Published in final edited form as:

Addict Behav. 2019 March ; 90: 362–368. doi:10.1016/j.addbeh.2018.11.033.

Investigating Associations between Caffeinated Beverage Consumption and Later Alcohol Consumption among Early Adolescents

Naomi R. Marmorstein, Ph.D.

Rutgers University, Camden

Abstract

Previous research has demonstrated that caffeinated beverage consumption predicts alcohol consumption among early adolescents. This study aimed to investigate this association in two ways: (1) by examining if this association remained significant once other established risk factors for alcohol were adjusted for statistically; and (2) by considering three possible moderators of this association: gender, sensation-seeking, and parental monitoring. Data from the Camden Youth Development Study, a longitudinal, community-based study of middle-school students, were used. Youth were initially assessed in 6th and 7th grade and followed-up 16 months later. Self-reports of frequency of energy drink, coffee, and alcohol consumption, as well as sensation-seeking, perceived peer and best friend alcohol use, alcohol expectancies, and parental monitoring, were used. Results indicated that both energy drink and coffee consumption predicted later alcohol consumption, even after adjusting for other risk factors for alcohol consumption. Parental monitoring was a significant moderator of this link, such that youth who consumed energy drinks and reported low parental monitoring were particularly at risk for later alcohol consumption. These findings indicate that the link between earlier caffeine consumption and later alcohol consumption is not simply due to the co-occurrence of caffeine consumption with other risk factors for alcohol use. In addition, risk associated with early energy drink consumption appears to be particularly pronounced for youth in families characterized by low parental monitoring.

Keywords

Caffeine; energy drinks; coffee; alcohol; adolescents

1. Introduction

Energy drink consumption in the United States has been growing exponentially (Neuman, 2009), and advertising for energy drinks is often aimed at children and teenagers (Meier,

Corresponding Author: Naomi Marmorstein, Ph.D., Department of Psychology, Rutgers University, Camden, 311 North 5th Street, Camden, NJ 08102, marmorst@camden.rutgers.edu, 856-225-6434.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

The author has no conflicts of interest to disclose.

2012a; Reissig et al., 2009). In 2010–11, the Monitoring the Future study found that approximately one-third of adolescents consume energy drinks (Terry-McElrath et al., 2014). Despite the increasing prevalence of energy drink use among children and adolescents (e.g., Azagba, Langille, & Asbridge, 2014) and increasing attention given to the effects of energy drinks on physical health (e.g., Brody 2011; Meier 2012b; Seifert et al. 2011), our understanding of their psychological and behavioral correlates is limited. Even less is known about correlates of coffee consumption among adolescents, perhaps because some studies indicate that it is less prevalent than energy drink consumption among adolescents (e.g., James, Kristjansson, & Sigfusdottir, 2011).

Evidence to date supports a link between caffeinated beverage consumption and alcohol consumption among adolescents and young adults, at least for certain types of beverages. Specifically, substantial evidence supports cross-sectional associations between energy drink consumption and alcohol consumption among mid-to-late adolescents and young adults (e.g., Arria et al., 2010; Leal & Jackson, 2018; Terry-McElrath, O'Malley, & Johnston, 2014), and some evidence indicates that these links apply to middle-school students as well (Mann, Smith, & Kristjansson, 2016). However, less attention has been paid to younger age groups (i.e., early adolescents) and other caffeinated beverages (e.g., coffee), and longitudinal research is scarce. Therefore, the goals of this study were to further our understanding of this link between caffeine use and later alcohol use in three ways: (1) to examine whether this association is due to the co-occurrence of caffeine use with other established risk factors for alcohol use; (2) to examine whether this association depends on characteristics of the child and/or family (i.e., moderators); and (3) to consider whether this association is unique to energy drinks or also applies to other beverages (e.g., coffee).

Early alcohol use is an important outcome to study, even if it occurs infrequently or in small quantities, due to its association with later heavy alcohol use and related problems (e.g., Aiken et al., 2018). Approximately 13% of 8th-grade students report alcohol use in the past 30 days (Terry-McElrath et al., 2014), making it a fairly common risk behavior even at young ages. Although some of the associated risk for future alcohol problems may be reflective of co-occurring disinhibitory behavior and psychopathology (McGue et al., 2006), even low-level use (e.g., sipping) in very early adolescence is predictive of heavy use by mid-adolescence (Jackson, Barnett, Colby, & Rogers, 2015).

Caffeine consumption could be linked to later alcohol use among early adolescents for several reasons. For example, there is evidence from animal research that caffeine promotes sensitization to other substances' reinforcing effects (e.g., Horger, Wellman, Morien, Davies, & Schenk, 1991; Shoaib, Swanner, Yasar, & Goldberg, 1999). In addition, youth who consume one beverage that changes how they feel (caffeine) may be particularly likely to use another beverage that changes how they feel (alcohol). Alternatively, the previously-reported associations between caffeine use and alcohol use may be due to factors that place youth at risk for both behaviors. These factors could be specific to the individual (e.g., demographic factors, personality traits) or related to the environment (e.g., low parental monitoring, peer substance use).

As noted above, evidence to date supports cross-sectional associations between caffeine consumption and alcohol use (Mann, Smith, & Kristjansson, 2016; Leal & Jackson, 2018; Terry-McElrath, O'Malley, & Johnston, 2014; Velazquez, Poulos, Latimer, & Pasch, 2012). Much of the existing research focuses on energy drinks (such as those studies cited above) or combines all types of caffeine together (e.g., James et al., 2011; Kristjansson, Sigfusdottir, Frost, & James, 2013), so it is not clear whether this association is limited to energy drink consumption or not.

Longitudinal research examining this association among adolescents is limited. Due to the possibility that this link could vary based on demographic factors (including age, race, and socioeconomic status (SES)), we comment on those factors as we describe previous research below. Barrense-Dias et al. (2016) found that in a Swiss sample, energy drink consumption at age 14 predicted alcohol and other substance use at age 16; racial/ethnic information was not provided for this sample, though it appears to be primarily upper-class (4.9–6.1% “below average SES” in different groups). In an ethnically-mixed sample (27% African-American, 30% White, 32% Hispanic, 11% other) of unclear SES, Choi et al. (2016) found that energy drink use at mean age 17 predicted alcohol use one year later. Despite the possibility of developmental differences in these associations, we know of only one other study examining young adolescents: Collins et al. (1997) found that among 7th-grade students who had not initiated alcohol or tobacco use, participants who consumed more than 6 cups of coffee per month were more likely to have initiated alcohol and/or tobacco use one year later than those who did not consume coffee. Demographic information about this sample is limited but noted to be “ethnically mixed, containing primarily Anglos, Latinos, and Asian-Americans.” Finally, in our previous work using this same sample, we found that frequency of energy drink consumption (at mean age 11.9) predicted frequency of alcohol use 16 months later, after controlling for initial frequency of alcohol use (Miyake & Marmorstein, 2015). The association between frequency of coffee consumption and later alcohol use followed a similar pattern, but was only significant at a trend level ($p < .10$).

The current study adds to our knowledge of links between caffeine use and risk for alcohol use in two important ways. First, there are developmental changes in both caffeine use and alcohol use across adolescence: for alcohol, rates of use increase across adolescence (Terry-McElrath et al., 2014), while for caffeine, less information is available but data generally support the same trend (e.g., Reid, Hammond, McCrory, Dubin, & Leatherdale, 2015). The only other longitudinal study of early-adolescent caffeine use of which we are aware was conducted in the 1990s (Collins et al., 1997), and substantial change has taken place since then both in the rates of caffeine use and in the types of caffeinated beverages available. Therefore, it is crucial that we increase knowledge about the risks that may (or may not) be associated with early-adolescent caffeine use in particular, with a consideration of how different beverages may relate differently to risk behaviors. Second, it is reasonable to expect that not all early-adolescent caffeine use is the same: that is, some youth may consume caffeine and not experience increased risk for alcohol use, while others may not. We hypothesize that the risk associated with caffeine consumption may depend on other factors, either within the child or within his or her environment. To our knowledge, this is the first study to specifically examine potential moderators of risk with respect to early adolescent caffeine use. As an additional contribution of this study, the participants are

primarily low-income and ethnic minority (Hispanic and African-American) backgrounds; we know of no other longitudinal study of caffeine use in adolescents with a similar sample.

As noted above, we considered it possible that established risk factors for alcohol use would be correlated with caffeine consumption and, when statistically controlled for, would account for the associations we previously found. Therefore, the first goal of this study was to examine whether the association between caffeine use and later alcohol use remained significant after adjusting for established risk factors for adolescent alcohol use. Specifically, in addition to demographic factors (age, gender, race/ethnicity), we controlled for sensation-seeking, perceptions of alcohol use (social behavior alcohol expectancies), perceptions of peers' and best friends' alcohol use, and family factors (parental monitoring). We selected these risk factors as representatives of major categories of risk for alcohol use: externalizing spectrum traits (e.g., Krueger et al., 2002), beliefs about alcohol's effects (e.g., Brown, Christiansen, & Goldman, 1987), associating with substance-using peers (e.g., Hawkins, Catalano, & Miller, 1992; Steinberg, Fletcher, & Darling, 1994), and low levels of parental monitoring (e.g., Steinberg et al., 1994). While we acknowledge that this list is not exhaustive of all risk factors for early alcohol use and encourage future research to consider other factors as well, we are hopeful that by representing these major categories of risk we capture representative constructs from important domains of development.

The second goal of this study was to examine whether the risk for early-adolescent alcohol use that is associated with earlier caffeine use is particularly pronounced for certain youth. Stated another way, we examined whether the apparent effect of caffeine use on later alcohol use depended on certain characteristics of the youths themselves or their families. Specifically, we considered a demographic factor (gender), personality (sensation-seeking), and a family factor (parental monitoring). We selected these variables because they are all linked to an increased risk for alcohol use among adolescents (e.g., as reviewed by Chassin & DeLucia, 1996; Krueger et al., 2002) and it seemed possible that each of these risks could be amplified by earlier consumption of a different psychoactive beverage (i.e., caffeine). In the case of gender, boys and girls may have different reasons for consuming caffeine, which could result in differential future risk for alcohol use across gender. Youth with high levels of sensation-seeking may find the "jolt" of energy resulting from caffeine use particularly reinforcing, which could encourage them to experiment with another substance (e.g., alcohol). Alternatively, they may be particularly responsive to perceptions of certain behaviors as "risky" or "edgy," and this could increase their likelihood of using both energy drinks and alcohol. Finally, youth who experience low parental monitoring could engage in caffeine consumption as a low-level risk behavior; when they find that their parent(s) do not find out or the consequences of use are minimal, they may assume they can use alcohol without consequences as well.

Although peer substance use is a predictor of an individual's likelihood of substance use (e.g., Hawkins et al., 1992; Steinberg et al., 1994), we did not examine peer alcohol use as a moderator because we did not expect that the association between caffeine consumption and alcohol use would be affected by peer alcohol use. Stated another way, although we expected that both caffeine consumption and peer substance use would be associated with increased risk for alcohol use (main effects), we were unaware of any theory that would indicate that

these risk factors would interact to produce even higher levels of alcohol use than would be expected based on additive effects alone.

We examined both energy drink and coffee consumption for several reasons. Both contain relatively high levels of caffeine (in some cases comparable amounts, depending on the brand/type of energy drink and the brewing method of coffee; Reissig, Strain, & Griffiths, 2009). However, they may be thought about and used differently among young adolescents, perhaps due to differences in perceptions and marketing (e.g., energy drinks are marketed specifically to adolescents and portrayed as edgy and associated with athletics and action-adventure lifestyles; Emond, Sargent, & Gilbert-Diamond, 2015; Marin Institute, 2008; US Senate Committee on Commerce Science and Transportation, 2013; Yale Rudd Center for Food Policy and Obesity, 2013). Supporting the potential for differentiation among these beverages, one study found that among college students, frequent energy drink consumption was linked to a variety of substance use and health risk behaviors, while frequent coffee consumption was not (Kelly & Prichard, 2016). In addition, past research on energy drink consumption among adolescents has clearly linked them to alcohol use and other externalizing behavior (Mann et al., 2016; Leal & Jackson, 2018; Miyake & Marmorstein, 2015; Terry-McElrath et al., 2014), while evidence to date on coffee consumption among adolescents is equivocal (Marmorstein, 2016; Miyake & Marmorstein, 2015).

We expected that the association between earlier caffeine consumption and later alcohol use would remain significant even net the effect of established risk factors for alcohol use. We tentatively expected that both sensation seeking and parental monitoring would moderate the link between caffeine consumption and later alcohol consumption (with the combination of caffeine consumption and either of these risk factors being associated with even higher risk for alcohol use). We did not expect to find a moderation effect of gender. We expected the patterns of association to be similar for energy drinks and coffee, though we considered it possible that the strength of the associations would be lesser for coffee.

2. Material and Methods

2.1 Participants

Participants for this study were drawn from the Camden Youth Development Study (CYDS), a longitudinal study of 6th- and 7th-grade youth attending a middle school (n=144; mean age at initial assessment=11.9, SD=0.8, range=10–14; 50% female; 32% African-American, 69% Hispanic, 6% Native American, 2% white, 6% other). Among students in these grades at this school, 81% qualified for free lunches (an indicator of low socio-economic status) and 43% received public assistance other than unemployment or social security benefits. At the initial assessment 94% of students whose parents consented for their participation chose to participate; at the assessment 16 months later, 96% of those eligible and still attend the school participated (n=134). Intermediate assessments were conducted but not included in this study due to lower participation rates.

This study was approved by the IRB of Rutgers University. Parents provided written consent prior to the start of the study and youth provided assent at each assessment.

2.2 Measures

Questionnaires were administered to youth in classrooms, using privacy screens on each desk to protect confidentiality. Questionnaires were read aloud by a masters-level research assistant, and at least one other research assistant was available in each classroom to answer questions and assist students. Students who were absent on the day of the questionnaire administration were offered the opportunity to take it approximately two days later.

2.2.1 Caffeine Use—Frequency of energy drink and coffee consumption were assessed at both the initial and final assessments on a 5-point scale assessing use in the previous 4 months (0=not in the past 4 months; 1=at least once in the past 4 months, but less than once per month; 2=one to three times per month; 3=one to three times per week; 4=most days). We included a list of possible energy drinks to ensure that participants understood the question as intended (“Red Bull, Monster, Rock Star, or other drinks like that”). This scale was constructed to be analogous to the scale measuring alcohol use, described below. Self-reports of caffeine use are generally valid and correlated with salivary caffeine concentrations (Addicott, Yang, Peiffer, & Laurienti, 2009). Frequencies of caffeine use are presented in Table 1.

2.2.2 Alcohol Use—Alcohol consumption (beer, wine, or hard liquor) at both the initial and final assessments was assessed over the same previous 4 month period (0=none; 1=less than once per month; 2=at least once a month, but less than once a week; 3=1 to 3 times per week; 4=most days). The questions specified that a drink of alcohol was “not just a sip or taste of someone else’s.” Questions were adapted from the Social and Health Assessment (SAHA; Weissberg et al., 1991; Schwab-Stone et al., 1999). Frequencies of alcohol use are presented in Table 1.

2.2.3 Demographic Characteristics—Age (in years), gender (male=0, female=1), and race/ethnicity were recorded at the first assessment. For race/ethnicity, African-American was coded 1 and non-African-American was coded 0; all of the non-African-American students endorsed being Hispanic (and some also endorsed membership in another racial category as well).

2.2.5 Sensation-Seeking—Sensation-seeking was assessed at the initial time point using the UPPS-P-Child version (Zapolski, Stairs, Combs, & Smith, 2010). The sensation-seeking subscale is comprised of eight questions, each answered on a 4-point scale (0=not at all like me, 3=very much like me). Cronbach’s alpha for this scale was adequate (.78 in our sample, .90 in Zapolski et al., 2010).

2.2.6 Parental Monitoring—To assess parental monitoring at the initial assessment, we used two previously-validated scales: the Perceived Parental Monitoring Scale (PPMS; Rai et al., 2003; Silverberg & Small, 1991; Xiaoming, Stanton, & Feigelman, 2000) and the Monitoring-personal interview (Dishion et al., 2006). Questions on the Monitoring-personal interview were converted from open-ended to the same 5-point scale as the PPMS (0–4, corresponding to “never” to “always”). Because some of the items inquired about parental knowledge (parents’ knowledge of the child’s whereabouts and actions) and others assessed

parental solicitation (parents' asking about the child's whereabouts and actions), "mirror" questions were added so that for each concept, one question asked about knowledge and one question asked about solicitation. Thus, the original 9-item scale (6 from the PPMS and 3 from the Monitoring-personal interview) yielded an 18-item scale with an internal consistency reliability (Cronbach's alpha) in this sample of .87. This is similar to the reliabilities reported in previous studies (PPMS alpha=.87-.92; Rai et al., 2003).

2.2.7 Peer and Best Friend Alcohol Use—To assess perceptions of peer and friend alcohol use at the initial time point, youth were asked "How many of your classmates do you think have tried alcohol?" and "Think of the person around your age you are closest to (your "best friend"). Do you think this person has tried alcohol?" Each was answered on a 4-point scale ("none"/"definitely not" to "A lot"/"Definitely"). Responses to these questions were significantly correlated ($r=.58$, $p<.001$).

2.2.8 Social Behavior Alcohol Expectancies—To assess alcohol expectancies at the initial time point, the Alcohol Expectancy Questionnaire-Adolescent Form (AEQ-A) was used (Brown, Christiansen, & Goldman, 1987). This measure has shown to predict future alcohol use (e.g., Goldman, Greenbaum, & Darkes, 1997). The Alcohol Can Enhance or Impede Social Behavior subscale, which assesses an individual's beliefs about the facilitating effect of alcohol on social behavior, was used in this study because it was the only subscale that significantly correlated with later alcohol use in this young sample ($r=.23$, $p<.05$). Internal consistency reliability (Cronbach's alpha) for this subscale in this sample was .70.

2.3 Statistical Analyses

Prior to analyses being conducted, questionnaires were eliminated if (1) the participant endorsed use of a fake drug, or (2) at the end of the questionnaire, the participant reported being "kind of honest" instead of "totally" or "mostly" honest. This resulted in 3 questionnaires being eliminated at the initial assessment and 8 questionnaires being eliminated at the final assessment. Frequencies of energy drink, coffee, and alcohol consumption, as well as CD symptoms, were skewed and therefore were log-transformed prior to analyses being conducted.

As a preliminary step, Pearson correlations were conducted to examine inter-correlations among caffeine use, alcohol use, and risk factors for alcohol use that were included in this study.

For all longitudinal hypothesis-driven analyses (i.e., all analyses described below), multiple imputation was used to appropriately deal with missing data. Data were assumed to be missing at random. The multiple imputation procedure included in SAS (PROC MI) version 9.4 was used. This procedure implements the Markov Chain Monte Carlo (MCMC) method; initial estimates are derived from the expectation-maximization (EM) algorithm. We conducted 40 imputations, and PROC MI takes 100 iterations between imputations (and 200 imputations prior to the first imputation). After the imputations were conducted, we used the MIANALYZE procedure to combine the results of analyses of imputations. This yielded

appropriate inferences derived from the parameter estimates and their associated standard errors from each imputation.

For all longitudinal, hypothesis-driven analyses discussed below, we modeled alcohol use at both time points using zero-inflated negative binomial distributions to reflect the fact that most youth had not consumed alcohol.

To examine whether energy drink and/or coffee consumption predicted later alcohol consumption after controlling for established risk factors for alcohol use, we conducted two regression analyses. In each, frequency of alcohol consumption at the final assessment was the dependent variable and (1) frequency of energy drink consumption at the initial assessment or (2) frequency of coffee consumption at the initial assessment were the predictor variables; also included in the models as control variables were demographic characteristics (age, gender, and race/ethnicity), sensation-seeking, perceptions of peer and best friend alcohol use, social behavior alcohol expectancies, and parental monitoring.

In order to examine our moderation hypotheses, we conducted a series of regression analyses analogous to those described above but also including in each an interaction term representing the interaction between frequency of caffeine consumption and one of the three hypothesized moderators: gender, sensation-seeking, and parental monitoring. This yielded six regression analyses for this portion of the study (three for energy drinks, three for coffee).

3. Results

3.1 Preliminary analyses

Pearson correlations among the variables examined in this study are presented in Table 2. Energy drink consumption frequency at the initial assessment was positively associated with age, gender (being male), concurrent alcohol use frequency, perceptions of peer and best friend's alcohol use, social behavior alcohol expectancies, sensation-seeking, and alcohol consumption at the final assessment, and was negatively associated with parental monitoring. Coffee consumption at the initial assessment was positively associated with race/ethnicity (not being African-American, which in this sample meant being Hispanic), perceptions of peer and best friend's alcohol use, social behavior alcohol expectancies, sensation-seeking, and alcohol consumption at the final assessment. Coffee consumption frequency and energy drink consumption frequency were correlated with each other ($r=.43$, $p<.001$).

3.2 Specific associations between caffeine consumption and later alcohol consumption

As shown in Table 2, once established risk factors for alcohol use were statistically adjusted for, both energy drink and coffee consumption remained significant predictors of alcohol use 16 months later.

3.3 Moderators of links between caffeine consumption and later alcohol consumption

As shown in Table 3, we examined interaction effects between energy drink and coffee consumption and four hypothesized moderators: gender, CD symptoms, sensation-seeking,

and parental monitoring. In all analyses, the risk factors listed in Table 2 were adjusted for by including them in the models.

Interaction effects between caffeinated beverages (energy drinks and coffee) and gender and sensation-seeking were non-significant, indicating that the association between earlier caffeine consumption and later alcohol consumption did not depend on these factors. Energy drink consumption interacted significantly with parental monitoring, such that those youth who consumed energy drinks and scored lower on parental monitoring at the initial assessment were particularly at risk for alcohol use at the final assessment. In order to describe this association, we dichotomized energy drink use at the initial assessment (no use versus any use) and parental monitoring at the initial assessment (above versus below the 50th percentile in this sample) and examined rates of alcohol use (any frequency) at the final assessment. The results are depicted in Figure 1. Rates of alcohol use at the final assessment were approximately five times higher among the group with energy drink use and low parental monitoring at the initial assessment, compared to all other groups.

4. Discussion

The results of this study indicate that even after the effects of established risk factors for alcohol use are adjusted for, caffeine consumption among early adolescents predicts later alcohol use. Therefore, this effect is not simply due to the co-occurrence of caffeine consumption with other measured risk factors. In addition, this study demonstrates that this link between early energy drink consumption and later alcohol use may be particularly pronounced for youth whose families are characterized by low levels of parental monitoring.

These results are consistent with previous research supporting a link between caffeine consumption and later alcohol consumption (Barrense-Dias et al., 2016; Choi et al., 2016; Miyake & Marmorstein, 2015) and extend previous findings in several ways. First, as indicated by previous research and replicated here (Table 2), caffeine consumption is correlated with known risk factors for alcohol use among adolescents (e.g., sensation-seeking, parental monitoring). To our knowledge, this is the first study to demonstrate that the link between caffeine consumption and later alcohol consumption remains even after statistical adjustment for these (and other) known risk factors for alcohol use. The present results demonstrate that caffeine consumption is a unique and important risk factor for alcohol consumption among young adolescents. Second, this study points to the importance of family factors, specifically parental monitoring, in understanding this association. Perhaps youth who are not monitored as closely use caffeinated beverages in different ways than youth who are closely monitored (e.g., consuming caffeine with friends after school as opposed to with parents in the morning), or perhaps if a youth discovers that he or she can consume caffeine (perhaps specifically energy drinks) without his or her parents' knowledge he or she considers it possible to consume alcohol without parental knowledge. Third, the results of this study, taken together, indicate that both energy drinks and coffee are associated with risk for future alcohol use among early adolescents. The pattern of risk (e.g., which caffeine-consuming youth are most at risk) may differ across different beverages, however; future research examining this issue will be important in advancing our understanding of these links. Finally, the results of this study indicate that these patterns of

risk are present for low-income, ethnic minority youth. Particularly striking is the finding that even after adjusting for many known individual and environmental risk factors for alcohol use, caffeine consumption remains a significant predictor of risk for alcohol use among these youth.

Somewhat unexpectedly, despite the overall significant correlation between alcohol use at the initial and final assessments (Table 2), initial alcohol use did not predict later alcohol use once other risk factors for alcohol use were included in the models (Tables 3 and 4). This is likely due to the low levels of use combined with the fact that the risk factors that were adjusted for accounted for much of the variance that would otherwise have been attributed to alcohol use itself.

These findings should be interpreted in light of this being a fairly low-risk sample for alcohol use. Specifically, only 15% of participants were drinking to any degree at the final assessment. Given this and the young nature of the sample, it is quite striking that caffeine use accounted for significant variance in change in alcohol use at all, and particularly so for certain youth. This points to the importance of prevention and/or intervention for young caffeine users as a possible prevention strategy for early alcohol use (and later alcohol-related problems). That said, these findings should also be interpreted in light of the small, low-income, ethnic-minority nature of the sample. These findings highlight the need for additional research on larger, more diverse samples to examine whether the current effects replicate and whether they apply to broader groups of youth.

Our moderation hypotheses for sensation-seeking was not supported. We expected that risk for later alcohol use would be especially pronounced among youth who used caffeine and were high on sensation-seeking, but instead, the risk associated with caffeinated beverage consumption appears to be similar across youth with different levels of sensation-seeking. Future research using larger and more diverse samples will be instructive in determining whether this lack of effect is consistent across different groups of youth.

Strengths of this study include the excellent retention rate over time, the examination of different caffeinated beverages, and the under-studied sample (low-income, ethnic minority youth). However, there are several limitations of this study. The exact amount of caffeine (in milligrams) consumed by the participants is unclear. We do not have data on the exact kinds or sizes of beverages consumed, and caffeine content of these beverages varies substantially. In addition, energy drinks contain ingredients other than caffeine (e.g., herbal supplements, glucose, taurine; e.g., Childs, 2014), which may contribute in unclear ways to their effects. Although we control for many risk factors for alcohol use, it remains possible that risk factors not included in this study could account for some effects. Although the low-income, ethnic-minority nature of this sample represents a strength, it also may limit generalizability, and particularly so because all youth attended a single school. Finally, we did not ask about alcohol mixed with energy drink or other caffeinated alcohol use; therefore, our results cannot speak to the potential risks associated with consuming these beverages together.

In addition to these issues, the interrelated issues of statistical power to detect effects and multiple comparisons need to be considered when interpreting the results of this study. Due

to the relatively small sample size, we may have failed to detect effects that would be present in a larger (or more diverse) sample. On the other hand, we conducted six moderator analyses, which could have resulted in a significant finding due to chance. Instead of using a formal correction for multiple comparisons, we elected instead to probe the one significant moderation finding to examine its magnitude. We judged the 5-fold increase in risk for later alcohol use among youth with energy drink use and low parental monitoring at the initial assessment to be worth reporting and interpreting. That said, future research with larger and more diverse samples will be important to confirm or refute these findings—both those that were non-significant (which could be due to low statistical power) and those that were significant (which could be due to the inclusion of multiple comparisons).

The results of this study have implications for future research. Studies attempting to understand whether the increased risk for alcohol use among early-adolescent caffeine users is primarily related to the amount of caffeine consumed (milligrams) or the beverage choice would be helpful. In addition, due to the significant moderating effect of parental monitoring found in this study, consideration of other aspects of the family environment (e.g., conflict, parental views about substance use) could lead to increased understanding of how caffeine consumption leads to risk. Examining patterns of caffeine use (e.g., time of day) and reasons for caffeine use could assist in our understanding of these results.

In conclusion, the association between caffeine consumption in early adolescence and later alcohol use is robust, and not simply due to the co-occurrence of caffeine use with established risk factors for alcohol use. This effect appears to be particularly pronounced for youth whose families are characterized by low parental monitoring, and perhaps particularly youths who consume energy drinks. Interventions aimed at reducing caffeine use among early adolescents and/or enhancing parental monitoring of youths who do consume caffeine would be appropriate.

Acknowledgements

This study was funded by the National Institute on Drug Abuse (DA-022456). The author appreciates the assistance of the school administrators, teachers, and student participants who made this project possible, as well as the research assistants who helped with data collection and entry for this project.

References

- Addicott MA, Yang LL, Peiffer AM, & Laurienti PJ (2009). Methodological considerations for the quantification of self-reported caffeine use. *Psychopharmacology*, 203, 571–578. [PubMed: 19011837]
- Arria AM, Caldeira KM, Kasperski SJ, O'Grady KE, Vincent KB, Griffiths RR, & Wish ED (2010). Increased alcohol consumption, nonmedical prescription drug use, and illicit drug use are associated with energy drink consumption among college students. *Journal of Addiction Medicine*, 4, 74–80. [PubMed: 20729975]
- Azagba S, Langille D, & Asbridge M (2014). An emerging adolescent health risk: Caffeinated energy drink consumption patterns among high school students. *Preventive Medicine*, 62, 54–59. [PubMed: 24502849]
- Barrense-Dias Y, Berchtold A, Akre C, & Suris J-C (2016). Consuming energy drinks at the age of 14 predicted legal and illegal substance use at 16. *Acta Paediatrica*, 105, 1361–1368. [PubMed: 27513298]
- Brody JE (2011). Scientists see dangers in energy drinks. *New York Times*, D7.

- Brown SA, Christiansen BA, & Goldman MS (1987). The Alcohol Expectancy Questionnaire: An instrument for the assessment of adolescent and adult alcohol expectancies. *Journal of Studies on Alcohol*, 48, 483–91. [PubMed: 3669677]
- Chassin L, & DeLucia C (1996). Drinking during adolescence. *Alcohol Research and Health*, 20, 175–181.
- Childs E (2014). Influence of energy drink ingredients on mood and cognitive performance. *Nutrition Reviews*, 72 (supplement 1), 48–59.
- Choi HJ, Wolford-Clevenger C, Brem MJ, Elmquist J, Stuart GL, Pasch KE, & Temple JR (2016). The temporal association between energy drink and alcohol use among adolescents: A short communication. *Drug and Alcohol Dependence*, 158, 164–166. [PubMed: 26632245]
- Dishion TJ, Burraston B, & Li F (2006). Family management practices: Research design and measurement issues. In Sloboda Z & Bukowski W (Eds.), *Handbook for drug abuse prevention: Theory, science, and practice* Kluwer: New York, pp. 587–607.
- Emond JA, Sargent JD, & Gilbert-Diamond D (2015). Patterns of energy drink advertising over U.S. television networks. *Journal of Nutrition Education and Behavior*, 47, 120–126. [PubMed: 25754297]
- Goldman MS, Greenbaum PE, & Darkes J (1997). A confirmatory test of hierarchical expectancy structure and predictive power: Discriminant validation of the Alcohol Expectancy Questionnaire. *Psychological Assessment*, 9, 145–157.
- Hawkins JD, Catalano RF, & Miller JY (1992). Risk and protective factors for alcohol and other drug problems in adolescence and early adulthood: Implications for substance abuse prevention. *Psychological Bulletin*, 112, 64–105. [PubMed: 1529040]
- Hogger BA, Wellman PJ, Morien A, Davies BT, & Schenk S (1991). Caffeine exposure sensitizes rats to the reinforcing effects of cocaine. *Neuroreport: An International Journal for the Rapid Communication of Research in Neuroscience*, 2, 53–56.
- Jackson KM, Barnett NP, Colby SM, & Rogers ML (2015). The prospective association between sipping alcohol by the sixth grade and later substance use. *Journal of Studies on Alcohol and Drugs*, 76, 212–221. [PubMed: 25785796]
- James JE, Kristjansson AL, & Sigfusdottir ID (2011). Adolescent substance use, sleep, and academic achievement: Evidence of harm due to caffeine. *Journal of Adolescence*, 34, 665–673. [PubMed: 20970177]
- Kelly CK, & Prichard JR (2016). Demographics, health, and risk behaviors of young adults who drink energy drinks and coffee beverages. *Journal of Caffeine Research*, 6, 73–81. [PubMed: 27274417]
- Kristjansson AL, Sigfusdottir ID, Frost SS, & James JE (2013). Adolescent caffeine consumption and self-reported violence and conduct disorder. *Journal of Youth and Adolescence*, 42, 1053–1062. [PubMed: 23358888]
- Krueger RF, Hicks BM, Patrick CJ, Carlson SR, Iacono WG, & McGue M (2002). Etiologic connections among substance dependence, antisocial behavior, and personality: Modeling the externalizing spectrum. *Journal of Abnormal Psychology*, 111, 411–424. [PubMed: 12150417]
- Leal WE & Jackson DB (2018). Energy drinks and escalation in drug use severity: An emergent hazard to adolescent health. *Preventive Medicine*, 111, 391–396. [PubMed: 29197534]
- Mann MJ, Smith ML, & Kristjansson AL (2016). Energy drink consumption and substance use risk in middle school students. *Preventive Medicine Reports*, 3, 279–282. [PubMed: 27419027]
- Marin Institute [11 2013]; Alcohol, energy drinks and youth: a dangerous mix 2008:330 Available at <http://www.eatdrinkpolitics.com/wp-content/uploads/AEDReportSimon2007.pdf>.
- Marmorstein NR (2016). Energy drink and coffee consumption and psychopathology symptoms among early adolescents: Cross-sectional and longitudinal associations. *Journal of Caffeine Research*, 6, 64–72. [PubMed: 27274416]
- McGue M, Iacono WG, Legrand LN, Malone S, & Elkins I (2006). Origins and consequences of age at first drink. I. Associations with substance-use disorders, disinhibitory behavior and psychopathology, and P3 amplitude. *Alcoholism: Clinical and Experimental Research*, 25, 1156–1165.
- Meier B (2012a, 12 1). FTC urged to review energy drink advertising. *New York Times*, B3.
- Meier B (2012b, 10 24). More than a case of the jitters. *New York Times*, B1.

- Miyake ER, & Marmorstein NR (2015). Energy drink consumption and later alcohol use among early adolescents. *Addictive Behaviors*, 43, 60–65. [PubMed: 25576951]
- Neuman W (2009, 7 11). Little bottle, big punch. *New York Times*, B1.
- Seifert SM, Schaechter JL, Hershorin ER, & Lipshultz SE (2011). Health effects of energy drinks on children, adolescents, and young adults. *Pediatrics*, 127, 511–528. [PubMed: 21321035]
- Rai AA, Stanton B, Wu Y, Li X, Galbraith J, Cottrell L, et al. (2003). Relative influences of perceived parental monitoring and perceived peer involvement on adolescent risk behaviors: An analysis of six cross-sectional data sets. *Journal of Adolescent Health*, 33, 108–118. [PubMed: 12890602]
- Reid JL, Hammond D, McCrory C, Dubin JA, & Leatherdale ST (2015). Use of caffeinated energy drinks among secondary school students in Ontario: Prevalence and correlates of using energy drinks and mixing with alcohol. *Canadian Journal of Public Health*, 106, e101–e108. [PubMed: 26125234]
- Reissig CJ, Strain EC, & Griffiths RR (2009). Caffeinated energy drinks—A growing problem. *Drug and Alcohol Dependence*, 99, 1–10. [PubMed: 18809264]
- Schwab-Stone ME, Ayers TS, Kaspro W, Voyce C, Barone C, Shriver T, & Weissberg RP (1995). No Safe Haven: A study of violence exposure in an urban community. *Journal of the American Academy of Child and Adolescent Psychiatry*, 34, 1343–1352. [PubMed: 7592272]
- Shoaib M, Swanner LS, Yasar S, & Goldberg SR (1999). Chronic caffeine exposure potentiates nicotine self-administration in rats. *Psychopharmacology*, 142, 327–333. [PubMed: 10229056]
- Silverberg S, & Small S (1991). Parental monitoring, family structure and adolescent substance use. Paper presented at the meeting of the Society of Research in Child Development, Seattle, WA.
- Steinberg L, Fletcher A, & Darling N (1994). Parental monitoring and peer influences on adolescent substance use. *Pediatrics*, 93, 1060–1064. [PubMed: 8197008]
- Terry-McElrath YM, O'Malley PM, & Johnston LD (2014). Energy drinks, soft drinks, and substance use among US secondary school students. *J Addict Med*, 8, 6–13. [PubMed: 24481080]
- U.S. Senate Committee on Commerce Science and Transportation. Hearings: Energy drinks, Exploring concerns about marketing to youth. [10 2013]; What's all the buzz about? A survey of popular energy drinks finds inconsistent labeling, questionable ingredients and targeted marketing to adolescents. 2013 Available at http://www.commerce.senate.gov/public/index.cfm?p=Hearings&ContentRecord_id=8d4fc1e4-18a4-40e0-8ae5-aab438ecba22&ContentType_id=14f995b9-dfa5-407a-9d35-56cc7152a7ed&Group_id=b06c39afe033-4cba-9221-de668ca1978a&MonthDisplay=7&YearDisplay=2013.
- Xiaoming L, Stanton B, Feigelman S (2000). Impact of perceived parental monitoring on adolescent risk behavior over 4 years. *Journal of Adolescent Health*, 27, 49–56 [PubMed: 10867352]
- Waschbusch DA, & Elgar FJ (2007). Development and validation of the conduct disorder rating scale. *Assessment*, 14, 65–74. [PubMed: 17314181]
- Weissberg RP, Voyce CK, Kaspro WJ, Arthur MW, & Shriver TP (1991). *The Social and Health Assessment* New Haven, CT: Authors.
- Yale Rudd Center for Food Policy and Obesity. Energy drink marketing to teens: 2010 to 2013 Rudd Center; 2013 [10 2013]. Available at http://www.yaleruddcenter.org/resources/upload/docs/what/advertising/Energy_Drink_Marketing_Teens.pdf.
- Zapolski TC, Stairs AM, Settles RF, Combs JL, Smith GT (2010). The measurement of dispositions to rash action in children. *Assessment*, 17, 116–125. [PubMed: 19955108]

Highlights

- Early adolescent caffeine consumption predicts later alcohol use
- This effect is not accounted for by established risk factors for alcohol use
- This effect is present for both energy drink and coffee consumption
- This effect is particularly strong for youth who consume energy drinks and experience low parental monitoring

Figure 1.

Associations among initial levels of parental monitoring and energy drink consumption and later alcohol use.

Table 1.

Frequencies of caffeine and alcohol use

	None	Infrequent use (at least once in the past 4 months, but less than once per week)	Frequent use (once per week or more)
Energy Drinks			
Initial assessment	59%	33%	8%
Final assessment	50%	38%	12%
Coffee			
Initial assessment	37%	39%	24%
Final assessment	39%	36%	25%
Alcohol			
Initial assessment	89%	10%	1%
Final assessment	85%	13%	2%

Table 2.

Correlations among caffeine consumption, risk factors for alcohol use, and alcohol use among early adolescents.

	Gender	Race	Initial alcohol use	Initial peer alcohol use	Initial friend alcohol use	Initial social behavior expectancies	Initial sensation-seeking	Initial parental monitoring	Initial energy drink use	Initial coffee use	Final alcohol use
Age	.04	-.09	.16 [§]	.25**	.17*	.32**	-.10	-.28***	.16*	.10	.09
Gender		.03	.03	.05	.09	.04	-.23**	.04	-.20**	-.06	.14
Race (Af-Am=1)			.02	.02	-.01	-.09	.001	-.14 [§]	-.13	-.22**	-.12
Initial alcohol use				.32***	.32***	.30**	.11	-.38***	.18*	.01	.32***
Initial peer alcohol use					.58***	.37***	.10	-.31***	.31***	.23**	.14
Initial friend's alcohol use						.30**	.11	-.23**	.28**	.24**	.21*
Initial soc beh expectancies							.20*	-.35***	.23*	.21*	.23*
Initial sensation-seeking								-.22**	.37***	.30***	.11
Initial parental monitoring									-.34***	-.14	-.22*
Initial energy drink use										.43***	.31***
Initial coffee use											.20*

§ p<.10

* p<.05

** p<.01

*** p<.001

Table 3.

Associations between caffeine consumption and later alcohol use, adjusting for risk factors for alcohol consumption

Predictor	Predicting Alcohol Use by Energy Drinks Estimate (SE)	Predicting Alcohol Use by Coffee Estimate (SE)
Age	.06 (.24)	-.01 (.31)
Gender	.95 (.46) *	.85 (.47) ^{\$}
Race	-.35 (.52)	-.21 (.55)
Initial alcohol use	.49 (.33)	.47 (.37)
Initial perceived peer alcohol use	-.38 (.33)	-.27 (.32)
Initial perceived best friend's alcohol use	.20 (.28)	.19 (.31)
Initial social behavior expectancies	.11 (.08)	.09 (.10)
Initial sensation-seeking	-.09 (.34)	.17 (.33)
Initial parental monitoring	-.02 (.02)	-.03 (.02)
Initial caffeine use	.96 (.42) *	.81 (.39) *

^{\$}
p<.10

*
p<.05

Table 4.

Moderation analyses examining interactions between caffeine use and other risk factors in the prediction of later alcohol use

Predictor	Predicting Alcohol Use by Energy Drinks (estimate (SE))	Predicting Alcohol Use by Coffee (estimate (SE))
Gender:		
Gender	1.07 (.80)	.76 (1.02)
Caffeine	1.05 (.70)	.75 (.75)
Gender x caffeine	-.14 (.89)	.09 (.84)
Sensation seeking:		
Sensation-seeking	-.23 (.44)	-.20 (.60)
Caffeine	.46 (.99)	.25 (.90)
Sensation-seeking x caffeine	.25 (.45)	.35 (.52)
Parental monitoring:		
Parental monitoring	.03 (.03)	.01 (.04)
Caffeine	5.60 (2.06)**	2.89 (1.97)
Parental monitoring x caffeine	-.09 (.04)*	-.04 (.03)

p<.10

* p<.05

All analyses adjusted for main effects of age, gender, race/ethnicity, sensation-seeking, perceptions of peer and best friend alcohol use, social behavior alcohol expectancies, and parental monitoring.

Analyses were repeated adjusting only for demographic factors (age, gender, and race/ethnicity) and the pattern of moderation results remained identical.