol-related harm in a group of undergraduates. These techniques did not lead to more substantial reductions in these outcome measures in isolation, or in combination, than that experienced by participants in a control group. Given all participants were assessed on outcome variables at baseline, provided with information on alcohol consumption limits to reduce the per-occasion and lifetime risk of alcohol-related harm, and email summary and SMS reminders, this may have been sufficient to account for behavior change. Future research should attempt to ascertain whether this effect can be replicated in multiple samples in similar contexts.

Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent was obtained from all individual participants included in the study.

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Figure 1. Participant flow diagram

Table 1. *Participant Age and Gender Information by Condition.*

Measurement	Condition	<i>N</i>	Male		Female	
			<i>n</i> (%)	<i>M</i> _{Age} (<i>SD</i>)	<i>n</i> (%)	<i>M</i> _{Age} (<i>SD</i>)
Baseline (<i>N</i> = 202)	Control	54	13 (24.07%)	20.69 (2.10)	41 (75.93%)	20.29 (4.58)
	Autonomy Support	49	14 (22.45%)	21.86 (2.85)	35 (71.43%)	21.97 (5.22)
	Implementation Intention	49	11 (22.45%)	23.73 (6.03)	38 (77.55%)	20.34 (3.78)
	Combined	50	17 (34.00%)	20.71 (1.83)	33 (66.00%)	20.27 (2.49)
Follow-up (<i>N</i> = 117)	Control	30	10 (33.33%)	20.40 (2.01)	20 (66.67%)	20.50 (4.82)
	Autonomy Support	32	9 (28.13%)	21.44 (2.35)	23 (71.88%)	22.00 (4.86)
	Implementation Intention	31	7 (22.58%)	20.86 (1.95)	24 (77.42%)	20.75 (4.64)
	Combined	24	4 (16.67%)	20.00 (1.15)	20 (83.33%)	20.20 (2.71)

Table 2. *Baseline-adjusted Means for Averaged Item Psychological Variables*

Measure	Intervention Condition							
	Control		Autonomy Support		Implementation Intention		Combined	
	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>
GSC	3.79	.88	2.66	.92	3.94	.91	1.66	1.03
Attitude	4.03	.16	4.76	.16	4.37	.18	4.14	.18
PBC	5.26	.10	5.29	.10	5.07	.10	4.99	.11
Intention	3.73	.19	4.16	.20	4.17	.20	3.97	.22
Planning	3.27	.09	3.26	.10	3.18	.10	3.26	.11

Note. Statistics reported are means and standard errors, controlling for baseline measures. GSC = goal self-concordance; PBC = perceived behavioral control.

Participant Source Analyses

Of the 215 participants, of which, 13 did not complete the intervention, 185 participants (86.04%) were from the authors' university, of which 175 (81.39%) were from a recruitment pool, and 10 (4.65%) were not. A total of 29 participants (13.49%) were from one of four other universities; 8 (3.72%), 3 (1.40%), 12 (5.58%), and 6 (2.79%), respectively.

Kruskal-Wallis tests indicated that the differences in mean ranks across the six sources (i.e., pool, non-pool, and each other university) were not statistically significant, for baseline pre-drinking alcohol consumption: $\chi^2(5) = 5.14$, $p = .399$; and baseline B-YAACQ scores: $\chi^2(5) = 2.72$, $p = .742$. Collapsing pool and non-pool participants from the authors' university, the analyses returned similar results in terms of the five universities, in terms of pre-drinking alcohol consumption: $\chi^2(4) = 4.74$, $p = .315$; and B-YAACQ scores: $\chi^2(4) = 2.67$, $p = .614$.

Complete-Case Analyses

Effects of the intervention on pre-drinking alcohol consumption. No statistically significant three-way interaction effect of time, autonomy support, and implementation intention was observed ($F(1,113) = 2.19, p = .142, \eta_p^2 = .02$). There were no statistically significant two-way interaction effects of time and autonomy support ($F(1,113) = .02, p = .895, \eta_p^2 < .01$) and time and implementation intention ($F(1,113) = .01, p = .944, \eta_p^2 < .01$) on pre-drinking alcohol consumption. A statistically significant effect of time on pre-drinking alcohol consumption was found, with a large effect size ($F(1,113) = 23.57, p < .001, \eta_p^2 = .17$). Participant pre-drinking alcohol consumption at baseline ($M = 15.90, SE = 1.61$) was significantly different from that at follow-up ($M = 10.29, SE = 1.13$); a difference of 5.61 standard drinks.

Effects of the intervention on alcohol-related harm. We found no statistically significant three-way interaction effect of time, autonomy support, and implementation intention ($F(1,113) = .46, p = .498, \eta_p^2 = < .01$), and no statistically significant two-way interaction effects of time and autonomy support ($F(1,113) = .21, p = .644, \eta_p^2 < .01$) and time and implementation intention ($F(1,113) = .19, p = .663, \eta_p^2 < .01$), on alcohol-related harm. We also found the statistically significant main effect of time with a large effect size: ($F(1,113) = 86.04, p < .001, \eta_p^2 = .43$). Participant B-YAACQ scores at baseline ($M = 6.34, SE = .36$) were significantly reduced at follow-up ($M = 3.36, SE = .32$), a difference of 2.98.

Table 1.

Post-hoc Power Analyses for Achieved Power to Test Intervention Effects

Effects	Complete Case		LOCF	
	η_p^2	β	η_p^2	β
PDAC ^{a,b}				
AS x Time	< .01	.05	< .01	.06
II x Time	< .01	.05	< .01	.11
Time	.17	1.00	.12	1.00
AS x II x Time	.02	.31	< .01	.29
B-YAACQ ^{a,c}				
AS x Time	< .01	.07	< .01	.06
II x Time	< .01	.07	< .01	.09
Time	.43	1.00	.28	1.00
AS x II x Time	< .01	.10	< .01	.25

Note. β = observed power (SPSS). LOCF = last observation carried forward; AS = autonomy support; II = implementation intention; PDAC = pre-drinking alcohol consumption; B-YAACQ = brief young adult alcohol consumption questionnaire (i.e., alcohol-related harm).

^aComplete Case $n = 117$; ^bLOCF: $n = 201$; ^cLOCF: $n = 202$.