

# Weekly Energy Drink Use Is Positively Associated with Delay Discounting and Risk Behavior in a Nationwide Sample of Young Adults

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**Background:** Energy drink use is associated with increased risk behavior among adolescents and college students. This study examined this relationship in a nationwide sample of young adults and also examined relations between energy drink use and delay discounting.

**Methods:** Participants were 874 U.S. adults 18–28 years of age with past 30-day consumption of caffeine and alcohol. Participants completed an online survey of energy drink use, drug use, sexual activity, alcohol misuse (alcohol use disorders identification test [AUDIT]), sensation seeking (four-item Brief Sensation Seeking Scale [BSSS-4]), and delay discounting of monetary rewards and condom use.

**Results:** Over one-third of participants ( $n=303$ ) reported consuming energy drinks at least once per week. Weekly energy drink users were more likely than less-than-weekly energy drink users to report a recent history of risk behaviors, including cigarette smoking (56% vs. 28%,  $p<0.0001$ ), illicit stimulant use (22% vs. 6%,  $p<0.0001$ ), and unprotected sex (63% vs. 45%,  $p<0.0001$ ). Covariate-adjusted analyses found that weekly energy drink users did not have significantly higher BSSS-4 scores (3.5 vs. 3.1,  $p=0.098$ ), but they had higher mean AUDIT scores (8.0 vs. 4.8,  $p<0.0001$ ), and they more steeply discounted delayed monetary rewards. Although weekly energy drink users did not show steeper discounting of delayed condom use, they showed a lower likelihood of using a condom when one was immediately available.

**Conclusions:** This study extends findings that energy drink use is associated with risk behavior, and it is the first study to show that energy drink use is associated with monetary delay discounting.

## Introduction

THE POPULARITY of energy drinks is growing at a remarkable rate. According to industry reports, annual sales of energy drinks and shots rose 60% in the United States between 2008 and 2012, and sales are expected to continue to increase at a similar rate, exceeding \$21 billion per year in 2017.<sup>1</sup> Energy drink use has become particularly common among teenagers and young adults. Although recent nationwide data on energy drink consumption are scarce, some researchers estimate that over 18% of young adults consume energy drinks at least weekly,<sup>2</sup> and, among college students, this percentage may be as high as 39%.<sup>3</sup>

Emerging evidence points to a relationship between energy drink use and various risk behaviors, including

alcohol abuse,<sup>2–10</sup> cigarette smoking,<sup>2,6–9,11–13</sup> illicit drug use,<sup>2,6–9,11–13</sup> nonmedical use of prescription drugs,<sup>5,6,8,11,14</sup> fighting,<sup>8</sup> and sexual risk behavior.<sup>8</sup> One of the primary aims of this study was to replicate and extend these findings. Although previous studies typically surveyed high school and university students,<sup>3,4,7–11,14</sup> this study collected data from a nationwide sample of young adults using Amazon Mechanical Turk (MTurk), a website that allows researchers to rapidly and affordably collect data from a population of over 500,000 MTurk account holders.<sup>15–18</sup> MTurk is a popular platform for participant recruitment and data collection among behavioral and social scientists, and several studies conducted with MTurk have replicated empirical and descriptive results obtained through traditional laboratory and survey methods.<sup>19–22</sup>

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Another aim of this study was to examine associations between energy drink use and delay discounting.<sup>23–25</sup> As the delay to a reward increases, its perceived value typically decreases, and many risk behaviors are associated with increased delay discounting. For example, individuals with a history of risk behavior often discount delayed monetary rewards more so than individuals without such a history.<sup>26–28</sup> Importantly, the concept of delay discounting has been extended from monetary rewards to other domains, including condom use. The Sexual Delay Discounting Task was developed to examine hypothetical choices between immediate unprotected sex and delayed sex with a condom.<sup>29</sup> This task shows good test–retest reliability,<sup>30</sup> and the outcomes are associated with self-reported sexual risk behavior.<sup>29,31–33</sup> As with monetary delay discounting, individuals with a history of risk behavior (e.g., substance abuse) show steeper delay discounting of condom-protected sex.<sup>31–34</sup> Collectively, studies that examined monetary and sexual delay discounting outcomes suggest that delay discounting is a fundamental behavioral process related to risk behavior. To our knowledge, however, no studies have investigated the relationship between energy drink use and monetary or sexual delay discounting.

## Methods

### Participants

Participants were recruited via MTurk (www.mturk.com). Researchers created an MTurk “Requester” account and posted the study on a searchable database of “Human Intelligence Tasks” (HITs). Keywords for the HIT were as follows: survey, demographics, psychology, and questionnaire. The HIT could be viewed only by individuals registered as “Workers” on MTurk who resided in the United States and had an approval rating from former Requesters that was  $\geq 95\%$ .<sup>35</sup> The HIT was titled, “Behavioral health & decision-making study,” and its stated purpose was to learn how individuals “make decisions related to diet, sex, money, and drugs.” The HIT was launched on Tuesday, July 29, 2014 at 10:47 AM EST and closed on Sunday, August 3, 2014 at 9:40 PM EST.

Participants who selected the HIT were informed that they would receive up to \$3.00 for successful completion of the HIT: \$1.50 for completing the HIT and a \$1.50 bonus for paying attention during the survey and answering questions carefully. Participants were required to pass a brief qualification survey before they could access the main survey. After informed consent was obtained, the qualification survey assessed the following undisclosed inclusion criteria: participants had to be 18–28 years of age, reside in the United States, and correctly answer two attention check questions (i.e., “trick” questions<sup>35</sup>). Individuals who reported no caffeine or alcohol use in the past month were excluded from partic-

ipation. In addition, individuals who indicated that they did not want to answer questions about sexual, criminal, and drug use history were excluded from participation.

Of the 2794 participants who took the qualification survey, 1650 participants were excluded and not permitted to take the main survey because they reported that they were 29 years of age or older. Among the remaining participants, 1014 met all other inclusion criteria and took the main survey. The main survey took an average of 32 minutes and 14 seconds to complete. Data from participants who did not complete the main survey or failed to pass additional attention check questions contained within the main survey were excluded from analysis. The final study sample included 874 participants. Study procedures were approved by the Johns Hopkins University Institutional Review Board.

### Measures

The survey was hosted by Qualtrics (Provo, UT) and contained questions about demographics, energy drink consumption, drug use, sexual risk behavior,\* alcohol misuse, sensation seeking, and delay discounting.

Alcohol misuse was assessed with the 10-item alcohol use disorders identification test (AUDIT).<sup>36</sup> AUDIT scores range from 0 to 40, with higher scores indicating greater alcohol misuse.

A four-item version of the Brief Sensation Seeking Scale (BSSS-4),<sup>37,38</sup> was used to assess propensity for sensation seeking. BSSS-4 scores range from 1 to 5 with higher scores indicating greater sensation seeking.

A 27-item monetary choice questionnaire<sup>39</sup> was used to assess delay discounting of hypothetical monetary rewards. Discounting rates obtained with this commonly used brief task are well correlated with those obtained with a more comprehensive discounting procedure.<sup>40</sup> The monetary choice questionnaire contains nine questions about each of three delayed reward magnitudes: small (\$25, \$30, or \$35), medium (\$50, \$55, or \$60), and large (\$75, \$80, or \$85). Participants were presented with a series of choices between a smaller amount of money today and a larger amount of money after a variable delay (e.g., “Would you prefer \$20 today or \$55 in 7 days?”; see Kirby *et al.*<sup>39</sup> for a complete list of questions).

The Sexual Delay Discounting Task<sup>29</sup> was used to assess delay discounting of condom use in casual sex situations. A detailed description of the task, including an illustration, has been previously published.<sup>32</sup> Briefly,

\*Sexual risk questions were adapted from Miller.<sup>8</sup> These and all other survey questions were the same across participants with one exception—a question about past year unprotected sex contained different languages for “never-married” versus “ever-married” participants. Never-married participants were asked, “During the past year, how many times have you had sexual intercourse without using a condom?”; whereas, ever-married participants were asked, “During the past year, how many times have you had sexual intercourse without using a condom with someone other than your current or former spouse?”

participants were presented with an array of 60 photographs of racially and ethnically diverse, clothed individuals (30 men and 30 women) and instructed to check a box next to the photograph of each individual with whom they would be willing to have sex, assuming they were not in a committed relationship, they liked the individual's personality, and there was no risk of pregnancy. Alternatively, participants could select the following option: "I would not have sex with any of the people above, even if I liked their personalities and was not in a committed relationship." Participants who selected this option and participants who did not select at least two photographs could not complete the remainder of the Sexual Delay Discounting Task.

Participants were asked to identify from among their selections the individual who they (1) most wanted to have sex with ("most sex"), (2) least wanted to have sex with ("least sex"), (3) believed was most likely to have a sexually transmitted infection ("most STI"), and (4) believed was least likely to have an STI ("least STI"). The remaining questions in the Sexual Delay Discounting Task pertained only to the photographs that represented these four partner conditions. In the presence of the photograph and the corresponding description of the partner condition (e.g., "This is the person you would MOST want to have sex with."), participants used a visual analog scale to rate the likelihood that they would use a condom to have sex with the partner if a condom was readily and immediately available (i.e., the "zero-delay trial"). The leftmost position on the scale specified "0" along with the text "I will definitely have sex with this person without a condom." The rightmost position on the scale specified "100" along with the text "I will definitely have sex with this person with a condom." Participants then used similar visual analog scales to rate the likelihood that they would have immediate sex without a condom versus waiting to have sex with a condom at each of the following delays presented in ascending order: 1 hour, 3 hours, 6 hours, 1 day, 1 week, 1 month, and 3 months. Due to a programming error, the 1 month delay scenario was not presented to some participants; thus, data from this delay scenario were excluded for all participants in data analyses.

#### Data analysis

**Energy drink use.** Participants were asked, "During a typical week, on how many days do you drink energy drinks?" (The following products were listed as examples: Red Bull, 5-hour ENERGY Shot, Monster Energy, Rockstar, NOS, Amp, Full Throttle, and Xyience.) From a drop-down menu, participants could choose one of eight response options, ranging from "0" to "7." Participants were dichotomized as "less-than-weekly energy drink users" if they reported drinking energy drinks on 0 days during a typical week ( $n=571$ ) or "weekly energy drink users" if they reported drinking

energy drinks on at least 1 day during a typical week ( $n=303$ ). Selection of these two response categories was informed by previous research<sup>2-4</sup> and the distribution of responses to this question (the majority of weekly energy drink users [ $n=168$ ] consumed energy drinks on 1 day per week, and very few weekly energy drink users [ $n=47$ ] consumed energy drinks on 4 or more days per week).

**Monetary delay discounting.** Delay discounting data were analyzed under the assumption of a hyperbolic model of decay:  $V=A/(1+kD)$ , wherein,  $V$  represents subjective reward value,  $A$  is the objective or nondiscounted reward value,  $D$  is the delay to reward, and  $k$  is a free parameter that corresponds with the rate of delay discounting.<sup>41</sup> The monetary choice questionnaire was designed such that a participant's discounting parameter,  $k$ , could be estimated based on the pattern of responding across the items.<sup>39</sup> We identified the point at which each participant switched from a smaller-sooner preference to a larger-later preference within each delayed reward magnitude and calculated the geometric mean of the  $k$  values for the last smaller-sooner choice item and the first larger-later choice item (see Kirby *et al.*<sup>39</sup> for a complete list of questionnaire items and corresponding  $k$  values). When choices were nonsystematic (i.e., more than one switch point), then  $k$  values were not estimated for that participant ( $k$  values were not estimated for 21% of the final sample;  $n=185$ ). Values of  $k$  ranged from 0.00016 (all larger-later choices) to 0.25 (all smaller-sooner choices). Because the distribution of  $k$  values was non-normal, we applied a  $\log_{10}$  transformation to all values before further analysis.

Responses on the monetary choice questionnaire were also analyzed in terms of the proportion of larger-later choices overall and at each reward magnitude for all participants. Although the proportion of larger-later choices is highly correlated with  $k$  values, it does not assume the hyperbolic model of delay discounting.<sup>42</sup>

**Sexual delay discounting.** Eighty-eight percent of participants ( $n=767$ ) completed the Sexual Delay Discounting Task. For these participants, likelihood of condom use was plotted as a function of delay to condom availability (in hours) and was summarized using an area under the curve (AUC) measure,<sup>43</sup> which ranged from 0 to 1 (corresponding to 0-100% likelihood of having condom-protected sex at each delay). Because individual differences occur in the likelihood of using an immediately available condom, a standardized AUC measure was calculated for each partner condition to isolate the effect of delay on the likelihood of condom use. For the standardized AUC measures, the likelihood value for each delay in each partner condition was divided by the likelihood value of the zero-delay trial in that condition. Thus, data from participants who reported zero

likelihood of using an immediately available condom ( $n=123$  in the “least STI” partner condition;  $n=9$  in the “most STI” partner condition;  $n=46$  in the “least sex” partner condition;  $n=120$  in the “most sex” partner condition) were excluded from the standardized AUC analysis because the effect of delay on the value of condom-protected sex was undefined. Lower standardized AUC values indicate a lower likelihood of waiting to engage in condom-protected sex (i.e., steeper delay discounting), and higher standardized AUC values indicate a greater likelihood of waiting to engage in condom-protected sex (i.e., shallower delay discounting).

**Statistical analyses.** Statistical analyses were conducted with SPSS® 22 (Armonk, NY) and SAS® 9.3 (Cary, NC). Demographic characteristics were compared between groups using independent  $t$ -tests and chi-square tests. To test the internal validity of the monetary choice task, discounting for the three magnitude ranges within the task were compared within-subjects using repeated measures analysis of variance (ANOVA). Subsequent analyses of the task used composite measures across magnitudes: mean  $\log_{10} k$  and overall proportion of larger-later responses. To test the internal validity of the Sexual Delay Discounting Task, discounting between the two pairs of partner conditions (i.e., “most sex” vs. “least sex” and “most STI” vs. “least STI”) were compared within-subjects using repeated measures ANOVA.

Logistic regression was used to examine the relationship between energy drink consumption and self-reported risk behavior (e.g., cigarette smoking, illicit drug use, unprotected sex) while adjusting for the following demographic variables: age, sex, race, employment, education, income, and marital status. In addition, AUDIT scores, BSSS-4 scores, monetary delay discounting measures (mean  $\log_{10} k$  values and proportion of larger-later choices), and sexual delay discounting measures (zero-delay likelihood of condom use and standardized AUC) were analyzed with a one-factor model (weekly energy drink use) covarying for the same demographic variables listed above plus past year cigarette smoking and past year use of any illicit drugs or nonmedical use of prescription drugs with a compound symmetry covariance structure in SAS Proc Mixed. These additional covariates were included in the analysis because previous research has shown that cigarette smoking and illicit drug use are related to delay discounting,<sup>24,27,32–34</sup> sensation seeking,<sup>44,45</sup> and alcohol misuse.<sup>46</sup> Further, AUDIT score was added as a covariate in the analysis of BSSS-4 scores, monetary delay discounting measures, and sexual delay discounting measures to adjust for the potential influence that alcohol misuse may have on these outcomes.

## Results

Demographic characteristics are displayed in Table 1. Weekly energy drink users and less-than-weekly energy

drink users were similar across most characteristics. The mean age of weekly energy drink users ( $M=24.1$ ,  $SD=2.6$ ) was significantly higher than that of less-than-weekly energy drink users ( $M=23.7$ ,  $SD=2.7$ ,  $t=-2.09$ ,  $p=0.037$ ); however, it is unlikely that this difference of 0.4 years was clinically meaningful. A significantly lower percentage of weekly energy drink users were female (51% vs. 68%,  $\chi^2=22.7$ ,  $p<0.0001$ ), students (21% vs. 32%,  $\chi^2=9.95$ ,  $p=0.002$ ), and unemployed (11% vs. 20%,  $\chi^2=11.5$ ,  $p=0.001$ ), and a significantly higher percentage of weekly energy drink users were employed full-time (50% vs. 33%,  $\chi^2=24.2$ ,  $p<0.0001$ ) and divorced (5% vs. 1%,  $\chi^2=14.4$ ,  $p<0.001$ ).

Outcomes related to past year drug use, sexual risk behavior, and other risk behavior are displayed in Table 2. After adjusting for demographic characteristics, weekly energy drink users were significantly more likely than less-than-weekly energy drink users to report all risk-related outcomes with the exception of one outcome (i.e., past year engagement in an activity that led to the physical injury of oneself or others).

AUDIT scores, BSSS-4 scores, and delay discounting outcomes are displayed in Table 3. Weekly energy drink users had significantly higher AUDIT scores ( $M=8.0$ ,  $SD=6.4$ ) than less-than-weekly energy drink users ( $M=4.8$ ,  $SD=4.3$ ,  $p<0.0001$ ), and they had significantly higher BSSS-4 scores ( $M=3.5$ ,  $SD=0.8$  vs.  $M=3.1$ ,  $SD=0.8$ ,  $p<0.0001$ ). As shown in Table 3, between-group differences in mean AUDIT scores remained significant after adjusting for demographic characteristics and past year drug use. However, between-group differences in BSSS-4 scores were no longer significant after adjusting for AUDIT score and other covariates.

In testing the internal validity of the monetary choice questionnaire, a significant main effect of magnitude was found in which larger rewards were discounted less steeply than smaller rewards ( $\log_{10} k$ ,  $F=664.32$ ,  $p<0.0001$ ; proportion larger later responses,  $F=731.55$ ,  $p<0.0001$ ), replicating a well-established finding of monetary delay discounting.<sup>47</sup> Also replicated was the finding that overall proportion of larger-later choices was highly correlated with mean  $\log_{10} k$  ( $r=-0.99$ ,  $p<0.0001$ ).<sup>42</sup> Weekly energy drink users had higher mean  $\log_{10} k$  values than less-than-weekly energy drink users ( $M=-1.79$ ,  $SD=0.66$  vs.  $M=-2.04$ ,  $SD=0.69$ ,  $p<0.0001$ ), indicating steeper discounting of delayed monetary rewards, and they chose a significantly lower proportion of larger-later rewards than less-than-weekly energy drink users ( $M=0.40$ ,  $SD=0.18$  vs.  $M=0.46$ ,  $SD=0.19$ ,  $p<0.0001$ ). As shown in Table 3, these differences remained significant following the covariate adjusted analyses.

In testing the internal validity of the Sexual Delay Discounting Task, a significant effect of partner condition on standardized AUC was found (“most sex” AUC < “least sex” AUC,  $F=372.18$ ,  $p<0.0001$ ; “most STI” AUC > “least STI,”  $F=439.48$ ,  $p<0.0001$ ), which

TABLE 1. DEMOGRAPHIC PROFILE OF STUDY SAMPLE

<i>Demographic characteristic</i>	<i>Less than weekly energy drink use (n=571)</i>	<i>Weekly energy drink use (n=303)</i>	<i>Total sample (n=874)</i>
Mean years of age (SD) <sup>a</sup>	23.7 (2.7)	24.1 (2.6)	23.9 (2.7)
Sex (% female) <sup>b</sup>	68	51	62
Ethnicity (% non-Hispanic)	92	92	92
Race (%)			
White or Caucasian	79	83	80
Black or African American	6	4	5
Asian	7	7	7
Native Hawaiian or other Pacific Islander	<1	0	<1
American Indian or Alaska Native	<1	1	<1
Other	2	<1	1
More than one race	5	6	5
Annual household income (%)			
Under \$25,000	31	29	30
\$25,000–\$34,999	18	17	18
\$35,000–\$49,999	17	19	18
\$50,000–\$74,999	16	20	17
\$75,000–\$99,999	9	7	8
\$100,000–\$124,999	5	6	5
\$125,000–\$150,000	2	1	2
Over \$150,000	3	1	2
Highest level of education (%)			
No high school diploma	1	1	1
High school diploma or equivalent	9	8	9
Some college, no degree	34	40	36
Trade, technical, vocational training	2	2	2
Associate's degree	8	11	9
Bachelor's degree	35	32	34
Master's degree	8	7	8
Professional/doctorate degree	2	<1	1
Employment status (%)			
Employed full-time <sup>b</sup>	33	50	39
Employed part-time	15	17	16
Student <sup>c</sup>	32	21	28
Unemployed <sup>b</sup>	20	11	17
Marital status (%)			
Married	19	19	19
Widowed	0	0	0
Divorced <sup>b</sup>	1	5	3
Never married	80	75	78

<sup>a</sup> $p \leq 0.05$  represent significant group differences between weekly energy drink users and less-than-weekly energy drink users based on results of *t*-tests for continuous variables and chi-square tests for categorical variables.

<sup>b</sup> $p \leq 0.001$  represent significant group differences between weekly energy drink users and less-than-weekly energy drink users based on results of *t*-tests for continuous variables and chi-square tests for categorical variables.

<sup>c</sup> $p \leq 0.01$  represent significant group differences between weekly energy drink users and less-than-weekly energy drink users based on results of *t*-tests for continuous variables and chi-square tests for categorical variables.

replicated a finding that there is typically steeper delay discounting of condom-protected sex when partners are perceived as more desirable and less likely to have an STI.<sup>29–33</sup> Weekly energy drink users were less likely than less-than-weekly energy drink users to use a condom if one was immediately available (i.e., during the zero-delay trial) in the “least STI” partner condition ( $M=0.57$ ,  $SD=0.41$  vs.  $M=0.71$ ,  $SD=0.38$ ,  $p < 0.0001$ ) and in the “most sex” partner condition ( $M=0.57$ ,  $SD=0.42$  vs.  $M=0.71$ ,  $SD=0.38$ ,  $p < 0.0001$ ). Weekly energy drink users also had a lower mean standardized AUC than

less-than-weekly energy drink users in the “least sex” partner condition ( $M=0.65$ ,  $SD=0.35$  vs.  $M=0.71$ ,  $SD=0.37$ ,  $p=0.05$ ); however, as shown in Table 3, this finding was no longer significant following the covariate adjusted analyses. Thus, the only between-group differences in the Sexual Delay Discounting Task data that remained significant following the adjusted analyses were the mean likelihoods of using an immediately available condom when partners were perceived as less likely to have an STI (“least STI”) or more desirable (“most sex”).

TABLE 2. RETROSPECTIVE REPORTS OF DRUG USE, SEXUAL RISK BEHAVIOR, AND OTHER RISK BEHAVIOR

Behavior	Percentage		Adjusted analyses <sup>a</sup>	
	Less-than-weekly energy drink use (n=571)	Weekly energy drink use (n=303)	W (p)	Odds ratio (95% CI)
Past year drug use				
Cigarettes	28	56	56.0 (<0.0001)	3.27 (2.40–4.45)
Cannabis	38	56	23.0 (<0.0001)	2.06 (1.53–2.76)
Sedatives (e.g., Valium, Xanax)	13	24	16.2 (<0.0001)	2.17 (1.48–3.16)
Prescription stimulants (e.g., Ritalin, Adderall)	9	20	23.2 (<0.0001)	2.81 (1.85–4.29)
Illicit stimulants (e.g., cocaine, crystal meth)	6	22	37.9 (<0.0001)	4.11 (2.62–6.44)
Prescription opioids (e.g., Vicodin, OxyContin)	12	27	30.6 (<0.0001)	2.87 (1.97–4.17)
Illicit opioids (e.g., heroin, opium)	2	6	8.5 (0.004)	3.51 (1.51–8.20)
Other (e.g., ecstasy, LSD, bath salts)	9	19	17.9 (<0.0001)	2.47 (1.63–3.76)
Past year sexual risk behavior				
Unprotected sex (with someone other than spouse)	45	63	34.2 (<0.0001)	2.53 (1.82–3.51)
Taken advantage of someone sexually or been taken advantage of by someone sexually	4	14	13.3 (<0.001)	2.89 (1.64–5.12)
Sex with someone who was drunk or high	41	66	51.5 (<0.0001)	3.04 (2.24–4.12)
Sex while drunk or high	43	69	54.7 (<0.0001)	3.20 (2.35–4.35)
Sex with someone not known very well	15	31	26.1 (<0.0001)	2.52 (1.77–3.60)
Sex that was later regretted	15	22	9.7 (0.002)	1.81 (1.25–2.63)
Past year other risk behavior				
Physical fight	4	14	21.0 (<0.0001)	3.60 (2.08–6.24)
Drove/rode in vehicle without wearing safety belt	43	53	11.0 (0.001)	1.64 (1.22–2.87)
Drove while intoxicated	14	30	23.7 (<0.0001)	2.40 (1.69–3.41)
Rode with intoxicated driver	21	37	22.4 (<0.0001)	2.16 (1.57–2.96)
Activity that led to arrest of self or other	2	6	8.4 (0.004)	3.43 (1.49–7.88)
Activity that led to injury of self or other	8	12	2.1 (0.15)	1.43 (0.88–2.31)
Dangerous/risky activity on dare	9	19	15.4 (<0.0001)	2.38 (1.55–3.67)
Played extreme sport	16	26	9.6 (0.002)	1.77 (1.23–2.54)

<sup>a</sup>Adjusted for age, sex, race, employment status, education, income, and marital status. All *p*-values in bold represent significant group differences between weekly energy drink users and less-than-weekly energy drink users at  $\alpha=0.05$ .

## Discussion

The results of this study replicate and extend findings that self-reported patterns of energy drink consumption are associated with retrospective reports of risk behavior. Participants who consumed energy drinks at least once per week were more likely than less-than-weekly energy drink users to report past year cigarette smoking, nonmedical use of prescription drugs, illicit drug use, unprotected sex, and other risk behavior (Table 2). In addition, weekly energy drink users were more likely to report alcohol misuse as indicated by significantly higher AUDIT scores (Table 3). Notably, AUDIT scores  $\geq 8$  are highly correlated with hazardous alcohol use,<sup>36,48</sup> and significantly more weekly energy drink users had AUDIT scores in this range (45% vs. 21%,  $\chi^2=54.5$ ,  $p<0.0001$ ). Although weekly energy drink users demonstrated a greater propensity for sensation seeking than less-than-weekly energy drink users as evidenced by significantly higher BSSS-4 scores, this difference was no longer significant after adjusting for AUDIT score and other covariates.

To our knowledge, this study is the first to demonstrate that weekly energy drink use is associated with steeper delay discounting of monetary rewards. That is, relative to less-than-weekly energy drink users, weekly energy drink users chose significantly fewer larger-later reward options on the monetary choice questionnaire, and they had significantly higher mean  $\log_{10} k$  values after adjusting for demographic characteristics, past year cigarette smoking, AUDIT score, and past year illicit drug use or nonmedical use of prescription drugs (Table 3).

Analyses of the Sexual Delay Discounting Task data revealed no evidence that weekly energy drink users more steeply discounted delayed condom use after adjusting for covariates. However, data from the task show that, when a condom is readily and immediately available (i.e., during the zero-delay trials), weekly energy drink users were significantly less likely to use a condom with partners they perceived as more desirable and less likely to have an STI (Table 3). Taken together, results of this study suggest that energy drink use is associated with a broad pattern of impulsivity that can be

TABLE 3. RESULTS OF AUDIT, BSSS-4, MONETARY DELAY DISCOUNTING, AND SEXUAL DELAY DISCOUNTING ASSESSMENTS

Assessment	Mean (SD)		F (p)	
	Less-than-weekly energy drink use	Weekly energy drink use	Unadjusted analyses	Adjusted analyses <sup>a</sup>
AUDIT score	4.8 (4.3)	8.0 (6.4)	76.5 (< <b>0.0001</b> )	24.1 (< <b>0.0001</b> )
BSSS-4 score	3.1 (0.8)	3.5 (0.8)	30.6 (< <b>0.0001</b> )	2.8 (0.098)
Monetary delay discounting				
Proportion of larger later choices	0.46 (0.19)	0.40 (0.18)	20.7 (< <b>0.0001</b> )	8.9 ( <b>0.003</b> )
Mean log <sub>10</sub> k	-2.04 (0.69)	-1.79 (0.66)	20.1 (< <b>0.0001</b> )	9.6 ( <b>0.002</b> )
Sexual delay discounting				
Least likely to have STI partner condition				
Likelihood of using condom when immediately available	0.71 (0.38)	0.57 (0.41)	22.6 (< <b>0.0001</b> )	10.9 ( <b>0.001</b> )
Standardized AUC	0.50 (0.40)	0.46 (0.42)	1.0 (0.31)	0.3 (0.59)
Most likely to have STI partner condition				
Likelihood of using condom when immediately available	0.92 (0.19)	0.90 (0.22)	2.5 (0.12)	0.7 (0.4)
Standardized AUC	0.78 (0.33)	0.74 (0.35)	1.4 (0.23)	1.1 (0.29)
Least want to have sex with partner condition				
Likelihood of using condom when immediately available	0.83 (0.29)	0.78 (0.30)	4.6 (0.03)	2.1 (0.15)
Standardized AUC	0.71 (0.37)	0.65 (0.35)	4.0 ( <b>0.05</b> )	0.2 (0.68)
Most want to have sex with partner condition				
Likelihood of using condom when immediately available	0.71 (0.38)	0.57 (0.42)	21.4 (< <b>0.0001</b> )	7.9 ( <b>0.005</b> )
Standardized AUC	0.46 (0.40)	0.40 (0.42)	2.5 (0.12)	0.6 (0.45)

<sup>a</sup>In the adjusted analyses, all assessment outcomes were analyzed with a one-factor model (weekly energy drink use) covarying for age, sex, race, employment status, education, income, marital status, past year cigarette smoking, and past year use of any illicit drugs or nonmedical use of prescription drugs. For BSSS-4, monetary delay discounting, and sexual delay discounting outcomes, AUDIT score was also included as a covariate. All *p*-values in bold represent significant group differences between weekly energy drink users and less-than-weekly energy drink users at  $\alpha=0.05$ .

AUC, area under the curve; AUDIT, alcohol use disorders identification test; BSSS-4, four-item Brief Sensation Seeking Scale; STI, sexually transmitted infection.

assessed via self-report and performance on decision-making tasks.

Future studies should evaluate the extent to which these findings generalize from MTurk users to the general population. Although the prevalence of weekly energy drink use observed in the current sample (35%) was similar to that observed in some college samples (39%),<sup>3</sup> it was higher than that observed in a nationwide sample of young adults in 2008 and 2009 (19%).<sup>2</sup> Notably, participants in this study were slightly younger than participants in that previous study (i.e., 18–28 vs. 20–34 years of age), and data from this study were collected 5–6 years after data were collected in the previous study. Nonetheless, the primary aim of this study was not to estimate the prevalence of weekly energy drink use in the United States; rather, the aims were to examine relations between energy drink use, risk behavior, and delay discounting. Indeed, many of the relationships observed among current study outcomes replicated findings from previous studies that used more traditional survey methods. For example, energy drink users were more likely to be male,<sup>2,5,8,11</sup> employed,<sup>13</sup> have higher AUDIT scores,<sup>3</sup> and they were more likely to engage in various risk be-

haviors.<sup>2–11,13,14</sup> In addition, results from the delay discounting tasks replicated results from studies that found that larger monetary rewards are discounted less steeply than smaller rewards<sup>47</sup> and delay discounting of condom-protected sex is steeper when partners are perceived as more desirable and less likely to have an STI.<sup>29–33</sup>

The results of this study should be interpreted within the context of several limitations. First, all outcomes were based on self-report. Consequently, over- or under-reporting may have occurred in response to retrospective report questions. Second, questions on the monetary choice questionnaire and Sexual Delay Discounting Task were hypothetical. Importantly, however, similar rates of delay discounting have been observed with both hypothetical and real monetary rewards.<sup>24,49,50</sup> In addition, previous studies have shown associations between performance on the Sexual Delay Discounting Task and self-report of real-world sexual risk behavior.<sup>29,31,33</sup> Third, the sample was relatively racially and ethnically homogeneous. Over 90% of the sample was non-Hispanic and 80% was White. Future studies should extend the results of this study to a more racially and

ethnically diverse sample. Fourth, to increase the likelihood that the study sample would include participants with exposure to energy drinks and alcohol, the study included only participants who reported consuming caffeine and alcohol at least once during the past month. Future studies should include caffeine and alcohol abstiners for comparison. Finally, this study was not designed to examine the independent relationships between impulsivity and alcohol use, impulsivity and energy drink use, and impulsivity and alcohol mixed with energy drink use. To our knowledge, these relationships have not been prospectively examined within the same study. However, some research has shown that a history of consuming alcohol mixed with energy drinks is associated with many of the outcomes examined in this study, including various risk behaviors<sup>51</sup> and monetary delay discounting.<sup>52</sup> Notably, few participants in this study reported consuming alcohol mixed with energy drinks on a weekly basis (9%;  $n=76$ ), but many more participants reported past year consumption of alcohol mixed with energy drinks (34%;  $n=299$ ). After adjusting for the latter variable in subsequent analyses, differences between energy drink users and less-than-weekly energy drink users remained significant across all but two risk-related outcomes (“drove/rode in vehicle without wearing safety belt” and “played an extreme sport”; data not shown). In addition, differences observed in AUDIT scores, monetary choice questionnaire outcomes, and outcomes from the Sexual Delay Discounting Task remained significant after adjusting for this additional covariate, suggesting that frequent energy drink use was associated with risk behavior and impulsivity regardless of whether participants consumed alcohol mixed with energy drinks. Nevertheless, future studies are needed to prospectively investigate the combined and independent effects of alcohol and energy drink use on impulsivity and risk behavior.

The nature of the relationship between energy drink use and risk behavior remains unclear. Some researchers have proposed that energy drink use is one of many activities associated with a larger pattern of impulsive or risky behavior.<sup>4,8</sup> If this theory is correct, then marketing strategies that advertise the stimulant effects of energy drinks may promote energy drink consumption among individuals who are predisposed to or already engaging in risk behavior. However, the key to the relationship between energy drink use and risk behavior might also lie in the main psychoactive ingredient in energy drinks—caffeine. Some research has shown that caffeine dependence and heavy caffeine use from other sources (e.g., coffee) are associated with dependence on alcohol and illicit drugs.<sup>53</sup> Other recent research has shown that frequent soft drink consumption<sup>9</sup> and coffee consumption<sup>54</sup> are positively and independently associated with drug use. These studies further show that soft drink and coffee consumers who also frequently consume energy drinks are even more likely to use drugs than individuals who consume only

soft drinks or coffee. Future research should attempt to further clarify associations between caffeine use, energy drink consumption, and impulsivity by prospectively examining the acute and chronic effects of caffeine and energy drink consumption on measures of impulsivity, such as monetary delay discounting.

The results of this study add to a growing literature pointing to frequent energy drink use as a marker for risk behavior in teenagers and young adults. Given that rates of illicit drug use and STI transmission are highest in this age group,<sup>55,56</sup> further investigation of this behavioral marker is warranted to determine whether it has potential to aid parents, educators, and clinicians in identifying individuals who are most likely to engage in risk behavior.

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