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ALCOHOL DEMAND, FUTURE ORIENTATION, AND CRAVING MEDIATE THE
RELATION BETWEEN NEGATIVE AFFECTIVE SYMPTOMS AND
ALCOHOL PROBLEMS

by

Kathryn Elizabeth Soltis

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Abstract

Elevated depression and stress have been linked to greater levels of alcohol problems among young adults even after taking into account drinking level. The current study attempts to elucidate variables that might mediate the relation between symptoms of depression and stress and alcohol-related problems, including demand, future time orientation, and craving. Future orientation and craving significantly mediated the relation between depressive symptoms and alcohol-related problems. Alcohol demand, future orientation, and craving significantly mediated the relation between stress symptoms and alcohol-related problems. Heavy drinking young adults who experience stress or depression are likely to experience alcohol problems, and this is due in part to elevations in craving and alcohol demand, and less sensitivity to future outcomes. Interventions targeting alcohol misuse in young adults with elevated levels of depression and stress should attempt to increase future orientation and decrease craving and alcohol reward value.

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Alcohol Demand, Future Orientation, and Craving Mediate the Relation Between Negative Affective Symptoms and Alcohol Problems

A significant percentage of college students experience symptoms of depression (33%) and stress (38%) (Beiter et al., 2015). Further, about 44% of college students report one or more binge-drinking episodes (4/5 drinks on one occasion for females/males) in the previous two weeks (Core Institute, 2012). Alcohol and substance misuse are significant public health concerns that commonly co-occur with depression and stress (Grant et al., 2004; Wolitzky-Taylor, Bobova, Zinbarg, Mineka, & Craske, 2012). Among college students, symptoms of stress, depression, and stress-related disorders have been linked to higher levels of alcohol-related problems (Edwards, Dunham, Ries, & Barnett, 2006; Martens et al., 2008; Pedrelli et al., 2010; Weitzman, 2004), in a manner that is at least partially independent of alcohol consumption level (Dennhardt & Murphy, 2011). One study suggests a circular pattern of negative affect, drinking, and alcohol-related problems, which makes deciphering the effects of each of these variables on the others difficult (Hussong, Hicks, Levy, & Curran, 2001; Mallett et al., 2013). More importantly, however, it seems that chronic patterns of problematic alcohol use, such as drinking to cope with negative affective symptoms, has the potential for more problems in the long term (Merrill & Read, 2010).

Negative Affect, Alcohol Use, and Related Problems

Individuals with affective disorders have been shown to be disproportionately more likely to relapse or re-initiate drug use after a period of abstinence (Conner, Sorensen, & Leonard, 2005; Hasin & Grant, 2002; Kodl et al., 2008), and a recent review of the literature suggests strong associations between alcohol use and depression (Pedrelli, Shapero, Archibald, & Dale, 2016). One theoretical approach that has been used to understand this relation is “self-

medication” theory (Kushner, Sher, & Beitman, 1990; Smith & Book, 2010), which posits that individuals with emotional disorders, such as depression, will use alcohol or other substances to alleviate the distress brought on by the emotional disorder (Khantzian, 1997). However, the association between alcohol use and depression appears to be dependent on a variety of factors, including gender, developmental phase (adolescent vs. young adult), and the severity of the problem(s) examined within a study (Pedrelli et al., 2016). For example, Alcohol Use Disorder (AUD) and subthreshold AUD in adolescence has been shown to be predictive of Major Depressive Disorder (MDD) in adolescence and young adulthood (Brière, Rohde, Seeley, Klein, & Lewinsohn, 2014; Edwards et al., 2014; Fergusson, Boden, & Horwood, 2013; Rode, Lewinsohn, Kahler, Seeley, & Brown, 2001), and heavy drinking at 16 has shown a small association with MDD in young adulthood, but heavy drinking at 18 did not predict MDD in young adulthood (Hill, White, Chung, Hawkins, & Catalano, 2000; Mason et al., 2008). A recent meta-analysis found small, but significant, effect sizes for higher alcohol consumption and frequent alcohol use with higher levels of depression (Cairns, Yap, Pilkington, & Jorm, 2014). Cross-sectional studies on the association between AUD and MDD are also mixed (Brière et al., 2014; Dawson, Grant, Stinson, & Chou, 2005; McCarty et al., 2009). Further, it appears that the association between mood and drinking behaviors changes over time. Specifically, the effect of depressive symptoms on alcohol use and frequency lessens (Owens & Shippee, 2009; White, Kraus, & Swartzwelder, 2006). As a result, Pedrelli and colleagues (2016) suggest moderators, such as age and gender, due to the heterogeneity of study samples examined.

Alternatively, elevated psychological distress, depressive symptoms, and negative affect have also shown strong associations with alcohol-related problems, and not with alcohol consumption (Geisner, Larimer, & Neighbors, 2004; Nagoshi, 1999; Park & Grant, 2005;

Patock-Peckham, Hutchinson, Cheong, & Nagoshi, 1998; Wood, Nagoshi, & Dennis, 1992). While this is somewhat inconsistent with self-medication theories, the results of these studies still suggest that college students with negative affective symptoms drink in a manner that results in more alcohol-related problems. Consistent with previous research indicating that drinking to cope with negative affect is associated with alcohol problems (Wood et al., 1992), one study conducted with an ethnically diverse college sample found that depressive symptoms were associated with more alcohol-related problems (Dennhardt & Murphy, 2011). It is possible that, among college students with depressive symptoms, the reasons for drinking, specifically drinking to cope, result in alcohol-related problems that are, at least partially, independent of consumption level. Protective behavioral strategies have also been associated with depressed affect and implicated as a significant mediator between depression and alcohol-related problems in young adults (Martens et al., 2008). Specifically, greater depressed affect decreased the use of protective behavioral strategies, which in turn lead to an increased number of alcohol-related problems. Research on the association, including the direction of the association, between depression and alcohol use is inconsistent and, at times, unclear, despite a stronger relation between depression and alcohol-related problems.

Previous research has indicated that drinking to cope with stress is also associated with greater alcohol consumption (Park, Armeli, & Tennen, 2004), which is consistent with Conger's tension reduction theory that states that alcohol use is reinforced, especially in individuals experiencing stress, because of the tranquilizing or depressing effects alcohol has on the nervous system, thereby reducing tension or anxiety (Conger, 1956). However, college students with general anxiety symptoms have reported drinking to cope with negative emotions and more alcohol-related problems, but also less actual alcohol consumption (Armeli et al., 2014). Other

studies have found college students who report elevated stress levels also report an increased number of alcohol-related problems, but less actual alcohol consumption (Camatta & Nagoshi, 1995; McCreary & Sadava, 2000), indicating that there may be other mechanisms that account for the relation between stress and alcohol problems outside of consumption level. Additionally, stress-related disorders, such as Posttraumatic Stress Disorder (PTSD), have also been shown to predict alcohol-related problems in college students (Tripp et al., 2015), but have not shown significant associations with actual consumption level (Murphy et al., 2013).

Despite strong support for the general association between negative affective symptoms and alcohol-related problems, relatively little research has examined specific mechanisms that might account for this relation. A few exceptions for this are the aforementioned studies linking depression and alcohol problems via deficits in protective behavioral strategies and drinking to cope. It is possible that dysregulated drinking patterns, characterized by, elevated alcohol reward value, reduced valuation of the future, and heightened alcohol craving, may account for the association between negative affective symptoms and alcohol-related problems.

Theoretical Mechanisms: Alcohol Demand, Future Orientation, and Craving

Alcohol Demand. The behavioral economic model of addiction is a theoretical approach that has been used to both better understand substance use severity and develop ways to intervene (Murphy et al., 2012). Addiction has been referred to as a *reinforcement pathology* (Bickel, Johnson, Koffarnus, MacKillop, & Murphy, 2014), characterized by elevated drug/alcohol reward value and reduced valuation of the future (Bickel et al., 2014). To better understand the extent to which an individual values a reinforcer, behavioral economic researchers most frequently use demand curve analyses (Hursh & Silberburg, 2008). As in economics, demand is the amount of a good that is purchased or consumed by an individual at a

given price. This information can then be used to generate a demand curve by plotting consumption as a function of price. Demand indices include intensity (drinks consumed at price = \$0), O_{\max} (maximum alcohol expenditure), and elasticity (sensitivity of consumption to changes in price), and are typically derived from the Alcohol Purchase Task (APT; Murphy & MacKillop, 2006).

Elevated demand appears to be a clinically relevant indicator of risk given its consistent associations with risky patterns of drinking (MacKillop & Murphy, 2007; Murphy & MacKillop, 2006), alcohol-related consequences (Skidmore, Murphy, & Martens, 2014), Alcohol Use Disorder severity (MacKillop et al., 2010), and poor response to brief alcohol interventions (Dennhardt, Yurasek, & Murphy, 2015; MacKillop & Murphy, 2007; Murphy et al., 2013). Recent research has also made significant connections between negative affective symptoms and alcohol demand. In a laboratory study, Rousseau, Irons, and Correia (2011) induced negative affect in a sample of college students to examine the relation between mood and the reinforcing value of alcohol within a drinking to cope paradigm. The authors found that drinking to cope was a risk factor for both alcohol use and related problems, and that individuals with drinking to cope motives experiencing a period of negative mood would report increased alcohol demand. Further, Murphy and colleagues (2013) found in a sample of heavy drinking college students that symptoms of depression and posttraumatic stress disorder (PTSD) contribute to elevated demand for alcohol. Specifically, symptoms of depression predicted elevated intensity and lower elasticity (i.e., less sensitivity to price). As these findings relate to self-medication and tension reduction theories, it is possible that the symptom relief alcohol provides for individuals with negative affective symptoms increases their reward value of alcohol. As such, these individuals would likely report drinking more if the drinks were free and being less affected by increases in

drink prices. Especially relevant to the current study, recent research found demand intensity and elasticity to be significant mediators in the relation between PTSD symptoms and alcohol-related problems (Tripp et al., 2015). Given these findings, it seems experiencing negative affective symptoms contributes to a greater reinforcing value of alcohol, which in turn may lead to riskier drinking patterns and an increased number of alcohol related problems.

Future Orientation. Future orientation or time perspective refers to the degree to which current behavior is guided by future outcomes (Kastenbaum, 1961). Individuals who have little consideration of future consequences (CFC) are motivated more by the immediate consequences of an action and consider to a lesser extent the potential future costs or benefits (Strathman et al., 1994). As mentioned above, reduced valuation or discounting of future outcomes is a central element of behavioral economic models of substance misuse. Greater discounting of the value of larger delayed future rewards (e.g., good health, positive social or career outcomes) shifts preferences toward smaller immediate rewards such as drug and alcohol use. Delay discounting (DD) is the most commonly used behavioral economic index of impulsivity (present orientation vs. future orientation; Ainslie, 1975) and quantifies how rapidly a reward loses value as it is temporally delayed (Green & Myerson, 2004; Mitchell, Fields, D'Esposito, & Boettiger, 2005; Myerson, Green, & Warusawitharana, 2001). Delay discounting is typically measured by providing individuals with a series of choices between smaller sooner, and larger delayed monetary amounts that are used to quantify the degree of reduction in current subjective value as a function of reward delay (Rachlin, Raineri, & Cross, 1991).

DD has shown consistent significant associations with alcohol misuse (Amlung, Vedelago, Acker, Balodis, & MacKillop, 2016; Bjork, Hommer, Grant, & Danube, 2004; Field, Christiansen, Cole, & Goudie, 2007; Mitchell et al., 2005; Mitchell, Tavares, Fields, D'Esposito,

& Boettiger, 2007; Petry, 2001; Vuchinich & Simpson, 1998), including alcohol consumption (Murphy & MacKillop, 2012) and AUD symptoms (MacKillop et al., 2010), as well as with other addictive behaviors (Amlung, Petker, Jackson, Balodis, & MacKillop, 2016; MacKillop et al., 2011). Substance abusers have been shown to discount delayed rewards more steeply than non-dependent or non-addicted individuals, with the most robust findings for DD in studies comparing cigarette smokers (Baker, Johnson, & Bickel, 2003; Bickel, Odum, & Madden, 1999; Epstein et al., 2003; Reynolds, 2006; Sweitzer, Donny, Dierker, Flory, & Manuck, 2008), cocaine users (Washio et al., 2012), and heroin users (Cheng, Lu, Han, González-Vallejo, & Sui, 2012; Odum, Madden, Badger, & Bickel, 2000) to non-using controls (Bickel et al., 2007). Associations between DD and alcohol misuse in college student populations have been less consistent (Dennhardt & Murphy, 2011; Dennhardt et al., 2015; Gonzalez, Reynolds, & Skewes, 2011; Kollins, 2003; MacKillop et al., 2007; Murphy et al., 2012). Similarly, the relation between DD and other behavioral economic and alcohol-related variables, including demand and craving, has also been inconsistent (Amlung et al., 2013; Joos et al., 2013; MacKillop et al., 2010). DD has shown significant associations with demand indices and craving in some studies (MacKillop et al., 2010), but not others (Amlung et al., 2013; Joos et al., 2013).

Negative affective states such as depression or stress may also lead individuals to focus more on present outcomes and to devalue the future. In a sample of adults with Major Depressive Disorder (MDD), rate of discounting was associated with severity of hopelessness, and patients with MDD showed preference toward more immediate financial rewards compared to both healthy subjects and remitted MDD patients (Pulcu et al., 2014). Dennhardt and Murphy (2011) found discounting to be inversely related to distress tolerance in an ethnically diverse sample of college students, indicating an inability or unwillingness of individuals with a lower distress

tolerance to value delayed rewards over more immediate rewards. Fields, Ramos, and Reynolds (2015) suggest that individuals under stress will tend to shift their mindset to the more immediate present, with the intention of risky behaviors such as alcohol or drug use to alleviate this stress. Further, delay discounting has also been shown to be a significant mediator between perceived stress and cigarette use (MacKillop et al., 2011). That is, greater perceived stress increased delay discounting (impulsivity), which in turn contributed to more cigarette use. Unfortunately, these findings do not appear consistent as some studies have failed to find associations between DD and negative affect (Acheson, Vincent, Sorocco, & Lovallo, 2011; Dennhardt & Murphy, 2011; Pulcu et al., 2014).

The Consideration of Future Consequences (CFC) Scale (Strathman et al., 1994) is a traditional questionnaire-based measure of future orientation used in studies of alcohol misuse (McKay, Percy & Cole, 2013; Murphy et al., 2012; Vuchinich & Simpson, 1998). Greater CFC has been associated with less alcohol and tobacco use (Strathman et al., 1994), more frequent exercise (Ouellette, Hessling, Gibbons, Reis-Bergan, & Gerrard, 2005), and more fiscally responsible behavior (Joireman, Sprott, & Spangenberg, 2005). Not surprisingly, it has also been inversely associated with impulsivity (Joireman, Anderson, & Strathman, 2003) and positively associated with personality traits related to delay of gratification and self-control (Strathman et al., 1994). Joireman and colleagues (2005) examined how CFC relates to temporal, or delayed reward, discounting in a sample of college students, and found CFC to be inversely related to delay discounting. However, in a sample of heavy-drinking college students, Murphy and colleagues (2012) did not find a similar relation. It appears these measures of future orientation do overlap somewhat; however, they may be assessing different aspects of the same construct. To our knowledge, CFC has not been extensively examined in the context of negative affective

symptoms and alcohol-related problems. However, given that impulsivity has shown significant associations with negative affect, CFC, and delay discounting, it is likely that individuals experiencing negative affective, especially depressive, symptoms will report lower CFC and greater discounting of delayed rewards, which in turn may contribute to more problematic patterns of alcohol use.

Craving. Craving has been considered a hallmark of alcohol dependence for several decades now (Kozlowski, Mann, Wilkinson, & Poulos, 1989; Ludwig & Stark, 1974; Ludwig & Wikler, 1974; Marlatt, 1985) and was originally viewed as a result of drinking that would elicit more drinking and ultimately lead to a loss of control in the consumption of alcohol (Ludwig & Wikler, 1974; Ludwig, Wikler, & Stark, 1974). Craving has been defined as a strong urge, subjective to the individual, to use a substance (Hore, 1974; Kavanagh & Connor, 2013; Kozlowski & Wilkinson, 1987), and is a diagnostic criterion of alcohol dependence and AUD in the *International Statistical Classification of Diseases and Related Health Problems (ICD-10*; World Health Organization, 1992) and the *Diagnostic and Statistical Manual of Mental Disorders (DSM-5*, American Psychiatric Association, 2013), respectively. From a behavioral standpoint, craving has been conceptualized as a product of classical conditioning (O'Brien, Childress, McLellan, Ehrman, & Ternes, 1990; Siegel, 1983; Stewart, de Wit, & Eikelboom, 1984). That is, individuals begin to respond to stimuli other than alcohol as if it were alcohol due to previous salient associations with alcohol. Driving by a bar or hanging out with friends one typically drinks with are examples of external stimuli that may elicit craving. Craving is typically assessed using a self-report-type measure, such as the Penn Alcohol-Craving Scale (PACS; Flannery, Volpicelli, & Pettinati, 1999), and addresses frequency of, severity of, and ability to resist cravings.

Previous research examining the relation between craving and alcohol consumption and post-treatment relapse has been mixed (Bottlender & Soyka, 2004; Rohsenow et al., 1994; Fazzino, Harder, Rose, & Helzer, 2013). Among young adult and college student drinkers, however, craving has shown significant associations with level and severity of alcohol use (Rosenberg & Mazzola, 2007), typical weekly consumption, and alcohol-related problems (Tripp et al., 2015). Behavioral economic researchers have recently had a growing interest in the role of craving in behavioral economic models. Lowenstein (1996) theorized that visceral factors, such as craving, heavily influence the reward value of, or demand for, alcohol, and that this reward value will fluctuate as a function of these visceral factors (Badger et al., 2007; de Wit & Chutuape, 1993; MacKillop, Menges, McGeary, & Lisman, 2007; MacKillop, Miranda et al., 2010; MacKillop, O'Hagen et al., 2010; Sayette, Marti, Wertz, Shiffman, & Perrott, 2001).

Further, Baker, Morse, and Sherman (1987) suggest that aversive internal states or stimuli, such as depression or stress, have the potential to elicit craving. It has also been suggested that *relief craving*, or the desire to reduce arousal or tension, in particular, is related to experiencing anxiety or stress symptoms (Verheul, van den Brink, & Geerlings, 1999). In a sample of college students, Goldsmith and colleagues (2012) found significant associations between generalized anxiety, tension-reduction alcohol expectancies, and alcohol-related problems. While the authors did not directly connect craving to any of these variables in their study, a substantial amount of research has made strong connections between negative affect and craving (Cooney, Litt, Morse, Bauer, & Gaupp, 1997; Sinha & O'Malley, 1999; Witkiewitz & Bowen, 2010). In a laboratory study, Cooney and colleagues (1997) found that the combination of negative affective imagery and the presentation of an alcoholic beverage not only led to an increase in reported craving but also predicted the time to relapse in a sample of men treated for

alcohol problems. Additionally, in a different sample of treatment seeking adults, craving significantly mediated the relation between depressive symptoms and alcohol use days following a mindfulness-based relapse prevention intervention (Witkiewitz & Bowen, 2010). Most relevant to the current study, Tripp and colleagues (2015) found in a sample of non-treatment seeking college students that craving significantly mediated the relation between symptoms of PTSD and alcohol-related problems. Taken together, it seems that craving plays a substantial role in the initiation and maintenance of problematic use, especially in individuals with affective disorders. Thus, individuals experiencing stress symptoms may show higher levels of craving due to using, or expecting, alcohol to help cope with these symptoms, and craving may then lead to patterns of alcohol use that are problematic.

Clearly, there are many possible mechanisms by which negative affective symptoms and alcohol-related problems influence one another. Identifying these mechanisms that account for the relation between negative affective states and alcohol-related problems could lead to improved interventions for college students with comorbid psychiatric and alcohol use problems.

Present Study

The present study expanded upon the study conducted by Tripp and colleagues (2015) and attempted to further elucidate behavioral economic and visceral variables that might mediate the relation between symptoms of negative affect and alcohol-related problems. It is hypothesized that negative affective symptoms will show significant positive associations with alcohol demand, craving, delay discounting, and alcohol-related problems, and inverse associations with consideration of future consequences. It is also hypothesized that alcohol craving, demand, and delay discounting will show significant positive associations with alcohol-related problems, and consideration of future consequences will show significant negative

associations with alcohol-related problems. Finally, it is hypothesized that alcohol demand, future orientation, and craving will significantly mediate the relation between negative affective symptoms of depression and stress and alcohol-related problems. Specifically, it is hypothesized that greater symptoms of depression or stress decrease future orientation and increase craving and demand for alcohol, which in turn increases the number of alcohol-related problems.

Method

Participants

The present study is a secondary analysis from a larger project that evaluated brief alcohol interventions. Participants were 393 undergraduate college students recruited from two large public universities in the southeastern United States (60.8% women; average age = 18.77, $SD = 1.07$, range = 18-25). Students were eligible to participate if they were at least 18 years old, had reported 2 or more binge drinking episodes in the past month (4/5 or more standard drinks for women/men, respectively, on one occasion), worked fewer than 21 hours per week, and were either a freshman or sophomore. Most participants were freshmen ($n = 244$, 62.1%), and were not involved in a fraternity or sorority ($n = 267$, 67.9%). The sample was 78.9% White, 10.9% Black, 1.8% Asian, 1.8% American Indian, and .5% Hawaiian/Pacific Islander. Additionally, 5.9% of the sample identified their ethnicity as Hispanic.

Procedure

Data were collected as part of the baseline assessment session of an alcohol intervention study with nontreatment-seeking college student heavy drinkers. All data were collected prior to any exposure to the study's intervention elements. Participants were recruited from undergraduate courses and from campus-wide research participation solicitation emails. Study personnel screened students over the phone for eligibility, and then, if eligible, described the

study in more detail and scheduled the baseline assessment and brief intervention session.

Assessment and intervention sessions were scheduled in a manner that allowed study personnel to conduct 1-month follow-up assessments prior to the universities' observed holiday break for undergraduate students. Participants were compensated with extra course credit (for those in psychology courses) or cash payments (\$25) for completing the 2 hr assessment and brief intervention session. Participants completed self-report measures online on computers in the lab. The university's Institutional Review Board approved all procedures.

Measures

Depression, Anxiety, and Stress Symptoms. The Depression, Anxiety, and Stress Scale (DASS-21; Antony, Beiling, Cox, Enns, & Swinson, 1998) is a 21-item measure that includes subscales assessing past week depression, anxiety, and stress. Examples of items include: "I couldn't seem to experience any positive feeling at all," "I felt that I was using a lot of nervous energy," and "I was worried about situations in which I might panic and make a fool of myself." Participants are asked to rate how much each item applied to them from 0 (Did not apply to me at all) to 3 (Applied to me very much, or most of the time). Subscale items are separated, summed, and multiplied by 2 to generate subscale total scores. This measure distinguishes well between depression, anxiety (physical arousal), and stress (psychological tension), and has been shown to have good internal consistency and concurrent validity (Antony et al., 1998). Crawford and Henry (2003) found good discriminant and convergent relations with positive and negative affect (using the PANAS; Watson, Clark, & Tellegen, 1988) and other anxiety and depression measures. Internal consistency (Cronbach's alpha) in the current sample was .89 for the depression subscale and .83 for the stress subscale.

Future Orientation. Two measures were used to assess the extent to which participants were future oriented. A 60-item delay discounting task, based on the Monetary Choice Questionnaire (MCQ; Kirby, Petry, & Bickel, 1999), was administered. Participants were presented with 60 choices between two hypothetical amounts of money. Each item varies in amounts presented, and participants must choose between a smaller, immediate amount and a larger delayed amount (i.e., \$50 today vs. \$100 in 1 month). Each item contributes to the estimate of the participant's discounting rate (k). Higher k values indicate steeper discounting, or greater preference for smaller immediate rewards. Delay discounting tasks such as the MCQ provide valid and reliable estimates of discounting rates (MacKillop, Miranda et al., 2010).

The Consideration of Future Consequences Scale (CFCS; Strathman et al., 1994) is a 9-item measure assessing both the extent to which individuals consider future consequences or outcomes and how these potential outcomes influence their decision-making. Examples of items include: "I only act to satisfy immediate concerns, figuring the future will take care of itself" and "I think it is more important to perform a behavior with important distant consequences than a behavior with less-important immediate consequences." Participants are asked how characteristic each item is for them from 1 (Extremely uncharacteristic) to 5 (Extremely characteristic). Certain items require recoding. All items are summed to generate a total score where higher scores indicate more future orientation. The CFCS has demonstrated good test-retest reliability and internal consistency (Strathman et al., 1994), as well as construct and convergent validity (Adams & Nettle, 2009; Murphy et al., 2012). The 9-item measure in the current sample showed acceptable internal consistency ($\alpha = .71$) for the total score.

Alcohol consumption. The Daily Drinking Questionnaire (DDQ; Collins, Parks, & Marlatt, 1985) asks participants to estimate the total number of standard drinks they consume

each day during a typical week in the past month. This number is then summed to produce an estimate of drinks per week. This measure is highly correlated with other measures of alcohol consumption and has been widely used in the college drinking literature (Kivlahan, Marlatt, Fromme, Coppel, & Williams, 1990).

Alcohol-related consequences. The YAACQ, Young Adult Alcohol Consequences Questionnaire, is a 49-item Yes/No self-report measure of alcohol-related consequences experienced over the past 6 months, and has good predictive validity and test-retest reliability (Read, Kahler, Strong, & Colder, 2006). Internal consistency in the current sample was $\alpha = .89$ for the total score. The YAACQ consists of 8 subscales (Social-Interpersonal Consequences, Impaired Control, Self-Perception, Self-Care, Risk Behaviors, Academic/Occupational Consequences, Physical Dependence, and Blackout Drinking). Examples of items include: “The quality of my work or schoolwork has suffered because of my drinking,” “I have driven a car when I knew I had too much to drink to drive safely,” and “I have been unhappy because of my drinking.”

Alcohol craving. Craving was measured using the Penn Alcohol Craving Scale (PACS; Flannery et al., 1999), a 5-item, self-report measure assessing past-week frequency of alcohol craving, intensity of alcohol craving, duration of alcohol craving, and ability to resist alcohol. Examples of items include: “During the past week how often have you thought about drinking or about how good a drink would make you feel?” and “During the past week how difficult would it have been to resist taking a drink if you had known alcohol was in your house?” The measure uses a 0-6 Likert-type scale for each item. Higher scores indicate higher levels of craving, and the items may be summed to create a total past-week craving score. Flannery and colleagues

(1999) found excellent construct validity and internal consistency. Cronbach's alpha in the current sample was .85.

Alcohol Demand. The Alcohol Purchase Task (APT; Murphy & MacKillop, 2006) was used to assess alcohol demand. The task instructs participants to imagine that they are with friends at a party from 9 p.m. until 1 a.m. They are also told that they will not consume alcohol before or after the party, and that the available drinks at the party are standard size domestic beers (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), and mixed drinks containing one shot of hard liquor. Participants are then asked how many drinks they would consume at each of the following 17 prices: \$0 (free), \$0.25, \$0.50, \$1.00, \$1.50, \$2.00, \$2.50, \$3.00, \$4.00, \$5.00, \$6.00, \$7.00, \$8.00, \$9.00, \$10.00, \$15.00, and \$20.00. Consumption as reported is plotted as a function of price. Demand *intensity* is the reported number of drinks consumed when price = \$0 (free). Demand *elasticity* is a derived index of demand that represents the sensitivity of consumption to increases in price.

Data Analysis

Prior to running any analyses, elasticity and delay discounting were derived using GraphPad Prism v. 5.04 for Windows (GraphPad Software, San Diego, CA, www.graphpad.com). The macro for deriving elasticity is available online through the Institute for Behavioral Resources website (www.ibrinc.org). A modified, exponentiated version of Hursh and Silberberg's (2008) exponential equation:

$$\log Q = \log Q_0 + k (e^{-\alpha Q_0 C} - 1) \quad (1)$$

was used to generate demand elasticity values, where Q = quantity consumed, Q_0 = consumption at \$0.00 (derived demand intensity), k = range of alcohol consumption in logarithmic units, C =

varying cost of each reinforcer, and α = elasticity (sensitivity to change in price). The equation when both sides are raised to the power of 10:

$$Q = Q_0 * 10^{k(e-\alpha Q_0 C - 1)} \quad (2)$$

allows unaltered zeros to be included in the curve fit (Koffarnus, Franck, Stein, & Bickel, 2015). For the purpose of the current study, observed demand intensity was used as opposed to demand intensity derived (Q_0) from the exponentiated equation. Based on procedures described in Koffarnus et al (2015), the constant k value for all analyses was set at 1.726, which was determined by subtracting the \log_{10} -transformed average consumption at the highest price (\$20) from the \log_{10} -transformed average consumption at the lowest price (\$0). This allows the parameters of Q_0 and α to vary freely. Larger α values indicate greater elasticity (i.e., greater price sensitivity and lower alcohol reward value).

To ensure quality of the data, each participant's data on the APT were examined for missing data and inconsistencies (i.e., when drinks purchased at a given price were greater than the preceding price, beginning with the second lowest price point). Participant data with more than one inconsistency as described were eliminated from elasticity calculations ($N = 9$). Delay discounting rate was calculated from the Delay Discounting Task using Kirby and colleagues' (1999) approach. Participants were assigned a k value, or hyperbolic temporal discounting function, which was estimated based on each participant's responses across the task. The assigned k value reflects the highest relative consistency among discounting values, with larger k values reflecting greater discounting (lower future orientation).

Next, outliers in all variables were corrected using methods described by Tabachnick and Fidell (2012). Values exceeding 3.29 standard deviations above or below the mean were recoded to be one unit greater or lower than the greatest non-outlier value, respectively. Distributions

were checked for skewness and kurtosis, and transformed using square root or log transformations as appropriate. The following variables were transformed: depressive symptoms, stress symptoms, typical drinks per week, demand intensity, demand elasticity, and delay discounting (k).

To examine hypotheses one and two, bivariate Pearson correlations were computed between the depression and stress subscales of the DASS, typical weekly drinking, demand variables (intensity & elasticity), Consideration of Future Consequences Scale (CFCS) total score, delay discounting estimates (k), Penn Alcohol-Craving Scale total score, YAACQ total score, and reported parent income. To examine hypothesis three, ten single mediation analyses were conducted using PROCESS Macro (Hayes, 2013) for SPSS to examine whether demand intensity and elasticity, delay discounting, and consideration of future consequences, and craving mediated the relation between stress, depressive symptoms, and alcohol-related problems. To test the indirect association of depressive symptoms and stress on alcohol-related consequences through the path of demand indices, future orientation, and craving, a nonparametric bootstrapping method of 5,000 samples using a confidence interval of 95% was used. This approach makes no assumptions about the sampling distribution (Hayes, 2013). An indirect association is considered to be significant if the confidence interval does not include 0 (zero). Consistent with the recommendation of Hayes (2009), we investigated possible indirect, mediating effects on the relation between stress and depressive symptoms and alcohol problems even in the absence of significant bivariate relations. Each of the mediation models included covariates of gender, race, and typical drinks per week (Dennhardt & Murphy, 2011). Parent income was included as a covariate in a model if it showed significant associations with an identified mediator variable (i.e., intensity, delay discounting).

Results

Descriptive information on all variables in the study are presented in Table 1. As described above, demand elasticity (sensitivity to change in price) estimates were derived using a modified exponentiated exponential demand curve equation (Hursh & Silberberg, 2008; Koffarnus et al., 2015). This equation provided a good fit ($R^2 = .98$) to both the aggregated data (i.e. sample mean consumption), and to individual participant data (mean $R^2 = .90$).

Bivariate Pearson Correlations among Variables

Table 1 also presents correlations among depressive and stress symptoms, typical weekly alcohol consumption, demand intensity and elasticity, CFCS, delay discounting (k), craving, alcohol-related problems, and parent income. Depressive and stress symptoms were highly correlated with each other, as well as with craving and alcohol-related problems, and were significantly negatively correlated with CFCS. Typical weekly consumption was not correlated with depressive or stress symptoms, though it did show significant associations in the expected direction with demand intensity and elasticity, craving, and alcohol-related problems. Demand intensity was also significantly associated with CFCS, delay discounting, craving, and alcohol-related problems in the expected direction. Lower demand elasticity (i.e., less price sensitivity) was associated with greater demand intensity, alcohol problems, craving, and parent income, but with lower stress scores. Consistent with expectations, delay discounting was significantly negatively correlated with CFCS, and CFCS showed significant negative associations with depressive and stress symptoms, demand intensity, craving, and alcohol-related problems. Finally, alcohol-related problems were significantly associated with depressive and stress symptoms, typical drinks per week, demand intensity and elasticity, CFCS, and craving in the expected directions.

Demand, Future Orientation, and Craving as Mediators of the Relation between Depressive Symptoms and Alcohol-Related Problems

Demand intensity, elasticity, delay discounting, CFCS, and craving were tested separately as mediators of the relation between depressive symptoms and alcohol-related problems using the PROCESS macro. Gender, ethnicity, and typical drinks per week were controlled for in all models. Because parent income showed significant bivariate associations with intensity and delay discounting, it was included as a covariate in models examining intensity and delayed discounting as mediators. As shown in Table 2, only CFCS and craving were significant single mediators. Craving was associated with a larger indirect effect than CFCS. Approximately, 8.3% and 23.3% of the effect of depression on alcohol problems occurred indirectly through CFCS and craving, respectively. Craving was associated with a larger indirect effect than CFCS. The ratios of the indirect effects of CFCS and craving to the direct effects were both less than 1, indicating that more of the total effect in the models was determined by the direct effect of depression on alcohol problems.

Demand, Craving, and Future Orientation as Mediators of the Relation between Stress Symptoms and Alcohol-Related Problems

Demand intensity, elasticity, delay discounting, CFCS, and craving were tested separately as mediators of the relation between stress symptoms and alcohol-related problems in models that controlled for gender, ethnicity. Parent income was included as a covariate in models examining demand intensity and delay discounting as mediators. CFCS and craving were again significant single mediators (see Table 2). Demand intensity was also a significant single mediator. Craving was associated with a larger indirect effect than demand intensity and CFCS. Approximately, 4.1%, 5.7%, and 20.1% of the effect of stress on alcohol problems occurred

indirectly through demand intensity, CFCS, and craving, respectively. The ratios of the indirect effects of demand intensity, CFCS, and craving to the direct effects were all less than 1, indicating that more of the total effect in the models was determined by the direct effect of stress on alcohol problems.

Discussion

The goal of the present study was to expand upon current research and further elucidate behavioral economic and visceral variables that might mediate the established relation between symptoms of negative affect (depressive and stress) and alcohol-related problems (Dennhardt & Murphy, 2011). Depressive and stress symptoms showed significant positive associations with craving and alcohol-related problems, and significant inverse associations with CFC. Demand intensity, elasticity, CFC, and craving also showed significant associations with alcohol-related consequences in the expected directions. Demand intensity, CFC, and alcohol craving emerged as significant single mediators in the relation between negative affective symptoms and alcohol-related problems. Specifically, CFC and craving significantly mediated the relation between depressive symptoms and alcohol-related problems; and intensity, CFC, and craving significantly mediated the relation between stress symptoms and alcohol-related problems. That is, individuals with elevated depressive symptoms tend to consider future consequences less and this, in part, makes it more likely that they will drink in a manner that results in alcohol-related problems. These individuals also crave alcohol more as a result of these depressive symptoms, which also increases risk for alcohol-related problems. Similarly, individuals with elevated stress symptoms tend to value alcohol as a reward more, consider future consequences less, and crave alcohol more, which then leads to experiencing a greater number of alcohol-related problems. For example, students who are stressed or depressed may have less concern about the future which

may lead them to take excessive risks while drinking (e.g., drinking the evening before a college class, in the absence of trusted companions, or in a situation that requires driving). These same types of students may crave alcohol more as well which may lead them to drinking when they had originally planned not to or drinking more than they had planned. Further, students who are stressed may value alcohol more highly which may lead to them to be less physically active, neglect schoolwork, or less frequently engage in substance-free activities.

Contrary to our hypotheses, demand elasticity (sensitivity to price) was not a significant mediator. This is inconsistent with previous research indicating that demand elasticity mediated the association between post-traumatic stress symptoms and alcohol problems (Tripp et al., 2015). This inconsistency may be related to sample characteristics. Tripp and colleagues' (2015) sample had a wider age range with a higher average age (18-38 years, $M = 21.7$) compared to the current study (18-25 years, $M = 18.77$), perhaps leading to more experience with purchasing drinks, and on average reported about 50% lower levels of weekly drinking than the current sample ($M_s = 7.84$ & 16.76 , respectively). The restricted drinking range in the current sample may have contributed to the lack of significant mediation findings with elasticity. Consistent with previous research, however, elasticity was associated with delay discounting, craving, and alcohol problems in the expected direction (MacKillop, Miranda et al., 2010; Tripp et al., 2015).

Taken together, the current study provides further evidence that the relation between negative affective symptoms and alcohol-related problems is at least partially independent of alcohol consumption level (Dennhardt & Murphy, 2011; Martens et al., 2008; Tripp et al., 2015), challenging both tension reduction (Conger, 1956) and self-medication theories (Khantzian, 1997). Both theories assume that individuals wishing to reduce stress or alleviate distress resulting from stress-related or affective disorders will consume more of a substance than

individuals with different motives for consumption. The current study and previous research showing strong associations between negative affective symptoms and alcohol-related problems, but not with alcohol consumption, suggest this is not the whole story (Geisner, Larimer, & Neighbors, 2004; Nagoshi, 1999; Patock-Peckham et al., 1998; Park & Grant, 2005; Wood, Nagoshi, & Dennis, 1992). Martens and colleagues (2008) found that regardless of drinking level the relation between depressive symptoms and alcohol-related problems is influenced by the use of protective drinking strategies. The current results extend this line of research by identifying demand, future orientation, and craving as additional mechanisms.

Heavy drinking college students with elevated stress levels tended to value alcohol more, contributing to a greater number of alcohol-related problems. This is consistent with previous research showing that negative affective symptoms increase demand (Murphy et al., 2013; Rousseau et al., 2011; Tripp et al., 2015) and that demand is an indicator of risky alcohol use (Dennhardt et al., 2015; MacKillop, Miranda et al., 2010; MacKillop & Murphy, 2007; Murphy et al., 2013; Murphy & MacKillop, 2006; Skidmore et al., 2014). As it relates to self-medication and tension reduction theories, it is possible that using alcohol to cope with or alleviate symptoms effectively increases the reward value of alcohol, leading to a greater number of related problems.

Future orientation, or the consideration of future consequences, is the other primary risk factor in the behavioral economic model of addiction. That is, addiction as a reinforcement pathology is characterized by both an elevated alcohol reward value (demand), described above, and a reduced valuation of the future (Bickel et al., 2014). Although delay discounting (DD) is the most commonly used behavioral economic measure of future orientation and impulsivity and has shown robust relations with a variety of substance misuse indices (Baker, Johnson, & Bickel,

2003; Bickel et al., 2007; Bickel et al., 1999; Cheng et al., 2012; Epstein et al., 2003; Odum et al., 2000; Reynolds, 2006; Sweitzer et al., 2008; Washio et al., 2012), its relation with other behavioral economic and alcohol-related variables in young adult alcohol misuse has been inconsistent (Dennhardt & Murphy, 2011; Dennhardt et al., 2015; Gonzalez et al., 2011; Kollins, 2003; MacKillop, Mattson et al., 2007; Murphy et al., 2012). The current study is in line with this previous research in that no significant associations were found between DD and actual alcohol consumption, demand elasticity (sensitivity to price), craving, or alcohol-related problems, but it was significantly associated with demand intensity.

To our knowledge, this is the first study that has examined CFC in the context of negative affective symptoms and alcohol-related problems in a sample of heavy drinking college students. As expected, individuals with elevated levels of depression or stress tended to devalue the future more, or consider future consequences less, leading to a greater number of alcohol-related problems. Though CFC has been conceptualized as a more stable or trait characteristic (Strathman et al., 1994), Murphy and colleagues (2012) found that a brief alcohol intervention paired with a behavioral economic supplement (Substance Free-Activity Session, or SFAS) did in fact increase future orientation and was also especially helpful for students with depressive symptoms. Further, Episodic Future Thinking (EFT) has been shown to increase future orientation (Snider, LaConte, & Bickel, 2016; Stein et al., 2016) and may also be beneficial for heavy drinking college students experiencing stress or depression. Therefore, brief behavioral economic and EFT interventions may be able to target this mechanism of future orientation to not only reduce alcohol-related problems in heavy drinking college students, but also improve symptoms in those concurrently experiencing depressive or stress symptoms. Clearly, more work with CFC in heavy drinking populations is warranted.

Finally, similar to Tripp and colleagues' (2015) study, the current study found craving to be the strongest mediator between depressive and stress symptoms and alcohol-related problems in both single and multiple mediator analyses. However, it is likely that aspects of craving may be reflected in reported or experienced alcohol-related problems (e.g., drinking when planned not to, drinking more than originally planned, difficulty limiting how much; Read et al., 2006), which may account for the larger indirect effect. Regardless, few studies have examined the role of craving in the relation between negative affective symptoms and alcohol-related problems. Studies have consistently shown that aversive internal states, such as depression or stress, have the potential to elicit craving (Baker et al., 1987; Cooney et al., 1997; Sinha & O'Malley, 1999; Witkiewitz & Bowen, 2010). While this does not necessarily lead to increases in alcohol consumption, it appears to lead to the disordered use of alcohol in that individuals experience more alcohol-related problems as a result of their use.

Limitations

This study was conducted with cross-sectional data which is not ideal for conducting mediation analyses and cannot definitively conclude causality of depressive and stress symptoms on alcohol-related problems via demand intensity, CFC, and alcohol craving. Additionally, this temporal order is especially important given previous research showing bidirectional relations between depression and alcohol use (Pedrelli et al., 2016). Second, retrospective, self-report measures were used and do not allow for the capture of real-time variability in depressive and stress symptoms, demand, future orientation, craving, and alcohol use and related problems. Further, the DASS-21 is not a diagnostic measure of depression or stress and only allowed for the assessment of past week symptoms. Also, a number of demand elasticity values were unable to be computed due to an insufficient number of or missing data points. Finally, the study was

limited to heavy drinking college students from two large public universities (one urban and the other rural) and may not generalize to other heavy drinking populations or non-college student samples with a similar age range. However, this was consistent with our goal of understanding these phenomena in general, non-clinical samples of high-risk young adults given that previous research suggests that subclinical symptoms are associated with more problematic patterns of drinking that are less responsive to interventions (Dennhardt & Murphy, 2011).

Clinical Implications

The primary clinical implication is that heavy drinking college students with depressive or stress symptoms may have greater alcohol reward value, less future orientation, and higher levels of craving, which may then lead to a greater risk for experiencing alcohol-related problems such as impaired control while drinking, blackout drinking, and negative social or occupational consequences due to alcohol use. It may be particularly important to not only assess for drinking level in students with depressive or stress symptoms, but also to examine craving level, alcohol demand, and degree of future orientation. This suggestion aligns well with the recommendations by Kwako and colleagues (2015) that patients with addictions be assessed along the three Addictions Neuroclinical Assessment domains: executive function (i.e., response inhibition, planning, valuation of the future), incentive salience (i.e., motivation, conditioned reinforcement, reward), and negative emotionality. Further, interventions targeting alcohol use and problems in heavy drinking college students may be improved by including elements that increase future orientation and decrease craving and alcohol reward value. Specifically, interventions might integrate components from cue exposure (Rohsenow, Monti, & Abrams, 1995), Cognitive Behavior Therapy (CBT; Longabaugh & Morgenstern, 1999), or naltrexone pharmacotherapy that reduce craving (O'Malley, Krishnan-Sarin, Farren, Sinha, & Kreek, 2002)

with behavioral economic supplements to brief motivational interventions or Episodic Future Thinking (EFT) that increase future orientation and decrease alcohol reward value. Finally, stepped-care approaches for problematic alcohol use among young adults may be improved by providing an empirical basis for more intensive and integrated treatments for individuals who fail to respond to any one treatment alone due to comorbid depressive or stress symptoms.

Conclusion

The current study provides further evidence that, in heavy drinking college students with comorbid symptoms of depression and stress, elevated alcohol reward value, decreased future orientation, and elevated alcohol craving contribute significantly to experiencing alcohol-related problems above and beyond level of alcohol consumption. Future research should clarify this relation further through the use of longitudinal data, as well as more precise and clinically relevant measures. It is also important to take a similar approach with other high-risk, heavy-drinking samples. Future research may examine how drinking to cope motives influence the relation between negative affective symptoms and behavioral economic indices of demand, future orientation, and alcohol craving. Clarification of the mechanisms at work in these relations allows for better screening and more specific targeting of behaviors in interventions treating alcohol use and problems with the possibility of implementing stepped-care approaches to alcohol and substance abuse.

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Appendix

Table 1

Descriptive Characteristics and Correlations among Variables

	N	Mean	SD	1	2	3	4	5	6	7	8	9
1. Depression†	393	7.44	8.92	--								
2. Stress†	393	9.72	9.74	.63**	--							
3. Drinks Per Week†	393	16.67	11.97	-.01	-.05	--						
4. Intensity†	386	8.68	4.28	.03	.01	.59**	--					
5. Elasticity†	384	.01	.01	.05	.04	-.22**	-.38**	--				
6. CFC	393	30.40	6.53	-.22**	-.15**	-.06	-.12*	.08	--			
7. DD (<i>k</i>) †	392	.03	.07	.02	.08	.03	.14**	-.13*	-.24**	--		
8. Craving	393	7.34	4.55	.27**	.29**	.36**	.33**	-.21**	-.15**	.02	--	
9. YAACQ	393	13.06	7.89	.34**	.38**	.40**	.33**	-.17**	-.19**	.04	.45**	--
10. Parent Income	392	3.73	1.68	-.03	-.02	.02	-.11*	-.01	.06	-.16**	-.001	.03

Note. Means and Standard Deviations are prior to square root or log transformation; DD (*k*) = Delay Discounting magnitude; CFC = Consideration of Future Consequences; YAACQ = Young Adult Alcohol Consequences Questionnaire. ** $p < .01$. * $p < .05$. † Variable Transformed.

Table 2

Summary of Single Mediators Analyses Predicting Alcohol-Related Problems

	N	<i>a</i>	<i>b</i>	<i>c'</i> (SE)	95% confidence interval
Depression†					
Intensity†	383	.02	2.21***	.05 (.04)	[-.0124, .1658]
Elasticity†	382	.01	-2.63	-.02 (.03)	[-.1235, .0168]
DD (<i>k</i>) †	389	.01	.23	.001 (.02)	[-.0204, .0470]
CFC	391	-.90***	-.14**	.12 (.06)	 [.0322, .2738]
Craving	391	.74***	.47***	.35 (.10)	 [.1816, .5776]
Stress†					
Intensity†	383	.04*	1.95**	.07 (.04)	 [.0123, .1980]
Elasticity†	382	.01	-2.48*	-.01 (.03)	[-.0865, .0298]
DD (<i>k</i>) †	389	.04	.03	.001 (.02)	[-.0317, .0466]
CFC	391	-.68***	-.15**	.10 (.05)	 [.0248, .2316]
Craving	391	.81***	.43***	.35 (.10)	 [.1874, .5822]

Note. CFC = Consideration of Future Consequences; DD (*k*) = Delay Discounting magnitude; *a* = pathway from Independent Variable to Mediator; *b* = pathway from Mediator to Dependent Variable; *c'* = indirect effect of the Independent Variable on the Dependent Variable through the Mediator.

*** $p < .001$. ** $p < .01$. * $p < .05$, bold text indicates significant indirect effect. † Variable Transformed.

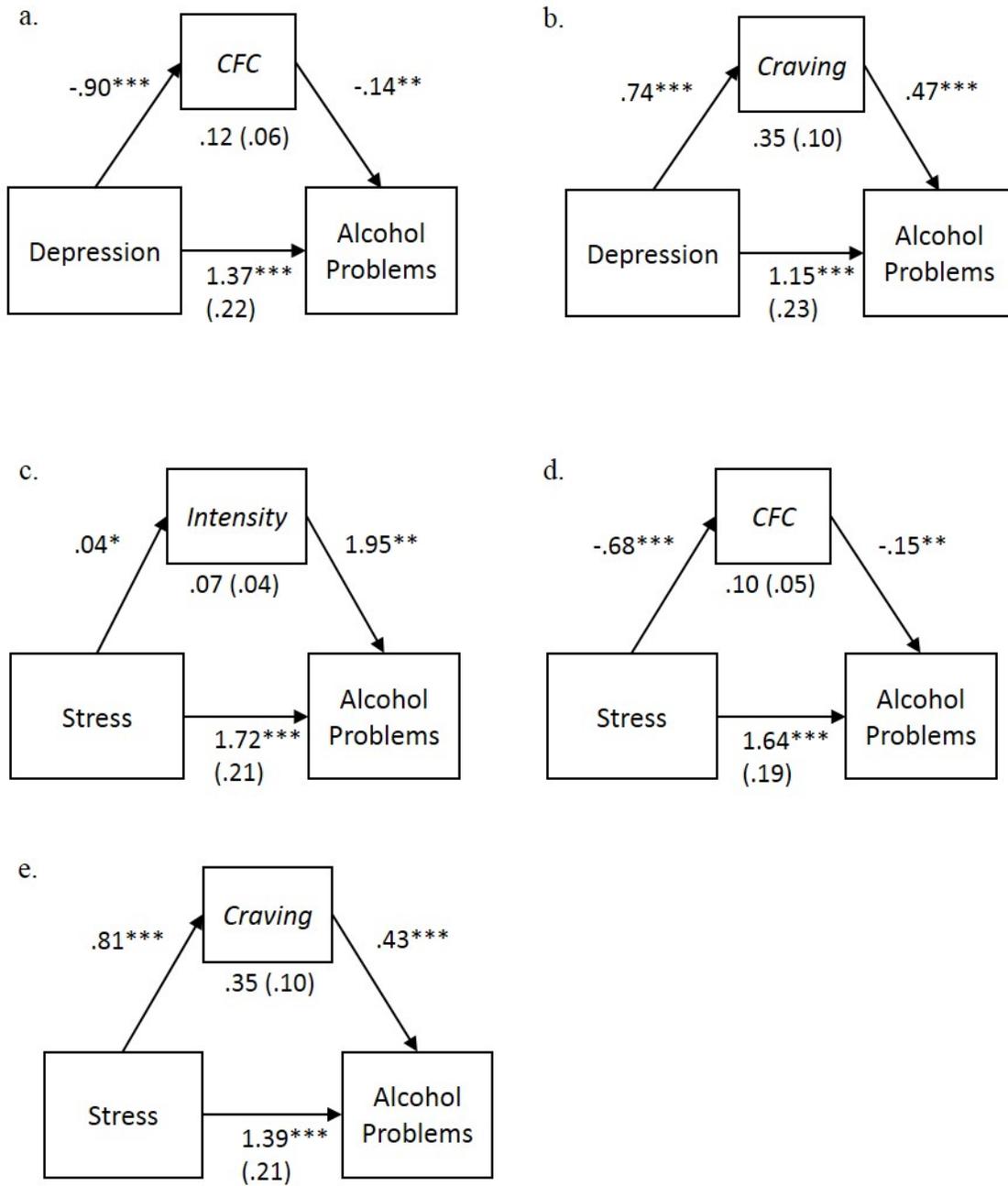


Figure 1. Summary of Final Single Mediator Models

Hello,

The University of Memphis Institutional Review Board, FWA00006815, has reviewed and approved your submission in accordance with all applicable statuses and regulations as well as ethical principles.

PI NAME: James Murphy

CO-PI:

PROJECT TITLE: Balanced Lifestyle for Undergraduate Excellence

FACULTY ADVISOR NAME (if applicable): N/A

IRB ID: #2152

APPROVAL DATE: 8/22/2014

EXPIRATION DATE: 3/6/2015

LEVEL OF REVIEW: Expedited Modification

RISK LEVEL DETERMINATION: No more than minimal

Please Note: Modifications do not extend the expiration of the original approval

Approval of this project is given with the following obligations:

- 1. If this IRB approval has an expiration date, an approved renewal must be in effect to continue the project prior to that date. If approval is not obtained, the human consent form(s) and recruiting material(s) are no longer valid and any research activities involving human subjects must stop.**
- 2. When the project is finished or terminated, a completion form must be completed and sent to the board.**
- 3. No change may be made in the approved protocol without prior board approval, whether the approved protocol was reviewed at the Exempt, Expedited or Full Board level.**
- 4. Exempt approval are considered to have no expiration date and no further review is necessary unless the protocol needs modification.**

Approval of this project is given with the following special obligations:

Thank you,

**Pamela M. Valentine
Interim Institutional Review Board Chair
The University of Memphis.**

Note: Review outcomes will be communicated to the email address on file. This email should be considered an official communication from the UM IRB. Consent Forms are no longer being stamped as well. Please contact the IRB at IRB@memphis.edu if a letter on IRB letterhead is required.