Elevated Behavioral Economic Demand for Alcohol in Co-Users of Alcohol and Cannabis

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ABSTRACT. Objective: Co-use of cannabis and alcohol is associated with increased drinking and other negative consequences relative to use of alcohol alone. One potential explanation for these differences is overvaluation of alcohol (e.g., alcohol demand) among co-users, similar to established overvaluation of alcohol among tobacco and alcohol co-users. This study examined differences in alcohol demand between an alcohol and cannabis co-user group and an alcohol-only group. **Method:** A large sample of adult drinkers ($n = 1,643$, 54% female) was recruited through an online crowdsourcing site (Amazon Mechanical Turk). Of the full sample, 476 participants reported weekly or greater cannabis use in the past 6 months (co-user group); 888 reported never using cannabis in the past 6 months (alcohol-only group). Assessments included a validated alcohol purchase task and self-report measures of alcohol and cannabis use. **Results:** Co-users reported significantly higher alcohol consumption across the elastic portion of the alcohol demand curve (i.e., $1.50–$9.00/drink). Analyses of covariance controlling for alcohol use and demographics revealed significantly higher breakpoint ($p = .025$) and Omax ($p = .002$) and significantly lower elasticity ($p < .003$) in the co-user group. Intensity and Pmax did not significantly differ between groups. **Conclusions:** Co-users of cannabis and alcohol overvalue alcohol compared with individuals who drink alcohol but do not use cannabis. This study is generally consistent with prior studies on alcohol and tobacco co-users, providing converging evidence that polysubstance use is associated with overvaluation of alcohol. These findings have important implications for treatment and prevention, particularly in the context of changes in cannabis legalization. (*J. Stud. Alcohol Drugs, 79, 929–934, 2018*)

CO-USE OF ALCOHOL AND CANNABIS is highly prevalent and known to contribute to numerous negative health outcomes and increased risk of other negative consequences (Yurasek et al., 2017). With the exception of nicotine, cannabis is the most commonly used drug among those who drink alcohol (Volkow et al., 2014). In addition, more than 75% of cannabis users also report consuming alcohol (Barrett et al., 2006; Collins et al., 1998; Pape et al., 2009). About one half of young adult cannabis users report simultaneous use of alcohol and cannabis, in which users consume both substances during the same occasion (Haas et al., 2015; Subbaraman et al., 2015). Co-users of alcohol and cannabis have been shown to consume greater amounts of alcohol compared with others who only consume alcohol (Brière et al., 2011). Moreover, the 12-month prevalence of alcohol use disorder among persons with cannabis use disorder is 68%, with lifetime prevalence of 88% (Stinson, 2006). Co-users are at higher risk of experiencing negative consequences, engaging in risky behaviors, and experiencing increased behavioral problems and worse treatment outcomes (Biecheler et al., 2008; Brière et al., 2011; Harrington et al., 2012; Li et al., 2012; Shillington et al., 2001; Staiger et al., 2012). Finally, co-use of alcohol and cannabis is associated with substantially higher risks from driving while impaired, including greater likelihood of fatal motor vehicle accidents (Asbridge et al., 2012; Brière et al., 2011; Hartman et al., 2015; Sewell et al., 2009; Staiger et al., 2012).

One factor that may influence heavier alcohol use among co-users is overvaluation of alcohol rewards. Behavioral economic demand (i.e., the quantitative relationship between consumption of a commodity and its cost) provides a framework for investigating this possibility (Bickel et al., 2014). A growing body of research using hypothetical alcohol purchase task (APT) assessments (Murphy & MacKillop, 2006) has demonstrated consistent associations between elevated alcohol demand and severity of alcohol misuse and associated harms (MacKillop, 2016). Prior research has shown that co-use of alcohol and tobacco is associated with significantly greater demand for alcohol compared with use of alcohol alone, even after controlling for differences in drinking and demographics (Amlung et al. 2017; Yurasek et al. 2013). This difference is hypothesized to result from several factors including cross-commodity craving and cue reactivity, as well as alcohol priming (Drobes, 2002; Lv et al., 2016; McKee et al., 2010).

We are aware of no studies to date examining behavioral economic alcohol demand in a sample of alcohol and cannabis co-users. To extend this line of research to cannabis use, the current study examined demand for alcohol in a large sample of adults who reported either co-use of alcohol and cannabis or alcohol alone. We hypothesized that co-users would report elevated alcohol demand relative to the alcohol-only users, even after controlling for differences in drinking level or demographic factors.

Method

Participants

Participants for the study were recruited through the Amazon Mechanical Turk (MTurk) crowdsourcing portal (www.mturk.com). MTurk is an online crowdsourcing platform that allows for surveys and tasks to be posted by "requesters" (researchers) and completed by "workers" given that the "workers" (participants) meet certain criteria (Paolacci & Chandler, 2014). The survey was posted on MTurk between September and December 2017. Participants had to be at least 18 years of age, geographically located in the United States, and have previously completed at least 100 MTurk surveys with minimum 95% approval rating on prior surveys to ensure valid data. Only one response per IP address was permitted. To reduce the possibility of dishonest or biased responding, the survey description included a general description of the surveys to be completed but did not explicitly state a focus on alcohol or cannabis use. Therefore, we recruited a large general sample of adults ($N = 3,024$), from which we extracted a subset of alcohol users ($n = 1,653$) who reported weekly or greater alcohol use in the last 12 months. Ten participants were excluded based on invalid data on the APT (see below). From the remaining 1,643 participants, we defined two groups: (a) Alcohol + cannabis co-users were participants who reported weekly or greater cannabis use in the past 6 months on the Cannabis Use Disorders Identification Test–Revised (CUDIT-R; Adamson et al., 2010) ($n = 476$), and (b) alcohol-only users were participants who reported never using cannabis in the past 6 months on the CUDIT-R ($n = 888$). The remaining 280 participants reported minimal cannabis use (i.e., monthly or less). However, these participants were not included in the primary analyses because their cannabis use was not sufficiently frequent to constitute co-use, nor did they fit the alcohol-only group definition. The study was approved by the Hamilton Integrated Research Ethics Board (Project #3566), and all participants gave informed consent. Participants received $2 for completing the study.

Measures

The general MTurk survey consisted of a battery of self-report questionnaires assessing decision making, personality, substance use, and other lifestyle behaviors. Alcohol use and misuse over the last 12 months was assessed via the Alcohol Use Disorders Identification Test (AUDIT; Saunders et al., 1993). Cannabis use and misuse over the last 6 months was assessed via the CUDIT-R. Demographic variables (e.g., sex, age, race/ethnicity, income, etc.) were assessed via a self-report questionnaire. Current cigarette smoking (yes/no) was assessed via a self-report item.

Alcohol demand was assessed using a validated APT (Murphy & MacKillop, 2006). Participants reported how many standard-sized drinks of their preferred alcoholic beverage they would consume at 30 drink prices, ranging from Free to $25/drink, in ascending order. A standard instructional set was used (complete vignette is provided in the online-only supplemental material that accompanies this article on the journal's website—Supplemental Figure S2). Participants were instructed to make choices based on their current income level, with no alcohol consumption before completing the APT, no opportunity to drink elsewhere, and no opportunity to stockpile drinks. A single attention check item was presented following the instructional vignette to check for comprehension of APT instructions; all included participants answered this item correctly.

Data analyses

Responses on the APT were examined for nonsystematic data (Stein et al., 2015), resulting in the exclusion of 10 participants from all analyses (6 failed the trend criterion; 4 failed the reversals from zero criterion). Four observed demand indices were generated from the APT (Murphy & MacKillop, 2006), as follows: (a) Intensity (i.e., consumption at free price); (b) Breakpoint (i.e., price that suppressed consumption to zero); (c) O_{max} (i.e., maximum expenditure); and (d) P_{max} (i.e., the price point corresponding to O_{max}). In addition, elasticity of demand (i.e., the proportionate slope of the demand coordinates in logarithmic units, denoted as α) was modeled for the mean consumption data for each group using the exponential demand curve equation of Hursh & Silberberg (2008) in GraphPad Prism 7. In this model, Q0 was fixed to the observed mean at free price. The value of k was shared across model fits and constrained to be less than 5.0, resulting in a best fitting k of 5.0. Six participants reported zero consumption across all prices. In each case, observed demand indices were coded as 0, but these participants were not included in the elasticity modeling. Intensity, O_{max}, and P_{max} were logarithmically transformed.

Results

Preliminary analyses

Sample characteristics are provided in Supplemental Table S1. Overall, the sample was 54.9% female, 73.8% White,

with a mean age of 35.11 years ($SD = 10.79$) and median income of \$52,500. Groups were significantly different with respect to age, income, education, current cigarette smoking, and AUDIT ($ps < .01$); these variables were included as covariates.

Each of the APT demand indices (except P_{max}) were positively correlated with AUDIT total score, albeit at differing magnitudes (rs .13–.41, $ps < .001$). The demand indices (except P_{max}) were also significantly correlated with CUDIT-R scores at generally small effect size (rs .07–.17, $ps < .01$). Complete correlation results are in Supplementary Table S2.

Alcohol demand in alcohol–cannabis co-users versus alcohol-only participants

Demand and expenditure curves by group are in Figure 1. Raw consumption values indicated greater consumption across all prices on the APT (Figure 1, top). However, as shown in the middle panel of Figure 1, after we controlled for alcohol use and demographic variables, price-level analyses of covariance (ANCOVA) revealed significantly greater consumption in the co-user group across the elastic portion of the demand curve (i.e., from \$1.50 to \$9.00/drink), Fs 4.20–14.90, $ps < .05$. Consumption at the remaining prices did not significantly differ between groups. At the index level, ANCOVA models revealed significantly higher values in the co-use group for breakpoint, $F(1, 1357) = 5.02$, $p = .025$, $\eta_p^2 = .004$, and O_{max}, $F(1, 1357) = 9.25$, $p = .002$, $\eta_p^2 = .007$. Intensity and P_{max} were nonsignificant ($ps > .39$). An extra-sums-of-squares F test comparing α values based on group mean consumption indicated significantly reduced elasticity in the co-use group, $F(1, 57) = 415.0$, $p < .0001$, reflecting reduced price sensitivity compared with the alcohol-only group (see Supplemental Figure S1). A follow-up ANCOVA was conducted using α values derived from individual subject demand curves. This analysis confirmed significantly reduced elasticity in the co-user group, $F(1, 1270) = 8.57$, $p = .003$, $\eta_p^2 = .007$.

To explore whether differences in alcohol demand remained after including participants with occasional cannabis use, we repeated the ANCOVA on the demand indices after including the 280 participants who reported using cannabis monthly or less in the co-user group. Only O_{max} remained significantly different between groups, $F(1, 1634) = 13.43$, $p < .001$, $\eta_p^2 = .008$ (Intensity $p = .08$; Breakpoint $p = .07$; P_{max} $p = .73$).

Discussion

This study sought to examine demand for alcohol in two groups: those who regularly consume both alcohol and cannabis, and those who only consume alcohol. Results from this study extend previous research examining alcohol and tobacco co-users (Amlung et al., 2011; Yurasek et al., 2013)
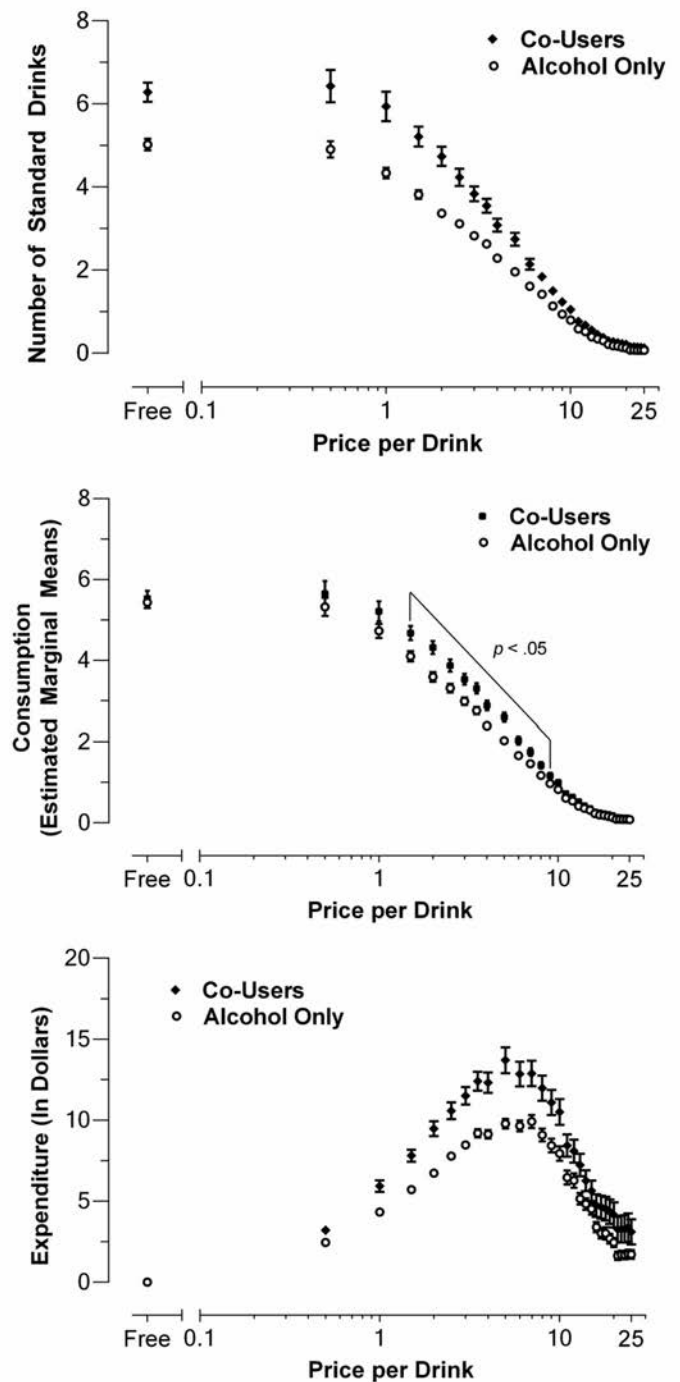

FIGURE 1.   Alcohol demand and expenditure curves by group. Top panel: Raw values for consumption in standard drinks across price for alcohol + cannabis co-users group (filled markers) and alcohol-only group (unfilled markers). Middle panel: Estimated marginal means from the analysis of covariance models comparing alcohol + cannabis co-users (filled markers) and alcohol-only users (unfilled markers). Bottom panel: Expenditure in dollars based on raw consumption values for alcohol + cannabis co-users group (filled markers) and alcohol-only group (unfilled markers). *Note:* Individual data points reflect mean and standard error. Price is plotted in logarithmic scale for proportionality.

by demonstrating for the first time in a relatively large and geographically diverse sample of adults that alcohol and cannabis co-users also overvalue alcohol rewards.

Several parallels to the previous alcohol and tobacco studies are noteworthy. First, the alcohol and cannabis co-user group reported greater alcohol consumption across the mid-range prices on the APT corresponding to the elastic portion of the demand curve. Similar price-level differences were observed in tobacco and alcohol co-users in the study by Amlung and colleagues (2017). Co-users were also willing to spend a greater amount of money in total on alcohol (O_{max}) and continue to consume at higher drink prices (Breakpoint) relative to alcohol-only users (Amlung et al., 2017; Yurasek et al., 2013). Importantly, these differences remained significant even after accounting for group differences in alcohol use or demographic characteristics. More inelastic demand among co-users is also consistent with the findings of Amlung et al. (2017), suggesting that co-users exhibit significantly lower price sensitivity compared with alcohol-only groups. Taken together, the price-level and demand index-level analyses provide relatively consistent evidence of higher alcohol demand in cannabis and alcohol co-users.

Another noteworthy finding was the lack of significant differences in intensity of demand after controlling for covariates. This is the third study to report no differences in intensity among co-users (Amlung et al. 2017; Yurasek et al. 2013). This finding can be interpreted in the context of the two-factor structure of substance demand that has been demonstrated in factor analytic studies (e.g., MacKillop et al. 2008; Bidwell et al. 2012). Intensity uniquely loads on the amplitude factor, which generally reflects the height of the demand curve or the overall amount of consumption. The second factor, persistence, is primarily reflected by breakpoint, elasticity, and O_{max}. Persistence generally reflects sensitivity to escalating price. Simply put, the differences between co-users and alcohol-only users appear to be largely driven by how far the person will go for alcohol, rather than how much alcohol they would consume (MacKillop et al., 2009).

With the expanding legalization of cannabis in North America, access to recreational cannabis is anticipated to increase. Therefore, understanding factors that contribute to risky behaviors and other negative outcomes associated with cannabis use, such as higher co-use of alcohol, is an important priority for clinicians and public health officials. This study contributes to the literature by providing initial behavioral economic evidence that one potential explanation for increased alcohol use among co-users is overvaluation of alcohol rewards. In previous research, co-users have been found to exhibit increased behavioral problems, higher risk for impaired driving, and poorer clinical treatment outcomes (Staiger et al., 2012; Subbaraman et al., 2017). Examining how differences in alcohol demand contribute to these nega-

tive outcomes is an important direction for future research. Another priority is to examine alcohol demand in groups of simultaneous alcohol and cannabis users (e.g., individuals who report consuming alcohol and cannabis at the same time). The present study did not distinguish between simultaneous use and use on separate occasions. This is an important issue because simultaneous users of alcohol and cannabis consume more alcohol and experience more consequences and harms than those who only consume alcohol (Subbaraman & William, 2015). In fact, findings on the day-level patterns of cannabis and alcohol co-use suggest that heavy drinking was more likely than drinking at moderate levels or not drinking on days when cannabis was also used, and individuals with comorbid alcohol and cannabis use disorder were particularly likely to drink heavily compared with moderately on co-use days (Metrik et al., 2018).

A final empirical question for future research concerns the economic interactions between alcohol and cannabis as commodities, including determining the extent to which the cannabis and alcohol are complements or substitutes (for a review, see Subbaraman, 2016). Epidemiological studies using individual-level outcomes indicate that cannabis use increases alcohol consumption, thereby serving as a complement (Subbaraman, 2016). Similarly, economic policies that increase the price of or reduce access to alcohol demonstrate complementary reductions in both alcohol and cannabis use (Farrelly et al., 1999; Pacula, 1998; Williams et al., 2004). However, several longitudinal population-level studies have also suggested that cannabis and alcohol can be substitutes (see Subbaraman, 2016). Importantly, the present findings only pertain to demand for a single commodity and cannot address cross-price relationships. Future research disentangling these economic relationships is warranted.

These findings should be considered in the context of the study's limitations. First, the purchase task assessment measured estimated consumption instead of actual alcohol purchases. However, a growing body of evidence from previous work has demonstrated the validity of hypothetical purchase task assessments (Amlung & MacKillop, 2015; Amlung et al., 2011; MacKillop et al., 2012). Moreover, this study focused on participants who frequently co-use alcohol and cannabis. Although the APT instructions specified that participants did not consume alcohol before making the decisions, no constraints on cannabis use were given. As such, it is plausible that participants in the co-user group may have responded differently if access to cannabis was restricted in the hypothetical drinking scenario. The use of only one measure to assess problematic alcohol use is another limitation. Although the AUDIT is widely used and extensively validated, the study may have benefited from additional measures focusing on alcohol problems and consequences, such as the Young Adult Alcohol Consequences Questionnaire (Read et al., 2006). A final potential limitation concerns the use of MTurk, which is characterized by a lack of experimental

control compared with in-person assessment. However, we implemented rigorous inclusion criteria and attention checks that are commonly used in MTurk studies. In addition, recent studies support the validity of MTurk for behavioral science research (Hauser & Schwarz, 2016), including in addictions samples (Kim & Hodgins, 2017).

In conclusion, this study provides initial evidence of elevated demand for alcohol in a sample of cannabis and alcohol co-users. Moreover, this study replicates and extends similar findings in the literature from samples of tobacco and alcohol co-users. Additional research is needed to replicate these findings outside of an online setting and using higher-resolution measures of alcohol and cannabis use. The development of treatment interventions and harm reduction strategies for co-users of cannabis and alcohol is an important priority given the ongoing legalization of cannabis throughout North America.

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