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Sensitivity to reward and punishment and alcohol outcomes: Metacognition as a moderator

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ABSTRACT

Introduction: The purpose of this study was to examine associations between inhibitory (sensitivity to punishment [SP], adaptive metacognition) and facilitatory (sensitivity to reward [SR], maladaptive metacognition) factors of alcohol consumption and problems among young adults.

Methods: Three hundred fifty-five young adults (ages 18–25, 61% female) recruited from Amazon Mechanical Turk and a large public midwestern university in the United States self-administered a Web survey. Two multiple regression models were tested.

Results: SR significantly moderated the effects of SP and the maladaptive metacognition (MC) subscale Uncontrollability/Danger on alcohol consumption. Alcohol problems were also significantly predicted by SR and Uncontrollability/Danger. The interaction between SR and SP on alcohol problems was conditional upon levels of the maladaptive MC subscale Lack of Cognitive Confidence, with a significant moderating effect only at high levels of Lack of Cognitive Confidence.

Conclusions: Consistent with the literature, individuals with high levels of SR coupled with low SP are at risk for increased alcohol consumption. This effect on drinking behaviors is further influenced by maladaptive MC, such that individuals characterized by high SR and low SP are significantly more likely to report more alcohol-related problems if they believe that worrying is dangerous and uncontrollable or lack cognitive confidence; however as SP increases, this effect significantly diminishes.

1. Introduction

Alcohol use and problems are pervasive among young adults. The highest rate of alcohol abuse occurs in young adults, ages 18–25 (Substance Abuse and Mental Health Services Administration; SAMHSA, 2015). Sixty percent (20.8 million) of young adults in the U.S. currently use alcohol, about 40% (13.2 million) binge drink, and 11% (3.8 million) drink heavily (SAMHSA, 2015). Also common among young adults are alcohol-related consequences, which negatively impact life areas including social, educational, as well as both mental and physical health (Champion, Lewis, & Myers, 2015; Read, Haas, Radomski, Wickham, & Borish, 2016). Each year almost 2000 college students pass away from unintentional alcohol-related injuries, nearly 100,000 students report alcohol-related sexual assault or date rape, and one in four students experience academic difficulties directly related to drinking (National Institute on Alcohol Abuse and Alcoholism, 2018). The prevalence of alcohol use on college campuses has remained stable for nearly two decades, suggesting that effective strategies are lacking (Champion et al., 2015). Therefore, the purpose of this study was to examine associations between inhibitory (sensitivity to punishment, adaptive metacognition) and facilitatory (sensitivity to reward, maladaptive metacognition) factors of alcohol consumption and problems among young adults.

1.1. Reward and punishment sensitivity: theory and alcohol outcomes

Gray's revised Reinforcement Sensitivity Theory (rRST; Gray & McNaughton, 2000), a prominent neuroscience theory of personality, provides a valuable framework for understanding problematic alcohol use etiology (Keough & O'Connor, 2014). The rRST postulates three motivational systems of emotion and behavior, the Fight-Flight-Freeze System (FFFS), the Behavioral Activation System (BAS), and the Behavioral Inhibition System (BIS) to underlie responses to reward (SR) and punishment sensitivity (SP; Gray & McNaughton, 2000). The BAS is a multidimensional construct encompassing reward interest and reactivity, goal planning and persistence, and impulsivity (Corr & Cooper, 2016) and is associated with an increased SR (Corr & Cooper, 2016; Gray, 1975). Alternatively, the BIS functions to resolve conflict between

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and within the FFFS (i.e., behavioral avoidance) and BAS (i.e., behavioral approach), and is associated with an increased SP (Corr, 2002). The BIS/BAS systems also act interdependently, per the joint subsystems hypothesis (JSH; Corr, 2002, 2013). Hence, various levels of the interaction between SR and SP (SR × SP) underly unique responses between individuals (Emery & Simons, 2017; Simons, Dvorak, & Lau-Barraco, 2009) and provide further insight into the risk for increased alcohol use and problems.

Several studies have demonstrated that high SR coupled with low SP significantly increases alcohol use (Keough & O'Connor, 2015; Wardell, O'Connor, Read, & Colder, 2011), however the effect of SR × SP on alcohol problems warrants further examination. First, individuals characterized by SP are more likely to use alcohol but only when SR is also elevated (Wardell et al., 2011). Similarly, individuals high in BIS, or "anxiety-prone individuals," that were also high in BAS impulsivity were more likely to continue misusing alcohol after graduating university, whereas those low in BAS rapidly "matured out" of problematic alcohol use (Keough & O'Connor, 2015). Among heavy drinking college students, those characterized by high SR drank more and were more likely to receive an alcohol-related violation from the university, whereas individuals high in SP significantly reduced alcohol use after a violation (Wray, Simons, & Dvorak, 2011). Consistent with alcohol use, high SR coupled with low SP predicted more alcohol problems (Wardell et al., 2011). Hence, SR and SP not only influence the amount of alcohol consumption, but also the likelihood of alcohol consequences. Therefore, examining the effect of SR × SP on alcohol-related problems (e.g., blackout drinking, risky behaviors) is warranted given prior research suggesting alcohol problems tend to occur independently of consumption (Hasking, Boyes, & Mullan, 2015; Simons, Hahn, Simons, & Gaster, 2015; Wardell et al., 2011). Understanding the effect of SR × SP on alcohol problems, while controlling for use, will demonstrate how these behavioral systems predict adverse consequences and disruptions in life beyond drinking.

1.2. Metacognition, sensitivity to reward and punishment, and alcohol outcomes

Metacognitive beliefs (Flavell, 1979; Wells, 2000), or metacognition (MC), refer to the beliefs and knowledge individuals hold about their internal states (i.e., appraisals), ability to cope, and how to cope most effectively (Wells, 2000). Importantly, metacognitive beliefs direct the processes of the Self-Regulatory Executive Function (S-REF) model (Spada, Caselli, Nikčević, & Wells, 2015; Wells & Matthews, 1996). The S-REF model is a cognitive model which aims to reduce internal discrepancies between current (e.g., anxious) and desired states (e.g., relaxed, happy). Thus, MC is an important cognitive mechanism which identifies goals (e.g., desired mood states) and how to achieve them (e.g., coping strategies) via the S-REF model. Notably, MC is further conceptualized as adaptive and maladaptive, and both inform different methods of managing distress based on beliefs about one's cognitive capabilities, knowledge, and past experiences.

Adaptive MC is comprised of three traits including confidence in ability to control and stop worry, engagement in self-reflection and evaluation of external and internal factors (e.g., situation, emotion), and flexibility in problem-solving (Beer & Moneta, 2010). Adaptive MC fosters positive appraisals and effective coping strategies during stressful situations, in addition to inhibiting ineffective coping. As such, adaptive MC is associated with less perceived stress and maladaptive coping (e.g., substance use, rumination) and more adaptive coping (e.g., positive reframing, using functional support; Beer & Moneta, 2012). Individuals that are more likely to engage in self-reflection and have flexibility in problem-solving are likely to report fewer episodes of heavy drinking and debilitating alcohol-related consequences. However, this area of research is underdeveloped.

Maladaptive MC is comprised of five conceptually distinct dimensions: positive beliefs about worry, uncontrollability and danger, cognitive confidence (i.e., attention, memory), need to control thoughts, and cognitive self-consciousness (i.e., awareness of thoughts; Wells & Cartwright-Hatton, 2004). Maladaptive MC promotes ineffective coping strategies (e.g., alcohol use, rumination) thus maintaining distress (Beer & Moneta, 2012). Individuals who desire to control thoughts, have trouble doing so, and lack confidence in their cognitive abilities may be more likely to utilize alcohol to reduce distress. Indeed, maladaptive MC is associated with a range of alcohol-related behaviors. Positive alcohol MC (e.g., drinking helps control my thoughts) predicted higher levels of weekly alcohol use (Clark et al., 2012). Additionally, alcohol dependent drinkers tend to report significantly more negative alcohol MC (e.g., my drinking persists no matter how I try to control it; Spada & Wells, 2010). Positive and negative alcohol MC predict drinking behaviors over and above alcohol expectancies (Spada, Moneta, & Wells, 2007). Maladaptive MC beliefs concerning the need to control thoughts and low cognitive confidence have been demonstrated to predict alcohol use (Spada, Caselli, & Wells, 2009; Spada & Wells, 2005). Maladaptive MC also significantly influences risk factors for alcohol use, such as negative emotions. Individuals with high levels of maladaptive MC were more likely to approach alcohol in response to negative emotions, whereas low levels of maladaptive MC was associated with avoiding alcohol (Monta, 2011). However, alcohol-related consequences were not included in this model. Adaptive MC was also excluded, precluding the potential moderating effect of strategic and flexible thinking on the association between negative emotions and alcohol use.

Metacognitive beliefs may further elucidate the associations between SR, SP, and alcohol use and problems. Namely, engagement in a potentially rewarding behavior induces a positive mood and likely reinforces the respective behavior (i.e., SR), whereas engagement in a behavior characterized by continuous assessment for risk and conflict is associated with more negative emotions (e.g., anxiety) and likely reinforces avoidance of the respective behavior (i.e., SP; Corr & Cooper, 2016). Hence, SR and SP motivate behaviors via anticipated emotions. Adaptive and maladaptive MC may further influence behaviors that are motivated by emotions (i.e., more joy, less anxiety). MC directs attention, assesses capability and knowledge, and subsequently guides the most ideal method to achieve the goal (e.g., obtain reward or avoid punishment; Wells & Cartwright-Hatton, 2004). Thus, understanding how both adaptive and maladaptive MC predict risk of alcohol consumption and alcohol-related problems will inform treatment interventions. For example, interventions may be tailored to reduce maladaptive MC (e.g., worrying is dangerous and uncontrollable) and increase adaptive MC (e.g., increased confidence to manage stress and worry) to decrease the risk of ineffective coping skills, such as alcohol use, motivated by SR and SP. The current study aims to examine the role of cognition (i.e., adaptive and maladaptive MC) in the associations between emotions (i.e., SR and SP) and behaviors (i.e., alcohol use and consequences).

1.3. Current study

The current study examined the effects of adaptive MC and maladaptive MC subscales on the associations between SR, SP, and alcohol use and problems. Namely, the effect of SR × SP on alcohol use and problems was expected to vary as a function of the strength and nature of MC. Adaptive MC, SR, and SP were hypothesized to interact such that adaptive MC would attenuate the effect of SR on the association between SP and alcohol outcomes, resulting in less alcohol use and problems. Maladaptive MC subscales, SR, and SP were expected to interact such that maladaptive MC subscales would exacerbate the effect of SR on the association between SP and alcohol outcomes, in turn increasing alcohol use and problems.

2. Method

2.1. Participants

Eight hundred participants were recruited through Amazon Mechanical Turk (mTurk) and an online research participation program at a midwestern university during Fall 2017 and Spring 2018. Participants provided informed consent and all procedures were approved by the institutional review board. Participants received monetary compensation or partial course credit for participation. Responses were anonymous and all surveys were completed online. The validity of online data collection is supported by previous research (Gosling, Vazire, Srivastava, & John, 2004).

Participant eligibility criteria included being 18 to 25 years old and drinking at least once in the past 90 days. One hundred seventy participants reported their ages outside of the 18–25 range and 133 participants reported either reported no alcohol consumption in the past 90 days or did not respond to this item. Participants who completed the set of measures under 250 s were excluded from analyses (112 participants). Therefore, 415 participants were excluded from analyses due to ineligibility. Thirty additional participants were removed as a result of data cleaning (see Data Handling and Preparation). Final analyses and descriptive statistics are based on data from 355 participants.

The mean age of the analysis sample was $M = 21.12$ ($SD = 2.31$). The analysis sample was 61% female and 39% male. Three percent of the analysis sample identified their ethnicity as.

Hispanic or Latino. With regard to racial demographics, 69% identified as White, 17% as Asian, 5% as Black or African American, 1% as Native American or Alaskan Native, 1% as Native.

Hawaiian or Pacific Islander, 3% as Multiracial, 2% as Other, and 3% did not wish to respond.

2.2. Measures

2.2.1. Reinforcement sensitivity theory of personality questionnaire

Sensitivity to reward and punishment were assessed with the RST-PQ (Corr & Cooper, 2016). The RST-PQ is comprised of 65 items organized into six subscales: Behavioral Inhibition System, Fight-Flight-Freeze System, and four factors of the Behavioral Activation System (reward interest, goal-drive persistence, reward reactivity, impulsivity). Given the significant differences between the BAS subscales (Krupić, Corr, Ručević, Križanić, & Gračanin, 2016), the current study defined SR by summing the reward reactivity and impulsivity subscales. Impulsivity measures the final execution of an action (e.g., drinking) and reward reactivity measures the emotional reaction of receiving a reward (e.g., relaxed, happy; Krupić et al., 2016). These two subscales best capture SR described by the rRST and together are consistent with the conceptualization and measurement of BAS in previous questionnaires (e.g., BIS/BAS Scales, SRSPQ). The RST-PQ uses a 4-point scale ranging from 0 (Not at all) to 3 (Highly) to rate how much the statement generally describes the participant. The scores are summed, and a high score reflects stronger SR or SP. The subscales demonstrated strong internal consistency in the current study (SR $\alpha = 0.87$, SP $\alpha = 0.95$).

2.2.2. Metacognition questionnaire-30

Maladaptive MC was measured with the MCQ-30 (Wells & Cartwright-Hatton, 2004). The MCQ-30 measures five maladaptive MC traits: Positive Beliefs about Worry (e.g., “worrying helps me cope”), Negative Beliefs about Worry concerning Uncontrollability and Danger (e.g., “my worrying could make me go mad”), Lack of Cognitive Confidence (e.g., “I do not trust my memory”), Beliefs about the Need to Control Thoughts (e.g., “I should be in control of my thoughts all the time”), and Cognitive Self-Consciousness (e.g., “I am constantly aware of my thinking”). Each subscale is measured by six items and is scored on a 4-point scale ranging from 0 (Do not agree) to 3 (Agree very much). The scores were summed, where a higher score indicates higher levels of maladaptive MC. The maladaptive MC subscales demonstrated strong internal consistency in the current study ($\alpha = 0.80$–0.91).

2.2.3. Positive metacognitions and positive meta-emotions questionnaire

Adaptive MC was assessed with the PMCEQ (Beer & Moneta, 2010). The PMCEQ includes three subscales: Confidence in Extinguishing Perseverative Thoughts and Emotions, Confidence in Interpreting Own Emotions as Cues, Restraining from Immediate Reaction, and Mind Setting for Problem Solving, and Confidence in Setting Flexible and Feasible Hierarchies of Goals. Each subscale is measured by six items and is scored on a 4-point scale ranging from 0 (Do not agree) to 3 (Agree very much). Scores were summed, with higher scores reflecting high levels of adaptive MC. The adaptive MC scale demonstrated strong internal consistency in the current study ($\alpha = 0.87$).

2.2.4. Modified daily drinking questionnaire

Alcohol consumption was assessed via the DDQ-M (Collins, Parks, & Marlatt, 1985; Dimeff, Baer, Kivlahan, & Marlatt, 1999). Respondents reported the number of standard drinks and hours spent drinking each day during a typical week within the last 30 days. Responses were freely entered numbers. Scores of alcohol consumption were calculated by summing number of drinks for the typical week. Previous research supports the validity and one week test-retest reliability ($r = 0.93$) of this measure of alcohol use (Dimeff et al., 1999). For screening purposes, frequency of alcohol use in the past 90 days was assessed on a 9-point rating scale (e.g., 0 = not at all, 9 = more than once per day).

2.2.5. Young adult alcohol consequences questionnaire

Alcohol-related problems were measured with the YAACQ (Read, Kahler, Strong, & Colder, 2006). The YAACQ is a 48-item self-report measure of negative consequences of alcohol. Responses are rated yes/no. Scores were summed and the total score reflects the number of consequences that were experienced within the past 90 days. Thus, a high score indicates more alcohol consequences experienced. The YAACQ is a valid and reliable measure for alcohol-related consequences in this population and had excellent internal consistency in the current study ($\alpha = 0.97$).

2.2.6. Positive and negative affect schedule scale

Negative affect was assessed via the PANAS (Watson, Clark, & Tellegen, 1988). The PANAS is a 20-item self-report measure used to measure the extent of experiencing positive (e.g., enthusiastic; proud) and negative affect (e.g., irritable; scared) in general. Negative affect is assessed by ten items on a 5-point Likert-type scale from 1 (very slightly or not at all) to 5 (extremely). Negative affect was calculated by averaging the items, where a high score represents high levels of negative affect. Watson et al. (1988) report good internal consistency, as well as good convergent and discriminant validity for this scale. The negative affect subscale has strong internal consistency in the current study ($\alpha = 0.92$).

2.2.7. Careless responding

Careless responding to survey items was measured using three self-report single item (SRSI) indicators (Meade & Craig, 2012). The items measured effort (“I put forth ___ effort towards this study”) and attention (“I gave this study ___ attention”) on 5-point Likert-type scale from 1 (almost no) to 5 (a lot). The third item measured the participant's opinion regarding the use of their data (“In your honest opinion, should we use your data in our analyses in this study?”) with a yes/no response. The SRSI indicators effectively capture careless response tendencies in lengthy online self-report questionnaires (Meade & Craig, 2012).

Table 1
Descriptive statistics.

Variable	N	M (SD)	Range	Skewness	Kurtosis
Gender	354	–	139 (M), 215 (F)	–	–
Source	355	–	126 (T), 229 (U)	–	–
Negative affect	348	1.30 (0.9)	0–4.00	0.47	2.49
Alcohol consumption	352	8.16 (8.43)	0–46.00	1.69	6.41
Alcohol problems	352	13.05 (11.95)	0–48.00	0.92	2.99
SR	348	26.08 (8.65)	0–54.00	−0.21	3.37
SP	348	29.82 (15.06)	0–69.00	0.05	2.45
Adaptive MC	349	26.73 (7.93)	0–54.00	0.38	4.06
Maladaptive MC	352	32.34 (17.48)	0–86.00	0.21	2.52
a. Cognitive conf.	352	5.25 (4.33)	0–18.00	0.59	2.51
b. Positive beliefs	352	5.44 (4.37)	0–18.00	0.50	2.59
c. Self-consciousness	352	8.75 (4.02)	0–18.00	0.05	2.79
d. Uncontrollability	352	6.68 (5.16)	0–18.00	0.31	2.14
e. Need to control Th.	352	6.23 (4.13)	0–18.00	0.38	2.43

Note. N's differ due to missing data. MC = metacognition; SR = sensitivity to reward; SP = sensitivity to punishment. The lettered rows are maladaptive MC subscales. Alcohol Consumption = DDQ-M summed scores.

2.3. Data handling and preparation

All data analyses were performed in Stata 13 (StataCorp, 2013). Preliminary analyses were conducted to determine the ranges and distributions of variables and test assumptions of the model. Observed values were examined for univariate outliers as defined by 3.29 standard deviations away from the mean (Tabachnick & Fidell, 2013). Each case was examined individually and adjusted by reducing the outlying value to one score above the next highest value in the distribution (Tabachnick & Fidell, 2013). This procedure identified 12 outlying values in the self-report data. Variables were also examined for skewness and kurtosis. All variables included in the analyses were relatively normally distributed, and thus no transformations were necessary (see Table 1). Correlations between variables indicated no signs of multicollinearity. Lastly, three cases were removed due to unreliable responses (e.g., reporting 0 alcohol use and 40 alcohol consequences). Twenty-six cases were removed due to careless responding. Hence, 30 of 385 eligible participants (7.8%) were excluded from the analyses.

In the regression models, continuous variables were centered at the mean to facilitate interpretation of interactions (Aiken & West, 1991). Influential cases were determined by Cook's D statistic and leverage-versus-residual squared plots (Cook & Weisberg, 1982). Assumptions of the regression models with respect to homoscedasticity, normality, and lack of patterning of residuals were examined and met by each model (Tabachnick & Fidell, 2013).

3. Results

3.1. Descriptive statistics and correlations

A total of 85% of the analysis sample reporting drinking at least once in the past 30 days and 88% reported at least one alcohol-related problem in the past 90 days. Males indicated significantly more alcohol consumption ($M = 10.52$, $SD = 0.83$) relative to females ($M = 6.66$, $SD = 0.49$), $t(350) = -4.30$, $p < .001$, $d = 0.47$. Males also reported significantly more alcohol problems ($M = 16.09$, $SD = 1.08$) relative to females ($M = 11.10$, $SD = 0.76$), $t(350) = -3.90$, $p < .001$, $d = 0.43$. With respect to source differences, participants from the mTurk sample reported significantly more alcohol problems ($M = 14.53$, $SD = 1.15$) relative to the university participants ($M = 12.21$, $SD = 0.75$), $t(351) = 1.75$, $p = .041$, $d = 0.19$. Lastly, alcohol problems and negative affect were significantly positively correlated. Hence, gender, source, and negative affect were included as covariates in the regression models.

Contrary to hypotheses, alcohol consumption was not significantly correlated with any independent variables. SR, SP, and all maladaptive MC subscales exhibited weak to moderate, positive correlations with alcohol problems. All maladaptive MC subscales also exhibited positive moderate to strong correlations with SR and SP; whereas adaptive MC exhibited a moderate negative correlation with SP and a weak positive correlation with SR. Adaptive MC was significantly negatively correlated with the Lack of Cognitive Confidence and Self-Consciousness subscales and positively correlated with the Uncontrollability/Danger subscale. Adaptive MC was not significantly correlated with any dependent variables; hence this predictor was excluded from the regression analyses. See Table 1 for descriptive statistics and Table 2 for the correlation matrix.

3.2. Regression models

A series of multiple regression analyses were run in which gender, negative affect, and source were controlled and each of the maladaptive MC subscales that were significant in the bivariate analyses were entered simultaneously as interactions with SR and SP (e.g., SR × SP × Uncontrollability/Danger). Nonsignificant ($p > .05$) three-way interactions were removed and nonsignificant two-way interactions were removed iteratively to select a more parsimonious model.

3.2.1. Alcohol consumption

The following interactions were included in the final model: SR × SP and Uncontrollability/Danger × SR. Both two-way interactions were statistically significant, final model, $F(8, 330) = 3.29$, $p = .001$, $R^2 = 0.07$ (see Table 3). The effect size for SR × SP was $f^2 = 0.01$, a small effect (Cohen, 1988). The simple slope of SP on alcohol consumption was significant at 1 *SD* above mean SR ($b = -3.05$, $p = .056$) and nonsignificant at mean SR ($b = -1.01$, $p = .414$) and 1 *SD* above mean SR ($b = 1.02$, $p = .527$; see Fig. 1). The effect size for SR × Uncontrollability/Danger was $f^2 = 0.01$, a small effect (Cohen, 1988). The simple slope of Uncontrollability/Danger on alcohol consumption was significant at 1 *SD* above mean SR ($b = 0.41$, $p = .036$) and nonsignificant at mean SR ($b = 0.08$, $p = .615$) and 1 *SD* below mean SR ($b = -0.25$, $p = .280$; see Fig. 2).

3.2.2. Alcohol problems

Significant interactions retained for the final model included: Lack of Cognitive Confidence × SR × SP, Lack of Cognitive Confidence × SP, Lack of Cognitive Confidence x SR, SR × SP, and Uncontrollability/Danger × SR. The three-way interaction Lack of Cognitive Confidence × SR × SP and two-way interaction Uncontrollability/Danger × SR were statistically significant, final model, $F(13, 325) = 22.15$, $p < .001$, $R^2 = 0.47$ (see Table 4). The effect size for Lack of Cognitive Confidence × SR × SP was $f^2 = 0.06$, a

Table 2
Correlation matrix.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Source	–													
2. Gender	−0.19***	–												
3. Negative affect	0.01	0.05	0.92											
4. Alcohol consumption	0.01	0.23***	0.07	–										
5. Alcohol problems	−0.09	0.21***	0.43***	0.47***	0.97									
6. SR	−0.01	−0.12*	0.16**	0.10	0.29***	0.87								
7. SP	−0.06	−0.10	0.56***	0.03	0.32***	0.44***	0.95							
8. Adaptive MC	−0.11*	0.09	−0.32***	0.07	0.01	0.13*	−0.41***	0.87						
9. Maladaptive MC	−0.21***	0.03	0.51***	0.06	0.43***	0.40***	0.74***	−0.15**	0.95					
a. Cognitive conf.	−0.17**	0.08	0.40***	0.09	0.37***	0.29***	0.47***	−0.11*	0.70***	0.87				
b. Positive beliefs	−0.14**	0.04	0.42***	0.02	0.31***	0.29***	0.55***	−0.07	0.81***	0.48***	0.89			
c. Uncontrollability	−0.19***	0.02	0.22***	0.06	0.25***	0.35***	0.49***	0.14**	0.72***	0.25***	0.51***	0.80		
d. Self-consciousness	−0.14**	−0.06	0.53***	0.04	0.36***	0.31***	0.80***	−0.39***	0.87***	0.51***	0.62***	0.55***	0.91	
e. Need to control Th.	−0.22***	0.07	0.40***	0.05	0.41***	0.39***	0.61***	−0.07	0.87***	0.55***	0.61***	0.59***	0.71***	0.81

Note. Gender was coded (Men = 1, Women = 0). Source (mTurk = 0, University = 1). SR = sensitivity to reward; SP = sensitivity to punishment; MC = metacognition. The lettered rows are maladaptive MC subscales. Cronbach's alphas are on the diagonal.

* $p < .05$.

** $p < .001$.

*** $p < .0001$.

Table 3
Multiple regression of alcohol consumption (N = 339).

	B	*SE B*	*t*	*p*	β
Source	0.58	0.94	0.62	0.539	0.034
Gender	3.70	0.93	3.98	< 0.001	0.219
Negative affect	0.30	0.59	0.51	0.612	0.034
Uncontrollability	0.08	0.15	0.50	0.615	0.047
SR	2.48	1.03	2.40	0.017	0.144
SP	−1.01	1.24	−0.82	0.414	−0.081
Uncontrollability × SR	0.69	0.32	2.14	0.033	0.201
SR × SP	−4.24	2.12	−2.00	0.046	−0.185

Note. Source (mTurk = 0, University = 1). Gender (Women = 0, Men = 1). SR = sensitivity to reward; SP = sensitivity to punishment; Uncontrollability = MCQ-30 uncontrollability/danger subscale.

small effect (Cohen, 1988). The simple slope of SP on alcohol problems was significant at 1 *SD* above mean SR and mean Lack of Cognitive Confidence ($b = -4.02$, $p = .028$) and at 1 *SD* above mean SR and Lack of Cognitive Confidence ($b = -7.25$, $p = .004$); but was not significant at 1 *SD* below mean Lack of Cognitive Confidence and 1 *SD* below mean SR ($b = -2.50$, $p = .231$), mean SR ($b = -1.65$, $p = .299$), and at 1 *SD* above SR ($b = -0.80$, $p = .699$) or 1 *SD* above Lack of Cognitive Confidence and 1 *SD* below mean SR ($b = 4.23$, $p = .152$; see Fig. 3). The effect size for SR × Uncontrollability/Danger was $f^2 = 0.05$, a small effect (Cohen, 1988). The simple slope of Uncontrollability/Danger on alcohol consumption was significant at 1 *SD* above mean SR ($b = 0.76$, $p = .001$) and at mean SR ($b = 0.33$, $p = .048$) and non-significant at 1 *SD* below mean SR ($b = -0.10$, $p = .700$; see Fig. 4).

4. Discussion

The current study assessed associations between sensitivity to reward and punishment, adaptive and maladaptive metacognition traits, and alcohol consumption and related problems. The hypotheses were partially confirmed and the results were consistent with the joint subsystems hypothesis (JSH; Corr, 2002, 2013). Although the hypothesized three-way interactions did not significantly predict alcohol

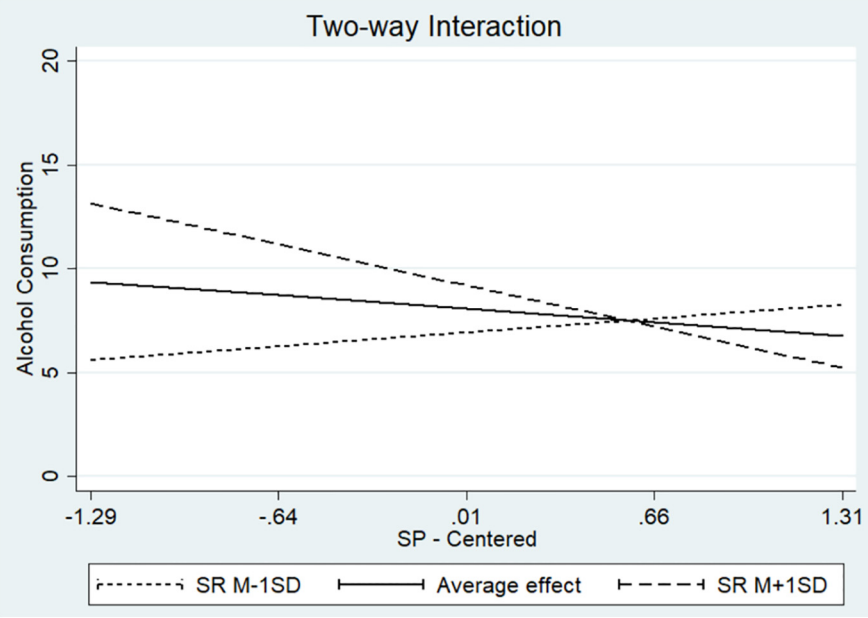

Fig. 1. Association between sensitivity to punishment (SP) and alcohol consumption as a function of sensitivity reward (SR). SP and SR are centered at the mean.

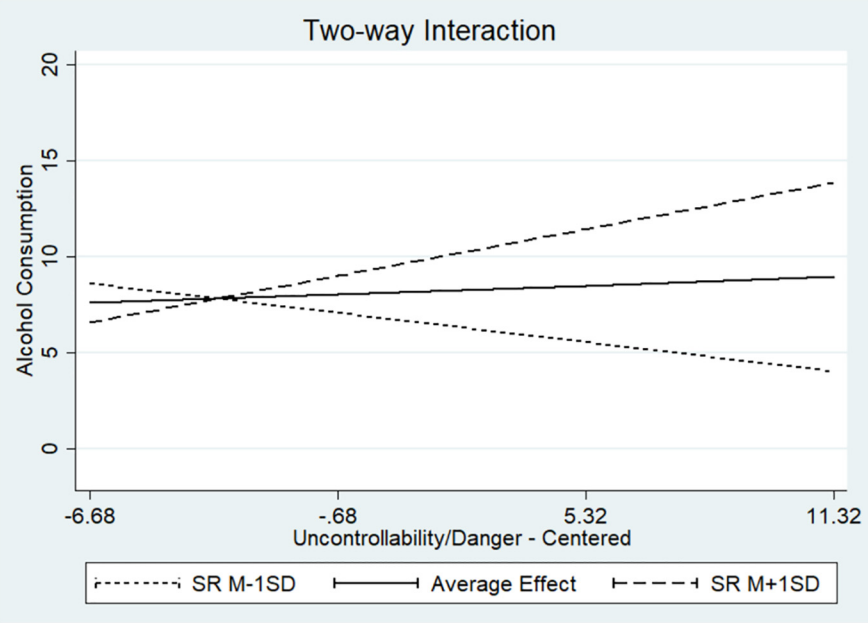

Fig. 2. Association between the Uncontrollability/Danger subscale and alcohol consumption as a function of sensitivity to reward (SR). Uncontrollability/Danger and SR are centered at the mean.

Table 4
Multiple regression of alcohol problems (N = 339).

	B	*SE B*	*t*	*p*	β
Alcohol consumption	0.53	0.06	8.81	< 0.001	0.371
Source	−1.43	1.04	−1.37	0.171	−0.059
Gender	2.58	1.04	2.48	0.014	0.107
Negative affect	3.68	0.66	5.61	< 0.001	0.290
Uncontrollability	0.33	0.17	1.98	0.048	0.145
Cognitive conf.	0.42	0.14	2.90	0.004	0.153
SR	7.42	1.43	5.20	< 0.001	0.302
SP	−1.58	1.38	−1.15	0.252	−0.088
SR × SP	−5.09	2.71	−1.88	0.062	−0.156
Uncontrollability × SR	0.90	0.36	2.51	0.013	0.184
Cognitive conf × SR	−0.17	0.35	−0.49	0.623	−0.031
Cognitive conf. × SP	0.01	0.21	0.07	0.947	−0.003
Cognitive conf. × SR × SP	−1.34	0.43	−3.13	0.002	−0.210

Note. Source (mTurk = 0, University = 1). Gender (Women = 0, Men = 1) SR = sensitivity to reward; SP = sensitivity to punishment; Uncontrollability = MCQ-30 uncontrollability/danger subscale; Cognitive Conf. = MCQ-30 lack of cognitive confidence subscale. Alcohol Consumption = DDQ-M summed scores.

consumption, the interactions SR × SP and SR × Uncontrollability/Danger (i.e., Negative Beliefs about Worry concerning Uncontrollability and Danger) were significant predictors. In addition, the interaction SR × Uncontrollability/Danger significantly predicted more alcohol problems. The hypothesized three-way interaction between SR, SP, and Lack of Cognitive Confidence was a significant predictor of alcohol problems. Overall, understanding the effect of metacognitive beliefs on the associations between SR, SP, and alcohol outcomes is valuable in order to elucidate the interactive cognitive, affective and behavioral mechanisms which facilitate and impede drinking behaviors.

4.1. Alcohol consumption

Contrary to hypotheses, the three-way interactions (SP × SR × adaptive MC; SP × SR × maladaptive MC subscales) did not significantly predict alcohol consumption. Prior studies demonstrated that adaptive and maladaptive MC have been associated with risky drinking and coping motives (Beer & Moneta, 2012; Clark et al., 2012; Spada & Wells, 2005, 2010). However, MC may not be as strongly associated with lower mean levels of drinking quantity, as reported in the current study.

The two-way interaction between SR × SP significantly predicted alcohol consumption. The negative association between SP and alcohol consumption was strongest at high levels of SR. This pattern is consistent with prior research where alcohol use is highest at high levels of SR and low levels of SP; then as SP increases, alcohol use significantly decreases (Keough & O'Connor, 2015; Keough, O'Connor, & Colder, 2016; Wardell et al., 2011). Moreover, the results are theoretically consistent with the rRST and the JSH which suggest that the BIS and BAS influence both reward-mediated and punishment-mediated behavior (Corr, 2002). Namely, the relative strengths of the appetitive or aversive stimuli are associated with particular SR × SP patterns such that facilitatory factors (i.e., high SR, low SP) are more likely to be at work with appetitive stimuli (Corr, 2002). The positive correlation between alcohol use and SR approached significance and the non-significant alcohol use-SP association suggests the current sample of young adults viewed drinking as a more rewarding, rather than threatening or risky activity. Accordingly, the SR × SP interaction indicated that individuals with high levels of SR coupled with low SP consumed the most alcohol. Notably, the association between SP and alcohol consumption is negative at high levels of SR, suggesting that SP may be a protective factor via buffering the effect of SR on alcohol consumption. In sum, the results suggest that individuals tend to consume more alcohol due to high levels of appetitive motivation and few worries or concerns about potential consequences, but then significantly reduce consumption as sensitivity to punishment increases, irrespective of appetitive motivation.

The two-way interaction between SR × Uncontrollability/Danger significantly predicted alcohol consumption. The positive association between Uncontrollability/Danger and alcohol consumption was also strongest when SR was high. Previous studies have demonstrated the effect of subscales Need to Control Thoughts and Lack of Cognitive Confidence on alcohol use via regression models (Spada et al., 2009; Spada & Wells, 2005), citing the deleterious effects of maladaptive MC on drinking in response to negative beliefs about thoughts. However, previous studies reported Uncontrollability/Danger to only demonstrate significant correlations with alcohol use (Spada et al., 2009) as

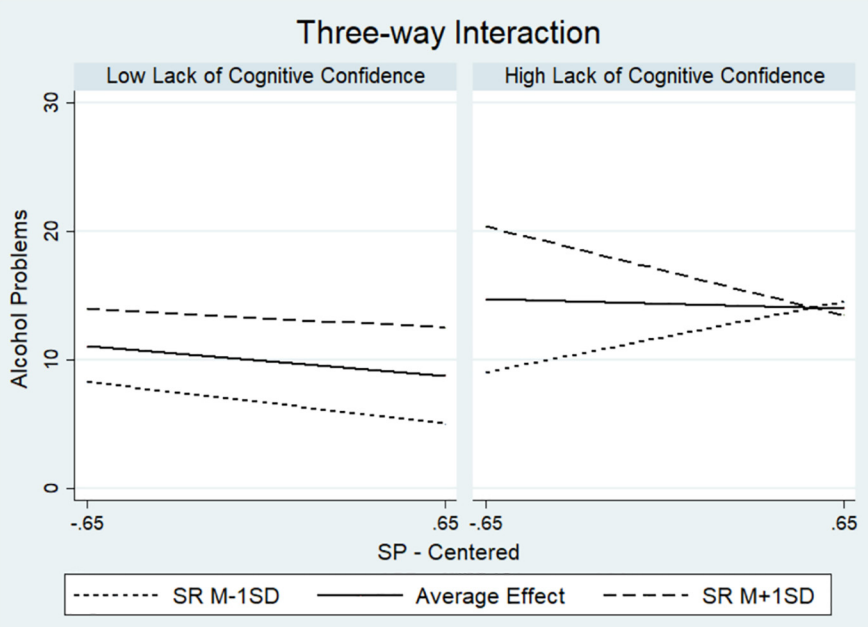

Fig. 3. Sensitivity to reward × sensitivity to punishment at M-1 SD lack of cognitive confidence (left) and M + 1 SD lack of cognitive confidence (right). SP = sensitivity to punishment, SR = sensitivity to reward, MC = metacognition. SR, SP, and lack of cognitive confidence are centered at the mean.

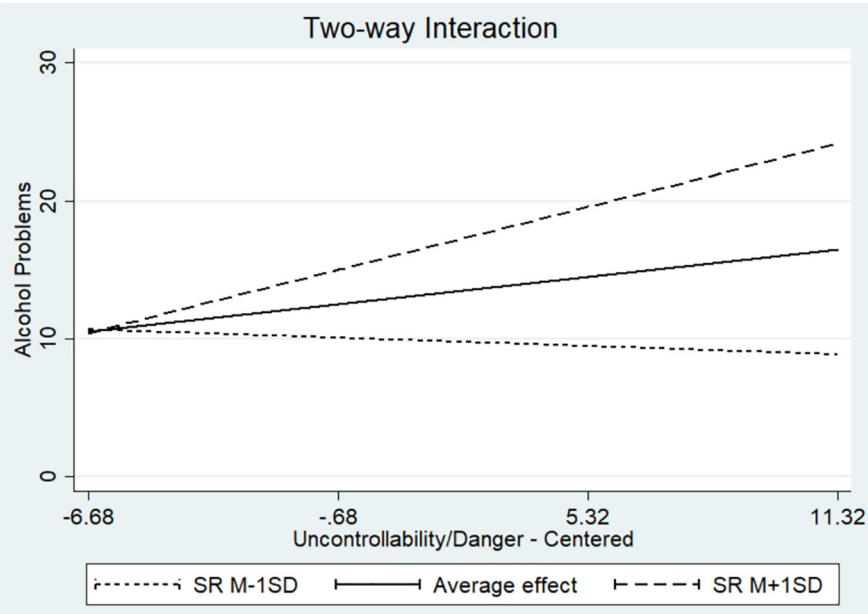

Fig. 4. Association between the Uncontrollability/Danger subscale and alcohol problems as a function of sensitivity to reward (SR). Uncontrollability/Danger and SR are centered at the mean.

well as symptoms of alcohol dependence, anxiety, and depression; notably, Uncontrollability/Danger is most strongly correlated with anxiety ($r = 0.68$) and alcohol dependency symptoms ($r = 0.28$) relative to the other maladaptive MC subscales (Spada & Wells, 2005). The current study provides further understanding of the effect of maladaptive MC on drinking behaviors, demonstrating that traits of impulsivity and reward-orientation appear to significantly increase the risk of acting (e.g., drinking) in response to the negative beliefs about uncontrollability and danger. Given that negative beliefs about worry concerning uncontrollability and danger consist of fears related to not being able to control worrying thoughts and their consequences (Wells & Cartwright-Hatton, 2004), individuals may feel a sense of hopelessness, thus perceive few effective, regulation strategies; thus, an increased SR may move individuals towards attempting to control these thoughts with alcohol for immediate relief.

4.2. Alcohol problems

As hypothesized, the three-way interaction between Lack of Cognitive Confidence, SR, and SP significantly predicted alcohol problems, controlling for alcohol consumption. Specifically, the two-way interaction between SR and SP changed as a function of Lack of Cognitive Confidence, such that the buffering effect of SP on the association between high SR and alcohol problems significantly strengthened at mean and high levels Lack of Cognitive Confidence. Also, the number of alcohol-related problems was the highest at high levels of

Lack of Cognitive Confidence coupled with high SR and low SP. The results are consistent with previous research demonstrating that the effect of reward reactivity on drinking behaviors is strengthened by poor inhibitory control (Kim-Spoon et al., 2016). Moreover, this study further contributes to existing research by incorporating the JSH. Poor cognitive confidence appears to strengthen the effect of the interaction SR × SP on alcohol consequences, suggesting that poor confidence in cognitive self-regulation may contribute to a greater influence of reward and punishment sensitivity on drinking behaviors.

The current results integrate a self-regulatory cognitive processing model (i.e., S-REF model) and personality theory of motivational systems of emotion and behavior (i.e., SR and SP) to further understand inhibitory and facilitatory factors of alcohol use and problems. The results suggest that maladaptive MC further affects behaviors motivated by SR × SP. The S-REF model functions to achieve a desired state, such as feeling happier or less sad. The current study demonstrated that as maladaptive MC guides this self-regulation process, a strong and impulsive desire for immediate reward (i.e., high SR) coupled with little concern for the potential consequences (i.e., low SP) significantly increases the risk for alcohol-related problems; however, this risk is significantly buffered by high levels of SP. Moreover, SR × Uncontrollability/Danger significantly predicted increased alcohol-related problems while controlling for alcohol consumption. This is consistent with the results of the alcohol consumption model, such that risk for alcohol problems significantly increase when negative beliefs about uncontrollability and danger are exacerbated by SR.

The hypothesized three-way interaction between SR, SP, and adaptive MC was not supported. Although adaptive MC has not been extensively studied in the substance use research literature, one study has reported that adaptive MC is negatively associated with perceived stress and coping with substances (Beer & Moneta, 2012). Therefore, adaptive MC may be associated with more general reward cues, extending beyond the specific effects of alcohol.

4.3. Limitations

There are several limitations that should be noted. First, causal relationships cannot be determined due to the cross-sectional design of the study. Second, the measures used in this study are self-report items assessing behaviors from the past one to three months. Therefore, the responses are susceptible to memory biases as well as positive or negative impression management. Future research may benefit from examining the associations between MC, SR, SP and drinking motives to parse out negative and positive reinforcement motivation. Furthermore, future research may also benefit from examining interactions between self-regulatory beliefs and behavioral tendencies in other substances of abuse and risk-taking behaviors (e.g., non-suicidal self-injury).

5. Summary

Examining the independent and interactive effects of cognitive, affective, and behavioral processes on alcohol outcomes is important for clarifying and advancing the conceptualization of maladaptive patterns of substance use. This study tested the effects of adaptive and maladaptive MC traits, SR, and SP on alcohol consumption and problems. First, the effects of SP and Uncontrollability/Danger on alcohol consumption were strongest at high levels of SR. Second, Lack of Cognitive Confidence moderated SR × SP, where SP had an increasingly strong buffering effect on the association between high SR and alcohol-related problems when Lack of Cognitive Confidence was high. These results demonstrate the significance of metacognitive beliefs in understanding the risk of alcohol use and problems associated with different patterns of reward and punishment sensitivity.

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Contributors

Rebecca Sistad and Raluca Simons designed the study and wrote the protocol. Rebecca Sistad conducted literature searches, wrote the manuscript, and completed the suggested revisions. Jeffrey Simons assisted with statistical analyses. All authors contributed to and have approved the final manuscript.

Declaration of competing interest

All authors declare that they have no conflicts of interest.

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