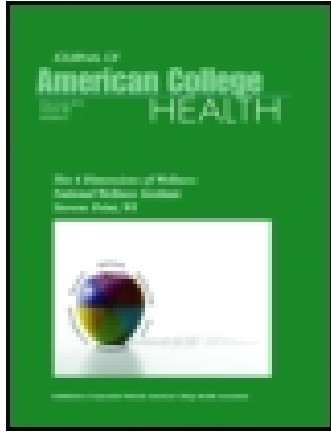


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### An Intervention to Decrease Heavy Episodic Drinking in College Students: The Effect of Executive Function Training

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**Brief Report**

**An Intervention to Decrease Heavy Episodic Drinking in College Students:  
The Effect of Executive Function Training**

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**Abstract. Objective:** To develop and test a planning-ability, executive function (EF) intervention to reduce heavy episodic drinking (HED). **Participants:** 55 heavy-drinking, first-year college students, recruited from May-October, 2012. **Methods:** Participants were randomly allocated to an experimental or active control group and then completed the AUDIT-C and demographic questions. Over one week, the experimental group completed four progressively harder, planning tasks, while the control group completed four easier, consistent-difficulty, planning tasks. Participants then recorded their daily alcohol consumption for two weeks. **Results:** As hypothesized, both mean and maximum per-occasion alcohol consumption was significantly reduced in the experimental group compared to the control group. There were no significant differences in frequency of HED. **Conclusions:** These results provide initial support for the use of a planning-ability intervention in decreasing per-occasion alcohol consumption. Future researchers can examine the mechanism of effect, the long-term efficacy and the specific EFs involved in other aspects of alcohol consumption.

**Keywords:** alcohol, binge drinking, executive function, heavy episodic drinking, planning, self-regulation, planning

## 1. Introduction

Heavy episodic drinking (HED) or ‘binge drinking’ is both prevalent and harmful.<sup>1</sup> The National Institute on Alcohol Abuse and Alcoholism defines binge drinking as five or more U.S. standard drinks on a single occasion for men and four or more drinks on a single occasion for women.<sup>2</sup> In Australia, the definition is similar: drinking more than four Australian standard drinks (equivalent to 2.9 U.S. standard drinks) on one occasion, for both genders.<sup>1</sup> Due to the setting, the Australian definition is used in the current study.

Despite the risks, many college students regularly engage in HED. Approximately one third of college students in the U.S.A. (32.7%)<sup>3</sup> and Canada (36%)<sup>4</sup> report at least one instance of HED in the previous two weeks. Similarly, almost half (48%) of Australian college students report at least one instance of HED in the previous four weeks.<sup>5</sup> It is therefore important to develop and disperse effective interventions to reduce HED, particularly for college students, who also engage in HED more frequently than do their non-college-student peers.<sup>6</sup>

One mechanism believed to relate to alcohol consumption is self-regulation.<sup>7</sup> Self-regulation refers to the capacity to monitor and alter cognitions, emotions and behaviors in order to align them with perceived standards or goals.<sup>8</sup> The neuropsychological basis of self-regulation is suggested to be executive function (EF),<sup>9</sup> which broadly refers to those skills involved in goal formation and execution such as planning, reasoning, attention, working memory, inhibitory control and flexibility of thought.<sup>10</sup>

There is evidence suggesting a bidirectional relationship between self-regulation, EF and alcohol consumption.<sup>11</sup> For example, not only does alcohol intoxication impair executive function<sup>12, 13</sup>, but depleted self-regulatory capacity also increases alcohol consumption.<sup>14, 15</sup> One

specific EF that has been linked with HED is planning ability.<sup>16</sup> Planning is involved in the generation of goals and, in this way, planning may help individuals generate and execute healthy-drinking goals.<sup>10</sup> For example, planning may help individuals to predetermine a drinking limit, to limit the quantity of alcohol purchased in advance or to avoid contexts known to encourage excessive drinking. Indeed, binge drinkers have demonstrated lower planning ability than moderate drinkers, who are able to limit their consumption.<sup>16</sup> This suggests that those who engage in HED may benefit from planning-ability training as improved planning ability may lead to more-effective plans to reduce the frequency or quantity of HED.

Recent studies have utilized EF tasks to both improve EF and decrease alcohol consumption. For example, training on both inhibitory control<sup>17, 18</sup> and working memory<sup>19</sup> tasks has been successfully used to modify alcohol consumption. Further, increasingly more difficult working memory training also resulted in improvements in working memory.<sup>19</sup> This result suggests both that EF can be improved, and that EF training can subsequently affect alcohol consumption. However, outcome measures were limited to total weekly consumption and lab-based, pseudo taste tests, and no studies have examined the influence of EF training on HED.

The present pilot study extends current literature by exploring the efficacy of a novel, planning-ability intervention in decreasing HED. The intervention utilizes progressively more difficult tasks, in order to challenge participants and improve planning ability. This is compared to an active control group, who completed the same type of tasks, but at an easier, consistent level. It was hypothesized that the intervention would improve planning ability in the experimental condition, relative to the control condition, and thus, the experimental group would consume less alcohol than the control group.

## 2. Methods

### 2.1 Design

This was a two-group, randomized controlled trial with post-test assessment of the dependent variables. The project was approved by the University's Human Research Ethics Committee.

### 2.2 Measures

The AUDIT-C is a three-item questionnaire that assesses drinking frequency, typical quantity consumed and frequency of drinking more than six drinks on one occasion, on five-point scales. In a college-student population, the AUDIT-C has demonstrated satisfactory reliability, strong internal consistency and strong concurrent validity with an objective measure of drinking (breath alcohol concentration).<sup>20</sup> Scores can range from 0 to 12, where higher scores indicate heavier drinking.

Planning ability was assessed using the Tower of London task. This task requires participants to manipulate three different-colored balls across three pegs, in order to achieve a goal state.<sup>21</sup> Successful completion in the minimum possible moves requires pre-planning the series of responses. Seven different versions of the task were created: four of equivalent difficulty and from these four, a further three of increasing difficulty. Task difficulty was manipulated using number of minimum moves required and start-configuration ambiguity.<sup>22</sup> Scores on the tasks reflected both total time and number of failed attempts.<sup>23</sup> Scores could range from -36 to +108, with higher scores representing better performance.

Alcohol consumption was recorded daily for two weeks, using a diary that contained a standard drink guide. From this, three primary outcome measures were calculated: the mean

number of standard drinks consumed per occasion, the maximum number of standard drinks consumed on one occasion and the frequency of HED.

### *2.3 Participants*

Participants were college students, enrolled in a first-year, undergraduate psychology unit. They were recruited via the unit's online participant pool and they received course credit for their participation. Participants were screened for inclusion using the three-item Alcohol Use Disorders Identification Test consumption questions (AUDIT-C), to detect heavy drinkers. Participants were excluded if they scored less than four, a cut-off based on past research.<sup>24</sup> Participants were also required to be at least 18 years of age, the legal age for alcohol consumption in Australia. Based on medium-large effect sizes found in similar studies<sup>17, 19</sup>, it was calculated that 44-92 participants would be required to achieve 80% power for detecting a similar effect.

### *2.4 Procedure*

This was a multi-part, online study; all components of recruitment, intervention administration and data collection were conducted online, with no face-to-face contact between experimenters and participants. Participants were randomly allocated to the experimental or active control groups, using a computerized random number generator. Randomization occurred at the time of participation, and in this way, participants' allocations were concealed from the researchers, prior to participation.

The first part consisted of a questionnaire administered through LimeSurvey, assessing demographics and the AUDIT-C. Current Australian alcohol-consumption guidelines and

information detailing some of the consequences of excessive alcohol consumption were also provided. This was followed by the first Tower of London, administered by Inquisit.

Over the next week, participants completed three more Tower of London tasks. The experimental group completed progressively harder tasks, while the active control group completed easier, fixed-difficulty tasks. On the day after completing the last Tower of London task, all participants began completing the daily alcohol consumption diary, and continued for 14 days. After returning the diary, participants received debriefing information and course credit.

### 3. Results

#### 3.1 Participants and Baseline Characteristics

The initial sample consisted of 59 first-year students. Two participants from the control group withdrew participation before returning the alcohol consumption diary. Following study completion, a manipulation check led to the exclusion of data from two control-group participants, who had completed less than 85% of the Tower of London items. There were no baseline differences between the final sample and the excluded participants (all  $ps > .05$ ).

Due to technical errors, eight participants (three experimental, five control) received duplicate emails containing the Tower of London task links. As such, one control participant completed two additional tasks and the remaining seven completed one additional task. The additional tasks were completed at the difficulty levels appropriate to each group. Data from these participants were retained as there was no significant difference in the number of tasks completed between groups (experimental:  $M = 4.09$ ,  $SD = 0.35$ , control:  $M = 4.20$ ,  $SD = 0.51$ ,  $t_{53} = 0.927$ ,  $p = .358$ ). Further, if this were to affect results, the direction of the (non-significant) difference suggests it would underestimate the intervention effect.



Of the final sample of 55 (experimental:  $n = 28$ ; control:  $n = 27$ ) participants, most ( $n = 46$ ) were drinking more than four standard drinks on a typical occasion, and most ( $n = 45$ ) were drinking more than six drinks on one occasion at least monthly. There were no baseline differences between groups on age (experimental:  $M = 19.25$ ,  $SD = 1.86$ , control:  $M = 20.22$ ,  $SD = 5.40$ ,  $t_{53} = 0.90$ ,  $p = .373$ ), gender (experimental:  $n = 17$  women, control:  $n = 19$  women,  $\chi^2_{1, N=55} = 0.57$ ,  $p = .452$ ), AUDIT-C (experimental:  $M = 6.75$ ,  $SD = 1.48$ , control:  $M = 6.78$ ,  $SD = 1.58$ ,  $t_{53} = 0.07$ ,  $p = .947$ ) or Tower of London scores (experimental:  $M = 61.29$ ,  $SD = 9.96$ , control:  $M = 62.41$ ,  $SD = 12.54$ ,  $t_{53} = 0.37$ ,  $p = .714$ ).

### *3.2 Efficacy of the Intervention in Reducing Alcohol Consumption*

In order to both increase sensitivity, and to confirm that any post-intervention, between-group differences in alcohol consumption existed over and above baseline consumption, analyses of covariance were chosen over independent samples  $t$ -tests.

Three analyses of covariance were conducted, using baseline AUDIT-C responses as covariates.

The AUDIT-C questions closest to the dependent variables were chosen as the covariates:

question two (typical quantity per occasion) for both the mean drinks and maximum drinks per occasion, and question three (frequency of consuming more than six drinks) for HED frequency.

As can be seen in Table 1, mean drinks per occasion and maximum drinks consumed on one occasion were both significantly reduced in the experimental group compared to the control group. There were no significant differences in the frequency of HED.

INSERT TABLE 1 NEAR HERE

#### 4. Comment

The aim of the present pilot study was to execute a novel planning ability intervention and test the efficacy of this intervention in decreasing HED. Overall, the intervention was successful in reducing average and maximum per-occasion alcohol consumption. Specifically, the experimental group consumed 1.7 and 2 standard drinks fewer than the control group, on typical and peak occasions, respectively. This result adds to the expanding EF intervention literature, which has already demonstrated the efficacy of working memory and inhibitory control tasks in decreasing weekly alcohol consumption.<sup>17, 19</sup>

The intervention did not significantly affect the frequency of HED. This is somewhat in contrast to previous research.<sup>17-19</sup> It may be that different types of EF are involved at different stages of alcohol consumption, explaining the differential intervention effects by dependent variable. An interesting area for future research would be to determine which EFs are differentially involved in the initiation, continuation and cessation of alcohol consumption. Alternatively, due to the episodic nature of HED, longer follow-up periods may be needed to detect differences in the frequency of HED.

Two possible explanations for the intervention success include the hypothesized increase in planning ability and/or a change in intention. The challenging nature of the tasks in the experimental condition may have motivated a decrease in alcohol consumption, in order to compensate for any subjective difficulties experienced with the tasks. Alternatively, as hypothesized, the challenging tasks may have improved the planning ability of those in the experimental group, making them better able to plan and execute effective strategies to reduce

their alcohol consumption. Future research incorporating dependent measures of planning ability\* and intention could test these explanations.

#### *4.1 Strengths, Limitations and Future Directions*

To the authors' knowledge, this was the first study to employ Tower of London training in order to reduce HED. Further, only two participants dropped out of the study, and two did not sufficiently engage with all tasks. As such, there were markedly higher rates of both study (97%) and intervention (100%) adherence compared to similar-length, online interventions (77% and 68%, respectively).<sup>27</sup> Therefore, it is likely that the current intervention was sufficiently engaging. Further, due to technical issues, eight participants completed extra, unnecessary tasks. Therefore, it seems promising that similar, more-intensive interventions may remain engaging. Future research could investigate whether interventions that are more intensive would further reduce consumption.

There are some methodological factors to consider when interpreting the findings. Firstly, alcohol consumption was recorded over two weeks. As a result, it is not possible to determine whether the demonstrated decrease in per-occasion alcohol consumption would be maintained in the longer-term. Secondly, there is some debate surrounding which specific EF is measured by the tower tasks. While they are usually considered measures of planning<sup>21, 28</sup>, some have suggested that other abilities such as working memory, cognitive flexibility<sup>10</sup> and/or inhibitory control<sup>29</sup> may be involved. Therefore, any possible improvements in EF may not have been

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\* Due to the incremental nature of the training, the difficulty level of the final Tower of London task completed differed between groups. Therefore, it was not possible to examine changes in planning ability in the current study.

planning-specific. EF interventions for health behaviors are still relatively new; future research will further elucidate which specific EFs and EF tasks are useful for this purpose, as well as determine the manner through which participants translate improved EF into healthier behaviors. Finally, the external validity may be limited, given the relatively small sample size and the experimental context of one institution in Australia. This was a pilot study and subsequent research may strengthen the applicability of these findings across other institutions and countries.

## *4.2 Applications*

While further research is needed regarding the mechanism of effect, long-term efficacy and external validity, these results indicate that this type of intervention could be practicable and effective in college contexts. The intervention is online and relatively automated. Therefore, the intervention link could be provided to students at college orientation week events or the program could be placed on residence hall public computers. These techniques would allow the intervention to reach large numbers of students with minimal practitioner input. Alternatively, the intervention techniques could be incorporated into current, widely-used online interventions for college students, such as AlcoholEdu.<sup>30</sup> As noted, both intervention and study adherence were high in the current study. It may be that the game- or puzzle-like nature of the EF tasks appeals to those students who are less engaged by traditional techniques. In this way, incorporation of these tasks into existing interventions may increase engagement and adherence.

## *4.3 Conclusion*

The experimental group demonstrated lower, post-intervention, per-occasion alcohol consumption, compared to the control condition. Given the numerous negative consequences of

HED, this pilot research is a valuable first step towards reducing alcohol-related harm amongst college students.

## **Conflict of Interest Disclosure**

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

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## **Note**

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Table 1

*Means and ANCOVA Statistics Testing Post-Intervention, Between-Group Differences in Alcohol Consumption*

	Experimental	Control	Experimental	Control			
	Unadjusted Mean ( <i>SD</i> )		Adjusted Mean ( <i>SE</i> )		$F_{1,53}$	$p$	$\eta_p$
Mean per occasion	4.64 (2.54)	6.35 (3.42)	4.54 (0.47)	6.46 (0.48)	8.16	.006	.136
Maximum	7.43 (4.43)	9.42 (4.56)	7.31 (0.77)	9.54 (0.79)	4.09	.048	.073
HED frequency	2.46 (2.29)	2.52 (1.85)	2.43 (0.38)	2.55 (0.39)	0.05	.832	.001

*Note.* Mean per occasion = mean number of standard drinks consumed, per drinking occasion; maximum = the highest number of standard drinks consumed on one occasion; HED frequency = the number of days on which participants consumed more than four standard drinks.