Title

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Journal

Experimental and clinical psychopharmacology, 26(6)

ISSN

1064-1297

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Publication Date

2018-12-01

DOI

10.1037/pha0000223

Peer reviewed

HHS Public Access

Author manuscript

Exp Clin Psychopharmacol. Author manuscript; available in PMC 2019 December 01.

Published in final edited form as:

Exp Clin Psychopharmacol. 2018 December ; 26(6): 560–569. doi:10.1037/pha0000223.

Alcohol Family History Moderates the Association between Evening Substance-Free Reinforcement and Alcohol Problems

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Abstract

Behavioral economic theories of substance abuse posit that deficits in substance-free reward increase risk for substance misuse, but little research has examined potential moderators of this relationship, including dispositional risk factors. Here, we tested the hypothesis that young adult heavy drinkers with family histories of alcohol misuse would show a stronger association specifically between low evening substance-free reinforcement and alcohol problems compared to those without a family history of alcohol misuse. Participants were 317 college students reporting heavy episodic drinking (M_{age} = 18.8, SD = 1.1, 61% female, 79% white) who completed a questionnaire about engagement and enjoyment in rewarding activities not involving substance use after 7pm, along with measures of personal and parental alcohol use/problems. Evening substance-free reinforcement was negatively associated with typical drinking level for women, but not for men. Family history status did not show a significant association with typical alcohol consumption or evening substance-free reinforcement (operationalized as activity participation × enjoyment), but did show a significant association with alcohol problems. Evening substance-free reinforcement was significantly negatively related to alcohol problems for both men and women. However, the presence of a family history of alcohol misuse moderated this relationship, such that only individuals with familial risk for alcohol misuse who reported lower evening substance-free reinforcement evidenced greater alcohol-related problems. These findings suggest that lower evening substance-free reinforcement is associated with alcohol misuse among young adults, and that this association is exacerbated among individuals with familial risk for developing alcohol problems.

Keywords

Behavioral Economics; Substance-free Reinforcement; Family History; College Student Drinking; Alcohol Problems

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The authors declare no conflicts of interest.

These ideas and results were presented in the form of a poster and a symposium presentation at the 2018 Collaborative Perspectives on Addiction Conference. The symposium was titled '*Behavioral Economic Contributions to Understanding Substance Misuse in Different Life Stages,*' (chair: K.J. Joyner).

Alcohol misuse results in over $200 billion in preventable healthcare costs in the U.S. each year (Rehm et al., 2009). Young adults are the highest risk demographic group: despite two decades of prevention efforts, nearly 2 out of 5 of college students report drinking to drunkenness in the past month (Johnston, O'Malley, Bachman, Schulenberg, & Miech, 2016). Effective prevention of this public health problem requires a more nuanced and scientifically based understanding of the dispositional and contextual risk factors that contribute to alcohol misuse. Behavioral economic theories of substance abuse propose that misuse of alcohol and drugs arises from, and is maintained by, heightened valuation of substance-related reinforcement and diminished alternative (substance-free) reinforcement (Bickel, Johnson, Koffarnus, Mackillop, & Murphy, 2014). Although there is robust evidence that behavioral economic variables such as drink price and the presence of alternative reinforcers have significant predictive power, relatively little research has investigated *for whom* these parameters are most predictive of drinking risk. The current study evaluated whether the association between lack of substance-free reinforcement and alcohol problems is stronger among individuals who have a family history of alcohol problems versus those who do not.

Substance-Free Reinforcement and Alcohol Problems

Behavioral economic models posit that substance misuse is more likely in contexts that are devoid of alternatives to drug and alcohol use (Bickel et al., 2014; Vuchinich & Tucker, 1988). This general hypothesis is consistent with the matching law (e.g. Herrnstein, 1974), which states that the amount of engagement in/with a stimulus or action is commensurate with reinforcement derived from that stimulus/action. From this perspective, increases in the availability of, and engagement with, rewarding substance-free activities should generally be associated with decreases in substance use, and vice versa. Consistent with this notion, individuals who do not have access to substance-free rewarding stimuli in their environment (e.g., due to poverty, lack of recreational opportunities, disability/health problems, or social alienation) tend to show increased substance use and substance-related problems (Higgins, Heil, & Lussier, 2004). Indeed, recent research using a behavioral measure of reward engagement provides evidence that individuals who have difficulty accessing natural rewards in their environment exhibit more alcohol use disorder symptoms (Joyner et al., 2016). Further, several successful intervention approaches have facilitated reductions in substance use by increasing engagement with substance-free reinforcement (Murphy et al., 2012; Petry et al., 2000; Daughters et al., 2008). This line of work is consistent with basic laboratory research demonstrating that environmental enrichment suppresses drug administration (Ahmed, 2005; Green, Gehrke, & Bardo, 2002; Stairs & Bardo, 2009), including the seminal "rat park" studies (Alexander, Coambs, & Hadaway, 1978; Alexander, Beyerstein, Hadaway, & Coambs, 1981), and studies with human drug abusers (Hart, Haney, Foltin, & Fischman, 2000).

Reinforcement survey schedules are commonly used to quantify substance-free reinforcement in applied-clinical settings (Correia, Simons, Carey, & Borsari, 1998; Correia, Carey, & Borsari, 2002; see Heinz, Lilje, Kassel, & de Wit, 2012 for a review). These self-report inventories quantify frequency of engagement and enjoyment of a wide range of

typically pleasurable activities (MacPhillamy & Lewinsohn, 1982). Typically, scores reflecting the total products of responses for these two parameters (i.e., frequency × enjoyment) are computed to index the individual's level of reinforcement. Using this approach, Van Etten, Higgins, Budney, & Badger (1998) found that cocaine users reported limited reinforcement from substance-free activities. Similarly, Correia, Carey, Simons, and Borsari (2003) demonstrated that binge drinkers reported lower substance-free reinforcement than their non-binge-drinking peers, and furthermore, a subsequent study from this group showed that an increase in substance-free activities predicted a subsequent reduction in drinking over a one-month period (Correia, Benson, & Carey, 2005).

One possible limitation of current reinforcement survey indices is that they do not specify a time frame in which the substance-free activities take place. Previous work has indicated that binge drinking is actually associated with heightened overall substance-free reinforcement in social domains (e.g., Skidmore & Murphy, 2010), and that drinking may facilitate social bonding in college students (Sayette et al., 2012). Because most young adult drinking occurs in the evenings (Murphy, Barnett, & Colby, 2006), substance-free activities that occur specifically in the evening may be the most relevant substitutes for drinking. We addressed this issue in the current study by using an alternative measure of substance-free reinforcement, the Leisure Activities Evening Questionnaire (LAEQ; Murphy et al., 2012) that specifically assesses evening activity participation and enjoyment. One previous study that used a daily timeline follow-back approach to examine evening activity participation and enjoyment found that that there was a negative association between past-month alcohol consumption and past-month substance-free evening activity enjoyment for college women, but not for college men (Murphy, Barnett, Goldstein, & Colby, 2007). As such, gender may be a potential moderator for the relationship between evening activities and alcohol problems.

The Implications of Family History of Alcohol Misuse

There is abundant evidence suggesting that parental psychopathology puts offspring at risk for similar psychopathology (Kendler, Davis, & Kessler, 1997). Having a family history of psychopathology is said to put offspring at a dispositional risk for similar kinds of psychopathology due to shared genetic influences as well as gene-environment correlations that affect parenting styles and the home environment (Elder et al., 1986; Rutter et al., 1990). In the case of problematic drinking, offspring with a positive family history of such problems (FH+), relative to those lacking a family history (FH−), are more likely to progress into heavier drinking over time, have higher rates of alcohol use disorder diagnosis (Grant, 1998), and show blunted reactivity to the sedating effects of alcohol (Pollock, 1992; Schuckit & Smith, 2001). Possibly as a function of experiencing decreased sedating effects of alcohol, FH+ women have more positive alcohol expectancies than their FH− peers (Pastor & Evans, 2003), and this effect was replicated for both genders in a large sample of college student drinkers (LaBrie, Migliuri, Kenney, & Lac, 2010). Additionally, taste-elicited conditioned neural responses (i.e. brain response to the taste of beer, despite lack of alcohol content) in reward-areas of the brain are stronger in FH+ individuals (Oberlin et al., 2013). Similarly, visual cues (pictures of alcohol) elicit greater neural response in temporo-parietal brain regions in FH+ individuals (Dager et al., 2013). Thus, reinforcement derived from

alcohol appears to be greater for FH+ individuals. Consequently, given the greater reinforcement from alcohol among FH+ individuals, engagement with highly reinforcing substance-free alternatives may be an especially important protective factor for FH+ individuals. Whereas young adults without a positive history of alcohol misuse may be able to regulate their alcohol use even in the absence of alternatives, those with a family history of alcohol misuse may struggle to regulate their drinking in the absence of compelling alternatives, thus contributing to a stronger association between level of substance-free reinforcement and alcohol problems.

Current Study

Evidence reviewed in the preceding section indicates that substance-free reinforcement may play a causal and/or maintaining role in alcohol use and problems (Bickel et al., 2014), and that this could be potentially even more important for those at familial risk for alcohol misuse. For the current study, we hypothesized (1a) that LAEQ-operationalized (evening) substance-free reinforcement would show a negative association with alcohol use and alcohol-related problems. Based on previous research showing that evening substance-free activity enjoyment was negatively associated with alcohol use for college women but not men (Murphy et al., 2007), we sought to (1b) replicate a gender × LAEQ interaction in prediction of alcohol use and problems. Additionally, we hypothesized (2) that FH+ individuals would show more alcohol use and alcohol-related problems than FH− individuals. Finally, there is evidence to suggest that FH status is associated with deriving heightened substance-related reinforcement (Pastor & Evans, 2003; LaBrie et al., 2010; Oberlin et al., 2013), and may amplify the effect of lacking substance-free reinforcement on substance use and problems. Thus, we hypothesized (3) that FH status will moderate the association between evening substance-free reinforcement and alcohol problems (i.e., amplify the negative relationship).

Method

Participants

Participants were 393 undergraduate students who reported past-month heavy drinking from two large public universities. All procedures were approved by both universities' IRBs and complied with established ethical guidelines. Sixty-one ($n = 61$) participants were excluded from these analyses due to ambiguous responses concerning parental alcohol problem history (see below for the decision tree for exclusion), five participants were excluded for a missing income variable, and ten participants were excluded for a missing age variable, resulting in a final sample size of 317.[1] The monthly disposable income of the participant was used as a covariate in the below analyses. Responses for the monthly disposable income of the participant were binned on a 1–7 ordinal scale (40.1% = $0–$100, 23.3% = $101–$200, 9.5% = $201–300, 11.7% = $301–$500, 3.5% = $501–$750, 6.3% = $751–$1,500, and 5.7% = $1,500+).

[1]The 76 participants excluded did not differ from the rest of the sample on age ($t(379) = -.93$, $p = .35$), gender ($\chi^2(1, 392) = .53$, $p = .47$), ethnicity ($\chi^2(7, 386) = 2.38$, $p = .94$), income ($\chi^2(6, 382) = 5.31$, $p = .51$), evening substance-free reinforcement ($t(391) = -.48$, $p = .63$), drinks per week (equal variances not assumed; $t(86.49) = .53$, $p = .60$), or alcohol-related problems ($t(391) = -.90$, $p = .37$).

Data for the current analyses were collected as a part of a clinical trial that evaluated a brief alcohol intervention (R01 AA020829). All participants were a) non-treatment seeking; b) full-time freshmen or sophomore college students above the age of 18; c) worked less than 20 hours per week; and d) reported two or more binge drinking episodes in the past month (5/4 drinks per occasion for men/women). All data used in the current analyses were collected before randomization to intervention condition. Participants (M_{age} = 18.8, SD = 1.1, 61% women) were mostly Caucasian (79%), with a minority of participants being African-American (8%), Multiracial (7%), Hispanic (3%), or Asian (1%). Participants drank an average of 16.77 (SD = 11.56) alcoholic drinks per week and experienced 13.17 (SD = 7.97) alcohol-related problems in the past month. Based on a large (N > 1,000) norming sample, 13.17 alcohol-related problems is considered “moderate risk” drinking behavior for this population (see Read, Haas, Radomski, Wickham, & Borish, 2016).

Measures

Current Alcohol Use Level—Typical drinking level was gathered using the Daily Drinking Questionnaire (DDQ; Collins et al., 1985). Participants reported the number of standard drinks they consumed on each day of a typical week in the past month. Daily consumption is summed to estimate typical weekly consumption. The DDQ has been shown to correlate highly with other measures of alcohol use (Kivlahan et al., 1990), and has been widely used in college student alcohol use literature (Borsari, Neal, Collins, & Carey, 2001).

Alcohol Problems—The Young Adult Alcohol Consequences Questionnaire (YAACQ; Read et al., 2006) was utilized to measure alcohol-related problems most commonly experienced by younger adults. The YAACQ is a 48-item questionnaire that demonstrates excellent internal consistency (in our sample, α = .89, greatest lower bound [GLB] = .94, see McNeish, 2017) and has demonstrated good convergent validity with other established measures of alcohol problems (Read et al., 2007).

Substance-Free Reinforcement—The Leisure Activity Evening Questionnaire (LAEQ; Murphy et al., 2012) is a reinforcement survey schedule measure assessing 17 potentially enjoyable activities, in which participants rate how frequently they engaged in each activity without drinking or using drugs, and how much they enjoyed it, specifically in the evenings (after 7pm) of the previous month. Some example items include “Engage in a hobby or creative activity”, “Going to a sporting event”, and “Spending time with a date or romantic partner.” This time period was chosen because college drinking typically takes place in the evening, and evening alternatives may be most relevant to students’ decisions to drink versus engaging in other activities (Murphy et al., 2006; 2007). Commonly, reinforcement surveys include mostly social items, and may provide a limited assessment of non-social substance-free activities (Skidmore & Murphy, 2010; Hallgren, Greenfield, & Ladd, 2016). Due to the minimal inclusion of solitary enjoyable activities, these inventories may not adequately reflect important non-social activity categories such as academic activities and many hobbies. The LAEQ has a more balanced representation of solitary and social activities (the questions in the full LAEQ measure are included in the Supplementary Materials). Products of responses (frequency × enjoyment) for each item are summed, reflecting the total amount of reinforcement derived from the listed evening substance-free activities. This

quantification approach has been widely validated (Cautela & Lynch, 1983; MacPhillamy & Lewinsohn, 1982), including adaptations that differentiate substance-related and substance-free activity participation and enjoyment (Correia, Carey, & Borsari, 2002; Hallgren et al., 2016). The LAEQ total score (M = 71.66/Med = 67.00, SD = 33.65) showed high internal consistency (α = .85, GLB = .90). Exploratory analyses were also conducted separating out frequency and enjoyment metrics from the LAEQ.

Family History of Alcohol Problems—Family history of alcohol problems was determined by asking participants whether their "biological mother or father have/had a problem with alcohol". This method for identifying familial history of alcohol problems is highly similar to the family history assessment methods utilized in the Addiction Severity Index (McLellan et al., 1992), Project MATCH (Project Match Research Group, 1998), and other published work (Park, Armeli, & Tennen, 2004). Previous research has indicated offspring are able to accurately identify alcohol problems in their parents generally (Sher & Descutner, 1986). A conservative approach was taken to determine whether participants were FH+ or FH−. If a participant answered 'yes' to either their biological mother or father having a history of alcohol problems, they were coded as FH+, regardless of what response they gave about their other biological parent. However, to be coded FH−, a participant had to have answered 'no' to questions about both their mother and father. If a participant answered 'no' to one, but answered that they did not know their other biological parent, they were excluded from analyses. If a participant answered 'maybe' or 'not sure' to one parent, and 'no' to the other, they were excluded from analyses. Thus, only a definitive answer of 'no' to both parents was coded as FH−. 61 participants were dropped due to ambiguity in their responses.

Data Analytic Plan

All analyses were performed using SPSS version 22. Prior to inferential analyses, data were screened for outliers using the criterion of median value ± two interquartile ranges; this criterion was chosen because the presence of outlying values have greater influence over the mean and standard deviation values (which are commonly used in outlier detection) than they do on the median and interquartile ranges (Donoho & Huber, 1983). There were 23 outliers identified using this method for typical weekly drinks. One value (156 drinks/week) was discarded as an excessive outlier, but the other 22 were retained (41–71 drinks/week) as plausible real values in a heavy drinking sample. Any other outlier values on other variables were winsorized to one unit above the highest non-outlying value. Next, skewness and kurtosis values were inspected to ensure that data were within normal limits (±2; Trochim & Donnelly, 2006) for multivariate data analyses, which all outlier corrected variables were, with the exception of typical weekly drinks. The distribution was slightly leptokurtic (2.27); however, linear regressions are robust against slight deviations from normal distributions (Gelman & Hill, 2006), so no further action was taken. To test Hypothesis 1, the partial correlations between the LAEQ and typical weekly drinks and alcohol problems were assessed, controlling for gender, age, ethnicity, and monthly disposable income. As an exploratory analysis, the LAEQ frequency and enjoyment metrics were separated to test for differential relations with typical weekly drinks and alcohol problems, pursuant with Magidson et al. (2017).[2] The size of the differences in the correlations between activity

enjoyment and alcohol problems and activity frequency and alcohol problems, respectively, were tested for significance using Steiger Z tests (see Steiger, 1980). A linear regression analysis was conducted to test for the interactive effect of gender and LAEQ on alcohol use and problems reported by Murphy et al. (2007), while controlling for age, ethnicity, and monthly disposable income. To test Hypothesis 2, a *t*-test was conducted to examine the effect of FH on current drinking level and alcohol-related problems. An additional exploratory analysis was conducted to test the effect of FH status on LAEQ score. Lastly, a linear regression analysis was conducted to test for an interactive effect of FH and LAEQ in prediction of alcohol-related problems, while controlling for gender, age, ethnicity, monthly disposable income, and current drinking level, as these covariates have well-characterized effects on alcohol problems (Hypothesis 3).

Results

Hypothesis 1: Evening Substance-Free Reinforcement

The LAEQ showed significant partial correlations in the expected negative direction with typical weekly drinks ($r = -.20$, $p < .001$) and with alcohol-related problems ($r = -.13$, $p = .022$), while controlling for gender, age, ethnicity, and monthly disposable income. Furthermore, the enjoyment and frequency metrics of the LAEQ were tested separately in relation to weekly drinks (enjoyment, $r = -.22$, $p < .001$; frequency, $r = -.18$, $p = .001$) and alcohol-related problems (enjoyment, $r = -.17$, $p = .002$; frequency, $r = -.13$, $p = .023$), but Steiger Z-tests indicated that the size of their correlations were not significantly different from one another (weekly drinks, $Z = 1.01$, $p = .311$; alcohol-related problems, $Z = -1.05$, $p = .293$).

Gender by Evening Substance-Free Reinforcement Interaction—A linear regression model including covariates of age, ethnicity, and monthly disposable income, centered main effects of gender and LAEQ, and the gender × LAEQ interaction was tested in prediction of typical drinking level. The overall model was significant $F(6, 310) = 8.75$, $p < .001$, $R^2 = .15$, and there was a significant interaction between gender and LAEQ ($\beta = .13$, $p = .018$), and the main effects of gender ($\beta = -.26$ $p < .001$) and LAEQ ($\beta = -.22$, $p < .001$) remained significant. Probing the interaction through recentering the dichotomous gender variable around the corresponding values for men and women and recomputing the interaction term, respectively, revealed that for men, evening substance-free reinforcement did not significantly predict typical drinking level ($\beta = -.09$, $p = .174$). But for women, evening substance-free reinforcement was significantly negatively related to typical drinking level ($\beta = -.35$, $p < .001$). However, when testing the same linear regression model with alcohol problems as the DV, there was no evidence of a gender × LAEQ interaction (interaction $\beta = .05$, $p = .403$) suggesting that LAEQ was negatively associated with alcohol problems for both men and women.

[2]There are current questions in the field as to whether frequency and enjoyment scales should be multiplied to form a cross-product. Magidson, Robustelli, Seitz-Brown, and Whisman (2017) reported similar predictive relations for frequency and enjoyment scores with depression (negative in each case), but not substance problems (where only enjoyment evidenced a significant negative association), possibly pointing to the representation of distinct sources of variance reflected in these two scores. We tested for this divergence in the current work, though we did not have strong hypotheses about this separation in our evening-activities reinforcement measure.

Hypothesis 2: Family History

An independent samples *t*-test was used to test for differences in YAACQ total score based on FH status. Levene's test for equality of variances was significant, $F = 4.86$, $p = .028$, thus, equality of variances was not assumed. FH+ individuals showed a significantly greater number of alcohol-related problems than FH− individuals, $t(250.10) = -2.86$, $p = .005$, Cohen's $d = .34$. Levene's test was nonsignificant for the subsequent tests, so equality of variances was assumed. Current drinking level did not differ as a function of FH status, $t(315) = -.96$, $p = .336$, $d = .11$, likely due to sample composition (i.e., all participants were heavy drinkers). Number of binge episodes did not differ as a function of FH status either, $t(315) = -1.90$, $p = .059$, $d = .22$, also likely due to sample composition. LAEQ scores also did not differ as a function of FH status, $t(315) = -.67$, $p = .501$, $d = .08$. Table 1 displays the comparison of FH+ to FH− participants on all measures from the current work.

Hypothesis 3: Substance-Free Reinforcement and Family History Interaction

A linear regression model including covariates of gender, age, ethnicity, monthly disposable income, and typical drinking level, centered main effects of a family history of alcohol problems and LAEQ, and the interaction between family history and LAEQ was tested in prediction of YAACQ total score. The overall model was significant, $F(8, 308) = 11.71$, $p < .001$, $R^2 = .23$. Additionally, there was a significant interaction in prediction of alcohol-related problems (interaction $\beta = -.12$, $p = .017$), and the main effect of family history ($\beta = .12$, $p = .022$), but not LAEQ ($\beta = -.07$, $p = .182$), remained significant. Probing the interaction through centering the dichotomous FH variable around the corresponding values for FH− and FH+ and recomputing the interaction term, respectively, revealed that for individuals who have no family history of alcohol misuse, evening substance-free reinforcement did not significantly predict alcohol problems ($\beta = .05$, $p = .449$). However, for individuals who did have a family history of alcohol misuse, evening substance-free reinforcement was significantly negatively related to alcohol problems ($\beta = -.19$, $p = .015$; see Figure 1).[3]

Discussion

Behavioral economic models provide unique explanations for alcohol and substance misuse (e.g. Bickel, Jarmolowicz, Mueller, & Gatchalian, 2011; Bickel et al., 2014). Central to these models is the assumption that levels of drug use are critically related to the engagement with alternative (substance-free) rewards in the environment. Numerous studies have shown that greater substance-free reinforcement is associated with decreased alcohol and substance misuse (Bickel et al., 2012; Higgins et al., 2004; Vuchinich & Tucker, 1988), and is protective against teen drug use (Audrain-McGovern, Rodriguez, Rodgers, & Cuevas, 2011; Khoddam & Leventhal, 2016; Leventhal et al., 2015). However, our results suggest that, among college student drinkers, this effect may be most pronounced among individuals who are at dispositional risk for alcohol misuse (those having a family history of alcohol misuse). FH− individuals did not show a significant association between substance-free

[3]There was no evidence of a three-way interaction between family history, evening substance-free reinforcement, and gender in prediction of alcohol problems.

reinforcement and alcohol use or problems. As such, future work should examine this moderation effect when studying substance-free reinforcement, as family history status appears to influence these effects to a significant degree.

Our results also partially replicate the work by Murphy and colleagues (2007), showing evidence of a significant gender by evening substance-free reinforcement interaction in prediction of drinking level, such that evening substance-free reinforcement is particularly influential on women's typical weekly drinking level. However, the protective effect of evening substance-free reinforcement on alcohol-related problems was present across both men and women equally. Additionally, gender did not further moderate the interaction between family history status and evening substance-free reinforcement. This gender moderation effect is consistent with data showing that college men were overall less likely to socialize on nights they abstained from using alcohol (Murphy et al., 2006). As such, drinking may be more tightly tied to socialization more generally for men, whereas substance-free reinforcement may function as more of a replacement for drinking for women. These moderators of the effect of substance-free reinforcement point towards the need for a greater understanding of the person-specific characteristics (e.g., family history, gender) and event-specific characteristics (e.g., time of day, type of activity) that play a role in the protective effects of substance-free activity participation on alcohol problems. Future work should also investigate these interactive effects on other types of substance problems.

These data have implications for research on family history as a risk factor for alcohol misuse. Studies on family history of alcohol misuse in college students have found conflicting evidence about whether FH+ status actually increases risk of alcohol problems (Engs, 1990; Harrell, Slane, & Klump, 2009). In college populations, normative drinking is driven primarily by social factors (Borsari & Carey, 2001), and makes the influence of FH status complicated and conditional. For example, Murphy and colleagues (2014) observed no differences amongst FH+ and FH− college students in their overall alcohol demand (hypothetical drink purchases across a range of prices), but did find that FH+ students showed lower reductions in demand in a higher-risk drinking context (a demand curve task asking them to imagine them having an important college exam the next morning). It has also been found that family history status modulates drinking patterns in first-year college students (LaBrie, Kenney, Lac, & Migliuri, 2009), and is associated with greater positive expectancies about the effects of alcohol use despite experiencing more negative consequences (LaBrie et al., 2010). In the current study, we found a significant zero-order relationship between FH status and alcohol problems. However, if individuals reported higher levels of evening substance-free reinforcement, the differences in alcohol problems among FH+ and FH− individuals were no longer observed. Thus, these data could be interpreted as substance-free reinforcement playing a protective role against risk conferred by FH+ (i.e., if substance-free reinforcement was viewed as the theoretical moderator). Both lines of research focused more on dispositional risk factors (family history studies) and lines of research borne out of behaviorist traditions (behavioral economics) should examine the interplay between them when studying college student alcohol misuse.

The current study has several limitations. First, the sample was relatively homogeneous in terms of drinking level given that heavy drinking was an inclusion criterion. Light drinking

individuals may exhibit variance in drinking problems that could be differentially related to substance-free reinforcement. Second, although our self-report method of assessing family history was consistent with what was used in previous research (McLellan et al., 1992; Murphy et al., 2014; Park, Armeli, & Tennen, 2004), this approach introduces error due to the fact that young adults may not have full knowledge of their parents' drinking patterns. Moreover, family history of alcohol misuse was treated as a dichotomous variable, which attenuates the sensitivity of prediction. Future research should explore continuous measures of disinhibitory liability (e.g. Patrick, Kramer, Krueger, & Markon, 2013) and/or low level of response to alcohol (e.g. Schuckit & Smith, 2000), both of which are related to family history of alcohol misuse, as moderators in future investigations to help clarify the nature of this interaction. Behavioral genetics (e.g., twin designs) and molecular genetics studies should also be conducted to better understand different genetic and environmental influences exerted on substance-free reinforcement and alcohol use and problems by FH+ status.

We also encourage the replication of these results in other samples to ensure replicability and generalizability across sample demographics. The way in which family history confers risk in college student heavy drinkers may differ from how it may express itself in a general community sample, or a more severe sample of treatment-seeking individuals. Among young adults, drinking is often driven by social-contextual factors and can be seen as largely normative (Borsari & Carey, 2001). Additionally, there are often high numbers of alternative activities for college students to engage in (Murphy et al., 2006), and thus, substance-free reinforcement may only be relevant to alcohol misuse in those who have already elevated dispositional risk characteristics (e.g. FH+). However, in samples where access to alternative reinforcers may be more variable, such as in adult treatment samples, substance-free reinforcement may play a larger role even in the absence of dispositional risk characteristics (Higgins et al., 2004). Future studies should also investigate these results in relation to other drugs. Though similar mechanisms may be largely responsible for the familial transmission of substance use disorders other than alcohol (Hicks, South, Dirago, Iacono, & Mcgue, 2009; Hicks, Iacono, & Mcgue, 2012), it is unknown whether substance-free reinforcement would be moderated in the same fashion for other substance problems. Lastly, the cross-sectional design including retrospective measurement of alcohol use substance-free reinforcement could be improved upon in future studies using more frequent and prospective assessment of substance-free reinforcement and alcohol use and problems, possibly facilitated by the growing interest in ecological momentary assessment (EMA) methods.

The current study also featured several notable strengths. Due to the recruitment of heavy drinkers, the representation of family history of alcohol problems was larger than that of the general population, which helps initial investigations of the effect of this variable. The current study is also the first to integrate two central risk factors for the development of substance misuse – low levels of substance-free reward and positive family history of alcohol misuse and the observed interaction between these variables can extend and integrate these research literatures. The LAEQ also displays suitable psychometric properties as a research instrument in terms of its internal consistency reliability (α = .85, GLB = .90) and associations with alcohol-related problems. Additionally, the LAEQ focuses on evening-time activity engagement and enjoyment, whereas time of day is unspecified in other reinforcement survey schedules. Because the majority of drinking by young adults occurs in

the evenings, this likely pits choices between alcohol-free and alcohol-related rewards directly against one another.

The results of the current study may also have implications for the treatment of alcohol problems in college student populations. Previous brief motivational interviewing protocols have demonstrated a decrease in alcohol problems partially as a function of increased substance-free activity engagement (Murphy et al., 2005, 2012). Future research should examine the possibility of differential treatment-related mechanisms of change for individuals as a function of family history status. For FH+ individuals, treatments focused on increasing substance-free rewards, such as a behavioral economic theory based supplemental treatment (Murphy et al., 2012; Yurasek, Dennhardt, & Murphy, 2015) that increases motivation for and engagement in value-relevant substance-free activities, or behavioral activation (i.e. LETS ACT; Daughters et al., 2017) may be specifically effective in reducing problematic substance use. For FH− individuals, there may be additional considerations in these types of treatments to address, but further research, including longitudinal examinations, will be needed to delineate what these may be. Future studies should examine the mechanisms of behavior change in treatment studies that select based on FH status to better understand what mechanisms may be responsible for differential treatment responses.

In summary, the results of the current study suggest that substance-free reinforcement levels in the evenings are particularly important for suppressing alcohol problems in college students. Specifically, those students who are at dispositional risk for alcohol problems (i.e. FH+) that also have lower levels of evening substance-free reinforcement are at risk for experiencing the greatest number of alcohol problems. Evening substance-free reinforcement also is more protective against heightened drinking levels for women compared to men. Interventions designed to reduce alcohol problems in college student populations may benefit from examining the dispositional characteristics of the individuals in the treatment when studying possible mechanisms of change.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This research was supported by grant R01 AA020829 to James G. Murphy from the National Institute on Alcohol Abuse and Alcoholism (NIAAA). The content of the paper is the responsibility of the authors and does not represent official views of the NIAAA.

All authors contributed in significant ways to the creation of the current manuscript; Keanan J. Joyner developed the study concept, performed the primary data analysis, and was responsible for the initial drafting of the paper. Samuel Acuff and Lidia Meshesha provided particular expertise in behavioral economic theory and made valuable revisions to the paper. Christopher J. Patrick contributed critical revisions to the framing of the paper and provided specific expertise about family history of alcohol misuse, and James G. Murphy served as the senior author on the paper, overseeing all aspects of the work from all authors and significantly influenced Keanan J. Joyner's conception, data analysis, and writing of the paper. All authors have read and approved the current manuscript.

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Public Significance Statement

Consistent with behavioral economic theory, this study suggests that engagement with enjoyable substance-free evening activities may be protective against alcohol problems among college student heavy drinkers. Furthermore, moderation analyses suggest that alternatives may be especially protective for young adults with a family history of alcohol misuse. This finding provides support for prevention efforts that attempt to provide enjoyable evening alternatives to drinking (e.g., social, leisure, or academic activities), especially for college students with a positive family history of alcohol misuse.

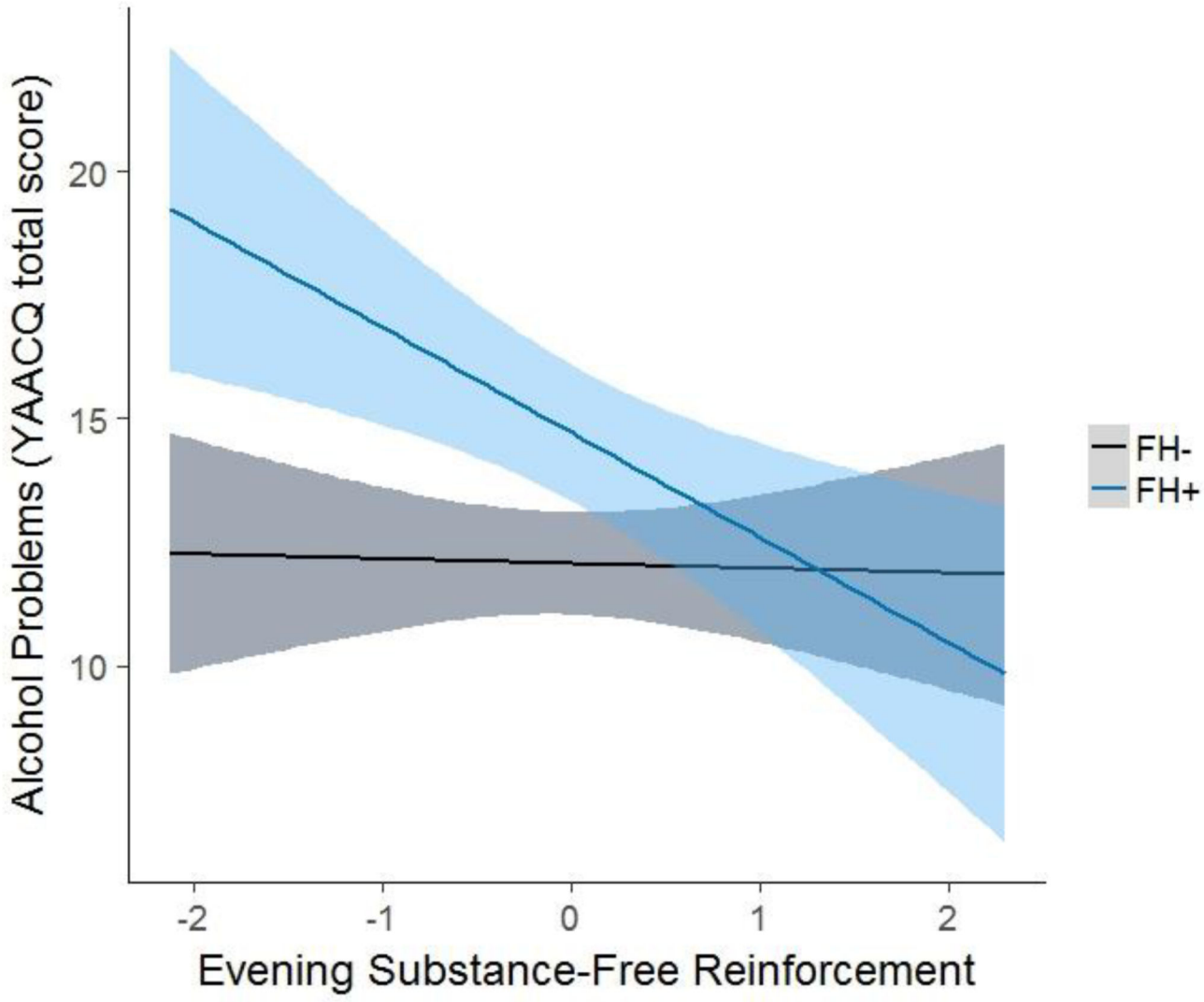

Figure 1.

Depiction of the Family History status by Evening Substance-free Reinforcement (LAEQ) Interaction predicting Alcohol Problems (YAACQ total score). Numbers on the y-axis are unadjusted values, representing the overall number of alcohol consequences experienced in the past month. Evening Substance-Free Reinforcement (LAEQ) values on the x-axis are in standardized units. FH+ (blue line) and FH− (black line) refers to groupings by positive or negative family history of alcohol misuse, respectively. Shading represents the 95% confidence interval.

Table 1

Current study variables descriptive statistics separated by family history of alcohol misuse status.

Demographics	**FH− (*n* = 187)**	**FH+ (*n* = 130)**	**Total (*N* = 317)**
Gender	55.6% Female	66.2% Female	59.9% Female
Age	18.78 (*SD* = 1.08)	18.81 (*SD* = 1.18)	18.79 (*SD* = 1.12)
Race/Ethnicity	White - 80.2% Black – 5.9% Hispanic – 3.7% Asian – 2.1%	White – 77.7% Black – 10.8% Hispanic – 1.5% Asian – 0%	White - 79.2% Black - 7.9% Hispanic - 2.8% Asian – 1.3%
Main Study Variables			
LAEQ total	70.60 (32.95)	73.19 (34.69)	71.66 (33.65)
LAEQ-enjoyment	33.57 (12.22)	33.88 (12.52)	33.70 (12.33)
LAEQ-frequency	25.28 (8.69)	25.78 (8.73)	25.49 (8.70)
DDQ total	16.25 (11.02)	17.52 (12.30)	16.77 (11.56)
*YAACQ total**	12.09 (7.36)	14.73 (8.55)	13.17 (7.97)

Note. Means presented for current study variables in the table with associated standard deviations in parentheses.

* Indicates a significant difference between family history groups in an independent samples *t*-test.

LAEQ = Leisure Evening Activity Questionnaire. DDQ = Daily Drinking Questionnaire. YAACQ = Young Adult Alcohol Consequences Questionnaire.

Table 2

Correlation matrix of study variables.

	Age	Gender	Income	Family History Status	LAEQ Total	LAEQ – Frequency	LAEQ – Enjoyment	DDQ Total	YAACQ Total
Age	--								
Gender	.055	--							
Income	−.079	−.133*	--						
Family History Status	.012	.106	−.097	--					
LAEQ Total	.078	.084	−.003	.038	--				
LAEQ – Frequency	−.004	−.050	.054	.028	.888**	--			
LAEQ – Enjoyment	.015	.114*	−.001	.012	.881**	.711**	--		
DDQ Total	.030	−.284**	.123*	.054	−.212**	−.161**	−.248**	--	
YAACQ Total	.005	.133*	.037	.164**	−.110	−.126*	−.150**	.373**	--

Note.

* $p < .05$,

** $p < .01$.

LAEQ = Leisure Evening Activity Questionnaire. DDQ = Daily Drinking Questionnaire. YAACQ = Young Adult Alcohol Consequences Questionnaire.