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Time Constraints in the Alcohol Purchase Task

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Hypothetical purchase tasks have advanced behavioral economic evaluations of demand by circumventing practical and ethical restrictions associated with delivering drug reinforcers to participants. Numerous studies examining the reliability and validity of purchase task methodology suggest that it is a valuable method for assessing demand that warrants continued use and evaluation. Within the literature examining purchase tasks, the alcohol purchase task (APT) has received the most investigation, and currently represents the most experimentally validated variant. However, inconsistencies in purchase task methodology between studies exist, even within APT studies, and, to date, none have assessed the influence of experimental economic constraints on responding. This study examined changes in Q_0 (reported consumption when drinks are free), breakpoint (price that suppresses consumption), and α (rate of change in demand elasticity) in the presence of different hypothetical durations of access to alcohol in an APT. One hundred seventy-nine participants (94 males, 85 females) from Amazon Mechanical Turk completed 3 APTs that varied in the duration of time at a party (i.e., access to alcoholic beverages) as described in the APT instructions (i.e., vignette). The 3 durations included 5-hr (used by Murphy et al., 2013), 1-hr, and 9-hr time frames. We found that hypothetical duration of access was significantly related to Q_0 and breakpoint at the individual level. Additionally, group-level mean α decreased significantly with increases in duration of access, thus indicating relatively higher demand for alcohol with longer durations of access. We discuss implications for conducting hypothetical purchase task research and alcohol misuse prevention efforts.

Public Health Significance
This study examines the degree to which hypothetical alcohol consumption event duration impacts relative consumption of alcohol drinks in a commonly used purchase task. Results suggest that drinking duration affects alcohol demand in unexpected ways. Assessing effects of duration on alcohol demand may help provide novel insights into pregaming drinking as well as extended event drinking.

Keywords: behavioral economics, demand, alcohol purchase task, closed economy

The field of behavioral economics applies concepts and terminology from microeconomics to understand decision making within a behavior analytic perspective (Hursh, 1980, 1984). One prominent area of research in behavioral economics quantifies reinforcer efficacy through operant demand analyses, the results of which are most typically depicted in the demand curve. Behavioral economic demand curves model how reinforcer consumption declines as a function of increases in that reinforcer's cost (i.e., demand elasticity). Demand curves are multifaceted and result in several independent, yet interrelated, measures: Q_0 (i.e., maximum demand/intensity) represents the amount of the commodity the organism will consume at minimal costs (i.e., free or near free; can be derived or observed); breakpoint is either the highest price that maintains any nonzero consumption (i.e., BP_1) or the first price that fully suppresses consumption (i.e., BP_0); α describes the rate of change in elasticity across the range of prices (Hursh & Silberberg, 2008); and P_{max} is the price associated with unit elasticity and, typically, but not always, O_{max}, the maximum amount of behavior or resources expended (P_{max} and O_{max} can be derived or observed). Although much of the early demand curve research was conducted with nonhuman animals working in operant cham-

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bers (e.g., Hursh, 1978), behavioral pharmacologists transitioned focus to human operant approaches as behavioral economic considerations of addiction became accepted (Higgins & Hughes, 1998).

In the human operant tradition, the demand paradigm was extended to humans working for substances such as cigarette puffs (M. W. Johnson & Bickel, 2006; Madden, Bickel, & Jacobs, 2000), hydromorphone (Greenwald & Hursh, 2006), methadone (Spiga, Martinetti, Meisch, Cowan, & Hursh, 2005), and buprenorphine (Petry & Bickel, 1999). Ethical and practical considerations spurred the development of hypothetical purchase task (HPT) questionnaires as a credible alternative to human operant studies (Jacobs & Bickel, 1999). In addition, the advanced verbal repertoire of humans obviates the need to have participants respond on operanda to earn and experience the reinforcer. Rather, as is the case in HPTs, participants are asked to report how many units of a reinforcer they would purchase and consume at increasing prices (most typically in monetary amounts). Responses on the HPT consistently resemble the downward sloping pattern found in traditional operant demand tasks. Furthermore, an increasing number of studies have demonstrated various forms of reliability and validity of the HPT (for a more comprehensive overview, see Reed, Kaplan, & Becirevic, 2015).

In the seminal article using HPTs, Jacobs and Bickel (1999) asked non-treatment-seeking heroin-dependent individuals to report how many cigarettes and bags of heroin they would purchase at 15 progressively increasing prices, starting at $0.01 and ending at $1,120. As price increased, participants reported purchasing fewer cigarettes and fewer bags of heroin. In addition, Jacobs and Bickel found demand for heroin was greater than demand for cigarettes. Extending Jacobs and Bickel's research, Murphy and MacKillop (2006) asked 267 undergraduate students (who displayed a range of drinking problems) to complete an HPT for alcohol (appropriately named the *alcohol purchase task* [APT]). Results indicated Q_0, breakpoint, and O_{max} were all greater for self-reported heavy drinking students compared with light drinkers. During the last decade, HPTs have been adopted for a variety of commodities and situations, including alcohol (Amlung, Acker, Stojek, Murphy, & MacKillop, 2012; MacKillop & Murphy, 2007; MacKillop et al., 2009), cigarettes (MacKillop et al., 2012, 2008; Murphy, MacKillop, Tidey, Brazil, & Colby, 2011), heroin (Jacobs & Bickel, 1999), cocaine (Bruner & Johnson, 2014), bath salts (P. S. Johnson & Johnson, 2014), marijuana (Collins, Vincent, Yu, Liu, & Epstein, 2014), anabolic steroids (Pope Jr et al., 2010), food (Chase, MacKillop, & Hogarth, 2013), ultraviolet indoor tanning (Reed, Kaplan, Becirevic, Roma, & Hursh, 2016), essential/nonessential nonconsumables (Reed, Kaplan, Roma, & Hursh, 2014; Roma, Hursh, & Hudja, 2016), and even monetary compensation contingent on work tasks (Henley, DiGennaro Reed, Kaplan, & Reed, 2016).

An important aspect of the HPT is the inclusion of specific instructions and assumptions provided prior to displaying the price sequence. These instructions and assumptions are included to control for extraneous variables that could influence responding. Although specific instructions and assumptions in the HPT are usually provided, variations exist and there is no agreed upon "standard" set of assumptions. We briefly describe these specific instructional and assumption-based controls and provide relevant excerpts from the seminal HPT (Jacobs & Bickel, 1999) and, what we believe to be, the most comprehensive (at least in terms of specificity in instructions and assumptions) APT (Murphy et al., 2013). The Appendix provides full versions of these vignettes and variations.

The first type of control specifies constraint in commodity availability outside of the experimental vignette, to close the economy. Examples include statements such as,

> You cannot purchase more drugs or cigarettes, or any other drugs or tobacco products except those you choose below. Therefore, assume you have no other drugs or cigarettes stashed away, you have no prescriptions for anything, and you cannot get drugs or cigarettes through any other source, other than those you buy here. (Jacobs & Bickel, 1999, p. 415)

or

> Assume that you did not drink alcohol or use drugs before you went to the party, and that you will not drink or use drugs after leaving the party. You cannot bring your own alcohol or drugs to the party. You also can't bring the drinks home. (Murphy et al., 2013, p. 131)

In general behavioral economic parlance, these vignettes describe a *closed economy*, which is an experimental arrangement in which the organism must earn all of the commodity (i.e., none is given for "free"; Imam, 1993; Timberlake & Peden, 1987). On the other end of the spectrum, *open* economies imply some independence between the organism's behavior and total consumption (e.g., postsession free feeding). In the closed economy, comparisons between the "value" of reinforcers can be measured as a direct result of how much the organism will work. Comparisons of value under open economies may be influenced by type of, amount of, or delay to the good given for "free."

A second control specifies the length or duration of the closed economy. For example, "You also can't save up any heroin or cigarettes you buy and use them another day. Everything you buy is, therefore, for your own personal consumption within a 24-hour period" (Jacobs & Bickel, 1999) and "Everything you buy is, therefore, for your own personal use within the 5 hour period that you are at the party" (Murphy et al., 2013).

The third control specifies the target commodity and minimizes potential commodity interactions, such as substitutability and complementarity. Examples include, "Also, assume that you have no other drugs available to you. You cannot purchase more drugs or cigarettes, or any other drugs or tobacco products except those you choose below" (Jacobs & Bickel, 1999) or "The available drinks are standard size domestic beers [12 oz.], wine [5 oz.], shots of hard liquor [1.5 oz.], or mixed drinks containing one shot of liquor" (Murphy et al., 2013). Substitutes are alternative commodities that serve the same or similar functions as the target commodity and complements tend to enhance the value of the target commodity when combined together.

Finally, additional controls attempt to increase the likelihood that participants will respond honestly and minimize any interindividual variation. For example, "There are no consequences to your using the heroin. So, assume this is a study that has been approved by the police and all other organizations" (Jacobs & Bickel, 1999) and "Imagine that you do not have any obligations the next day [i.e., no work or classes]" (Murphy et al., 2013).

Establishing the aforementioned controls related to economy type and availability of substitutes are critical given that interactions between the two may differentially affect Q_0 and α. For example, Hursh (2014) reanalyzed data from a previous study he conducted on economy types (Hursh, 1993), wherein a rhesus monkey worked for food during a 12-hr work period with either 1-hr postsession feeding on a continuous reinforcement schedule (open economy) or no postsession feeding (closed economy). Demand intensity (i.e., Q_0) for food was equivalent between both economy types; however, the closed economy yielded more persistent demand than the open economy. Other studies using concurrently available substitutes have found that *both* demand intensity and α are affected (Hursh, 2014; M. W. Johnson & Bickel, 2003). The current study did not directly manipulate the relative openness (or closedness) of the economy, yet we know of no research that has explicitly compared differing lengths of economy type.

Literature suggests that participant's responding is sensitive to changes in the instructions and assumptions provided in the vignette, as recent studies have directly evaluated the instructional effects on APT demand (Gentile, Librizzi, & Martinetti, 2012; Gilbert, Murphy, & Dennhardt, 2014; Skidmore & Murphy, 2011). For example, Gentile et al. (2012) evaluated the effects of next-day academic constraints on demand for alcohol among college-aged students. Specifically, the researchers adapted the wording from the original Murphy and MacKillop (2006) APT to include additional assumptions. In their first experiment, participants read instructions and assumptions similar to that of Murphy and MacKillop, with the following addition (bolded):

> Imagine that you and your friends are at a bar from 9 p.m. to 2 a.m., **but you have a class at** [8:30 a.m./10:30 a.m./12:30 p.m.] the next day. The class is an upper-level seminar within your major and there are 12 students in the class. (p. 392)

Participants were randomly assigned to either a no-constraint condition (i.e., original wording) or one of the aforementioned constraint conditions (i.e., class time at 8:30, 10:30, or 12:30).

Results indicated relatively greater demand among participants in the no-constraint condition compared with the class-constraint conditions. In addition, demand for alcohol was lower for participants in the 8:30 a.m. and 10:30 a.m. conditions compared with those in the 12:30 p.m. condition. In their second experiment, Gentile et al. (2012) evaluated whether there might be an interaction between the time of the next-day constraint and "importance" of the constraint (i.e., class or exam). Similar to Experiment 1, participants read the following instruction (addition bolded): "Imagine that you and your friends are at a bar from 9 p.m. to 2 a.m., **and you have a(n)** [exam/class] at [8:30 a.m./12:30 p.m.] the following day" (p. 395). As might be expected, the 8:30 a.m. exam condition resulted in the lowest demand for alcohol, but that both 8:30 a.m. obligations (i.e., exam and class) resulted in lower demand compared with the afternoon constraint conditions. Taken together, the results of Gentile et al. indicate slight modifications of the APT result in predictable differences in participant responding, and that such differences are appropriately captured in the concept of demand.

In light of the results from Gentile et al. (2012), and because of the inconsistencies in the instructions and assumptions of HPTs in the demand literature in general, we sought to examine whether duration of the closed economy, as stated in the instructions of an HPT, would affect behavioral economic parameters of interest. Therefore, the current study used the most comprehensive APT (i.e., the APT with the most specific instructions and assumptions; see review of APT procedures in MacKillop, 2016) as a starting point to compare the effects of varying the duration of time participants were told they had to purchase and consume the alcoholic beverages. As previously described, APT instructions attempt to impose certain controls, such as specifying a closed economy that is absent of any substitutes, yet we do not know how different durations will affect Q_0 and α. If the APT scenario is acting as a pure closed economy, we theoretically expect no changes in α, but may expect Q_0 to increase with longer durations. Should the APT function as some kind of open economy, given some implicit availability of substitutes assumed by the participants, we theoretically expect both Q_0 and α to change in orderly ways with duration.

Method

Participants

We recruited 230 Amazon Mechanical Turk (www.mturk.com) workers to complete a battery on alcohol use. To be eligible for participation, we required the workers to have completed at least 100 Human Intelligence Tasks (HITs) with at least 95% of their work approved by HIT creators, and to be located in the United States. Remuneration entailed $0.60 upon HIT completion (verified via a unique code submitted at the end of the HIT). Among the 230 participants recruited, 200 (n_{females} = 101, n_{males} = 99; M_{age} = 36.94) completed the HIT and mean duration to HIT completion was 8.41 min (*SEM* = 19.2 s), approximating an hourly wage of $4.28. Although seemingly low, this hourly wage is well within range of other HITs administered through Amazon Mechanical Turk (Horton & Chilton, 2010; Paolacci, Chandler, & Ipeirotis, 2010).

Procedures

The University of Kansas Institutional Review Board approved all study procedures (IRB # 20635). Upon starting the HIT, participants clicked a link and were directed to a Qualtrics-hosted web survey. The first page of the survey presented the information statement, and participants continued if they agreed to participate. To evaluate the effects of differing durations of the closed economy, we used a within-subjects, semicounterbalanced design in which all participants first completed the standard 5-hr APT (9:00 p.m. until 2:00 a.m.) followed by the 1-hr (11:00 p.m. until 12:00 a.m.) and 9-hr (7:00 p.m. until 4:00 a.m.) APTs. We counterbalanced the order of presentation of the 1-hr and 9-hr conditions across participants. Finally, participants completed a demographics form and questions related to a larger battery on alcohol use. We constructed three versions of the Murphy et al. (2013) APT. Note that the version by Murphy et al. (2013) is nearly identical to that of Murphy, MacKillop, Skidmore, and Pederson (2009), with the addition of the sentence, "Imagine that you do not have any obligations the next day (i.e., no work or classes)." The first was identical to the version used by Murphy et al. (2013), specifying a 5-hr time frame (9:00 p.m. until 2:00 a.m.). We centered the remaining versions around the 5-hr time frame by adding and subtracting 2 hr from the both the start and end times. This resulted in a 9-hr time frame (7:00 p.m. until 4:00 a.m.) and 1-hr time frame (11:00 p.m. until 12:00 a.m.). These time frames have ecological validity in modeling some common high-risk drinking situations that have not previously been modeled with demand curve approaches, such as situations in which young adults consume large amounts of alcohol prior to attending an event in which alcohol is restricted or limited, and longer duration events such as drinking surrounding football games or festivals that may take place throughout an afternoon and evening (Yurasek, Miller, Mastroleo, Lazar, & Borsari, 2016). All other aspects of the APTs were identical to that of Murphy et al. (2013). The APTs thereby read,

> In the questionnaire that follows we would like you to pretend to purchase and consume alcohol. Imagine that you and your friends are at a party on a weekend night from ***(7:00, 9:00, 11:00)*** **p.m. until** (***12:00*** [midnight], 2:00, 4:00) a.m. to see a band. Imagine that you do not have any obligations the next day (i.e., no work or classes). The following questions ask how many drinks you would purchase at various prices. The available drinks are standard size domestic beers (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks containing one shot of liquor. Assume that you did not drink alcohol or use drugs before you went to the party, and that you will not drink or use drugs after leaving the party. You cannot bring your own alcohol or drugs to the party. Also, assume that the alcohol you are about to purchase is for your consumption only. In other words, you can't sell the drinks or give them to anyone else. You also can't bring the drinks home and you have no other alcohol at home. Everything you buy is, therefore, for your own personal use within the ***(9, 5, 1)*** **hour** period that you are at the party. Please respond to these questions honestly, as if you were actually in this situation.

After the vignette in each version, participants answered three attending questions to ensure exposure to the relevant independent variables: (a) How many hours do you have to consume the drinks?; (b) In this pretend scenario, how much did you drink before the party?; and (c) In this pretend scenario, what's the chance that you will have alcohol when you get home from the party? Upon correctly answering these questions, a two-column table appeared below the vignette. The left column displayed, in ascending order, the prices per drink, and the right column contained text boxes in which participants typed a numeric value indicating the number of drinks they would purchase and consume at each price. We used nearly the same prices as Murphy et al. (2013), ranging from $0.00 (free) to $20.00, with the exception of the $0.25 price.[1] Thus, the full price progression was $0.00 (free), 0.50, 1, 1.50, 2, 2.50, 3, 4, 5, 6, 7, 8, 9, 10, 15, and 20.

Data Analytic Plan

We considered participant responding unsystematic if, at any point, the number of drinks reported by the participant increased across any of the increasing prices (i.e., consecutive or not); note that this approach to identifying potentially unsystematic response sets is more conservative than the Criterion 2 suggested by Stein, Koffarnus, Snider, Quisenberry, and Bickel (2015). Applying this criterion, we identified 13, 14, and 11 unsystematic response sets in the 1-hr, 5-hr, and 9-hr conditions, respectively. An unsystematic response set identified in any of the conditions resulted in excluding that participant's data from all three time-frame conditions. In addition, we excluded one participant for reporting an unrealistically high-value number of drinks (i.e., 100) at the first price (i.e., $0.00) across all three conditions, and an additional three participants because they reported they had never drank alcohol. Because multiple participants met criteria for unsystematic responding on more than one APT, the total number of participants excluded in the demand analyses was 21. For the remaining 179 participants ($n_{\text{females}} = 85$; $n_{\text{males}} = 94$; $M_{\text{age}} = 37.53$), we identified individual-specific, atheoretical measures of demand (i.e., Q_0, BP_0, BP_1) and group-level measures of demand (i.e., α).

Among the atheoretical measures of demand, these included a stated (i.e., "empirical") Q_0 (defined as the number of drinks the participant reported willing to take and consume at no cost associated with the drink [$0.00 or free]), breakpoint$_0$ (BP_0; defined as the first price that fully suppresses consumption [participant reports purchasing and consuming 0 drinks]), and breakpoint$_1$ (BP_1; defined as the highest price maintaining any amount of consumption). For participants who showed no consumption at any price, we entered the following values: $BP_1 = 0$ and $BP_0 = .01$ (an arbitrarily low price). This occurred for three, one, and two participants in the 1-, 5-, and 9-hr conditions, respectively (three unique participants). Likewise, for participants whose consumption never reached 0, we entered the following values: $BP_1 = 20$ (the highest price assessed) and $BP_0 = 25$ (what would have been the next price given the progression of values). This occurred for 35, 54, and 65 participants in the 1-, 5-, and 9-hr conditions, respectively (69 unique participants). We limited our analyses to these measures because they are atheoretical and because of the documented complications of model fitting at the individual level (Koffarnus, Franck, Stein, & Bickel, 2015; Liao et al., 2013; Yu, Liu, Collins, Vincent, & Epstein, 2014). Finally, we compared participants' values of stated Q_0, BP_0, and BP_1 across the three APT conditions using a series of repeated-measures analysis of variance (ANOVA). Given the relatively large sample size, we specified a parametric ANOVA with the Geisser-Greenhouse correction (i.e., we did not assume sphericity) and Bonferroni correction for multiple comparisons.

To derive group-level measures of demand, we first averaged participant responses at each price. We subsequently normalized these mean, group-level responses and prices (within condition) using the following equation[2] (Hursh & Winger, 1995):

$$q = \frac{d}{dB} \cdot 100, \tag{1}$$

where q equals the "normalized dose" (simply to normalize consumption and price out of 100), d is the dose per reinforcer (in this case, one drink), and B is consumption at the lowest price ($0.00

[1] Although Murphy et al. (2013) report 17 prices assessed, only 16 prices are realized if individual prices are determined by following their instructions describing the price sequence, "ranging from $0 (free) to $3.00 increasing by 50-cent increments, $3.00–$10.00 increasing by $1.00 increments, and $10.00–$20.00 increasing by $5.00 increments" (p. 131).

[2] We normalized group-level responses and prices prior to fitting using Equation 2, as cost is normalized with respect to baseline levels of consumption in the exponent of Equation 2 (i.e., $Q_0 * P$). This was conducted as to more easily visualize differences in decreases in consumption as a function of *the closed economy duration* as opposed to *baseline levels of consumption*. We note that fitting Equation 2 to either the normalized or non-normalized data result in identical parameter estimates, so long as the appropriate constraints (i.e., k, Q_0) are maintained.

or free). Because d cancels, q simplifies to $q = 100/B$. We calculated normalized price (P) as $P = C/q$, where C is the cost per drink and normalized consumption (Q) as $Q = Rq$, where R is the mean number of drinks reportedly purchased and consumed at each price. The resulting normalized cost and consumption values were fit using the exponential demand equation (Hursh & Silberberg, 2008):

$$log_{10}Q = log_{10}Q_0 + k(e^{-\alpha \cdot Q_0 \cdot P} - 1), \quad (2)$$

where Q is normalized consumption at each normalized price, P, and Q_0 representing normalized consumption at no cost (i.e., P = free). The parameter k specifies the range of Q in logarithmic units, and α describes the rate of change in elasticity across the entire demand curve. We chose to constrain k to a value of 2 given that the range of normalized consumption could span from 1 to 100. We also chose to constrain Q_0 to 100 given that we normalized consumption (and price) out of that value (Q = 100 at no cost in Equation 1) and subsequently omitted that datum (i.e., consumption in which price equals $0.00) during the curve-fitting process.[3] Therefore, changes in elasticity were isolated to the α parameter in the nonlinear estimation process. Demand analyses were conducted using a freely available GraphPad Prism template provided by the Institutes for Behavior Resources (http://www.ibrinc.org/index.php?id=181; note that this GraphPad Prism solution uses standard nonlinear regression to minimize the sum of squares via the Marquardt method; Marquardt, 1963). We used GraphPad Prism 7.0a to conduct the simple ANOVAs, whereas mixed-effects models were conducted using the lme4 (Bates, Mächler, Bolker, & Walker, 2015) package in the R statistical software (Version 3.3.2; R Core Team, 2016). For all analyses, we set the significance level at $\alpha = .05$ (except for multiple comparisons following ANOVA; Bonferroni adjusted $\alpha = .0167$).

Results

Table 1 displays demographic and alcohol-related characteristics of the 179 participants. Compared with females, males, on average, tended to report more binge episodes during the past month ($range_{males}$ = 0–30; $range_{females}$ = 0–30), more drinks per week ($range_{males}$ = 0–100; $range_{females}$ = 0–38), more drinking days ($range_{males}$ = 0–7; $range_{females}$ = 0–7), and more drinks per occasion ($range_{males}$ = 0–14; $range_{females}$ = 0–8). Figure 1 depicts the individual-specific measures of Q_0, BP_1, and BP_0 among the participants. Within each of the three measures, we observed parametric differences between the three different time frames. For the following analyses, we report global comparisons for all participants (regardless of sex), while noting that, for each case, follow-up (pairwise) comparisons between duration conditions yielded statistically significant differences below the Bonferroni-adjusted significance level (i.e., $\alpha = .0167$). Mean values of Q_0 were 3.11 (SD = 2.61), 6.92 (SD = 3.98), and 9.17 (SD = 6.56) drinks for the 1-, 5-, and 9-hr conditions, respectively. Comparisons between the time frames yielded statistically significant differences in Q_0, $F(1.332, 237.1) = 166.7$, $p < .05$, $\varepsilon = 0.66$. Mean values for BP_1 for the 1-, 5-, and 9-hr conditions were 8.94 (SD = 6.50), 10.90 (SD = 6.83), and 11.83 (SD = 7.04), respectively. These differences were statistically significant, $F(1.581, 281.3) = 51.8$, $p < 0.05$, $\varepsilon = 0.79$, as well. Finally, comparisons of BP_0 across the 1- (M = 11.38; SD = 8.31), 5- (M = 13.94; SD = 8.65), and 9-hr (M = 15.10; SD = 8.86) conditions resulted in statistically significantly differences, $F(1.566, 278.7) = 55.0$, $p < 0.05$, $\varepsilon = 0.78$. Analyses within each sex were consistent with the overall findings. Collectively, these results indicate that longer durations of drink availability resulted in elevated levels of Q_0. Figure 2 depicts both non-normalized and normalized demand curves across the three conditions. Equation 2 provided an excellent fit of the data for the 1- ($RMSE$ [root-mean-square error] = 0.034, R^2 = .988), 5- ($RMSE$ = 0.033, R^2 = .991), and 9-hr ($RMSE$ = 0.038, R^2 = .985) conditions. Whereas the shortest (1 hr) time frame condition resulted in the highest α (; 0.012; SE [standard error] = 0.00028; 95% CI [confidence interval; 0.012, 0.013]), the longest (9 hr) time frame resulted in the lowest α (0.0040; SE = 0.00010; 95% CI [0.0038, 0.0043]). The standard time frame initially used in the Murphy et al. (2013) study (5 hr) resulted in $\alpha = .0062$ (SE = 0.00013; 95% CI [0.0060, 0.0065]). Table 2 provides a descriptive summary of demand indices per condition split by sex.

We used the extra sum-of-squares F test to examine whether α differed among the conditions (using all participants). Results indicated that α is statistically significantly different across the three curves, $F(2, 42) = 468.16$, $p < 0.05$. Subsequent extra sum-of-squares F tests revealed statistically significant differences in α between the 1- and 5-hr conditions, $F(1, 28) = 434.19$, $p < 0.05$, 1- and 9-hr conditions, $F(1, 28) = 875.74$, $p < 0.05$, and 5- and 9-hr conditions, $F(1, 28) = 174.77$, $p < 0.05$. Findings within each sex were consistent with the overall findings.

As an exploratory analysis, we examined the presence of sex differences and order effects. We conducted three linear mixed-effects regressions predicting Q_0, BP_1, and BP_0 (see Table 3) using restricted maximum likelihood estimation (Pinheiro & Bates, 2006). Results confirmed the findings of the simple repeated measures ANOVA for all three demand indices, indicating statistically significant main effects of hypothetical duration. Participants' number of drinks per occasion was statistically significantly positively associated with the three outcome variables, with greater numbers of drinks per drinking occasion associated with higher Q_0, BP_1, and BP_0 values. Although the model did not reveal any main effects of sex, the model indicated that, compared with males, females reported fewer drinks when drinks were free in the 9-hr condition.

Discussion

The current study evaluated the effects of different hypothetical durations of the closed economy (i.e., the amount of time at the party), as specified in the instructions of the APT, on measures of demand (i.e., Q_0, α, breakpoint). We originally theorized that different durations would result in different levels of Q_0, but not to changes in α if the assumptions in the APT were to reflect a pure closed economy. Otherwise, both indices may change if there is some implicit assumption of substitutes. Both individual- and group-level measures of demand were systematically related to duration of the closed economy. At the individual level, duration was positively related to levels of Q_0 and breakpoint. Group-level

[3] Although we could have normalized consumption and price to be out of 1 (a proportion) instead of 100, this would have merely changed the magnitude of α, but not the interpretations.

Table 1
Participant Characteristics

Variable	Overall (N = 179)	Males (n = 94)	Females (n = 85)
Age	M = 37.53 (SD = 12.69)	M = 35.85 (SD = 12.35)	M = 39.39 (SD = 12.86)
Race			
White/Caucasian	147 (82%)	78 (83%)	69 (83%)
African American	13 (7%)	5 (5%)	8 (9%)
Hispanic	8 (4%)	7 (7%)	1 (1%)
Other	11 (6%)	4 (4%)	7 (8%)
Relationship status			
Married	70 (39%)	31 (33%)	39 (46%)
Single	52 (29%)	40 (43%)	12 (14%)
Not married, in relationship	21 (12%)	10 (11%)	11 (13%)
Divorced	10 (6%)	3 (3%)	7 (8%)
Other	26 (15%)	10 (11%)	16 (19%)
Income			
<$20,000	32 (18%)	14 (15%)	18 (21%)
$20,000–$29,999	26 (15%)	14 (15%)	12 (14%)
$30,000–$39,999	19 (11%)	12 (13%)	7 (8%)
$40,000–$49,999	22 (12%)	7 (7%)	15 (18%)
$50,000–$74,999	44 (25%)	26 (28%)	18 (21%)
$75,000–$99,999	11 (6%)	6 (6%)	5 (6%)
≥$100,000	16 (9%)	9 (10%)	7 (8%)
Rather not say	9 (5%)	6 (6%)	3 (4%)
Binge episodes during past month	M = 2.64 (SD = 5.48)	M = 3.30 (SD = 6.21)	M = 1.92 (SD = 4.46)
Drinks per typical week during past month	M = 9.34 (SD = 12.93)	M = 12.06 (SD = 15.91)	M = 6.26 (SD = 7.62)
Days drinking per typical week during past month	M = 2.77 (SD = 2.15)	M = 2.92 (SD = 2.16)	M = 2.60 (SD = 2.16)
Drinks per occasion	M = 2.70 (SD = 2.52)	M = 3.36 (SD = 2.94)	M = 1.94 (SD = 1.66)

Note. A binge episode was defined as having 4+ or 5+ drinks in a single occasion for females and males, respectively.

values of α also differed systematically with duration. As duration increased, values of α tended to decrease suggesting relatively greater demand.

The values of Q_0 and breakpoint that our sample reported in the 5-hr condition differ from those reported by Murphy et al. (2013), whose participants displayed a mean Q_0 of 9.93 (SD = 5.98), whereas our participants displayed a mean Q_0 of 6.92 (SD = 3.98). Interestingly, Q_0 in the 9-hr condition (M = 9.17, SD = 6.56) was more comparable with their participants' values. Murphy and colleagues' participants had a mean BP_0 of 9.05 (SD = 5.40), whereas our participants had a mean BP_0 of 13.94 (SD = 8.65) in the 5-hr condition. Equation 2 provided excellent fits for both Murphy et al.'s data (R^2 = .98) and our overall data ($R^2 \geq$ .98). Direct comparisons should be taken with caution, as their participant sample was comprised of 133 undergraduate students who reported one or more heavy drinking episodes (5 or 4 drinks on one occasion for men and women, respectively) during the past month, and ours was from a general sample from Amazon Mechanical Turk. In addition, approximately 80% of our sample identified as White/Caucasian, whereas only 64% of their sample identified as European American. One quarter of our sample reported earning an annual income between $50,000 and $74,999, and although Murphy et al. do not report their participants' income, if differences exist, this could contribute to the higher breakpoint values observed in the current study.

Recall that basic research suggests economy types modulate both demand intensity and elasticity when substitutes are presented concurrently with a target commodity, but only elasticity when substitutes are available outside of the experimental session (Hursh, 2014). Advances in the APT have included more explicit instructions and assumptions to control participants' subjective perceptions of the alcohol purchase scenario (e.g., MacKillop et al., 2010; Murphy et al., 2009, 2013). In doing so, phrases such as "Assume that you did not drink alcohol before you are making these decisions, and will not have an opportunity to drink elsewhere after making these decisions" seemingly close the economy to isolate alcohol demand in the absence of competing substitutes. Given the commonly used language in the APT indicating no other alcohol is available for purchase outside those in the APT, we viewed the APT as a single-operant measure of alcohol demand. Our analyses found that *both* Q_0 and α were sensitive to duration manipulations, suggesting the possibility that the APT scenario performed similarly to an open economy operant demand assay; thus, despite enhanced controls in instructions (recall that we also included attending questions concerning the relevant control language in our task), our data suggest that participants' responding may have been sensitive to some perceived substitute availability.

The reasons why α values differed across durations could be due to the implicit availability of substitutes (i.e., commodities that may, to some degree or another, serve similar functions) and/or complements (i.e., commodities, when combined together, increase the value greater than when either are in isolation). Given the literature on social reinforcers associated with drinking (Brown, Goldman, Inn, & Anderson, 1980; Fromme & Dunn, 1992; Kuntsche, Knibbe, Gmel, & Engels, 2005), it might be expected that the programmed social context in the APT instructions (i.e., "Imagine that you and your friends are at a party on a weekend night . . . to see a band") might contain imperfect substitutes for drinking or, perhaps, even complementary reinforcers that would yield demand inconsistent with completely closed economies. For example, as duration increases, there may be more complementary reinforcers implicitly available to the participant, such as interacting with more novel party-goers, playing

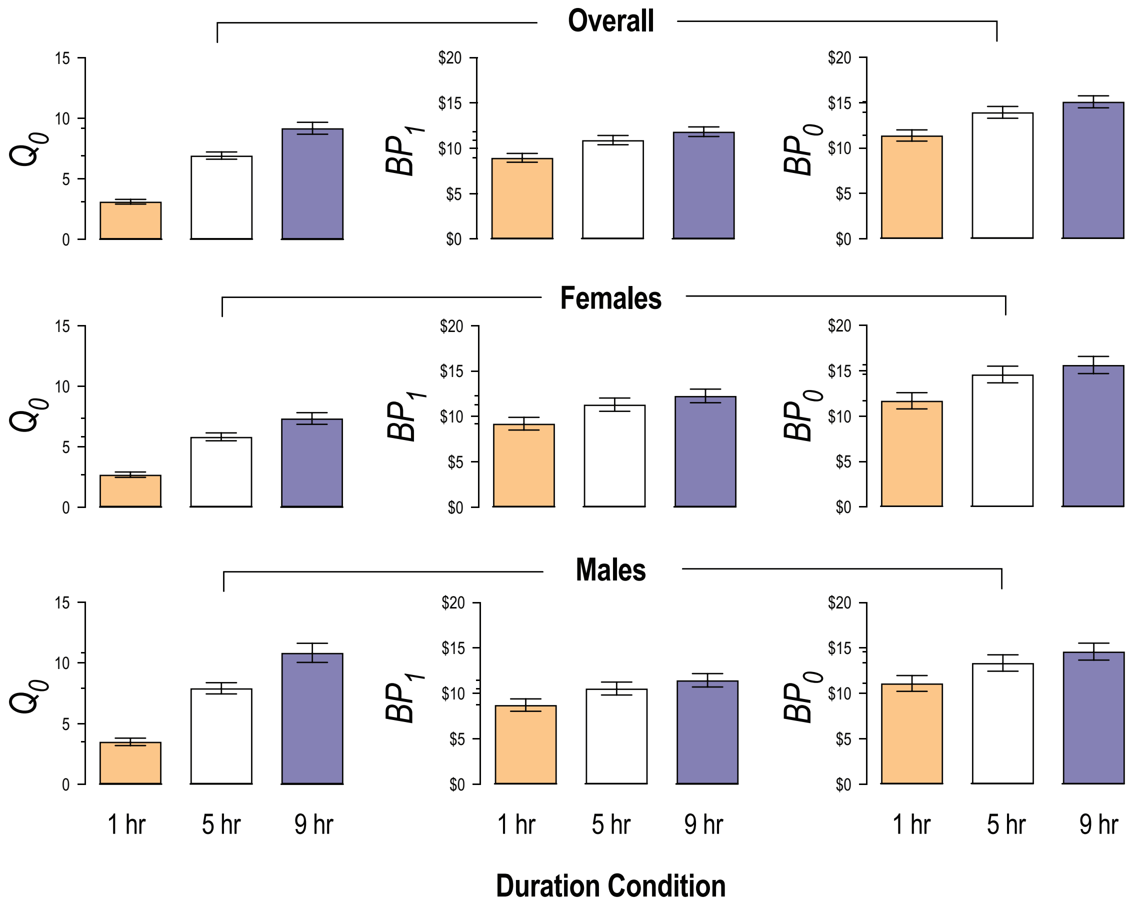

Figure 1. Individual-specific measures of Q_0 (left panel), BP_1 (middle panel), and BP_0 (right panel) across the three different conditions for all participants (top panel), females only (middle panel), and males only (bottom panel). Within each measure, global and pairwise (Bonferroni corrected) differences between the groups are statistically significant at the $p < 0.0167$ level. See the online article for the color version of this figure.

more "drinking games" (e.g., beer pong, flip cup), or experiencing the full performance from a band or other entertainment act. On the other hand, stating a shorter duration (e.g., 1 hr) might lead the participant to imagine the availability of imperfect substitutes to alcohol outside of the closed economy. Examples might include getting food with friends, attending another party, going home to spend time with a significant other, and other activities. Although participants were instructed to assume they would not drink or use drugs after leaving the party, the instructions did not specify any other engagements after leaving the party. Thus, in the APT's effort to control alcohol substitutes within the vignette, the real-world nature of the scenario—which enhances participants' ability to consider their own drinking histories—likely contains a number of confounding reinforcers that open the economy in unpredicted ways. Future research should seek to compare APT vignettes wherein the respondent is alone or with friends in the scenario. It is possible that individuals with alcohol use problems, whose drinking may be driven more so by coping motives, may show demand that is more consistent across social and nonsocial contexts compared with drinkers with lower levels of problems and more social drinking motives.

Another explanation for the finding that demand increased as drinking duration period increased is that demand is driven as much by a desire to achieve a certain level of intoxication as by a desire to obtain a specific number of drinks. Whereas two to three drinks would produce moderate or high degree of subjective intoxication during a 1-hr drinking episode, the number of drinks required to obtain a similar level of intoxication is much greater during a 5- or 9-hr episode, given the role of drinking episode duration in influencing blood alcohol content (Julien, 2013).

A potential limitation in the current methodology is the order in which participants completed the three APT versions; similar to other studies comparing within-subject performance on the APT (Amlung et al., 2012; Skidmore & Murphy, 2011), participants received a fixed order of APT presentations, wherein all participants first answered the standard 5-hr version, followed by the 1- and 9-hr versions (the order of the latter two counterbalanced across participants). We intentionally presented the 5-hr version first as it has the most psychometric validation (see review in MacKillop, 2016). In addition, the results of our mixed-effects model did not indicate the presence of statistically significant order effects. As is the case with many studies utilizing the APT, we did not directly measure drinking behavior. However, one of the reasons why we chose to use the APT is because of previous research that has shown good correspondence between responses on the task and actual laboratory alcohol administration (Amlung et al., 2012).

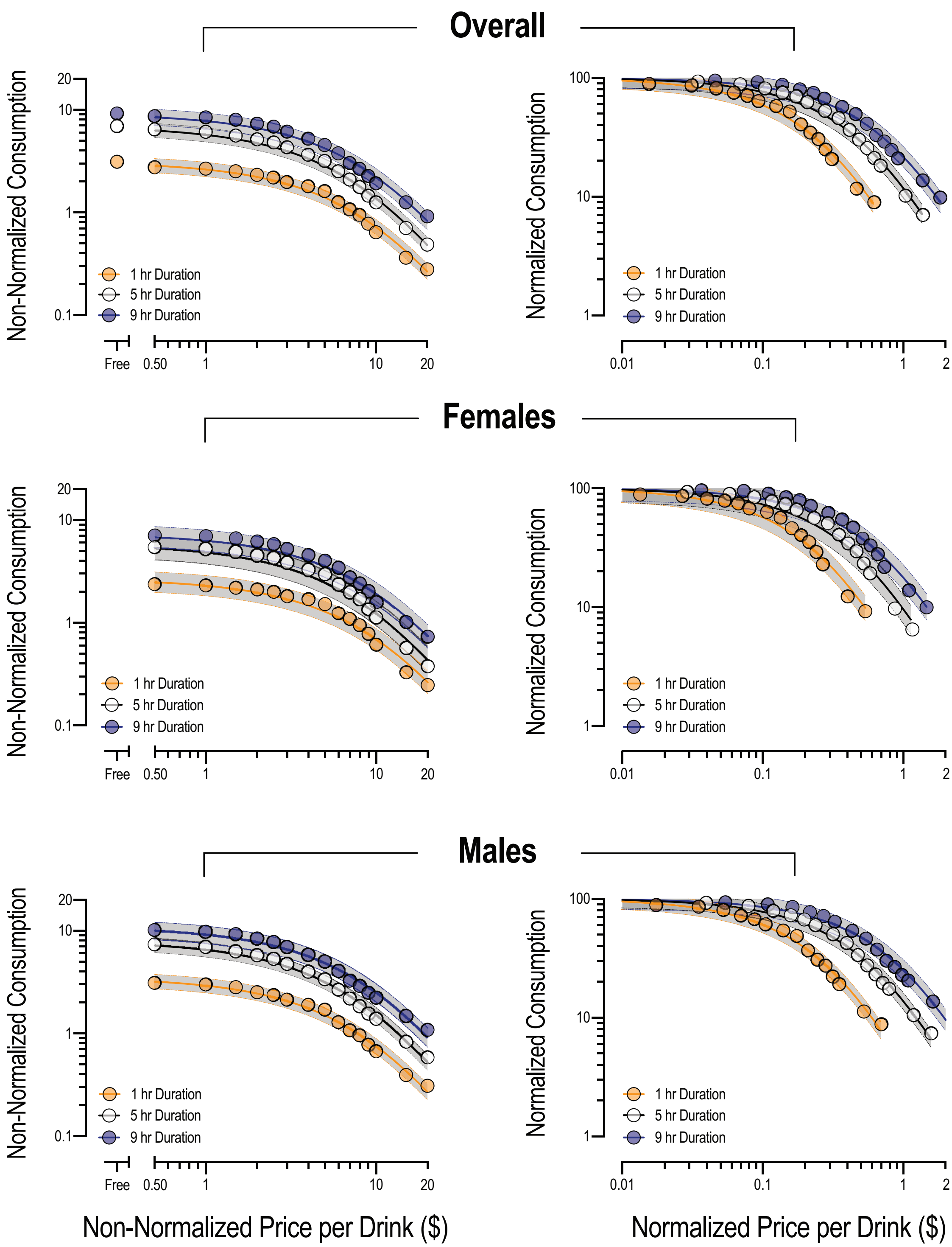

Figure 2. Non-normalized (left panel) and normalized (right panel) demand curves across the three conditions for all participants (top panel), females only (middle panel), and males only (bottom panel). Data points for each of the three hypothetical duration conditions are indicated in the legends. Shaded bands indicate 95% prediction intervals. See the online article for the color version of this figure.

In addition to the aforementioned limitations, we discuss several strengths of the current study. First, unlike the studies by Gentile et al. (2012) and Gilbert et al. (2014), we crowdsourced our participant sample via Amazon Mechanical Turk. Our sample demographic was similar to previous academic studies utilizing Amazon Mechanical Turk (Buhrmester, Kwang, & Gosling, 2011; Mason & Suri, 2012),

Table 2
Descriptive Statistics of Demand Indices (Mean [Standard Deviation])

Variable by condition	Overall (N = 179)	Males (n = 94)	Females (n = 85)
Q_0			
1 hr	3.11 (2.61)	3.50 (2.97)	2.68 (2.07)
5 hr	6.92 (3.98)	7.92 (4.46)	5.81 (3.03)
9 hr	9.17 (6.56)	10.84 (7.65)	7.33 (4.48)
BP_1			
1 hr	8.95 (6.50)	8.72 (6.59)	9.20 (6.44)
5 hr	10.90 (6.83)	10.53 (6.92)	11.30 (6.76)
9 hr	11.83 (7.04)	11.44 (7.15)	12.26 (6.93)
BP_0			
1 hr	11.39 (8.31)	11.10 (8.41)	11.71 (8.24)
5 hr	13.94 (8.65)	13.35 (8.78)	14.60 (8.51)
9 hr	15.10 (8.86)	14.60 (9.00)	15.65 (8.73)
α			
1 hr	.012 (SE = .00028)	.012 (SE = .00025)	.013 (SE = .00043)
	$RMSE$ = 0.034; R^2 = .988	$RMSE$ = 0.033; R^2 = .990	$RMSE$ = 0.046; R^2 = .978
5 hr	.0062 (SE = .00013)	.0056 (SE = .00011)	.0071 (SE = .00024)
	$RMSE$ = 0.033, R^2 = .991	$RMSE$ = 0.032; R^2 = .991	$RMSE$ = 0.053; R^2 = .978
9 hr	.0040 (SE = .00010)	.0036 (SE = .00009)	.0047 (SE = .00016)
	$RMSE$ = 0.038, R^2 = .985	$RMSE$ = 0.040; R^2 = .984	$RMSE$ = 0.048; R^2 = .976

and therefore was more representative of the general population compared with undergraduate samples. Second, we embedded attending questions at the end of each vignette, and participants were required to correctly answer these questions before proceeding. We believe including this procedural aspect increased the likelihood that participants attended to the relevant stimuli (i.e., the amount of time at the party).

The results of the current study provide implications for conducting research with HPTs. Researchers should provide specific and detailed instructions and assumptions at the beginning of the task. For example, a given participant's responses might appear very different if no time frame is specified. Such findings might be inaccurately attributed to some other aspect of the study. Importantly, many purchase task studies do not specify a consumption period, and it is possible that this introduces a source of error, as participants might have difficulty generating an accurate purchase estimate in the absence of a defined time frame (MacKillop et al., 2010). More generally, the results provide further support for the utility of the APT as a tool for examining the myriad contextual influences on drinking ranging from drink price, to next-day responsibilities, to drinking duration and potentially other influences (e.g., the presence or peers, drinking location, mood state, competing alternative activities).

The results of the current study may also have implications for alcohol misuse prevention efforts. For example, although most previous APT research has examined 5-hr drinking episodes (which might resemble a typical evening drinking episode for young adults), the 1-hr duration APT could be a useful way to model expected drinking during a "pregaming" drinking episode, and the 9-hr episode might resemble drinking at an all-day party or sporting event (Yurasek et al., 2016). It is possible that there are individual differences in risk for heavy drinking/intoxication

Table 3
Random Intercept Linear Mixed-Effects Models (REML)

	Q_0		BP_1		BP_0	
Fixed effects	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	4.822***	(.620)	7.685***	(1.127)	9.855***	(1.432)
1 hr	−4.415***	(.454)	−1.814***	(.400)	−2.250***	(.501)
9 hr	2.926***	(.454)	.910*	(.400)	1.255*	(.501)
Sex	−.879	(.629)	1.615	(1.039)	2.307	(1.319)
Order	.486	(.485)	1.803	(.953)	2.143	(1.212)
Drinks per occasion	.826***	(.099)	.518**	(.195)	.647**	(.248)
1 hr × Sex	1.285	(.658)	−.292	(.581)	−.644	(.726)
9 hr × Sex	−1.408*	(.658)	.049	(.581)	−.208	(.726)
N	537		537		537	
$RMSE$	3.11		2.74		3.43	
Random effects (σ)						
Participant	2.64		6.08		7.73	
Residual	3.11		2.74		3.43	

Note. Sex was dummy coded (0 = Male, 1 = Female). Order was dummy coded (0 = 1 hr → 9 hr, 1 = 9 hr → 1 hr). Significance levels: * $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

across those contexts, with some drinkers being more at risk for significant intoxication in shorter versus longer duration drinking episodes (pregaming) and other drinkers having a more difficult time managing drinking over longer periods. Similarly, some drinkers might be at higher risk for extreme intoxication and associated health/social consequences because their demand is less sensitive to variability in drinking duration, resulting in similar consumption across shorter and longer drinking episodes. Demand curves could be used in this manner to efficiently tailor brief intervention efforts to an individual's specific risk tendencies.

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(*Appendix follows*)

Appendix

Select Variations in Hypothetical/Alcohol Purchase Task Instructions

Instruction set of the seminal hypothetical purchase task by Jacobs and Bickel (1999, p. 415):

> In the questionnaires which follow we would like you to pretend to purchase heroin and cigarettes as you would have before entering treatment. Please answer the questions honestly and thoughtfully. The goods you may buy and their prices are listed on the following sheets. You may buy as much or as little as you'd like, and there are no consequences to your using the heroin. So, assume this is a study that has been approved by the police and all other organizations. Also, assume that you are NOT in treatment; you are not receiving buprenorphine, naltrexone, or antabuse. In other words, the only drugs you will receive are those you purchase here. Also, assume that you have no other drugs available to you. You cannot purchase more drugs or cigarettes, or any other drugs or tobacco products except those you choose below. Therefore, assume you have no other drugs or cigarettes stashed away, you have no prescriptions for anything, and you cannot get drugs or cigarettes through any other source, other than those you buy here. Also, assume that the heroin and cigarettes you are about to purchase are for your consumption only. In other words, you cannot sell them or give them to anyone else. You also cannot save up any heroin or cigarettes you buy and use them another day. Everything you buy is, therefore, for your own personal consumption within a 24-hr period.

Instruction set of the seminal alcohol purchase task by Murphy and MacKillop (2006, p. 222):

> Imagine that you and your friends are at a bar from 9 p.m. to 2 a.m. to see a band. The following questions ask how many drinks you would purchase at various prices. The available drinks are standard size beer (12 oz), wine (5 oz), shots of hard liquor (1.5 oz), or mixed drinks with one shot of liquor. Assume that you did not drink alcohol before you went to the bar and will not go out after.

Instruction set of Murphy et al. (2009), adapted from the original Murphy and MacKillop instructions (differences in bold; p. 398):

> **In the questionnaire that follows we would like you to pretend to purchase and consume alcohol.** Imagine that you and your friends are at a **party on a weekend night** from 9:00 p.m. until 2:00 a.m. to see a band. The following questions ask how many drinks you would purchase at various prices. The available drinks are standard size **domestic** beers (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks containing one shot of liquor. Assume that you did not drink alcohol **or use drugs** before you went to the **party**, and **that you will not drink or use drugs after leaving the party. You cannot bring your own alcohol or drugs to the party.**
>
> **Also, assume that the alcohol you are about to purchase is for your consumption only. In other words, you cannot sell the drinks or give them to anyone else. You also cannot bring the drinks home. Everything you buy is, therefore, for your own personal use within the 5 hour period that you are at the party. Please respond to these questions honestly, as if you were actually in this situation.**

Instruction set of MacKillop et al. (2010; differences in bold; p. 109):

> Please respond to these questions honestly, as if you were actually in this situation. Imagine that you **are drinking in a TYPICAL SITUATION when you drink.** The following questions ask how many drinks you would **consume if they cost various amounts of money**. The available drinks are standard size **domestic** beer (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks containing one shot of liquor. Assume that you did not drink alcohol before you **are making these decisions, and will not have an opportunity to drink elsewhere after making these decisions. In addition, assume that you would consume every drink you request; that is, you cannot stockpile drinks for a later date or bring drinks home with you.**

Instruction set of Murphy et al. (2013, p. 131):

> In the questionnaire that follows we would like you to pretend to purchase and consume alcohol.

Imagine that you and your friends are at a **party on a weekend night** from 9:00 p.m. until 2:00 a.m. to see a band. **Imagine that you do not have any obligations the next day (i.e., no work or classes).** The following questions ask how many drinks you would purchase at various prices. The available drinks are standard size **domestic** beers (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks containing one shot of liquor. Assume that you did not drink alcohol **or use drugs** before you went to the **party**, and **that you will not drink or use drugs after leaving the party. You cannot bring your own alcohol or drugs to the party. Also, assume that the alcohol you are about to purchase is for your consumption only. In other words, you cannot sell the drinks or give them to anyone else. You also cannot bring the drinks home. Everything you buy is, therefore, for your own personal use within the 5 hour period that you are at the party. Please respond to these questions honestly, as if you were actually in this situation.**

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