Drug and Alcohol Dependence 204 (2019) 107567

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep

Full length article

The effects of a working memory load on drinking-related decisions: The role of incentives, disincentives, and lifetime alcohol problems

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ARTICLE INFO

Keywords:
Working memory
Decision-making
Alcohol use
Alcohol use disorder

ABSTRACT

Background: This study extends this literature on effects of working memory (WM) load on impulsive and disadvantageous decision-making by investigating the impact of WM load on drinking-related decisions in different incentive and disincentive contexts in a large sample (n = 821, 373 women) of young adults, 558 of whom had an alcohol use disorder (AUD).

Methods: Decisions to attend and drink at hypothetical party events that varied in terms of alcohol party incentives (high *vs* low) and next day responsibility disincentives (high *vs* moderate *vs* low) were assessed. Subjects were randomly assigned to either a WM load (n = 387) or no load condition (n = 434).

Results: Analyses revealed that the WM load reduced the degree to which a high disincentive deterred attendance decisions; attendance decisions were more likely under WM load in the high disincentive contexts. This effect was not found in the moderate or low disincentive contexts. Additionally, a WM load increased the effects of high alcohol party incentives on both decisions to attend and drink. The WM load also resulted in faster attendance decision reaction times, suggesting that subjects were more impulsive under load.

Conclusions: These results suggest that a WM load had a general effect of disrupting the decision-making process, reducing the inhibitory effects of high disincentives, amplifying the facilitating effects of high party incentives on alcohol-related decisions, and reducing decision deliberation times (reaction times). This suggests that individuals under significant cognitive load engage in more impulsive and riskier decisions when deciding to attend and drink at party events.

1. Introduction

Studies of decision-making in individuals with alcohol use disorders (AUDs) consistently characterize their decision biases as impulsive, risky, and disadvantageous (Bobova et al., 2009; Finn et al., 2015, 2017; Gowin et al., 2018; Mazas et al., 2000; Petry, 2001). In addition, poor decision-making in those with AUD is associated with reduced working memory (WM) capacity (Bechara and Martin, 2004; Bobova et al., 2009; Bogg and Finn, 2010; Endres et al., 2014; Finn, 2002; Finn et al., 2009, 2015; van der Plas, 2009). This association is supported by studies indicating that compromising WM capacity *via* a cognitive load results in significant increases in impulsive, risky, or disadvantageous decision-making (Endres et al., 2014; Finn et al., 2015; Fridberg et al., 2013; Hinson et al., 2002, 2003).

WM capacity essentially reflects attentional control capacity (Barrett et al., 2004; Endres et al., 2014; Finn et al., 2015; Shipstead et al., 2012), which is central to the deliberation process involved in adaptive decision-making (Barrett et al., 2004; Endres et al., 2014). During adaptive decision-making, attention is shifted between different potential outcomes (costs and benefits) and compared with experience and goals (Endres et al., 2014; Finn et al., 2015). A WM load is thought to disadvantage decision-making by compromising the capacity to switch attention from more immediate and salient outcome information to more distal and delayed information, which tends to increase the impact of immediate contingencies and decrease the impact of delayed or longer term contingencies, resulting in more impulsive and risky decisions (Endres et al., 2014; Finn et al., 2015). Studying the relationship between WM load and decision-making is particularly important as decision-making, inside and outside of the laboratory, is vulnerable to common conditions that compromise WM capacity, such as emotional arousal and stress (Finn, 2002; Klein and Boals, 2001; Luethi et al., 2008). The current study extends the literature on decision-making in individuals with AUDs by investigating the effects of a WM load on drinking-related decisions observed in a recent paper by Finn et al. (2017).

Rather than using a behavioral economic decision task, such as a

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https://doi.org/10.1016/j.drugalcdep.2019.107567
Received 1 April 2019; Received in revised form 12 August 2019; Accepted 12 August 2019
Available online 20 September 2019

classic delay discounting task, in this study we use a task that directly assesses drinking related decisions using a hypothetical task format (c.f, Bogg and Finn, 2009; Finn et al., 2017), because of questions regarding the ecological validity of behavioral economic tasks to study drinking decisions (Bogg and Finn, 2009; Finn et al., 2015). Our task assesses the effects of alcohol party incentives and next-day responsibility disincentives on decisions to attend and drink at hypothetical party events (Finn et al., 2017). Decisions on this task have significant ecological validity insofar as they predict actual self-reported quantity and frequency measures of drinking (Finn et al., 2017). Previously, we found that alcohol party incentives promote attendance decisions, while next-day and delayed responsibility disincentives discouraged attendance decisions and were associated with decisions to drink less alcohol at party events (Finn et al., 2017). Additionally, lifetime (LT) alcohol problems were associated with being more sensitive to the effect of high alcohol party incentives on attendance decisions, while LT antisocial problems were associated with being less sensitive to responsibility disincentives (Finn et al., 2017).

This paper extends Finn et al. (2017) by examining the effects of a WM load on decisions to attend and drink at these hypothetical party events. In the initial design of Finn et al (2017), subjects were randomly assigned to either a WM load (n = 387) or no load condition (n = 434), the results of which were reported in Finn et al. (2017). In this paper, we combine that data from the no load condition with the data collected from subjects tested in the WM load condition. As in Finn et al. (2017), because high LT alcohol and antisocial problems are associated with more impulsive and risky decisions and with lower WM capacity, we hypothesized that those with high LT alcohol and antisocial problems would be more impacted by a WM load when making drinking-related decisions. Additionally, because the WM load will compromise attentional control and interfere with the deliberation process while making decisions, we hypothesized that WM load will (a) decrease the impact of the disincentives on drinking-related decisions; (b) increase the impact of immediate incentives on decisions, and, (c) decrease reaction time (deliberation time) for attendance decisions.

2. Methods

2.1. Participants

2.1.1. Recruitment

Participants were recruited using advertisements placed in local and student newspapers and around the community. This approach has been effective in attracting responses from individuals who vary widely in terms of alcohol and antisocial problems and disinhibited traits (Finn et al., 2002, 2009, 2015). The range of ads/flyers targeted "*daring, rebellious, defiant individuals*," "*impulsive individuals*," "*heavy drinkers wanted for psychological research*," persons with a "*drinking problem*" and "*social drinkers*."

2.1.2. Inclusion criteria

To participate, individuals had to: 1.) be 18–30 years old, 2.) be able to read and speak English, 3.) have completed at least 6th grade, 4.) have consumed alcohol on at least one occasion, and 5.) have no history of major head trauma, cognitive impairments, or severe psychological problems. In addition, as in Finn et al. (2015), the sample was recruited to represent a range of lifetime alcohol and antisocial problems. On the day of testing all participants had to: 1.) have a breathalyzer alcohol level of 0.0%, 2.) have at least 6 h of sleep the night before, 3.) have eaten within the last 3 h, and 4.) have not taken any recreational drugs in the past 12 h.

2.1.3. Sample characteristics

Participants (n = 821, 373 women) were primarily college students (76.2%) with a mean age of 21.3 years (SD = 2.5) and mostly Caucasian (78.0%). The remaining participants described themselves as African American (7%), Asian (6.0%), Hispanic (5%), Native American (0.8%), or other (2.3%). There were 232 (132 men / 100 women) who met DSM-IV criteria for lifetime Alcohol Abuse, 326 (181 men / 145 women) who met DSM-IV criteria for alcohol dependence, and 263 (135 men / 128 women) with neither alcohol abuse nor dependence. In addition, 197 (121 males and 76 females) met DSM-IV (APA, 1994) criteria for lifetime childhood conduct disorder and 103 (67 males and 36 females) met diagnostic criteria for adult antisocial personality disorder. Table 1 lists the sample characteristics by sex and WM load.

Table 1
Sample characteristics.

	Men	Women	No Load	WM Load
Sample Characteristics | Mean (SD)				
N	448	373	434	387
Age	21.5 (2.6)	20.9 (2.4)	21.3 (2.5)	21.2 (2.4)
Years education	13.9 (1.7)	14.1 (1.8)	14.1 (1.7)	13.9 (1.8)
LT alcohol problems	18.4 (14.7)	15.6 (12.9)	17.1 (14.1)	17.2 (13.9)
LT antisocial problems	7.9 (6.8)	5.3 (5.7)	6.7 (6.6)	6.7 (6.4)
LT marijuana problems	8.7 (9.8)	4.9 (7.4)	6.7 (8.9)	7.3 (9.1)
Drinking habits | Mean (SD)				
Two-week drinking				
Occasions per week	4.50 (3.25)	3.99 (2.99)	4.27 (3.15)	4.27 (3.14)
Amount per occasion	6.44 (4.98)	4.74 (3.79)	5.66 (4.39)	5.68 (4.73)
Three-month drinking				
Occasions per week	2.69 (1.82)	2.52 (1.63)	2.62 (1.71)	2.61 (1.77)
Amount per occasion	6.47 (5.24)	5.15 (4.01)	5.78 (4.54)	5.98 (5.01)
Diagnostic Status | % (n)				
LT alcohol abuse (no dependence)	30 (132)	27 (100)	26 (112)	31 (120)
LT alcohol dependence	40 (181)	39 (145)	41 (179)	38 (147)
No LT alcohol use disorder	30 (135)	34 (128)	33 (143)	31 (120)
LT childhood conduct disorder	27 (121)	20 (76)	24 (103)	24 (94)
Antisocial personality disorder	15 (67)	10 (36)	12 (51)	13 (52)
LT marijuana abuse	19 (84)	15 (58)	16 (68)	19 (74)
LT marijuana dependence	38 (171)	22 (84)	31 (133)	31 (122)
LT other drug abuse	6 (29)	3 (12)	5 (23)	4.6 (18)
LT other drug dependence	17 (76)	12 (45)	15 (67)	14 (54)
LT, lifetime				

2.2. Procedures

Participants were part of a larger, multi-session, multi-protocol study of the role of working memory in decision-making in those who varied widely in alcohol problems and comorbid externalizing symptoms (Finn et al., 2015; Fridberg et al., 2013). This paper reports the results of one particular protocol that examined the effects of a WM load on drinking-related decisions. After completing a range of diagnostic and other individual difference measures, participants were administered the drinking decision task as outlined below.

2.3. Assessments

2.3.1. Alcohol and antisocial problems

Lifetime alcohol and antisocial behavior problem counts, as well as lifetime DSM-IV diagnoses (*i.e.* alcohol abuse and dependence, childhood conduct disorder and antisocial personality disorder) were assessed with the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA; Bucholz et al., 1994). The SSAGA was administered in person by trained research technicians and Clinical Psychology graduate students under the supervision of the second author, Dr. Peter Finn, a clinical psychologist. In addition, as in Finn et al. (2015), the

sample was recruited to represent a range of lifetime alcohol and antisocial problems such that 25% had relatively low LT alcohol and antisocial, 50% with moderate levels of alcohol and antisocial problems, and 25% with very high levels of alcohol and antisocial problems. These proportions were targeted based on recruitment in earlier studies that employed a dimensional model of alcohol and antisocial problems (Bogg and Finn, 2010; Finn et al., 2009, 2015). Lifetime (LT) problem counts for alcohol and antisocial behavior (*i.e.* childhood conduct disorder and adult antisocial personality) were calculated by summing the number of positive responses to SSAGA questions in their relevant subsections. For the analyses LT alcohol and LT antisocial problem counts were normalized using a Blom transformation, which is an optimal transform for symptom count data (Finn et al., 2009; Krueger et al., 2002; van den Oord et al., 2000).

2.3.2. Current drinking

Current drinking levels were quantified as the mean frequency of drinking occasions (per week) and mean quantity consumed per occasion over the past 2 weeks and past 3 months. Drinking over the past 2 weeks was assessed for each day in the past 2 weeks using a timeline follow-back procedure. Drinking in the past 3 months was assessed as the typical amount consumed on each day of an average week.

2.4. Drinking decision task

The decision scenarios included the alcohol party incentive levels used in Bogg and Finn (2009), but expanded the range of responsibility discentives to include a moderate responsibility disincentive level in an attempt to assess dose-response effects of the level of responsibility disincentives. Rather than present negative consequences as a given, the potential for negative consequences are presented in terms of critical next day responsibility disincentives (*e.g.* a critical test, important job interview) with the implicit assumption that drinking and partying would interfere with meeting these responsibilities thereby increasing the probability of a delayed negative consequence. Disincentives varied by participant role (student, homemaker, nonstudent unemployed, or nonstudent employed).

Participants were presented with different scenarios that described upcoming drinking events on a computer screen (sentence by sentence) with a simultaneous pre-recorded narration of the text presented on the screen. After each scenario, participants decided whether they would attend the event and, if they would attend, they decided how much they would drink (called a consumption decision amount or CDA). As noted above, the scenarios varied in terms of the alcohol party incentives and responsibility disincentives framed in the context of the participant's current role (student, homemaker, nonstudent unemployed, or nonstudent employed). The majority of the sample was self-assigned the scenarios for the student role (79.2%), followed by the nonstudent working role (9.5%), nonstudent nonworking role (10.6%), and homemaker role (0.8%).

The scenarios were organized first with an invitation to attend the event. Then, information was provided about the participant's current context in terms of what responsibilities, if any, occur the next morning or further in the, which reflect the level of potential negative consequences should one attend and drink a lot. The scenario finishes with information about alcohol party incentives to attend. The student role scenarios are further outlined in Section 1 of the Supplemental Materials[2]. The scenarios are identical for all roles except for the responsibility disincentives which are presented for the nonstudent – employed, nonstudent unemployed, and homemaker roles in Section 2 of the Supplemental Materials. Section 3 of the Supplemental Materials outlines the specific task instructions.

2.4.1. WM load manipulation

Participants were randomly assigned to a WM load or no load condition with the goal of ensuring that the full range of externalizing problems were reflected in each condition (Finn et al., 2015). Table 1 indicates that the sample characteristics in each WM load condition are identical. In the WM load condition, after being presented with the scenario information (see below) a 3-digit number appeared on the screen, which participants were instructed to keep in mind for the remainder of the trial. This was followed 2 s later by a text prompt, "press the spacebar when you are ready to answer questions". After the subject pressed the spacebar, the first question appeared (will you attend the event?). After answering all questions, the subject was prompted to recall the 3-digit number and type it in a field on the computer screen. The overall accuracy in recalling the 3-digit number was 86.74%, which was not associated with either a history of alcohol problems ($r = -0.007$, $p = .89$) or antisocial problems ($r = -0.041$, $p = .43$). In the no load condition, after the end of the scenario information, the first question appeared (will you attend the event).

2.5. Data analyses

2.5.1. Decision to attend

Hypotheses regarding decisions (yes/no) to attend the drinking events were analyzed with a repeated measures logistic regression model using SPSS Generalized Linear Models (GenLin: binomial distribution and logit link function). The model was a Sex by WM load by Alcohol Party Incentive Level (AIL) by Responsibility Disincentive Level (RDL) by LT Alcohol Problems by LT Antisocial Problems, where AIL and RDL were repeated measures and LT alcohol and antisocial problems were treated as covariates crossed with each independent factor. Because alcohol problems were highly correlated with antisocial problems (r = .65), interactions involving both variables were not included in the model.

2.5.2. Decision about amount consumed

Hypotheses about consumption decision amounts (how much the participant decided to drink) were analyzed in two ways. The first analysis was a repeated measures regression model (SPSS Generalized Linear Models with normal distribution and identity link function) that assessed the effects of incentives, disincentives, and WM load (as well as LT alcohol and LT antisocial problems) using the entire sample where those who said that they would not attend a drinking event scenario were arbitrarily assigned a value of "0″ for they decided to consume. The second set of analyses (regressions examining the main effect of WM load and LT alcohol and antisocial problems) was conducted within each scenario and just included those participants who said that they would attend the scenario, because these subjects actually made a specific decision about how much they would drink.

3. Results

3.1. Decisions to attend the party event

3.1.1. Effects reported in Finn et al. (2017)

As expected, the current study found the same effects of alcohol party incentives, disincentives, LT alcohol problems, and LT Antisocial problems (and their interactions) reported in Finn et al. (2017). Alcohol party incentives increased attendance decisions ($p < .0001$), whereas disincentives decreased attendance decisions ($p < .0001$). LT alcohol problems were also associated with being more likely to decide to attend party events ($p = .008$). Sections 4,5, and 6 of the Supplementary Materials shows these results.

3.1.2. Effects of WM load on role of alcohol party incentives and responsibility disincentives

As hypothesized, the analyses revealed a significant Disincentive level by WM load interaction, χ^2 (2) = 14.031, p = .001. Table 2 shows these results. Consistent with our hypothesis, simple main effects analyses revealed that compared with the no load condition, the WM load

Table 2
Full table of main effects of linear models tested.

	Type I			Type III		
	Wald Chi-Square	df	Sig.	Wald Chi-Square	df	Sig.
Attendance Decisions						
Disincentives	977.700	2	.000	984.626	2	.000
Incentives	168.021	1	.000	168.585	1	.000
LT Alcohol	22.842	1	.000	7.143	1	.008
Disincentives * WM Load	14.018	2	.001	14.031	2	.001
Incentives * WM Load * LT Alcohol	5.294	1	.021	7.463	1	.006
Reaction Time						
WM Load	59.122	1	.000	60.180	1	.000
LT Alcohol	.025	1	.873	9.062	1	.003
LT Antisocial	22.619	1	.000	23.314	1	.000

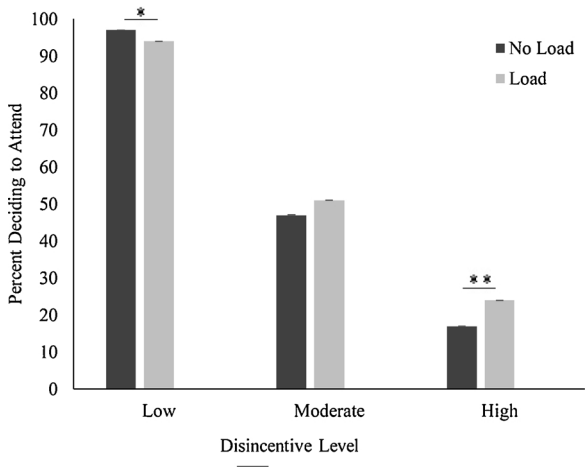

Fig. 1. Attendance decisions by disincentive level and WM Load. *p < .05; **p = .005.

was associated with higher attendance levels in the high disincentive contexts, χ^2 (1) = 7.92, p = .005, OR = 1.51 (95% CI: 1.18, 1.92), but no difference in attendance in the moderate disincentive context, χ^2 (1) = 1.66, p = .198, OR = 1.16 (95% CI: 0.96, 1.41). However, inconsistent with our hypothesis, a WM load was associated with lower attendance levels at the low disincentive contexts, χ^2 (1) = 4.24 p = .040, OR = 0.52 (95% CI: 0.32, 0.86). Fig. 1 displays these data.

The analyses also revealed a three-way interaction effect of Incentive level, WM load, and LT alcohol problems, χ^2(1) = 5.294, p = .006. Table 2 shows these results. Simple effects analyses revealed that the interaction between WM load and LT alcohol problems was significant in high alcohol party incentive contexts, χ^2 (1) = 5.28, p = .022, OR = 1.16 (95% CI: 0.99, 1.37), but not in the low alcohol party incentive contexts, χ^2 (1) = .033, p = .856, OR = 1.07 (95% CI: 0.91, 1.25). To illustrate the simple main effects for LT alcohol problems we divided the sample into high (n = 391, mean LT alcohol problems = 28.74, SD = 11.29) and low LT alcohol problems (n = 430, mean LT alcohol problems = 6.69, SD = 5.14) using a median split. Simple main effects revealed that within the high alcohol party contexts those with low LT alcohol problems were more likely to decide to attend after a WM load (61%, OR = 1.35, 95% CI: 1.08, 1.69) compared to the no load condition (51%), while a WM load was not associated with differences in decisions to attend for those with high LT alcohol problems (65% versus 65%, OR = 0.98, 95% CI: 0.77, 1.24). Fig. 2 displays these effects.

3.1.3. Effects of WM load on reaction time for attendance decisions

The repeated-measures ANOVA revealed a significant main effect of WM load, χ^2 (1) = 59.122, p < .0001. Table 2 shows these results. Attendance decisions were significantly faster after a WM load, 2.58 s (SD = 2.4, Cohen's d = −0.26, 95% CI: −0.31, −0.20) compared with the no load condition, 3.32 s (SD = 3.3). Fig. 3 displays these findings. The analyses also revealed significant main effects of LT alcohol problems, χ^2 (1) = 9.06, p = .003, LT antisocial problems, χ^2 (1) = 23.3, p < .0001, and disincentives, χ^2 (2) = 96.4, p < 00,001. Those with high LT alcohol problems had significantly faster attendance decision reaction times (2.93 + 2.6 s versus 3.01 + 3.2 s, Cohen's d = −0.02, 95% CI: −0.08, 0.03), while LT antisocial problems was associated with slower attendance decision reaction times, 3.13 + 2.9 s for high LT antisocial problems and 2.83 + 2.9 s for low LT antisocial problems (Cohen's d = 0.10, 95% CI: 0.05, 0.16). High and low LT antisocial problem groups were defined using a median split. The main effect of disincentive level revealed that reaction times in the low disincentive context were significantly faster than both the moderate (M = 2.53, SD = 1.84 *vs* M = 3.50, SD = 3.57; t(1) = −9.79, p < .00,001, Cohen's d = −0.34, 95% CI: −0.41, −0.27), and the high (M = 2.53, SD = 1.84 *vs* M = 2.88, SD = 2.98; t(1) = −4.05, p < .00,001, Cohen's d = −0.14, 95% CI: −0.21, −0.07) disincentive conditions. The main effect also revealed that the reaction times in the high disincentive context were also significantly faster than in the moderate disincentive context (M = 2.88, SD = 2.98 *vs* M = 3.50, SD = 3.57; t(1) = −5.40, p < .00,001, Cohen's d = −0.19, 95% CI: −0.26, −0.12).

The effects of WM load on the type of decision (Attend / Not Attend) was further explored within each disincentive condition to establish whether decision speed (*i.e.*, RT) was associated with type of decision (Attend/Not Attend) within each disincentive condition. The analyses (Decision type by WM load) revealed that WM load was significant associated with faster RTs across all conditions, Fs (1817) = 9.3–17.2, ps < 0.01 to .001, Cohen's ds = −0.34 to −0.21. The analyses also revealed with in the low disincentive contexts, RTs were faster for "YES/ Attend" compared with "NO/Not Attend" decisions, F (1817) = 10.9, p < .001, (M = 2.49, SD = 1.73 *vs* M = 3.44, SD = 3.38, Cohen's d = −0.52, 95% CI: −0.76, −0.28), while in the high disincentive contexts, RTs were faster for "NO/Not Attend" compared with "YES/Attend" decisions, F(1817) = 4.8, p < .05, (M = 2.79, SD = 2.86 *vs* M = 3.23, SD = 3.42, Cohen's d = −0.15, 95% CI: −0.27, −0.03). In the moderate condition there were no significant differences in RTs between the "YES/Attend" and "NO/Not Attend" decisions, F(1817) = 2.7, p = .10, (M = 3.52, SD = 3.53 *vs* M = 3.48, SD = 3.61, Cohen's d = −0.01, 95% CI: −0.11, 0.08). There were no significant WM load by Decision type interactions in any disincentive context.

3.2. Decisions about alcohol consumed

The first analysis of the consumption decision amounts (CDAs) for all subjects across all contexts revealed a significant WM load by incentive interaction, χ^2 (1) = 5.89, p = .015. Simple effects analyses revealed that there was significant effect of WM load in high alcohol party incentive contexts. χ^2 (1) = 7.50, p = .006, Cohen's d = 0.11, 95% CI: 0.03, 0.19, but not in low alcohol party incentive contexts, χ^2 (1) = 1.16, p = .281.

The analyses of the CDAs (within each scenario that included only those who said they would attend) revealed significant main effects of WM load in the high party incentive – low disincentive context, F (1794) = 6.14, p = .013, Cohen's d = 0.17, 95% CI: 0.04, 0.31, and in the high party incentive – high disincentive context, F(1204) = 3.89, p = .05, Cohen's d = 0.12, 95% CI: −0.16, 0.39. The WM load increased CDA amount in each of these two scenarios. Table 3 displays these results. LT alcohol problems significantly predicted CDAs within all scenarios, F(1204) = 20.61, p = .00,001, R^2 = .172; F (1316) = 47.61, p = .0001, R^2= .159; F(1483) = 49.06, p = .00,001, R^2 = .147; F(1794) = 59.29, p = .00,001, R^2 = .095; F (1771) = 99.40, p = .00,001, R^2 = .150, except the low party incentive - high disincentive context, F(1119) = 3.17, p = .08, R^2 =

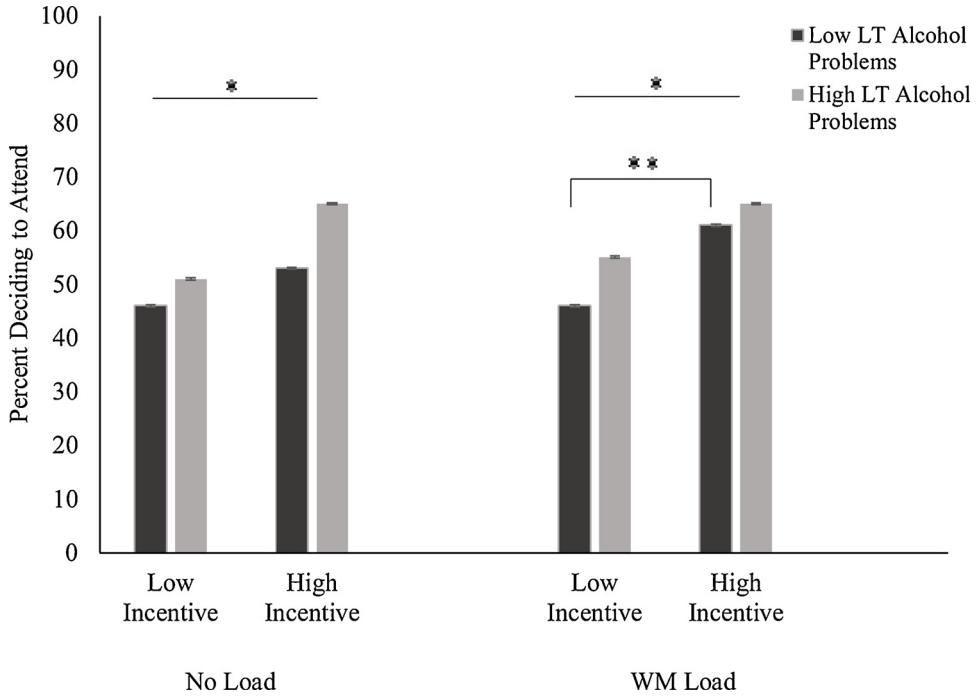

Fig. 2. Attendance decisions by incentive level, WM Load, and LT alcohol problems, *p < .0001, **p < .05.

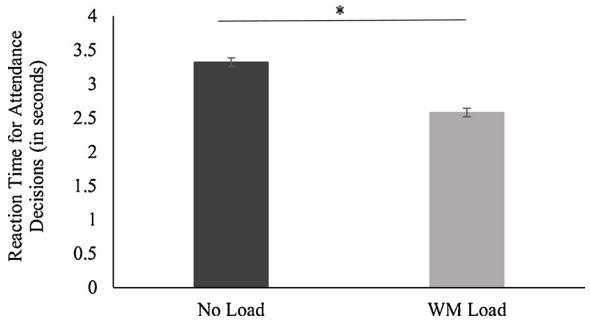

Fig. 3. Reaction times for attendance decisions by WM load, *p < .0001.

Table 3
Consumption decision amounts by party incentive – disincentive context (for participants who said they would attend the event).

Context Type	No Load (n = 434)	WM Load (n = 387)	*p*-value
Low Disincentive			
Low Incentive	4.24 + 2.8 (415)	4.59 + 3.8 (360)	.18
High Incentive	4.39 + 2.6 (427)	5.13 + 5.6 (371)	.01
Moderate Disincentive			
Low Incentive	2.95 + 2.8 (167)	3.05 + 2.6 (153)	.58
High Incentive	3.19 + 2.6 (243)	3.37 + 2.9 (244)	.18
High Disincentive			
Low Incentive	1.90 + 2.5 (52)	1.73 + 2.4 (71)	.89
High Incentive	1.66 + 2.2 (96)	1.94 + 2.6 (112)	.05

.066.

3.3. Drinking decision task validation

As in Finn et al. (2017), the validity of the decision-making task was examined using regression analyses on the association of decisions to attend party events with self-reported frequency of drinking, and the participants' consumption decision amounts with self-reported typical quantity of alcohol consumed per occasion. Logistic regression (Sex by Incentive Level by Disincentive Level by WM load by past 2-week frequency of drinking) was used to assess the degree to which attendance decisions were associated with typical self-reported frequency of drinking. Analyses showed a significant effect of past 2 week frequency of drinking on attendance decisions, χ^2 (1) = 28.162, p = .014, Cohen's d = 0.14, 95% CI: 0.08, 0.19. Regression analyses for each party scenario were conducted to examine the degree to which average quantity of alcohol consumed per drinking occasion over the past 2 weeks predicted drinking amount decisions. The average quantity of alcohol consumed per occasion over the past 2 weeks significantly predicted decisions about amount consumed in all scenarios; Low disincentive – high party, F(1796) = 92.3, p < .0001, R^2 = .10, and low party incentives, F(1773) = 184.8, p < .0001, R^2 = .19; Moderate disincentive – high party, F(1485) = 66.86, p < .0001, R^2 = .12 and low party incentives, F(1318) = 82.9, p < .0001, R^2 = .21; High disincentive – high party, F(1206) = 26.6, p < .0001, R^2 = .11 and low party incentives, F(1121) = 20.1, p < .0001, R^2 = 0.14.

3.4. Supplementary Tables

Sections 4,5, and 6 of the Supplementary Materials shows the full tables of the main effects of models of the decisions to attend, reaction time for attendance decisions, and consumption decision amounts.

4. Discussion

The main purpose of this study was to examine the effects of a WM load on decisions to attend and drink at hypothetical party events that vary in terms of incentives and disincentives in order to assess aspects of the role of WM in drinking-related decisions. The study tested three main hypotheses: the WM load would (a) decrease the impact of the disincentives drinking decisions, because the load should compromise the capacity to shift attention from immediate (reward) to more distal (next day, delayed disincentive) contextual information during the deliberation process thereby reducing the impact of the next-day disincentives on decisions; (b) increase the impact of immediate incentives on decisions, because the party incentives are more immediate and salient and retained more reliably under load; and (c) decrease reaction time for attendance decisions, because the WM load should reduce the

capacity to deliberate about whether to attend an event and, therefore, the amount of time spent deliberating about such decisions. As hypothesized, WM load decreased the impact of high responsibility disincentives on attendance decisions. Under load subjects were more likely to decide to attend high responsibility disincentive events compared with the no load condition. However, the second hypothesis was only partially supported as the WM load actually increased the impact of immediate disincentives on decisions to attend, but only for those low LT alcohol problems. In support of the third hypothesis, the WM load significantly decreased reaction time for attendance decisions as compared to the no load condition.

WM load is thought to impair decision-making by increasing the salience of immediate contingencies and interfering with the capacity to switch attention from more salient, immediate options to less salient, delayed options. This results in impulsive or disadvantageous decision-making, characterized by a tendency to be driven by immediate, and often rewarding, contingencies and less motivated by the potential impact of longer-term contingencies (Finn, 2002; Finn et al., 2015). Our results show that, while WM load appeared to have these effects in the high responsibility disincentive context, this was not characteristic of the low and moderate responsibility disincentive contexts. While it is difficult to interpret these results, it could be that WM load also impairs decision-making by making it more difficult for some to simply utilize the most salient contextual information, and switch attention between the high and low salient information, when making a decision. The most salient contextual information in the low disincentive scenarios is that these contexts are low risk. The most salient contextual information in the high disincentive scenarios is that these contexts are very high risk. However, the WM load resulted in a decreased likelihood of deciding to attend in the low disincentive scenario and an increased likelihood of deciding to attend in the high disincentive scenario, suggesting an impairment in the capacity to interpret or utilize the salient contextual information.

However, what is more clinically relevant is the fact that the WM load increased likelihood of deciding to attend in the higher risk (*i.e.*, high responsibility disincentive) party events. WM load appears to result in a serious neglect to consider the potential severe, but delayed, consequences of attending an event that could result in failing an important class and not achieving future academic goals. This is particularly relevant because a laboratory-induced WM load is thought to mimic real-life distraction, stress, and emotional distress – circumstances that often accompany decisions made in real-life (Finn, 2002; Klein and Boals, 2001; Luethi et al., 2008. Future research examining the specific mechanisms of WM load as it relates to stress and real-life distraction would provide significant insight into potential clinical interventions.

Our results also partially support for the idea that WM load increases the salience of immediate incentives. A WM load significantly increased attendance decisions, but only for those with low LT alcohol problems. The pattern of results suggests that the WM load resulted in those with low LT problems resembling those with high LT problems in the high alcohol party incentive condition. The load substantially increased attendance decisions in the low LT alcohol group making them essentially equivalent to those in the high LT alcohol group. The lack of an effect of the load on incentives in the high LT alcohol group may be due to the fact that the incentives already had a substantial impact on attendance decisions regardless of load in the high LT alcohol subjects.

The WM load also increased the consumption decision amounts in the high alcohol incentive condition. In the high incentive context, the load resulted in decisions to drink more alcohol. Thus, the load resulted in riskier drinking decisions in contexts when alcohol party rewards were more salient. This suggests that the WM load further increased the salience of the alcohol party incentives leading to increased consumption decisions.

Finally, the analysis of reaction time revealed significant main effects of disincentive level, WM load and both LT alcohol and antisocial problems. Reaction times were fastest in the low disincentive contexts. While significantly slower than the low disincentive contexts, reaction times in the high disincentive contexts were still rather fast and much faster than the moderate disincentive contexts. We interpret these effects as reflecting the relatively easy decision to attend the low risk, low disincentive contexts, where most (~95%) participants decided to attend. Likewise, the majority (~80%) of participants decided not to attend the high risk, high disincentive contexts, which also may have been an easy, "no-brainer," decision not to attend a clearly high risk context. On the other hand, the moderate disincentive context was more complex and perhaps more ambiguous concerning risk, thus requiring longer deliberation times. The WM load resulted in faster reaction times for attendance decisions. This is consistent with our hypothesis that the WM load would interfere with the deliberation process leading to less deliberation when making a decision. In cognitive experiments, response times in the range of 500–700 milliseconds are quite common and changes in reaction time in the order of 740 ms after an experimental manipulation (a WM load in this case) is considered to reflect a substantial impact of the experimental manipulation (Ratcliff and McKoon, 2008; Ratcliff et al., 2016). Response time on this scale also corresponds with known neural firing patterns (Dai and Busemeyer, 2014; Ratcliff et al., 2016), suggesting that this decrease in response time reflects a change in neural processing of the hypothetical decision-making task.

However, the effect of WM load on decision reaction times raises the question of whether the faster reaction times under load were associated with making more risky decisions. The follow-up analyses revealed that the decrease in decision reaction time after the load was not specifically associated with the degree of risk in attendance decisions. WM load was associated with faster reaction times for both attendance and non-attendance decisions. Furthermore, the follow-up analyses indicated speed of decision reaction time was not specifically associated with risk. We speculate that decision reaction time speed reflects the relative easiness or difficulty of the decision, where a more difficult decision requires more deliberation (longer RT) and an easy decision requires less (shorter RT). Consistent with this interpretation are the faster decision times for decisions to attend the low-risk, low disincentive scenarios, where the majority of participants said they would attend. Interestingly, reaction times for decisions not to attend the low disincentive events were significantly longer. On the other hand, decisions to attend the highest risk scenarios (*i.e.*, high disincentive contexts) were significantly slower than decisions not to attend. This suggests that a decision not to attend these scenarios did not require much deliberation, whereas a decision to attend, and accept the higher risk of the scenarios, required more deliberation, even though the decision was a "bad" or risky one. Consistent with this result are the findings of Arcurio et al. (2015), who found that alcohol dependent women had longer decision reaction time for risker drinking decisions. Finally, there were no differences in decision reaction times for attendance and nonattendance decisions in the moderate disincentive contexts, suggesting that these decisions were equally difficult and required a similar amount of deliberation regardless of the outcome. Interestingly, LT alcohol problems also were associated with faster reaction times on attendance decisions suggesting that those with higher LT alcohol problems didn't deliberate as long when making decisions about attendance.

The results of this study should be considered in light of its limitations. First, the behavioral task used in this study featured hypothetical contexts and, in turn, hypothetical decisions. This questions the validity of the task for real world decisions. In support of the task's validity are data showing that the task does predict alcohol consumption habits (Finn et al., 2017). In fact, the attendance decisions are most strongly related to the frequency of drinking, while decisions about the amount to drink are most strongly related to the average quantity an individual typically drinks (Finn et al., 2017). However, it is also possible that participants that decided not to attend a party within this task

(earning a '0' for drinks consumed in our analyses) would have decided to engage in drinking in other contexts, such as solo drinking at home or at a bar. This suggests that our findings regarding decisions about quantity of drinks consumed could be limited. Nonetheless, the decisions assessed with this task remain hypothetical and may not reflect exactly what happens in real life contexts. Future work combining this task with real world assessments of decisions using mobile technology, such as ecological momentary assessment methods, should be explored as a means to more accurately assessing the factors that affect drinking decisions. Another limitation of the current sample is our choice of incentives and disincentives. Future studies should examine other kinds of incentives, such as purely social incentives, and disincentives, such as relationship or health disincentives. Lastly, the sample is mainly Caucasian undergraduate students, which limits the generalizability of the results to this population.

4.1. Conclusions

In summary, this study investigated the effects of a WM load on decisions to attend and drink at hypothetical party events. The results indicate that a WM load decreased the impact of high disincentives suggesting that a load increased likelihood of risky decisions to attend drinking events. In addition, the load decreased reaction times for attendance decisions suggesting that the load compromised the deliberation process that is so critical to adaptive decision-making (Finn, 2002). Finally, the WM load increased the salience of the immediate incentives reflected by increased consumption decision amounts and attendance decisions for those low in LT alcohol problems in high incentive contexts. The key relevance of these results for risky, problem drinking is that the WM load had a general effect of disrupting the regulatory decision-making process, in which the influence of incentives and disincentives to drink are considered by thorough deliberation. A WM load can also be seen as a proxy for the effects of situational conditions, such as stress and emotional arousal, suggesting a mechanism by which these kinds of circumstances may increase risky or excessive drinking. These results underlie the importance of further research investigating the role of a WM load and stress or emotional arousal on risky drinking decisions.

Role of funding source

This work was supported by a grant from the National Institute on Alcohol Abuse and Alcoholism, R01AA13650, to Peter R Finn.

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Declaration of Competing Interest

The authors, Polly Ingram and Peter Finn, do not have any financial or personal conflicts of interest relating to the research project reported in the manuscript.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2019.107567.

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