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The effects of working memory load and attention refocusing on delay discounting rates in alcohol use disorder with comorbid antisocial personality disorder

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ABSTRACT

Executive working memory capacity (eWMC) is central to adaptive decision-making. Research has revealed reduced eWMC and higher rates of impulsive decision making in individuals with alcohol use disorders (AUDs: DSM-IV Alcohol Dependence of Alcohol Abuse) and antisocial psychopathology (AP). Recent work has shown that placing a load on working memory (WM) further increases impulsive decision making on the delay discounting (DD) task in those with AUDs and AP. The current study examined the effects of an attention refocusing manipulation to offset the effects of this WM-load on DD rates in control subjects, those with AUDs without AP, and AUDs with AP (AUD-AP). Results revealed that 1) the AUD-AP group had higher DD rates (i.e., more impulsive decision-making) than the AUD group, followed by controls, and 2) attention refocusing after a load is placed on WM was associated with lower DD rates compared to the load without refocusing in both AUD groups, but not controls. Results suggest that refocusing attention after a cognitive load may be an effective cognitive strategy for reducing the impulsivity-enhancing effects of cognitive load on decision making in individuals with AUDs and AP.

Introduction

Alcohol use disorders (AUD) co-occur at high rates with other externalizing psychopathology (EXT), particularly antisocial personality (AP). This comorbidity is explained, in part, by a shared underlying vulnerability for poor self-regulation and disinhibition (Bobova, Finn, Rickert, & Lucas, 2009; Endres, Rickert, Bogg, Lucas, & Finn, 2011; Krueger et al., 2002). Reduced executive working memory capacity (eWMC) is an important feature of this shared disinhibitory vulnerability. More specifically, eWMC plays a central role in impulsive decision-making (Barrett, Tugade, & Engle, 2004; Finn, Gunn, & Gerst, 2015; Hinson, Jameson, & Whitney, 2003). Our group recently found that putting a load on working memory (referred to as a WM-load from here onward) increased impulsive decision-making (i.e., delay discounting rates) in those with a wide range of EXT psychopathology (Finn et al., 2015). This study is a continuation of that work and examines the effects of a manipulation designed to increase available working memory resources, via an attention refocusing procedure, in an effort to offset the effects of a WM-load in a similar population.

eWMC, impulsive decision-making, and EXT

Working memory is a limited capacity, multi-component system responsible for the retaining and accessing of information in the presence of competing stimuli. Several models of working memory exist. Here, we consider the multi-component model, which conceptualizes working memory as involving four components, including the phonological loop, visuospatial sketchpad, episodic buffer, and, importantly, the central executive. Under this model, the *central executive* component of working memory is considered the system responsible for control of attention, resistance to distraction, and the shifting and retrieving of information (Baddeley, 2007). The central executive is critical for self-regulation, decision-making, and problem solving in general (Barkley, 2001; Barrett et al., 2004; Finn, 2002). Specifically relevant to the pattern of impulsive decision-making observed in EXT, the attentional control process of the central executive is fundamental to the deliberation period that occurs before a decision is

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made. Our model of decision-making posits that when attentional control (eWMC) is impaired, proximal rewards become more salient, resulting in more impulsive decision-making (Finn, 2002). Previous research has supported this conceptualization, revealing that cognitive (i.e., WM) loads limit attentional control capacity, resulting in disruptions in the system (e.g., poor self-regulation) (Ahmed & De Fockert, 2012; Lavie, 2010).

Critically, several studies have directly revealed an association between reduced eWMC and impaired decision-making in AUDs and AP (Bechara & Martin, 2004; Finn & Hall, 2004; Finn, Mazas, Justus, & Steinmetz, 2002; Finn et al., 2009; Nigg et al., 2006). Specifically, those with AUDs and AP make more impulsive decisions on several tasks, including the delay discounting (DD) task (Bobova et al., 2009; Petry, 2002; Reynolds, 2006) and the Iowa Gambling Task (Bechara & Martin, 2004; Fridberg, Gerst, & Finn, 2013). Those with AUDs and comorbid AP have also revealed even higher discounting rates and lower eWMC compared to those with AUD or AP only and controls (Bobova et al., 2009; Dom, De Wilde, Hulstijn, van den Brink, & Sabbe, 2006). Together, this work suggests that reduced eWMC may partially explain the relationship between impulsive decision-making and EXT, particularly AUDs and AP.

eWMC-load and impulsive decision making

The association between reduced eWMC and impulsive decision-making is further supported by recent experimental studies that induce cognitive load by challenging attentional control processes. These studies reveal that a WM-load increases impulsive or disadvantageous decision-making in both control samples and those with EXT psychopathology (Endres, Donkin, & Finn, 2014; Finn et al., 2015; Fridberg et al., 2013; Hinson, Jameson, & Whitney, 2002). The cognitive loads used in these studies require the central executive to maintain and simultaneously manipulate information in working memory. This puts large demands on available attentional control capacity (eWMC), thereby reducing overall attentional resources and compromising the capacity to shift attention during the deliberative process in decision-making.

One WM-load task used in delay discounting studies involves presenting the subject with a decision option (immediate and delayed sums of money), then applying a cognitive load (e.g., counting backwards by 3's and retaining an initial 3-digit number in the counting set), then asking the subject to choose between the *Now* or *Later* option (Finn et al., 2015). When not under a load, subjects deliberate between the more salient *Now* option and the less salient delayed option, which requires eWMC resources to shift attention. On decision trials under a WM-load, the subject must first shift attention from the distracting task back to the basic decision options, and then engage in the attention-shifting process involved in deliberating between the immediate and delayed options. We hypothesize that a cognitive load depletes eWMC attentional control resources, making it more difficult to shift attention back to the decision options from a cognitive load task. Depleting attention-shifting capacity increases the likelihood of an impulsive *Now* choice because making the delayed choice requires more eWMC attention shifting.

The current study

The current study follows up on Finn et al. (2015) by investigating the effects of a brief attention refocusing manipulation (refocus) designed to offset the effects of a WM-load. This study includes the data collected from our initial study ($n = 531$), as well as a new set of subjects recruited for the refocus manipulation ($n = 100$). The new refocus procedure targets the attentional control aspect of eWMC by specifically instructing subjects to focus their attention on the choice, thereby shifting their attention back to the specific decision (described in more detail below). For this study, subjects from the initial dataset published in Finn et al., 2015 (the no-load and WM-load conditions) were classified into one of three groups: an AUD with comorbid antisocial psychopathology group (AUD-AP), an AUD-only group (AUD), and controls without AUDs (DSM-IV Alcohol Abuse or Alcohol Dependence) or other externalizing disorders. We divided individuals with AUDs into those with and without AP because studies show that individuals with AUDs and comorbid AP are associated with more impulsive behavior and choices than individuals with AUDs without AP (Finn et al., 2002; Petry, 2002). Given that subjects were not required to fit this group criterion in the original study (Finn et al., 2015), eleven subjects were removed for the present analyses. The additional subjects recruited for the refocus condition were required to meet the same group criteria.

We hypothesized that: 1) the refocus manipulation would significantly offset the effects of a WM-load (lower discounting rates in the refocus compared to the WM-load condition) and 2) the effect of the refocus manipulation would be apparent in the two AUD groups, and not in controls. This second hypothesis was derived from the theory that the lower eWMC associated with these groups is characterized by higher levels of distractibility and poorer attentional control, the mechanism targeted by this refocus manipulation. Given that the control subjects are not as significantly affected by these deficits, we do not expect the refocus condition to have the same impact as in the AUD groups.

Materials and methods

Participants

Recruitment

Participants in both datasets (current study and Finn et al., 2015) were recruited in the same way, through flyers and newspaper advertisements posted throughout the local community.

Different flyers were created to attract individuals with varying levels of impulsive behavior and AUDs, as reported previously (e.g., Finn et al., 2009, 2015).

Inclusion criteria

Respondents to the flyers/ads were interviewed on the phone to ensure that participants: 1) were between 18 and 30 years old, 2) could read and speak English, 3) had completed at least 6th grade, 4) had consumed alcohol on at least one occasion, and 5) had no history of major head trauma (e.g., concussions or traumatic brain injury), severe cognitive impairments (e.g., inability to read or write, clinically significant memory impairments), or severe psychological problems (schizophrenia or any psychosis unrelated to alcohol/drug use). Participants who met these criteria were also asked questions pertaining to current and lifetime childhood conduct disorder, adult antisocial behavior, alcohol, and drug problems. Those who met the group inclusion criteria outlined below were recruited.

Prior to each session, participants were required to abstain from alcohol or recreational drugs for at least 12 h, have had at least 6 h of sleep the night before, and had eaten a meal within 3 h of the session. Participants were given a breath alcohol test an (Alco Sensor IV – Intoximeters Inc., St. Louis, MO) to ensure their level was 0.0%. To assess the remaining criteria (recent drug use, sleep, and meal), subjects completed an initial interview before any other session procedures were conducted. Sessions were rescheduled if these criteria were not met.

Sample characteristics

Participants in the total sample (n = 631; 297 women) were primarily college-aged (M = 21.33, SD = 2.48) and Caucasian (77.0%). The remaining participants described themselves as African American (7%), Asian (7.1%), Hispanic (5.9%), mixed race (1.7%), or other (1%). Table 1 presents demographics for the previously collected sample from Finn et al., 2015 and the additional participants for the present study. As reflected in Table 1, these samples were similar on all demographic variables except ethnicity, for which there was a significantly lower percentage of Caucasian individuals in the present sample and years of education, for which the present sample had a higher mean. However, in reviewing the means for both of these sample characteristics, it is unlikely that either represents a clinically significant difference between groups. Further, the reported standard deviations and amount of variability accounted for by group and interaction effects in the regression analyses reported below suggest that these differences were not clinically significant.

Group criteria

AUD and AP symptoms were assessed with the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA), provided by the COGA (Collaborative Study on the Genetics of Alcoholism) group. The SSAGA shows good test-retest reliability, inter-rater reliability, and good construct validity when compared with other semi-structured interviews (Bucholz et al., 1995, 1994; Hesselbrock, Easton, Bucholz, Schuckit, & Hesselbrock, 1999). Participants in the AUD group (n = 309) had a diagnosable AUD and did not meet DSM-IV criteria for childhood conduct disorder or antisocial personality disorder. Participants in the AUD-AP group (n = 137) had both a diagnosable AUD as well as childhood conduct disorder with or without antisocial personality disorder. Alcohol, antisocial and conduct disorder, as well as marijuana and other drug problem counts for each group are presented in Table 1.

Delay discounting tasks

Participants completed one of three computerized delay-discounting tasks. In all tasks, participants were asked to make a series of choices between an amount of money immediately or $50 at a delay. Immediate monetary amounts varied between $2.50 and $47.50 in increments of $2.50. Delay periods were either 1 week, 2 weeks, 1 month, 3 months, 6 months, or 1 year. Participants were told prior to starting the task that one trial would be selected at random and they would receive in cash the amount they chose on that trial. Cash would be dispensed immediately if the participant chose the immediate value on that trial; participants received a voucher for $50 that could be redeemed after the delay period if they chose the delayed value on that trial. Participants completed six randomly ordered blocks, one for each delay period. Within each block, participants were presented with both ascending and descending immediate values, presented sequentially. Ascending trials, of which there were a maximum of 19, stopped when the participant switched from choosing the delayed reward to the immediate reward. Similarly, descending trials stopped when the participant switched from the immediate to delayed option. This method of task administration has been shown to have strong test, re-test reliability (Odum, 2011; Ohmura, Takahashi, Kitamura, & Wehr, 2006).

This study used data from two variations of the delay discounting task, a WM-load and a no-load version, previously collected and reported in Finn et al., 2015, along with data from a refocus version collected from a new sample. In the WM-load version (n = 266), immediately following the decision options, participants were presented with a 3-digit number and asked to count backward by 3's while remembering the original 3-digit number. After counting backward, participants were presented with the prompt, *Now* or *Later* (actual values are not depicted) and instructed to choose one option. Finally, they were prompted to recall the original 3-digit number. In the no-load version of the task (n = 265), participants were presented with the decision options, and then waited 10 s before making their decision. Finally, the refocus version (n = 100) involved the same order of the WM-load version of the task, except immediately before participants were asked to make their decision, they were presented with the prompt "Refocus on the choice" (presented for 3 s), then were prompted, *Now* or *Later,* made their decision, and finally recalled the original 3-digit number.

Estimation of discounting rate

In order to estimate discounting rate, a single-parameter hyperbolic function was used (Mazur, 1987):

$$V_p = \frac{V}{1 + k \times dt}$$

In this equation, V_p is the present (discounted) value (the average of the switch point for ascending and descending trials at a particular delay), the constant V is the amount of the delayed reward ($50), dt is the length of the time the reward is delayed in days, and k is the discounting rate. To address the skewness in the distribution of k, the dependent variable used in these analyses is the $\log_{10}$ transformed k value.- This hyperbolic model accounts for significantly more variance than exponential function models (Bickel & Marsch, 2001; Kirby, 1997; Kirby & Herrnstein, 1995). It suggests that when the larger reward is more temporally distant, choices for those rewards can be described as more controlled, rational, and consistent with long-term goals. Conversely, choosing smaller, more immediate rewards can be described as impulsive and inconsistent with long-term goals. Lower (more negative) $\log_{10}$ (k) values reflect less discounting, while higher (more positive) values indicate higher discounting, or more preference for the smaller immediate reward (more impulsive decision-making).

We also followed guidelines presented by Johnson and Bickel (2008) for identifying nonsystematic data using this hyperbolic model, resulting in 100 subjects being removed from the analyses. Of these 100 subjects, 40 were in the control group, 32 were in the AUD group, and 28 were in the AUD-AP. Regarding condition, 38 were in the no-load condition, 43 were in the WM-load condition, and 19 were in the refocus condition. Six participants were excluded from the analyses because their choices were variable and unsystematic, exhibiting increases in the magnitude of switch points (starting at the second delay) by a magnitude greater than 20% of the larger reward. An additional 94 participants were excluded because they met Johnson and Bickel's second criterion of not discounting by at least 10% from the first to the last delay. Of

Table 1
Sample demographics.

	Finn et al., 2015 (n = 531)	Present study (n = 100)	Group comparisons
M(SD) Age	21.37 (2.53)	21.1 (2.24)	F(1,629) = 0.93, p = 0.34
M(SD) Yrs Ed	14.1 (1.8)	14.8 (1.7)	F(1,629) = 14.3, $p < 0.001$
% female	47	50	F(1,629) = 0.41, p = 0.52
% Caucasian	78.8	67	F(1,629) = 6.55, $p < 0.05$
% student	79	87	F(1,629) = 6.55, p = 0.06

Sample demographics for each data set presented separately, previously published data from Finn et al., 2015, and the additional data set collected for this study. Yrs Ed = total years of education at the time of the study. Far right column displays results of ANOVA testing group differences in each variable.

those 94, there were 68 participants who never discounted and always chose the $50 delayed reward (33 in the no-load condition, 21 in the WM-load condition, and 14 in the refocus condition), and 26 participants who always chose the immediate reward (5 in the no-load condition, 16 in the WM-load condition, and 5 in the refocus condition). These participants were excluded because the hyperbolic function cannot adequately estimate k, given that their choices do not have a rate of decline.

Current drinking

Measures of current drinking levels reported in the sample descriptives (Table 2) were the self-reported mean frequency of drinking occasions (per week) and mean quantity (standard drinks) consumed per occasion during the previous 3 months, collected through interview.

Data analyses

SPSS Version 22 (SPSS Inc., Chicago, IL) was used for these analyses. Step-wise linear regression was used to test main study hypotheses. In the first step, main effects of Group and Condition were entered. The interaction term (group by condition) was added in the second step to examine hypothesized differences in the effect of the refocus manipulation between groups. Planned comparisons were used to test our specific directional hypotheses regarding the cognitive load condition main effects (lower discounting rates in the refocus condition compared with the WM-load condition, and higher discounting rates in the WM-load condition compared with the no-load condition). Likewise, planned comparisons were used to test the specific hypotheses regarding the group differences (AUD-AP greater discounting than AUD only and AUD greater than controls, as well as specific effects of the refocus condition in the AUD groups).

Results

As hypothesized, regression analyses revealed a significant main effect of cognitive load condition, $\beta = 0.11$, $p < 0.01$, on discounting rate ($\log_{10}(k)$), indicating that discounting rates in the WM-load condition (M = −1.02, SD = 0.84) were higher than those in both the no-load (M = −1.35, SD = 0.79, $p < 0.001$, *Hedges*' $g = -0.41$, 95% CI [−0.58, −0.23]) and the refocus condition (M = −1.33, SD = 0.84, $p < 0.01$, *Hedges*' $g = 0.37$, 95% CI [0.14, 0.60]), respectively (see Table 3). Additionally, no-load did not differ significantly from refocus ($p = 0.98$). Mean discounting rates ($\log_{10}(k)$) for each condition are displayed in Fig. 1. These analyses revealed that the refocus condition was associated with significantly reduced levels of discounting compared to the WM-load condition and roughly equivalent to rates comparable to the no-load condition. Additionally, as hypothesized, this model revealed a significant main effect of group, $\beta = 0.22$, $p < 0.001$, on overall discounting rate ($\log_{10}(k)$). Planned comparisons revealed that Controls had significantly lower discounting rates (M = −1.47, SD = 0.82) compared to both AUD (M = −1.16, SD = 0.82), *Hedges*' $g = -0.38$, 95% CI [−0.57, −0.20], and AUD-AP (M = −0.97, SD = 0.80) groups, *Hedges*' $g = -0.623$, 95% CI [−0.38, −0.39]. Additionally, AUD-HiAP had significantly higher discounting rates compared to AUD, *Hedges*' $g = -0.24$, 95% CI [−0.44, −0.33].

When the interaction term was included in the model, the interaction of group and condition was not statistically significant, $\beta = -0.08$, $p < 0.55$. Additionally, the effect of condition was no longer significant. Planned comparisons revealed that discounting rates were significantly lower in the refocus condition compared to WM-load condition in the two AUD groups, but not controls. For the AUD-AP group, discounting rates were lower in the refocus: (M = −1.14, SD = 0.84) compared with the WM-load conditions: (M = −0.68, SD = 0.73), *Hedges*' $g = 0.602$, 95% CI [0.111, 1.093]. Likewise, within the AUD group discounting rates were lower in the refocus (M = −1.40, SD = 0.89) compared with the Load condition (M = −0.98, SD = 0.82), *Hedges*' $g = 0.497$, 95% CI [0.124, 0.870]. However, these effects were not observed in the control group (refocus: M = −1.40, SD = 0.80; WM-load: M = −1.31, SD = 0.85). Mean discounting rates ($\log_{10}(k)$) for each group are displayed in Fig. 2. Overall, these analyses show a meaningful reduction in

Table 2
Mean lifetime externalizing problem counts and alcohol use by group.

	Control (n = 185)	AUD (n = 309)	AUD-AP (n = 139)
	Mean (SD)		
Lifetime problems			
Childhood conduct	2.76 (2.93)	7.89 (4.35)	15.79 (4.42)
Adult antisocial	1.89 (2.55)	6.64 (4.91)	13.85 (6.89)
Alcohol	3.50 (3.75)	22.04 (10.40)	28.70 (14.98)
Marijuana	1.09 (4.02)	8.10 (8.35)	12.59 (10.40)
Other drugs	0.77 (5.90)	5.42 (12.85)	16.61 (26.96)
Alcohol use			
Alcohol quantity	2.94 (2.99)	7.73 (4.55)	7.55 (6.95)
Alcohol frequency	1.48 (1.35)	3.32 (1.46)	3.01 (1.95)

Lifetime problems were summed positive responses to questions from the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA; Bucholz et al., 1994) in the sections for specific disorders. Other drug problems were comprised of cocaine, stimulants, opiates, sedatives, or other substances such as hallucinogens. Alcohol use data represents mean quantity and frequency of standard drinks (per week).

Table 3
Linear regression predicting Delay Discounting Rates [$\log_{10}(k)$].

	B	SE (B)	β	t	p	R^2
Step 1						
Condition	0.08	0.03	0.11	2.87	0.004	
Group	0.26	0.05	0.22	5.77	0.000	0.060
Step 2						
Condition	0.12	0.17	0.17	1.56	0.12	
Group	0.32	0.27	0.27	3.09	0.002	
Condition × Group	−0.02	−0.08	−0.08	−0.59	0.55	0.061

Step-wise linear regression analyses testing the main effects of group (Controls, AUD, AUD-AP) and condition (No-Load, WM-load, refocus), and interaction of group and condition on $\log_{10}(k)$ discounting rates.

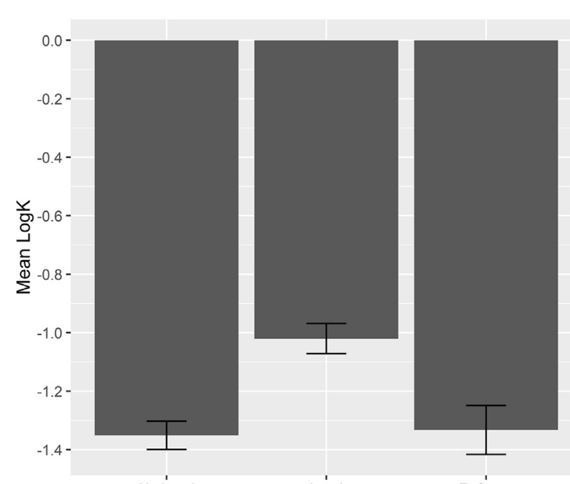

Fig. 1. Mean $\log_{10}(k)$ discounting rates for no-load, WM-load, and refocus conditions. Error bars represent 95% confidence interval for the group mean. Higher (more positive) numbers reflect more impulsive decision-making (preference for the immediate reward).

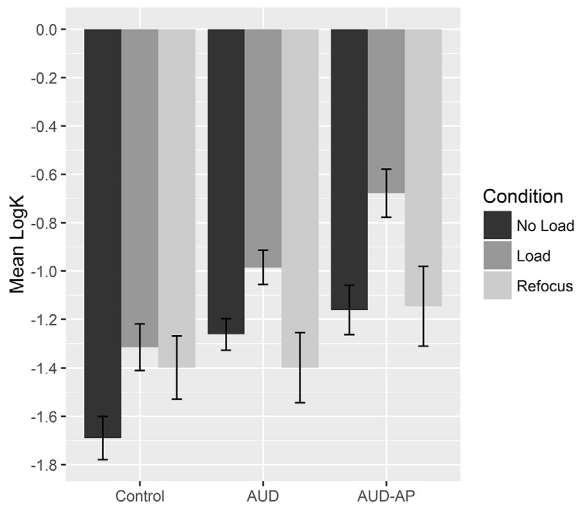

Fig. 2. Mean $\log_{10}(k)$ discounting rates by control, AUD, and AUD-AP groups in the no-load, WM-load, and refocus conditions. Error bars represent 95% confidence interval for the group mean. Higher (more positive) numbers reflect more impulsive decision-making (preference for the immediate reward).

discounting rate in the refocus condition for those with AUD and AP, but not control subjects.

Discussion

The goal of this study was to examine the effect of an attention refocusing manipulation designed to offset the effects of a WM-load on delay discounting in those with AUDs and AP. To accomplish this goal, we used delay discounting data previously collected under WM-load and no-load conditions (Finn et al., 2015) and combined it with delay discounting data collected for this study in a WM-load plus refocus condition. Finn et al. (2015) showed that a WM-load substantially increased impulsive decision-making (i.e., delay discounting rates). This study extends those results by testing the hypotheses that 1) instructions to refocus attention onto the decision offsets the impact of the WM-load on discounting decisions, and 2) that this effect would be more apparent in individuals with AUDs. Consistent with our hypotheses, delay-discounting rates were lower in WM-load with refocus condition compared with the WM-load condition, suggesting that the refocus manipulation offset the WM-load-related increases in discounting rates. In addition, planned comparison analyses indicated that the delay discounting rates after refocusing were only significantly lower than the WM-load condition for those with AUDs, suggesting that individuals with AUDs are particularly sensitive to the effects of attention refocusing. Finally, group effects remained consistent from Finn et al. (2015), in that the AUD-AP group had the highest overall discounting rates, followed by the AUD-only group, and then controls.

The major result of this study is that a rather simple attention refocusing instructional manipulation employed after a WM-load resulted in significantly lower delay discounting rates compared with rates after the cognitive load alone. This effect suggests that refocusing on the decision offsets the effects of the WM-load. Our model suggests that a WM-load leads to more impulsive *Now* choices (i.e., increases discounting rates) because WM-load effectively depletes attention and eWMC resources, making it more difficult to ultimately shift attention from the more salient *Now* impulsive choice option to the less salient, delayed *Later* option. In this study, the attention refocusing prompt serves as an external cue to facilitate the eWMC attention shifting process toward the decision. This result is very novel and, to our knowledge, this is the first study to investigate an intervention that might offset the effects of a cognitive load on impulsive decision-making. Although these results are consistent with the hypothesis that the refocus command directs the participant back to the decision by re-enlisting resources, it is also possible that the manipulation may simply provide additional time for the resources to replenish. Further research should examine similar methods to examine these mechanisms more closely. Regardless, these findings may prove useful in the development of a skills-based approach to offset the effects of events or experiences that can serve to deplete available working memory resources, such as stressful, emotionally charged, or highly stimulating contexts or events (Klein & Boals, 2001; Li, Li, & Luo, 2006; Unsworth, Heitz, & Engle, 2005).

We also hypothesized that AUDs would be more likely to experience the offsetting effects of attention refocusing on WM-load-related increases in delay discounting, because individuals with AUDs tend to have higher rates of delay discounting and lower eWMC, which allows for more room in improvement in discounting and eWM compared with controls. In other words, they may be more significantly impacted by a load, given that they have higher levels of distractibility and poorer attentional control, and therefore are more likely to benefit from an intervention designed to refocus attention. Although the group by condition interaction was not significant, planned comparisons were used to test this hypothesis, and revealed that only those with AUDs showed a reduction in discounting rates in the refocus compared with the WM-load condition. Although this may be due to the fact that controls had less room to improve (i.e., "ceiling effects") as a result of the refocus manipulation, it may also suggest that individuals with AUDs are particularly responsive to the effects of attention refocusing on discounting rates after a WM-load, compared to controls. Because individuals with AUDs have lower eWMC in the first place (Finn et al., 2015), the load likely disrupts overall executive control to a greater degree, making it difficult to shift attention during the decision process and increasing discounting rates. As such, individuals with AUDs may benefit more from the prompt to refocus attention, which serves as a type of external executive control command that is particularly necessary within this group.

Finally, the AUD-AP group had the highest discounting rates, followed by the AUD and control groups across all conditions, including the refocus condition. These results extend those of Finn et al. (2015), in which we observed that discounting rates varied as a function of the severity of externalizing psychopathology in the WM-load and no-load conditions. The present study extends this finding, revealing again that in the refocus condition, the AUD-AP had the highest discounting rates, followed by the AUD and control groups, respectively. Essentially, the AUD-AP group represents extreme elevations on externalizing psychopathology, while the AUD group reflects scores in the middle of the externalizing range, and controls are at the very low end, as evidenced by discounting rates.

Limitations and future directions

The results of this study need to be interpreted within the context of its limitations. First, the sample is mostly Caucasian, young adult college students, thus limiting the generalizability of the study. Although our second sample (refocus condition) included significantly fewer Caucasian individuals, reflecting more diversity, it likely did not represent a clinically significant difference. Although the sample represents young adult drinkers in higher education, and therefore lacks diversity, it is conceivable that an intervention to reduce impulsive decisions may be particularly effective among this high-risk sample. Second, while a within-subjects examination of the effects of the WM-load and the refocus conditions would provider a stronger test of the causal role of the refocus manipulation on discounting rates after the load, a between-subjects design was utilized here. Third, a control condition where subjects simply pause after the load was not included. It may be possible that simply pausing for 3 s after the load, rather than instructing subjects to refocus their attention, is sufficient to re-enlist eWMC resources and offset the effects of WM-load on delay discounting rates. Unfortunately, we did not include a condition where subjects simply paused to rule out this possibility. In addition, it is possible that the instructions to "Refocus on the decision" introduced a certain demand characteristic to choose the *later* option, making it difficult to conclude the exact mechanism by which discounting rates were reduced in this condition. Finally, although planned comparison analyses supported the hypothesis that the effects of refocusing would be more apparent in AUDs, the group by condition interaction was not significant, reducing confidence in the robustness of this result.

Conclusion

In summary, the major result of this study is that using an attention refocusing instructional manipulation after a WM-load appeared to offset the effects of the load on impulsive decision-making. Additionally, this effect is most apparent in AUDs. This is a very novel result and suggests that a skills-based intervention program might include this type of exercise in situations where decisions are being made under high cognitive load or duress, particularly among young adult heavy drinkers.

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