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Understanding alcohol motivation using the alcohol purchase task: A methodological systematic review

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A R T I C L E I N F O

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A B S T R A C T

Background: The Alcohol Purchase Task (APT) is a behavioral economic assessment of alcohol demand (i.e., motivation for consumption during escalating levels of response cost) using simulated marketplace survey techniques. While the APT is often used and widely cited, to date, there has yet to be a systematic review elucidating the variability in administering and analyzing the APT. The purpose of the current paper is to address this knowledge gap in the literature by cataloging the various purchase task methodologies and providing recommendations and future areas of inquiry.

Methods: The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was utilized (Prospero: No. CRD42017072159). Searches through Google Scholar, PsychINFO, PubMed, and SpringerLink databases identified 47 empirical articles referencing the use of an APT and published through the year 2016. Articles were coded for demographic and procedural characteristics, structural characteristics of the APT itself, and characteristics of data analysis.

Results: Results indicate substantial variation within categories and suggest that there is no standard approach to administering the APT or analyzing the responses generated from it. The results underscore the need for researchers to report as much information as possible related to administration, instructions, price structuring, and analytical approach, as we found that many articles did not provide these details.

Conclusion: Enhancing the transparency of APT methods and analyses in published reports will aid in reproducibility as well as future meta-analytic studies of alcohol demand that could lead to the development of best-practice recommendations for this procedure.

1. Introduction

Behavioral economics is a framework that integratesconcepts from economics and operant psychology to understand seemingly irrational decision making (e.g., substance abuse, risky sexual behavior; Bickel and Vuchinich, 2000). The behavioral economic methodology encompasses several constructs that have proved especially useful in understanding alcohol use disorder (AUD; MacKillop, 2016). Among the most frequently used constructs are delay discounting, proportionate alcohol-related reinforcement, alcohol-savings discretionary expenditure, and demand. Delay discounting is characterized by relative valuation towards more immediate outcomes over delayed outcomes (Ainslie, 1975; Madden and Bickel, 2010). During the past decade, research has shown that individuals with AUD tend to discount future outcomes to a greater extent than controls (e.g., Mitchell et al., 2005; Petry, 2001). The second construct, proportionate alcohol-related reinforcement, quantifies time and enjoyment associated with alcohol use relative to alcohol-free time and enjoyment (Morris et al., 2017; Murphy et al., 2005). With conceptual ties to the matching law (Herrnstein, 1961, 1970) and firmly rooted within the behavioral economic framework, measures of proportionate alcohol-related reinforcement have shown strong relations with AUD (Correia et al., 2003, 1998; Murphy et al., 2005). The third construct closely related to both delay discounting and proportionate alcohol-related reinforcement is the Alcohol-Savings Discretionary Expenditure (ASDE) index (e.g., Tucker et al., 2016a), which, instead of measuring participation

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and enjoyment, measures the allocation of discretionary spending patterns towards alcoholic beverages relative to spending patterns towards savings for the future. Thus, relative allocation may closely map onto a tradeoff between immediate (i.e., alcohol) and delayed (i.e., savings) rewards. Larger ASDE values indicate relatively greater alcohol valuation and these ASDE values have been shown to display incremental utility in predicting abstinence and relapse related outcomes (Tucker et al., 2009). The final construct is demand, which quantifies motivation towards obtaining some good (Hursh, 1980; Hursh and Silberberg, 2008; Reed et al., 2015, 2013). The *demand curve*, which quantifies changes in purchasing/consumption of a good as a function of changes in the price of that good, is thought to be reflective of reinforcer strength (Bickel et al., 2000; Hursh, 1984) or an organism's motivation to access the good. Put simply, demand curves and related analyses provide insights into the degree of resource allocation (effort, money) an organism will devote in order to obtain a commodity when costs associated with that commodity escalate.

Much headway has been made within the human operant approach to quantifying demand for reinforcers, especially within the drug self-administration literature (e.g., Bickel et al., 1991; Bickel and Madden, 1999; Higgins and Hughes, 2013; Spiga et al., 2005). In these human operant approaches, participants respond on manipulanda to earn access to the reinforcer (e.g., cigarette puffs, cocaine). Although there is little doubt that experiential drug self-administration studies have substantially advanced the field's understanding of the drug-behavior relationship, there are practical and ethical limitations associated with these paradigms. For example, it would not be feasible or ethical to have individuals who are underage or currently in treatment for AUD to complete an alcohol self-administration protocol, and social drinkers cannot ethically consume large quantities of alcohol they might consume in the natural environment when they are in a laboratory setting. Additionally, self-administration paradigms are time intensive, often requiring specialized equipment and safety training.

To address some of these limitations, Griffiths et al. (1993) were among the first to develop a time-efficient method for assessing the relative reinforcing efficacy of drugs. In this *multiple-choice procedure*, participants are first exposed to different drugs (blinded) and after exposure choose between concurrently available pairs of the experienced drugs and between a unit of drug and an alternative monetary reinforcer. On each choice trial, participants indicate if they would prefer the drug or a variable amount of money. After completing the multiple-choice procedure, one randomly selected choice is provided during a reinforcement session. Although time-efficient, this approach has two primary limitations. First, the task requires multiple sessions for both exposure to and reinforcement of the drug. Second, the task is limited to simple dichotomous choices; it is not possible to obtain volumetric measures either of the drug itself or the total amount willing to be expended to obtain the drug. In other words, the multiple-choice procedure characterizes the breakpoint from an operant paradigm, but does not measure other indices of relative reinforcing efficacy.

Recently, efforts have been made to translate the behavioral economic demand approach to a framework that avoids the ethical and practical constraints of drug self-administration. The Hypothetical Purchase Task (Jacobs and Bickel, 1999; Murphy and MacKillop, 2006; Roma et al., 2017) adapts the behavioral economic demand methodology into a self-report measure. Before discussing this measure, we briefly describe the historical relation of behavioral economic demand to traditional concepts of relative reinforcing efficacy and the core aspects of the demand curve.

1.1. Relative reinforcing efficacy

In the late 1970′s, Griffiths et al. (1979) proposed relative reinforcing efficacy (RRE), a theoretically homogeneous concept that integrated previous measures of reinforcer value (e.g., response rate, relative response rate, progressive-ratio breakpoint). Griffiths et al. stipulated that RRE should refer to the "…behavior-maintenance potency of a dose of a drug…" (pg. 192) in which there is convergence across multiple outcome measures. For example, a drug that maintains a higher response rate compared to another drug should also maintain a higher progressive-ratio breakpoint (i.e., the point at which no amount of the drug is earned). The concept of RRE provides a seemingly face-valid measure of reinforcer value, that different measures of value converge into one higher-order construct. However, inconsistencies between these measures compromised the internal validity of the RRE construct. For example, Bickel and Madden (1999) compared the RRE of money versus cigarettes and found that whereas progressive-ratio breakpoints were consistently higher for cigarettes (as compared to money), preference between the two goods switched as response requirements increased and peak response rate varied across participants. To reconcile such inconsistencies between measures, behavioral scientists have found value in the concept of behavioral economic demand.

1.2. Demand curve

The concept of demand as an indicator of reinforcer strength is rooted in the behavioral economic framework. As alluded to earlier, one focus of the field of behavioral economics as it is applied to substance use and misuse is how environmental constraints affect consumption of reinforcers. Within this framework, demand is the amount of a reinforcer an organism consumes (or estimates consuming/purchasing) at a given price. The demand curve (see Fig. 1) is produced when a series of prices are assessed and the corresponding amounts of the commodity earned and consumed (or purchased) are plotted (Bickel et al., 2000). Such an analysis attempts to emphasize the "response-reinforcer" relation at the molar level (i.e., how the relation between costs and benefits dynamically changes across a spectrum of costs). Briefly returning to the notion of RRE, because the demand approach emphasizes evaluation across a range of prices and a number of different metrics arise from the demand curve analysis, the demand approach by definition stipulates that there is "…no single measure [that] can provide a definitive assessment of [RRE]" and "…suggest[s] that reinforcing efficacy is not a homogeneous phenomenon, but rather may be viewed as heterogeneous phenomena" (Bickel et al., 2000; p. 54). Importantly, we note that both RRE and demand indices can be thought of as conceptually related but quantitatively distinct. Recent research has begun to investigate the interrelationships between demand measures (Bidwell et al., 2012; MacKillop et al., 2009) and results of this work suggest these indices may reflect two underlying constructs:

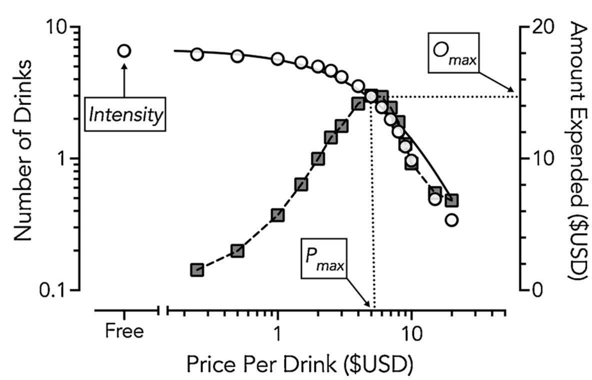

Fig. 1. Prototypical demand curve (circles; left y-axis) and expenditure curve (squares; right y-axis). Note the log-log axes of the demand curve. Intensity is the quantity of the good consumed (or purchased) at no price or very low price. P_{max} or unit-elasticity is the price where one relative unit change in price is equal to one relative unit change in consumption (or purchasing). O_{max} is the point of maximum expenditure. Elasticity (not labeled) is the sensitivity of consumption (or purchasing) to increases in price (e.g., the slope). Breakpoint (not depicted) is the first price at which no amount of the good is earned (or purchased).

amplitude and persistence. Here, we discuss each of the individual demand metrics and what they represent, as the APT articles published thus far have by and large restricted analyses to these indices.

A demand curve analysis yields several different key metrics, with each metric describing different facets of the response-reinforcer relation. *Elasticity* is the relative change in consumption of the good as a function of the relative change in the price of the good. Fig. 1 displays a prototypical demand curve (circle symbols), which is typically graphed (and, depending on the approach, quantified) in log-log coordinates to reflect elasticity (i.e., the slope of the tangent line). The portion of the demand curve when consumption is relatively insensitive to changes in price and elasticity is > -1 (i.e., more positive than -1) is referred to as inelastic demand. As consumption becomes sensitive to those increases in price (and elasticity is < -1; i.e., more negative than -1), the demand curve becomes elastic. Put simply, in the inelastic portion of the demand curve, a relative unit increase in price results in a less than one relative unit decrease in consumption, whereas in the elastic portion of the demand curve, a relative unit increase in price results in a greater than one relative unit decrease in consumption. The point of unit elasticity, where a one unit change in price is met with a one unit change in consumption, is termed P_{max}. Usually associated with P_{max} is O_{max}, or where the greatest amount of responding (i.e., peak work output, maximum expenditure) occurs; however, this is not always the case depending on the technique used to quantify P_{max}. Fig. 1 also displays a prototypical response output curve (square symbols; i.e., price times quantity of the good consumed; also referred to as an expenditure curve) where increases in price are associated with increasing amount of work output or expenditure, up to a point where thereafter total expenditure declines. Finally, demand *intensity* is the quantity of the good consumed at no price or at very low price and *breakpoint* is the first price at which no amount of the good is earned (or purchased).

These demand metrics are most commonly referred to as “observed” and “derived.” Observed measures include intensity of (or maximum) demand (i.e., participant’s actual reported consumption at free price), P_{max}, O_{max}, and breakpoint. These measures are computed directly from the participant’s responses or simple arithmetic conversions. Many of these measures may also be derived from the nonlinear regression line fitted to the data (e.g., Hursh and Roma, 2016; Kaplan and Reed, 2014; including a derived breakpoint; see Zhao et al., 2016). We note here and expand later on the point that correspondence between observed and derived measures tend to be good, but not perfect (Murphy et al., 2009).

1.3. Hypothetical and alcohol purchase tasks

Jacobs and Bickel (1999) conducted the initial study that demonstrated the validity of the behavioral economic purchase task. Seventeen opiate-dependent cigarette smokers completed three purchase tasks for heroin, cigarettes, and concurrently available heroin and cigarettes, wherein they self-reported the number of “bags” of heroin and cigarettes they would purchase at escalating prices. Demand analyses revealed drug specific sensitivity and orderly responding such that reported purchasing decreased with increasing prices. The traditional measure of breakpoint was highly correlated with values of P_{max}, O_{max}, and elasticity. Importantly, these results reflected the same general findings of Bickel and Madden (1999), who assessed demand within a human operant approach.

Seven years after the initial purchase task article publication, Murphy and MacKillop (2006) adapted the Hypothetical Purchase Task framework of Jacobs and Bickel (1999) to examine the relative reinforcing efficacy of alcohol among young adult drinkers. A sample of 267 undergraduate students completed several measures related to alcohol including the Daily Drinking Questionnaire (DDQ; Collins et al., 1985), the Rutgers Alcohol Problem Inventory (RAPI; White and Labouvie, 1989), and an Alcohol Purchase Task (APT). Murphy and MacKillop’s (2006) study was the first to examine clinical correlates of individual differences in demand; observed/derived intensity (Pearson’s *rs*: .27–.70) and observed/derived O_{max} (Pearson’s *rs*: .23–.45) statistically significantly correlated with all three self-reported drinking measures (i.e., number of drinks/week, number of heavy drinking episodes/week, RAPI). Breakpoint also statistically significantly correlated with number of drinks per week (Pearson $r = .21$) and number of heavy drinking episodes per week (Pearson $r = .24$). When classified as heavy versus light drinkers, individuals who reported a recent heavy drinking episode (> 5/4 drinks in an occasion for men/women) reported significantly higher breakpoint ($F_{1,\ 267} = 19.67$, $d = 0.596$), observed/derived intensity ($F_{1,\ 267} = 75.13$, $d = 1.167$; $F_{1,\ 267} = 32.34$, $d = 0.765$, respectively), and observed/derived O_{max} ($F_{1,\ 267} = 29.31$, $d = 0.729$; $F_{1,\ 267} = 31.13$, $d = 0.751$, respectively) than light drinkers. The results of Murphy and MacKillop provided initial evidence of the clinical utility of the APT. Since its initial development, a number of studies have evaluated the psychometric properties of the APT. Next, we briefly discuss some of the general findings.

1.4. Psychometric properties of the APT

1.4.1. Reliability

1.4.1.1. Temporal stability. Murphy et al. (2009) evaluated the test-retest reliability of the APT at two weeks. Of the 38 participants completing the initial APT, 17 were randomly selected to complete the same APT 14 days later. Between the two time points, individual-level consumption (i.e., number of drinks reported at each price) was highly correlated (Pearson *rs*: .71–.91) and *t*-tests revealed no statistically significant differences in mean levels of consumption. Comparisons of the behavioral economic demand indices across the two time points were also highly correlated, regardless of whether those measures were observed (Pearson *rs*: .67–.90) or derived (Pearson *rs*: .58–.84) and no significant differences were observed.

Acuff and Murphy’s (2017) findings were largely consistent with those of Murphy et al. showing moderate reliability at a 1-month follow-up among a sample of heavy drinking college students. Specifically, Acuff and Murphy found statistically significant differences in consumption values only at the $7.00 and $10.00 price points. Pearson *rs* indicated moderate reliability for observed measures intensity ($r = .69$), breakpoint ($r = .70$), and O_{max} ($r = .70$) but not P_{max} ($r = .30$). Derived measures (obtained from the exponentiated demand equation; Koffarnus, Franck, Stein and Bickel, 2015) also demonstrated moderate to good reliability: Q_0 (i.e., intensity; $r = .73$), P_{max} ($r = .67$), O_{max} ($r = .76$), and elasticity ($r = .71$). In terms of differences in demand indices, *t*-tests indicated breakpoint was the only observed measure to change significantly (decrease, $p = .03$), whereas derived P_{max} ($p = .04$) and derived O_{max} ($p = .03$) significantly changed (decrease). Importantly, among drinkers whose self-reported drinking remained stable over the one-month period, reported demand was also highly stable.

1.4.1.2. Internal reliability. To evaluate the internal consistency of the APT, Amlung and MacKillop (2012) recruited 91 regular drinking undergraduate participants to complete two versions of the APT that differed in the order of price presentation. In one version, price per drink increased in the typical ascending fashion, whereas the second version presented the same prices in a pseudo-randomized order. Overall, participants tended to respond consistently between the two versions (Pearson *rs*: .13–.89), although statistically significant differences were found at the $6, $9, $16, $18, and $25 price points (5/25 prices assessed). Although intensity ($r = .86$) and breakpoint ($r = .84$) were not statistically significantly different between the two versions, measures of observed O_{max} ($r = .79$), observed P_{max} ($r = .66$), and elasticity ($r = .84$) were significantly higher for the randomized APT. Importantly, whereas both versions demonstrated small proportions of reversals (consumption increased from a lower to a higher price), the randomized version displayed a statistically significantly higher proportion of reversals (M = 5.0%, SE = 0.6%) compared to the sequential version (M = 0.4%, SE = 0.2%), as might be expected.

1.4.2. Construct validity

1.4.2.1. Predictive validity. MacKillop and Murphy (2007) demonstrated the predictive validity of the APT by showing that elasticity (derived from Hursh et al., 1988; $\beta = .31$, $p \leq .05$) and observed measures of intensity ($\beta = .51$, $p \leq .0005$), breakpoint ($\beta = .33$, $p \leq .05$), O_{max} ($\beta = .49$, $p \leq .0005$) and P_{max} ($\beta = .25$, $p \leq .10$) all significantly and independently predicted the number of drinks per week consumed at six months following a brief alcohol intervention. After controlling for gender, baseline drinks per week, treatment condition, and reinforcement ratio, all measures except intensity ($\beta = .14$) incrementally predicted post-intervention drinks per week ($\beta = .22$ to .33, *ps* $\leq .05$). Heavy drinking ($\geq$ 5/4 drinks per occasion for men/women) post-intervention was also independently predicted by breakpoint ($\beta = .33$, $p \leq .05$), O_{max} ($\beta = .33$, $p \leq .05$), and elasticity ($\beta = .25$, $p \leq .10$), but not intensity ($\beta = .20$) or P_{max} ($\beta = .22$). Similarly, incremental analyses suggested breakpoint ($\beta = .33$, $p \leq .01$), O_{max} ($\beta = .27 p \leq .05$), P_{max} ($\beta = .21$, $p \leq .10$), and elasticity ($\beta = .24$, $p \leq .10$) predicted frequency of heavy drinking beyond the covariates (intensity did not; $\beta = .12$).

In addition, Murphy et al. (2015) evaluated three different brief alcohol interventions among 133 heavy drinking college students. Results indicated baseline intensity significantly predicted quantity of drinks consumed per week at a 1-month follow-up ($\beta = .298$, $p = .007$) and alcohol problems at a 6-month follow-up ($\beta = .270$, $p = .043$). Intensity (Brief Motivational Intervention: $d = .60$; Electronic Check-up To Go: $d = .46$) and O_{max} (Brief Motivational Intervention: $d = .59$; Electronic Check-up To Go: $d = .48$) was reduced immediately following two brief interventions with reductions in intensity ($\beta = -0.085$, $p = .04$) and O_{max} ($\beta = -0.041$, $p = .011$) significantly predicting reductions in drinking at a one-month follow-up (see also Dennhardt et al., 2015) and reductions in O_{max} significantly predicting alcohol problems at a one-month follow-up ($\beta = -0.036$, $p = .012$).

1.4.2.2. Concurrent and convergent validity. Literature suggests demand indices derived from the APT tend to correlate with self-report measures of drinking quantity and alcohol related problems (e.g., Bertholet et al., 2015; MacKillop et al., 2010a; Murphy and MacKillop, 2006; Murphy et al., 2009). Relatedly, demand indices tend to be sensitive to categorical classifications of severity of alcohol use; that is, elevated indices of demand are associated with greater severity of alcohol use (e.g., Murphy and MacKillop, 2006; Smith et al., 2010; Teeters and Murphy, 2015; Teeters et al., 2014). Recently, Kiselica et al. (2016) conducted a meta-analysis examining the validity of the APT. Sixteen articles met the inclusion criteria of reporting "…at least one bivariate relationship of a reinforcing efficacy metric with an alcohol-related outcome [alcohol consumption, binge/heavy drinking, alcohol-related consequences, alcohol use disorder (AUD) symptoms]" (pg. 808). Some effect sizes were not statistically significant, but of those that were effect sizes ranged from small to large. Intensity showed the largest effect sizes with alcohol-related outcomes (effect sizes [ES] r_{range}: .34–.51), followed by O_{max} (ES r_{range}: .23–.39). Although breakpoint was statistically significantly related to all alcohol-related outcomes, effect sizes tended to be small (ES r_{range} = .15–.19). P_{max} only statistically significantly related to alcohol consumption and binge/heavy drinking (ES *rs* = .05 and .03, respectively). Finally, measures of elasticity statistically significantly related to all alcohol-related outcomes except binge/heavy drinking (ES r_{range}: -0.11- -.20).

1.5. Variations of the APT

1.5.1. State vs. Trait

Two general variations of the APT exist: trait and state versions. Trait-based APTs are among the most common and their vignettes usually provide a specific scenario (e.g., at a bar or party). Trait-based APTs are intended to be a general measure of alcohol's reinforcing value to the individual, *ceteris paribus*. When the goal is to explicitly capture changes in alcohol's reinforcing value based on one or more experimental manipulations, state-based APTs have been utilized where vignettes typically reference the drinking setting as "right now" or for use during a self-administration phase. Demand measures derived from state-based APTs are conceptualized as complementary motivational channels to measures such as self-report craving, affect, or arousal. Indeed, research using these state-based APTs in cue-reactivity and stress induction paradigms has shown responses are sensitive to various acute experimental manipulations (e.g., Amlung and MacKillop, 2014, 2015; MacKillop et al., 2010b). For example, Bujarski et al. (2012) found that naltrexone (an opioid antagonist and FDA-approved pharmacotherapy for treating alcohol dependence) significantly reduced alcohol-demand measures of intensity ($\beta = 2.15$, $t = 2.58$, $p < .05$), O_{max} ($\beta = 5.97$, $t = 2.00$, $p = .05$), and breakpoint ($\beta = 6.01$, $t = 2.08$, $p < .05$) compared to placebo, when participants were both sober and under the influence of alcohol (i.e., breath alcohol concentration of 0.06 g/dl).

1.5.2. Real vs. hypothetical

Two studies suggest responses on APTs with hypothetical outcomes tend to be consistent with responses on versions of the APT where alcohol and monetary outcomes are actually experienced (Amlung et al., 2012; Amlung and MacKillop, 2015). Using the aforementioned state-based APTs, participants completed hypothetical and actual versions; in the actual version, the number of drinks reported at one randomly drawn price was delivered for the participants to consume. In both studies (Amlung et al., 2012; Amlung and MacKillop, 2015), demand measures (Pearson's *rs* = .78–.97) and raw consumption values (Pearson's *rs* = .65–1.00) between the versions were highly correlated. Further, there was a high correlation between reported consumption values and the amount of alcohol actually consumed (Pearson's *rs* = .87, $p < 0.001$).

1.6. Purpose of the present review

As evidenced by the breadth and depth of work discussed heretofore, the APT has received considerable attention in the alcohol misuse realm. Much of this work is promising; however, the recent findings from Kiselica et al. (2016) raise some doubts related to the clinical utility of the APT. One concern is that intensity was the only demand measure that provided incremental utility in predicting AUD symptoms above and beyond drinking measures. It is interesting that measures of elasticity demonstrated relatively small effect sizes and did not significantly contribute to incremental validity in AUD symptoms, despite elasticity being one of the fundamental dependent measures both theoretically and in animal laboratory demand curve analyses (Hursh and Silberberg, 2008). Throughout nearly the past three decades, there have been a number of developments in how to best quantify the degree to which consumption (or purchasing) is sensitive to increasing costs (i.e., elasticity; Ho et al., 2016; Hursh et al., 1988; Hursh and Silberberg, 2008; Koffarnus et al., 2015a; Liao et al., 2013; Yu et al., 2014; Zhao et al., 2016). Some of these proposals have occurred concurrently with the increased use of the APT and so there may be substantial variation in the quantification of elasticity measures, not only across but also within various methods.

In addition to the ways in which responses from the task are analyzed, there may be systematic differences in how the APT itself is administered. The general framework of the APT is to provide a "vignette" that describes a set of conditions under which the participant is to imagine him or herself; however, vignettes may differ based on the population recruited (e.g., for college students, the setting might be a party; for adults, the setting might be a bar) or based on the experimental design (e.g., acute experimental manipulations using state-based approaches; relations with AUD using trait-based approaches). APTs may also differ with respect to the number and/or progression of prices, which may induce differential rates of elasticity (e.g., rapid price progressions may result in rapid decreases in consumption). Therefore, given increasing popularity of the APT, we believe it is high time to take stock of contemporary developments in the APT literature and provide a systematic review of that literature, with particular focus on the methodology. Where possible, we will comment on how variations in administration and analyses may differentially affect relations between demand curve indices and alcohol related outcomes, but the larger overall goal is to generate important insights that are relevant to the behavioral economic studies on addiction, shed insight onto current practices, and provide guidance related to standardized implementation. This, in turn, may inform future research examining the APT's methodological and clinical implications, such as in meta-analytic studies.

2. Method

2.1. Literature search methods

We conducted a systematic search of publications using the Alcohol Purchase Task (APT) following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach. The databases searched included Google Scholar, PsycINFO, PubMed, ScienceDirect, and SpringerLink. The search included the following keywords with Boolean operators: "behavioral economic*" AND "purchase task" OR "simulated demand." Publication years were specified through the year 2016. We did not include alcohol as a specific search term, as the above search terms would presumably capture not only all APTs, but also all purchase tasks in general. Given there is only one instance in which an article had more than one experiment, hereafter when the term "article" is used, we mean the entire paper regardless of the number of experiments. However, because nearly all articles comprised one experiment, hereafter when the term "study/studies" is used, we mean specific experiments.

2.2. Criteria for study inclusion

Articles were included so long as full-text manuscripts were available, were published in a peer-reviewed journal, made any reference to use of the APT or a purchase task for alcohol, were written in English, and included human participants. Thus, articles implementing other variations of the purchase task (e.g., Cigarette Purchase Task), conference abstracts, as well as conceptual and review articles were not included. Hypothetical cross-price purchase tasks (e.g., Snider et al., 2017) assessing demand for more than one commodity (so long as one of the commodities was alcohol) would have been included, but the search did not yield any articles.

2.3. Study selection

The first author reviewed titles and abstracts from the results of the keyword searches to determine the relevance of articles. Full-text articles were retrieved and examined by the first author to determine if they met criteria for inclusion. The second author repeated all study procedures to ensure that search results were screened reliably and objectively, and disagreements were resolved through discussions related to inclusion criteria until full agreement was met. The initial search results for Google Scholar, PsycINFO, PubMed, and SpringerLink databases from April through July 2017 were 204, 284, 267, and 282, respectively.

2.4. Coding categories

Studies were coded for demographic and procedural characteristics (i.e., participant sample, number of participants, mean and standard deviation of participants' ages, type of compensation, additional measures), structural characteristics of the APT itself (i.e., number of prices, prices used, vignette), and characteristics of data analysis (i.e., software used, changes to any zero values, value of and method of obtaining k [i.e., the weighting parameter used in contemporary demand equations, the value of which is intimately tied with α, the measure of elasticity], use of the Hursh and Silberberg (2008) exponential equation).

2.5. Reliability and inter-observer agreement

First and second authors independently scored the individual studies included in the search. Study information was extracted using predefined coding spreadsheets and completed independently by the first and second authors. Following independent scoring, disagreements were addressed and resolved through discussions and examination of the studies until complete agreement was achieved. Although the authors on the present paper are also authors on many of the articles we reviewed, all study information was extracted from the articles themselves (independently by the first two authors).

3. Results

Forty-eight studies (47 articles) were included in this review. Of the 1037 articles within the initial search results, 89.5% (n = 928) were initially excluded because titles and abstracts did not indicate using a purchase task or an APT specifically, were not peer-reviewed, or were not full text. The remaining 109 articles were subjected to a full-text review and of those, four did not meet inclusion criteria. Of the remaining articles, 58 were duplicate results (resulting from the large overlap between results from Google Scholar and the other databases) leaving 47 distinct articles for final inclusion (see Fig. 2).

3.1. Meta-information

3.1.1. Year

Use of the APT has steadily increased since the seminal article in 2006. In the few years following 2006, approximately one article was published per year. This rate increased starting in 2009 and again in 2012.

3.1.2. Journal

The most frequently published journals include Experimental and Clinical Psychopharmacology (n = 10), Alcoholism: Clinical and

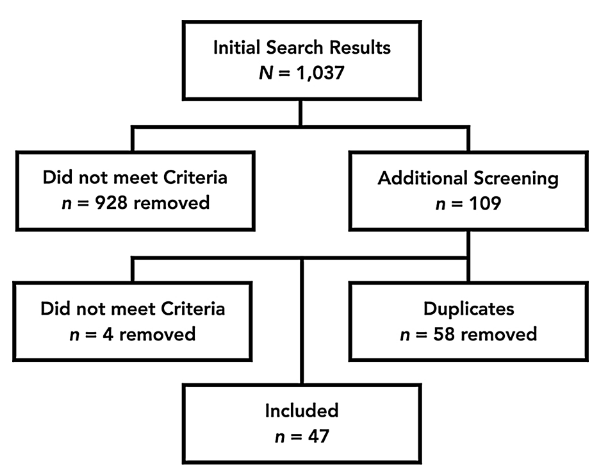

Fig. 2. PRISMA flow diagram.

Table 1
Descriptive Characteristics of Articles.

Authors (year)	Sample Description	N	% Male	Age (SD)	Compensation	Alcohol-related Measures
Acker et al. (2012)	From community, Caucasian heavy drinkers (~28/~20 drinks/week for men/women); hazardous drinkers based on AUDIT	61	57.4	23.80 (5.40)	Monetary; ($30/2-h session)	AUDIT; PACS; 28-day TLFB
Amlung et al. (2012)	From community; heavy drinkers (14+/7+ drinks/week for men/women)	41	56	22.80 (3.0)	Monetary; ($15/h; total = $105)	AUDIT; AUQ; BrAC; 28-day TLFB; Approach/avoidance motivation
Amlung et al. (2013)	Undergraduates reporting drinking on monthly basis	273	27	20.00 (1.70)	Research/extra credit	AUDIT; DDQ
Amlung and MacKillop (2012)	Undergraduates reporting drinking on monthly basis	91	41	20.70 (2.10)	Research/extra credit	DDQ
Amlung and MacKillop (2014)	From community; non-treatment seeking heavy drinkers (14+/7+ drinks/week for men/women)	84	50	22.10 (2.42); 22.38 (2.06); 22.24 (2.24)	Monetary; ($40 plus up to $15)	AUDIT; BrAC; ICCMCP; 28-day TLFB; Alcohol craving
Amlung and MacKillop (2015)	From university and community; non-treatment seeking, heavy-drinking males (21+ drinks/week)	19	100	22.84 (2.89)	NR	28-day TLFB
Amlung et al. (2015a)	From university and community; 5+ drinks/occasion during past 6 months	85	48	22.94 (3.41)	Monetary; ($12/hr)	BAAD; BrAC; YAACQ; Craving (i.e., how much do you want a drink right now?); Quantity/frequency from NIAAA
Amlung et al. (2016)	From university and community; 5+ drinks/occasion during past 6 months	134	NR	NR	Monetary; ($12/hr)	Drinking/driving behavior/cognitions; Quantity/frequency from NIAAA
Amlung et al. (2015b)	College students; 1+ heavy drinking episodes (5+/4+ drinks/occasion) during past month	207	47	19.50 (1.99)	Course credit/monetary payment	DDQ; YAACQ
Bertholet et al. (2015)	Swiss men approaching army recruitment	4790	100	21.20 (1.20)	None; army recruitment	AUDIT; BrAC; abuse/dependence criteria adapted from SSAGA/DSM-5; Past 12 months alcohol demographics
Bujarski et al. (2012)	Heavy drinkers (8+ on AUDIT) of East Asian Ethnicity; non-treatment seeking	32	71.4	22.3 (1.98)	NR	
Dennhardt et al. (2016)	Operations Enduring Freedom or Iraqi Freedom (OEF/OIF) veterans recruited from regional Veterans Affairs Medical Center (VAMC); screened positive for heavy drinking	68	91.2	32.31 (8.84)	NR	DMQ-R; DrInC; 30-day TLFB;
Dennhardt et al. (2015)	Undergraduates; heavy drinking (4/5+ drinks female/male)	97	41.2	20.10 (2.23)	NR	ARSS-SUV; DDQ; YAACQ
Gentile et al. (2012)	Undergraduates; 1+ drinks during past month	164	29	19.88 (1.53)	Research/extra credit	DDQ
Gentile et al. (2012)	Undergraduates; 1+ drinks during past month	66	19.7	19.20 (1.15)	Research/extra credit	DDQ
Gilbert et al. (2014)	Undergraduates; 1+ heavy drinking episode during past month	80	50	18.50 (0.69)	NR	DDQ; YAACQ
Gray and MacKillop (2014)	From community; smokers from parent study MacKillop et al. (2012) reporting any alcohol use during past year	720	61	29.70 (12.00)	NR	AUDIT
Herschl et al. (2012)	College students; 5+/4+ drinks/typical evening for men/women	297	45.8	19.88 (1.92)	NR; volunteers	AUDIT; CEOA; RAPI
Kiselica and Borders (2013)	Undergraduates; consumed alcohol in past 6 months	202	16.34	19.48 (1.42)	Course/extra credit	DDQ; Brief YAACQ
Lemley et al. (2016)	Undergraduates	80	27.5	Median: 19.50 (IQR: 18.70-20.64)	Extra credit	BCQ; YAACQ
Luehring-Jones et al. (2016)	From community; young adult social drinkers (average 3+ drinks/week)	36	39	19.60 (1.90)	Monetary	Modified IAT; 90-day TLFB
MacKillop et al. (2014)	From community; heavy drinking men (21+ drinks/week)	24	100	22.58 (2.62)	Monetary; ($15/hr)	28-day TLFB
MacKillop et al. (2010a)	From community; non-treatment seeking regular drinkers (18-60/14-53 drinks/week for men/women)	61	62	42.40 (13.10)	NR	PACS; SCID; 90-day TLFB
MacKillop and Murphy (2007)	Undergraduate drinkers (upper 20% of weekly drinking distribution for their gender)	54 (initial); 51 (follow-up)	33	20.00 (1.22)	Extra credit; ($15 for follow-up)	ARSS-SUV; DDQ

(*continued on next page*)

Table 1 (*continued*)

Authors (year)	Sample Description	N	% Male	Age (SD)	Compensation	Alcohol-related Measures
MacKillop et al. (2009)	Undergraduates reporting drinking on weekly basis	267	24	20.11 (0.1.51 [sic])	Research credit	DDQ; RAPI
MacKillop et al. (2010b)	Undergraduate heavy drinkers (21+/14+ drinks/week for men/women)	92	71	18.90	NR	AUQ
Miller and Droste (2013)	Undergraduates from Australian Universities; lifetime drug and/or alcohol use	485	34	20.31 (2.46)	NR	DEoDS; WHO-ASSIST ver. 3.0
Murphy et al. (2015)	Undergraduates; 1+ heavy drinking episode (5+/4+ drinks/occasion for men/women); secondary analysis to Murphy et al. (2006)	133	50.4	18.60 (1.20)	NR	ARSS-SUV; DDQ; RDEA; YAACQ
Murphy and MacKillop (2006)	Undergraduates reporting drinking on weekly basis	267	24	20.11 (SE = 0.09)	Extra credit	DDQ; RAPI
Murphy et al. (2009)	Undergraduates with history of past month heavy drinking (5+/4+ drinks/occasion for men/women) or drug use	38 (time 1); 17 (time 2)	50	19.92 (1.68)	Monetary; ($40-60)	ARSS-SUV; RDEA; 28-day TLFB; YAAPST
Murphy et al. (2013)	Undergraduates; 1+ heavy drinking (5+/4+ drinks/occasion for men/women) episode during past month	133	50.4	NR	NR	DDQ
Murphy et al. (2014)	Undergraduates; 1+ heavy drinking (5+/4+ drinks/occasion for men/women) episode during past month (see Murphy et al., 2006)	133 (family history); 74 (no family history)	47	19.50 (5.04)	Extra credit or monetary	DDQ; YAACQ; Family history of drinking problems
Owens et al. (2015a)	From community; heavy drinkers (14+/7+ drinks/week for men/women), > 7 on AUDIT	84	50	23.43 (1.76)	Monetary; ($30/2.5-hr session)	Alcohol craving
Owens et al. (2015b)	Non-treatment seeking heavy drinkers 8+ on AUDIT	62	64	20.76 (2.55)	NR	AUQ
Ramirez et al. (2016)	Undergraduates reporting consuming alcohol during past 3 months	223	41.3	18.60 (0.70)	Monetary; ($25-$75)	AAAQ; ASCS; AUDIT; DDQ; Modified IAT
Skidmore and Murphy (2011)	Heavy-drinking college students	207	46.9	19.50 (1.99)	Extra credit or monetary	DDQ
Skidmore et al. (2014)	Non-treatment seeking college students; > = 1 heavy drinking episode (5+/4+ drinks/occasion for men/women)	207	47	19.50 (1.99)	Extra credit or monetary	ARSS-SUV; DDQ; PBSS; RDEA; YAACQ
Smith et al. (2010)	Undergraduates consuming 1+ drinks during past 30 days	255	26.7	20.55 (4.30)	Course credit	DDQ; YAACQ
Snider et al. (2016)	Alcohol-dependent adults from the community	50	76	EFT: 38.0 (2.30); Control: 44.3 (1.90)	NR	AUDIT
Teeters and Murphy (2015)	College students reporting past month alcohol use	419	24.1	20.37 (2.56)	Course credit	DDQ; Driving after drinking (past 3 months)
Teeters et al. (2014)	Undergraduate students; 1+ heavy drinking episode (5+/4+ drinks/occasion for men/women) during past month	207	46.9	19.50 (1.99)	NR	DDQ; Driving after drinking (single item from YAACQ)
Tripp et al. (2015)	Undergraduate students reporting past month alcohol use	264	23	21.70 (5.00)	Course credit	DDQ; PACS; YAACQ
Tucker et al. (2016a)	From community; 2+ years problem drinking, recent cessation of high-risk drinking for 3 weeks to 3 months without alcohol-focused interventions	191	76.4	50.09 (11.94)	Monetary; ($75 for baseline data collection)	ADS; ASDE; BrAC; DPS; TLFB (during pre-resolution year)
Tucker et al. (2016b)	From community; 2+ years problem drinking, recent cessation of high-risk drinking for 3 weeks to 3 months without alcohol-focused interventions	175	75.4	50.65 (11.82)	Monetary; ($75/session; $50 completing all study procedures)	ADS; ASDE; DPS; Past-year TLFB; Postresolution drinking status outcomes
Wahlstrom et al. (2012)	Undergraduates; 5+ drinks/occasion	120	100	19.88 (1.83)	NR	AUDIT; RAPI
Weinstock et al. (2016)	From community; 4+ heavy drinking episodes (5+/4+ drinks/occasion for men/women) during past 60 days	73	46.6	42.20 (15.00)	Monetary; ($50)	SCID; 60-day TLFB

(*continued on next page*)

Table 1 (*continued*)

Authors (year)	Sample Description	N	% Male	Age (SD)	Compensation	Alcohol-related Measures
Yurasek et al. (2013)	Undergraduate students; 1+ heavy drinking episode (5+/4+ drinks/occasion for men/women) during past month	207	47	19.50 (5.04)	NR	DDQ; YAACQ
Yurasek et al. (2011)	College students drinking alcohol 1+ days during past month	215	28	20.65 (4.14)	Course credit	DDQ; DMQ-R; YAACQ

Note: NR = Not Reported.
AACQ = Approach and Avoidance of Alcohol Questionnaire.
ADS = Alcohol Dependence Scale.
ARSS-SUV = Adolescent Reinforcement Survey Schedule-Substance Use Version.
ASCS = Alcohol Self-Concept Scale.
ASDE = Alcohol-Savings Discretionary Expenditure Index.
AUDIT = Alcohol Use Disorders Identification Test.
AUQ = Alcohol Urge Questionnaire.
BAAD = Brief Assessment of Alcohol Demand.
BCQ = Beer Choice Questionnaire.
BrAC = Breath alcohol concentration.
CEOA = Comprehensive Effects of Alcohol Questionnaire.
DDQ = Daily Drinking Questionnaire.
DEoDS = Desired Effects of Drinking Scale.
DMQ-R = Modified Drinking Motives Questionnaire-Revised.
DPS = Drinking Problems Scale.
DrInC = Drinker Inventory of Consequences.
DSM-5 = Diagnostic and Statistical Manual of Mental Disorders, 5th Edition.
IAT = Implicit Association Task.
ICCMCP = Intertemporal Cross-Commodity Multiple-Choice Procedure.
NIAAA = National Institute on Alcohol Abuse and Alcoholism.
PACS = Penn Alcohol Craving Scale.
PBSS = Protective Behavioral Strategies Survey.
RAPI = Rutgers Alcohol Problem Index.
RDEA = Relative Total Discretionary Expenditures on Alcohol.
SCID = Structured Clinical Interview for DSM-Research Version.
SSAGA = Semi-Structured Assessment for the Genetics of Alcoholism.
TLFB = Timeline Follow-back.
WHO-ASSIST = World Health Organization-Alcohol, Smoking and Substance Involvement Screening Test.
YAACQ = Young Adult Alcohol Consequences Questionnaire.
YAAPST = Young Adult Alcohol Problems Screening Test.

Experimental Research (n = 6), and Drug and Alcohol Dependence and Journal of Studies on Alcohol and Drugs (n = 5 each). Other notable journals also include Psychology of Addictive Behaviors (n = 4), Addiction (n = 3), Psychopharamacology (n = 2), and Journal of the Experimental Analysis of Behavior (n = 2).

3.2. Demographics

3.2.1. Participant demographics

Table 1 displays summary information related to the demographic and procedural characteristics across studies. Twenty-nine studies used strictly convenience samples of university students, fifteen studies used strictly community participants (including Swiss men approaching army recruitment; Bertholet et al., 2015), and three studies recruited participants from both the university and the community.

Participants' average age tended to fluctuate around 20 years old. The lowest mean age was 18.50 (e.g., Gilbert et al., 2014) and the highest mean age was 50.65 (e.g., Tucker et al., 2016b). Breakdown of gender across all studies averaged to 50.72% male. The minimum percentage of males in a study was 16.34% (e.g., Kiselica and Borders, 2013) and the maximum was 100% (e.g., Amlung and MacKillop, 2015; Bertholet et al., 2015; MacKillop et al., 2014; Wahlstrom et al., 2012).

3.2.2. Inclusion criteria

Alcohol-related inclusion criteria varied, but most studies required some threshold of drinking (see Table 1). For example, many studies required participants to have engaged in at least one heavy drinking episode (e.g., 4/5+ drinks for men/women) within the past 30 days. Other studies selected participants based on weekly drinking levels, but with considerable variability in cutoffs (e.g., 7/14+ drinks per week to 20/28+ drinks per week for men/women). Other criteria were more general, for example, having at least one alcoholic drink during the past six months. We identified only two studies that did not explicitly state inclusion criteria related to alcohol use (Swiss men approaching army recruitment, Bertholet et al., 2015; undergraduate students; Lemley et al., 2016).

3.2.3. Sample size

Sample sizes varied considerably across individual studies (see Table 1), ranging from 17 (e.g., Murphy et al., 2009) to 4790 (e.g., Bertholet et al., 2015).

3.3. Additional alcohol measures

The final column in Table 1 displays additional measures collected in addition to the APT. We highlight and describe the most frequently used measures related to alcohol use.

3.3.1. Daily drinking questionnaire

The Daily Drinking Questionnaire (DDQ; Collins et al., 1985) assesses weekly alcohol use (both frequency and quantity) by asking respondents to imagine a typical week during the past three months and report the number of hours spent drinking and the number of standard drinks consumed for each day of the week (i.e., Monday-Sunday). Twenty-two of the 48 studies assessed weekly alcohol use via the DDQ.

3.3.2. Timeline followback

In the Timeline Followback (TLFB; Maisto et al., 1979; Sobell et al., 1979; Sobell and Sobell, 1992, 1995) procedure, participants retrospectively self-report the number of days they had consumed alcohol and the amount of alcohol they had consumed on each of those days, up to a one-year timeframe in the past. The TLFB procedure has been modified to shorten the window of recall, including 90- and 28-day versions. Nine studies assessed drinking using the TLFB. The 28-day TLFB has been the most common timeframe among APT studies.

3.3.3. Young adult alcohol consequences questionnaire

The Young Adult Alcohol Consequences Questionnaire (YAACQ; Kahler et al., 2005; Read et al., 2006, 2007) consists of 48 dichotomous (i.e., yes/no) endorsement questions representing a total score consisting of eight subscales. Subscales include: social/interpersonal, academic/occupational, risky behavior, impaired control, poor self-care, diminished self-perception, blackout drinking, and physiological dependence. Twelve studies used the YAACQ.

3.3.4. Alcohol use disorders identification task

The Alcohol Use Disorders Identification Task (AUDIT; Dawson et al., 2005; Saunders et al., 1993) is a 10-item questionnaire related to alcohol behavior and alcohol-related consequences. The AUDIT is scored by summing the weights of each of the 10 questions; with total scores of 8 or greater meeting criteria for hazardous and harmful alcohol use (Babor et al., 2001). Nine studies used the AUDIT.

3.3.5. Adolescent reinforcement survey schedule

The Adolescent Reinforcement Survey Schedule (ARSS; Holmes et al., 1987, 1991) is a self-report questionnaire, developed for adolescents, that estimates the amount of relative reinforcement obtained from engaging in various activities. An adapted version, the ARSS-Substance Use Version (ARSS-SUV; Murphy et al., 2005), presents participants with 54 activities in which they rate the frequency with which they engaged in each activity (within the past 30 days) and the enjoyment associated with each activity separately for substance-related and substance-free activities. The ARSS-SUV results in a ratio indicating the amount of reinforcement obtained by substance-related activities with larger scores reflecting relatively greater reinforcement coming from substance-related activities. Four studies used the ARSS-SUV.

3.3.6. Rutgers alcohol problem index

The Rutgers Alcohol Problem Index (RAPI; White and Labouvie, 1989) is a 23-item questionnaire assessing adolescent problem drinking. The RAPI is scored by summing the weights of each of the 23 questions, resulting in a total possible score of 69. Clinical samples' scores range from 21 to 25; nonclinical samples' scores range from 4 to 8 (these ranges are for adolescents ranging in age from 14 to 18 years old). Four studies used the RAPI.

3.4. Structural characteristics of the APT

3.4.1. Number of prices

The third column in Table 2 indicates the number of prices assessed in each study. Of the studies reporting the number of prices used, except Gilbert et al. (2014) and Owens et al. (2015a) where they only assessed free price, the minimum number of prices used was 11 (i.e., Bertholet et al., 2015) and the maximum number of prices used was 26 (i.e., Gray and MacKillop, 2014); however, in the latter case, only the first 21 prices were actually analyzed given the lack of variability in responding above $70. Two studies (e.g., Gilbert et al., 2014; Owens et al., 2015a) used only one price (i.e., how many drinks if they were free?) and two studies did not specify the number of prices used.

3.4.2. Price structure

The fourth column in Table 2 depicts the prices (and their structure) as reported in each study. Six studies reported using a randomized price sequence (e.g., Amlung and MacKillop, 2014; Amlung et al., 2012; Gentile et al., 2012 [Exps 1, 2]; Kiselica and Borders, 2013; MacKillop et al., 2014) and, as previously mentioned, four studies either did not specify or did not use any price sequence. Of the remaining studies that reported and used a price sequence, 41 reported the initial price assessed was free and three reported the initial price assessed was $0.01. Overall, the order of prices resembled a progressive-ratio like progression with relatively smaller step-sizes at low prices and increasing as

Table 2
Structural Characteristics of APTs.

Authors (year)	Response Medium	# Prices	Prices Specified ($USD/Drink)	State or Trait	Situation	Drinks	Drink Restriction	Manipulation	Budget
Acker et al. (2012)	Computer	25	0, .02, .05, .13, .25, .5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100	Trait	Typical situation	Standard size domestic beer (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks containing one shot of liquor.	No drinks before or after	No	NR
Amlung et al. (2012)	Computer	24	0, .02, .05, .1, .15, .20, .25, .5, .75, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	State	During 1-hr self-administration period	Typical alcoholic beverage; “mini-drinks” (half size of standard drinks)	No drinks after	No	$15 “bar tab”
Amlung et al. (2013)	Paper & pencil (90-min group testing)	21	0-10	Trait	Typical situation	NR	No other access or after	No	Current income level
Amlung and MacKillop (2012)	Paper & pencil (shown on Power- Point)	25	0, .02, .1, .25, .5, .75, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 22.5, 25, 27.5, 30 (also shown a randomized order)	State	During 1-hr self-administration period	Typical alcoholic beverage; half size of standard drinks	No drinks after	No	$30 “bar tab”
Amlung and MacKillop (2014)	NR	18	.01, .1, .5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 (shown in randomized order)	State	NR	NR	NR	NR	NR
Amlung and MacKillop (2015)	Computer	22	.01-15 (randomized order)	State	NR	Typical alcoholic beverage; “mini-drinks” (half size of standard drinks)	NR	No	$15 “bar tab”
Amlung et al. (2015a)	Computer	21	0-30	Trait	Typical drinking situation	NR	No other access or after	No	NR
Amlung et al. (2016)	NR	21	0-30	Trait	Typical drinking situation	Standard drinks	No access after	No	NR
Amlung et al. (2015b)	NR	17	0, .25, .5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20	Trait	Typical drinking situation	Standard drinks (12 oz. of beer, 5-oz. glass of wine, or a mixed drink containing 1.5 oz. of liquor)	NR	No	NR
Bertholet et al. (2015)	Paper & pencil/ online	11	0, 50cts, 1, 2, 3, 4, 6, 8, 10, 15, 20 Swiss Francs	Trait	Usually drink alcohol (at a bar, at a party, at home, etc.)	NR	No drinks before or after	No	NR
Bujarski et al. (2012)	NR	16	0-1120	Trait	Typical drinking situation	Standard drinks	NR	No	NR
Dennhardt et al. (2016)	NR	19	0-20	Trait	5-hr	Standard drinks	NR	No	NR
Dennhardt et al. (2015)	NR	19	0-20	Trait	5-hr	Standard drinks (domestic beers (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks containing one shot of liquor)	NR	No	NR
Gentile et al. (2012)	Computer (online, but in an on-campus lab)	14	5, .25, 7, 10, .5, 3, 1, 0, 4, .75, 8, 2, 6, 9 (randomized order)	Trait	With friends at a bar from 9 p.m. to 2 a.m.	Standard size beer (12 oz.), a glass of wine (5 oz.), a shot of hard liquor (1.5 oz.), or a mixed drink with one shot of liquor	No drinks before or after	Yes; next-day class [8:30 a.m./10:30 a.m./12:30 p.m.]	NR
Gentile et al. (2012)	Computer (online, but in an on-campus lab)	19	5, .25, 7, 13, 10, .5, 3, 15, 1, 0, 4, 12, .75, 8, 2, 11, 6, 9, 14 (randomized order)	Trait	With friends at a bar from 9 p.m. to 2 a.m.	Standard size beer (12 oz.), a glass of wine (5 oz.), a shot of hard liquor (1.5 oz.), or a mixed drink with one shot of liquor	No drinks before or after	Yes; next day [exam/class] at [8:30 a.m./12:30 p.m.]	NR
	NR	1	0	Trait		Standard drinks	NR		NR

(continued on next page)

Table 2 (*continued*)

Authors (year)	Response Medium	# Prices	Prices Specified ($USD/Drink)	State or Trait	Situation	Drinks	Drink Restriction	Manipulation	Budget
Gilbert et al. (2014)					Party at 9 pm; no responsibilities (standard condition only)			Yes; next day college class at 9:00 a.m., class at 10:00 a.m., class at 11:00 a.m., class at noon, an internship, extracurricular activity, volunteering, and paid employment (each at 9:00 a.m.)	
Gray and MacKillop (2014)	NR	26 (21)	0, .02, .05, .13, .25, .5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30, 35, 70, 140, 280, 560, 1120 (excluded 70-1120 due to lack of variability)	UK	NR	NR	NR	NR	NR
Herschl et al. (2012)	NR	14	0, .25, .5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9	UK	NR	NR	NR	NR	NR
Kiselica and Borders (2013)	Paper & pencil	19	5, .25, 7, 13, 10, .5, 3, 15, 1, 0, 4, 12, .75, 8, 2, 11, 6, 9, 14 (randomized order; shown on separate pages)	Trait	With friends at a bar from 9 p.m. to 2 a.m.	Standard size beer (12 oz.), a glass of wine (5 oz.), a shot of hard liquor (1.5 oz.), or a mixed drink with one shot of distilled spirits	No drinks before or after	No	NR
Lemley et al. (2016)	Paper & pencil	16	0, .25, .5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 12	Trait	With friends at a bar from 9 p.m. to 2 a.m. to see a band	Standard size beer (12 oz), wine (5 oz), shots of hard liquor (1.5 oz), or mixed drinks with one shot of liquor	No drinks before or after	No	NR
Luehring-Jones et al. (2016)	Computer	NR	NR	UK	NR	NR	NR	NR	NR
MacKillop et al. (2014)	Computer	22	.01, 1, 8, .75, 7, 15, 2, .25, 14, .05, 9, 3, 12, .5, 6, 11, 5, .1, 4, 13, .02, 10 (one of four randomized sequences in supplemental materials)	UK	NR	NR	NR	NR	NR
MacKillop et al. (2010a)	NR	16	0-1120	Trait	Typical situation	Standard size domestic beer (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks containing one shot of liquor	No drinks before or after	No	NR
MacKillop and Murphy (2007)	NR	14	0, .25, .5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9	Trait	With friends at a bar from 9 p.m. to 2 a.m. to see a band	Standard size beer (12 oz), wine (5 oz), shots of hard liquor (1.5 oz), or mixed drinks with one shot of liquor	No drinks before or after	No	NR
MacKillop et al. (2009)	Paper & pencil	14	0, .25, .5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9	Trait	With friends at a bar from 9 p.m. to 2 a.m. to see a band	Standard size beer (12 oz), wine (5 oz), shots of hard liquor (1.5 oz), or mixed drinks with one shot of liquor	No drinks before or after	No	NR
MacKillop et al. (2010b)	Paper & pencil	19	0, .01, .05, .13, .25, .5, 1, 2, 3, 4, 5, 6, 11, 35, 70, 140, 280, 560, 1120	State	Right now	Standard size domestic beer (12 oz), wine (5 oz), shots of hard liquor (1.5 oz), or mixed drinks with one shot of liquor	No drinks after	No	NR
Miller and Droste (2013)	Computer (online)	20 (inferred from figure)	0–20 in 1 increments (inferred from figure)	UK	NR	NR	NR	NR	NR

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Table 2 (*continued*)

Authors (year)	Response Medium	# Prices	Prices Specified ($USD/Drink)	State or Trait	Situation	Drinks	Drink Restriction	Manipulation	Budget
Murphy et al. (2015)	NR	17	0–20	Trait	5-h	Standard drinks	NR	No	NR
Murphy and MacKillop (2006)	NR	14	0, .25, .5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9	Trait	With friends at a bar from 9 p.m. to 2 a.m. to see a band	Standard size beer (12 oz), wine (5 oz), shots of hard liquor (1.5 oz), or mixed drinks with one shot of liquor	No drinks before or after	No	NR
Murphy et al. (2009)	NR	14	0–9; 0–3 by .5 increments; 3–9 by 1 increments	Trait	With friends at a party on a weekend night from 9 p.m. to 2 a.m. to see a band	Standard size domestic beer (12 oz), wine (5 oz), shots of hard liquor (1.5 oz), or mixed drinks with one shot of liquor	No drinks or drugs before or after; for your consumption only; cannot bring own drugs or alcohol to party	No	NR
Murphy et al. (2013)	Paper & pencil	17	0–20; 0–3 by .50 increments; 3–10 by 1 increments; 10–20 by 5 increments	Trait	With friends at a party on a weekend night from 9 p.m. to 2 a.m. to see a band; no obligations the next day	Standard size domestic beer (12 oz), wine (5 oz), shots of hard liquor (1.5 oz), or mixed drinks with one shot of liquor	No drinks or drugs before or after; for your consumption only; cannot bring own drugs or alcohol to party	No	NR
Murphy et al. (2014)	Paper & pencil	17	0–20; 0–3 by .50 increments; 3–10 by 1 increments; 10-20 by 5 increments	Trait	With friends at a party on a Thursday night from 9 p.m. to 2 a.m. to see a band; no obligations the next day (standard condition only)	Standard size domestic beer (12 oz.), a glass of wine (5 oz.), a shot of hard liquor (1.5 oz.), or a mixed drink with one shot of distilled spirits	No drinks or drugs before or after; for your consumption only; cannot bring own drugs or alcohol to party	Yes; next day test (worth 25% of your course grade) for a college class the next morning at 10:00 A.M.	NR
Owens et al. (2015a)	NR	1	0	UK	NR	NR	NR	NR	NR
Owens et al. (2015b)	Paper & pencil	16 (12)	0, .01, .05, .13, .25, .5, 1, 3, 6, 11, 35, 70, 140, 280, 560, 1120 (only up to 70)	State	Right now	Standard size domestic beer (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks containing one shot of liquor	No drinks after	No	NR
Ramirez et al. (2016)	Online	19	0–20	Trait	At a bar to see a band; 5-hr	Standard drinks	NR	No	NR
Skidmore and Murphy (2011)	Paper & pencil	17	0–20	Trait	With friends at a party on a Thursday night from 9 p.m. to 2 a.m. to see a band; no obligations the next day (no-responsibilities condition only)	Standard size domestic beers (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks that contain one shot of liquor	No drinks or drugs before or after; for your consumption only	Yes; next day test (worth 25% of your course grade) for a college class the next morning at 10:00 AM; next day class at 10:00 AM, but there is no test and the teacher does not take attendance.	NR
Skidmore et al. (2014)	NR	17	0–20	Trait	Hypothetical drinking scenario	Standard drinks	NR	No	NR
Smith et al. (2010)	NR	17	0–20; 0–3 by .5 increments, 3–10 by 1 increments, 10–20 by 5 increments	Trait	With friends at a party on a Thursday night from 9 p.m. to 2 a.m. to see a band; no obligations the next day	Standard size domestic beers (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks containing one shot of liquor	No drinks or drugs before or after; for your consumption only	No	NR
Snider et al. (2016)	Computer	13	0, .25, .5, 1, 2, 2.5, 3, 4, 5, 6, 7, 8, 9	Trait	With friends at a bar from 9 p.m. to 2 a.m. to see a band	Standard alcoholic beverages (beer, wine, and/or shots of liquor)	NR	No	NR
Teeters and Murphy (2015)	Computer (online)	17	0, .25, .5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20 (inferred from figure)	Trait	With friends at a party from 9 p.m. to 1 a.m.	Standard size domestic beers (12 oz.), wine (5 oz.), shots of hard liquor (1.5	No drinks or drugs before or after; for your consumption only	Yes; driving condition imagine that you were driving home at 2:00 AM at least 1 hour after you stopped drinking	NR

(*continued on next page*)

Table 2 (*continued*)

Authors (year)	Response Medium	# Prices	Prices Specified ($USD/Drink)	State or Trait	Situation	Drinks	Drink Restriction	Manipulation	Budget
						oz.), or mixed drinks containing 1 shot of liquor			
Teeters et al. (2014)	NR	17	0–20	Trait	With friends at a party on a Thursday night from 9 p.m. to 2 a.m. to see a band; no obligations the next day	Standard size domestic beers (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks containing 1 shot of liquor	No drinks or drugs before or after; for your consumption only	No	NR
Tripp et al. (2015)	Computer (online)	17	0, .25, .5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20	Trait	With friends at a party from 9 p.m. to 1 a.m.	Standard size domestic beers (12 oz.), wine (5 oz.), shots of hard liquor (1.5 oz.), or mixed drinks containing one shot of liquor	No drinks before or after	No	NR
Tucker et al. (2016a)	Phone and computer	18	0–20	Trait	Typical bar situation	Standard size	NR	No	NR
Tucker et al. (2016b)	Phone and computer	18	0–20	Trait	Imaginary drinking situation	Standard size	NR	No	NR
Wahlstrom et al. (2012)	NR	14	0, .25, .5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9	UK	NR	NR	NR	NR	NR
Weinstock et al. (2016)	NR	18	0, .25, .5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25	UK	NR	NR	NR	No	NR
Yurasek et al. (2013)	NR	17	0–20; 0–3 by .5 increments, 3–10 by 1 increments, 10–20 by 5 increments	Trait	With friends at a party on a Thursday night from 9 p.m. to 2 a.m. to see a band; no obligations the next day	Standard-size domestic beers (12 oz.), wine (5 oz.), shots of distilled spirits (1.5 oz.), or mixed drinks containing one shot of distilled spirits	No drinks or drugs before or after; for your consumption only	No	NR
Yurasek et al. (2011)	Computer (online)	17	0-20; 0-3 by .5 increments, 3-10 by 1 increments, 10-20 by 5 increments	Trait	With friends at a party on a Thursday night from 9 p.m. to 2 a.m. to see a band; no obligations the next day	Standard-size domestic beers (12 oz.), wine (5 oz.), shots of distilled spirits (1.5 oz.), or mixed drinks containing one shot of distilled spirits	No drinks or drugs before or after; for your consumption only	No	NR

Note: NR = Not Reported; UK = Unknown.

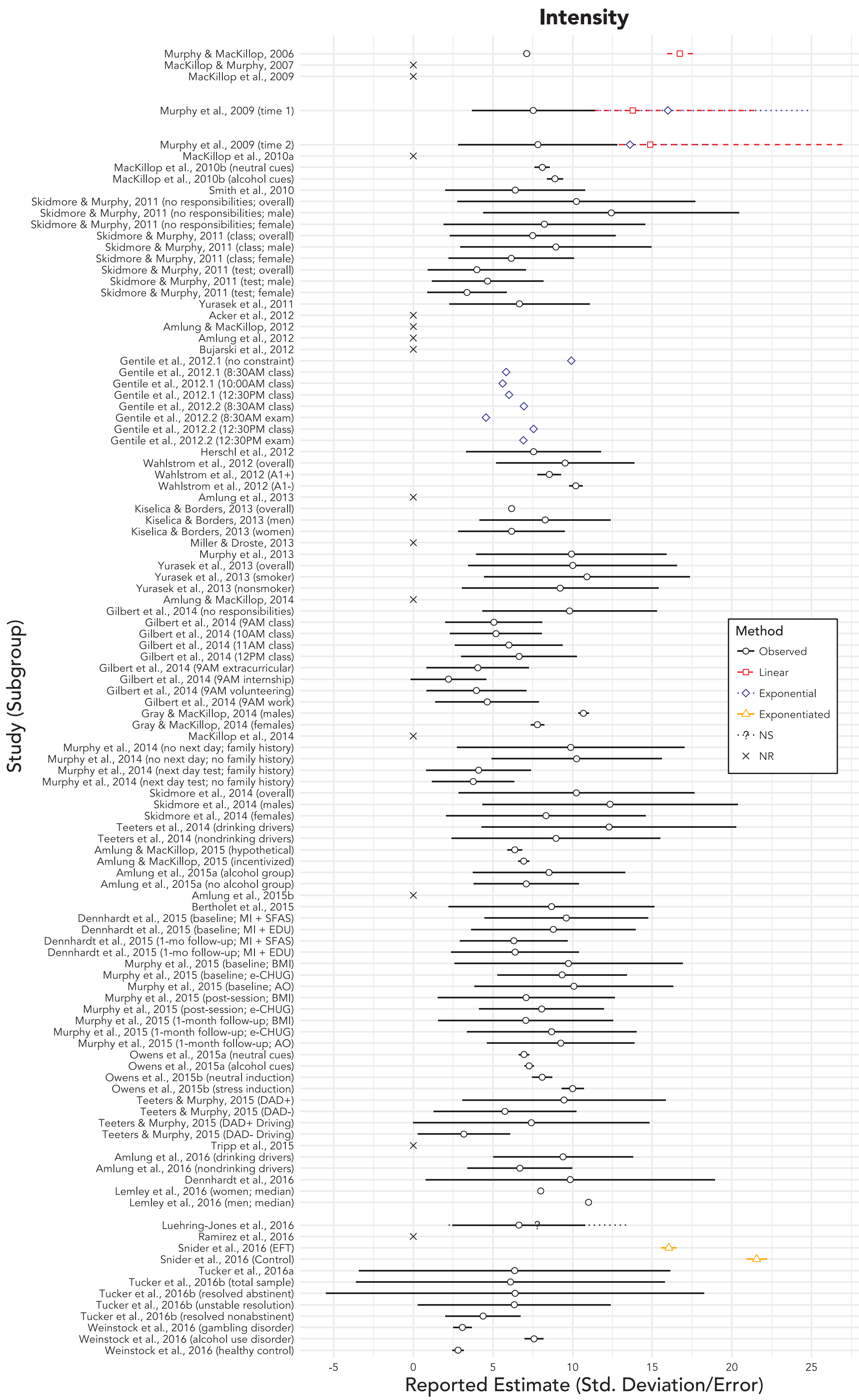

Fig. 3. Estimates of intensity across studies and subgroups depicted by method of obtaining values. Circles denote observed; squares denote Hursh et al.'s (1988) linear elasticity equation; diamonds denote Hursh and Silberberg's (2008) exponential equation; triangles denote Koffarnus et al.'s (2015a) exponentiated demand equation; ?s denote instances in which the equation was not specified; Xs denote instances that were not reported.

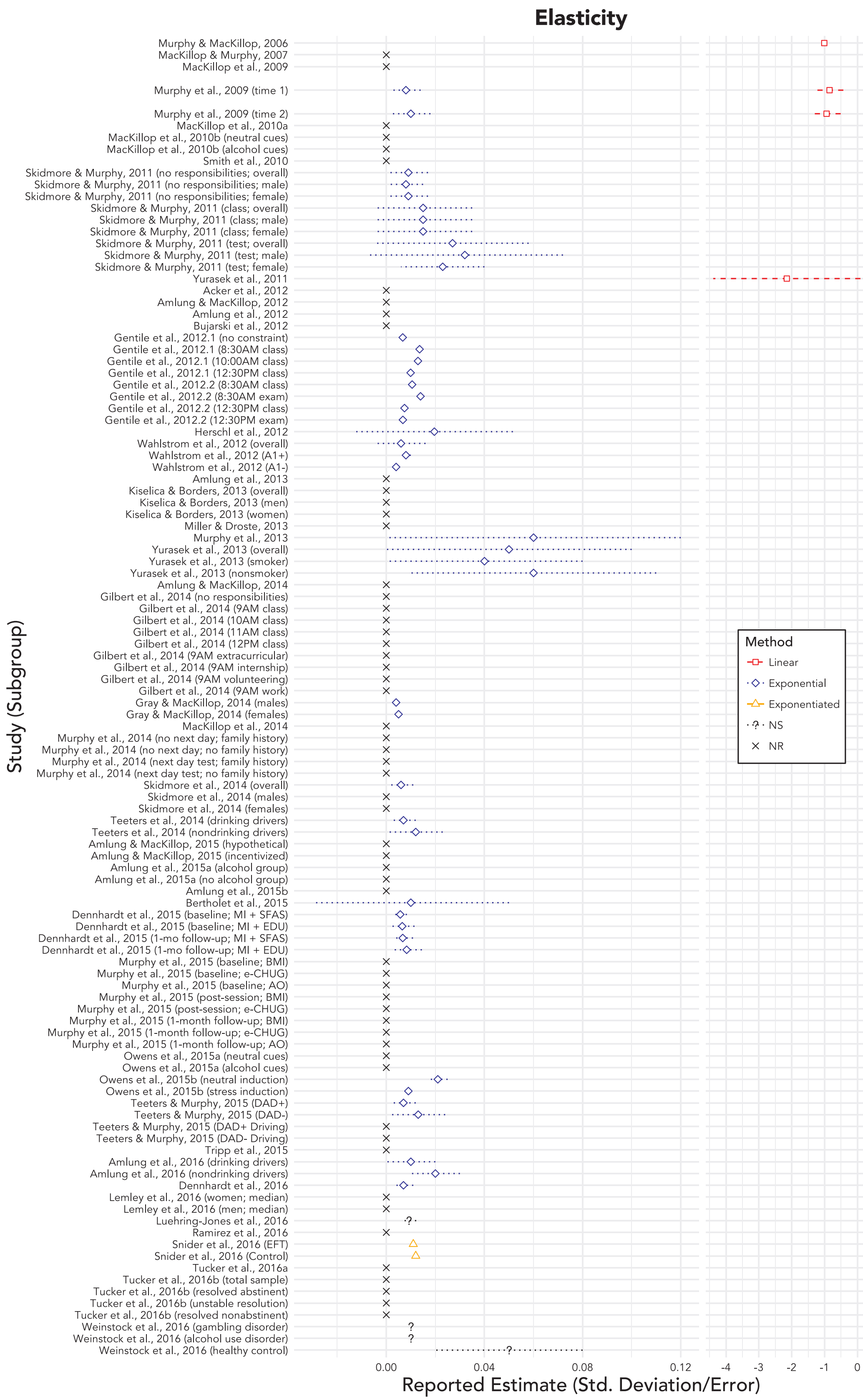

Fig. 4. Estimates of elasticity across studies and subgroups depicted by method of obtaining values. Squares denote Hursh et al.'s (1988) linear elasticity equation; diamonds denote Hursh and Silberberg's (2008) exponential equation; triangles denote Koffarnus et al.'s (2015a) exponentiated equation; ?s denote instances in which the equation was not specified; Xs denote instances that were not reported.

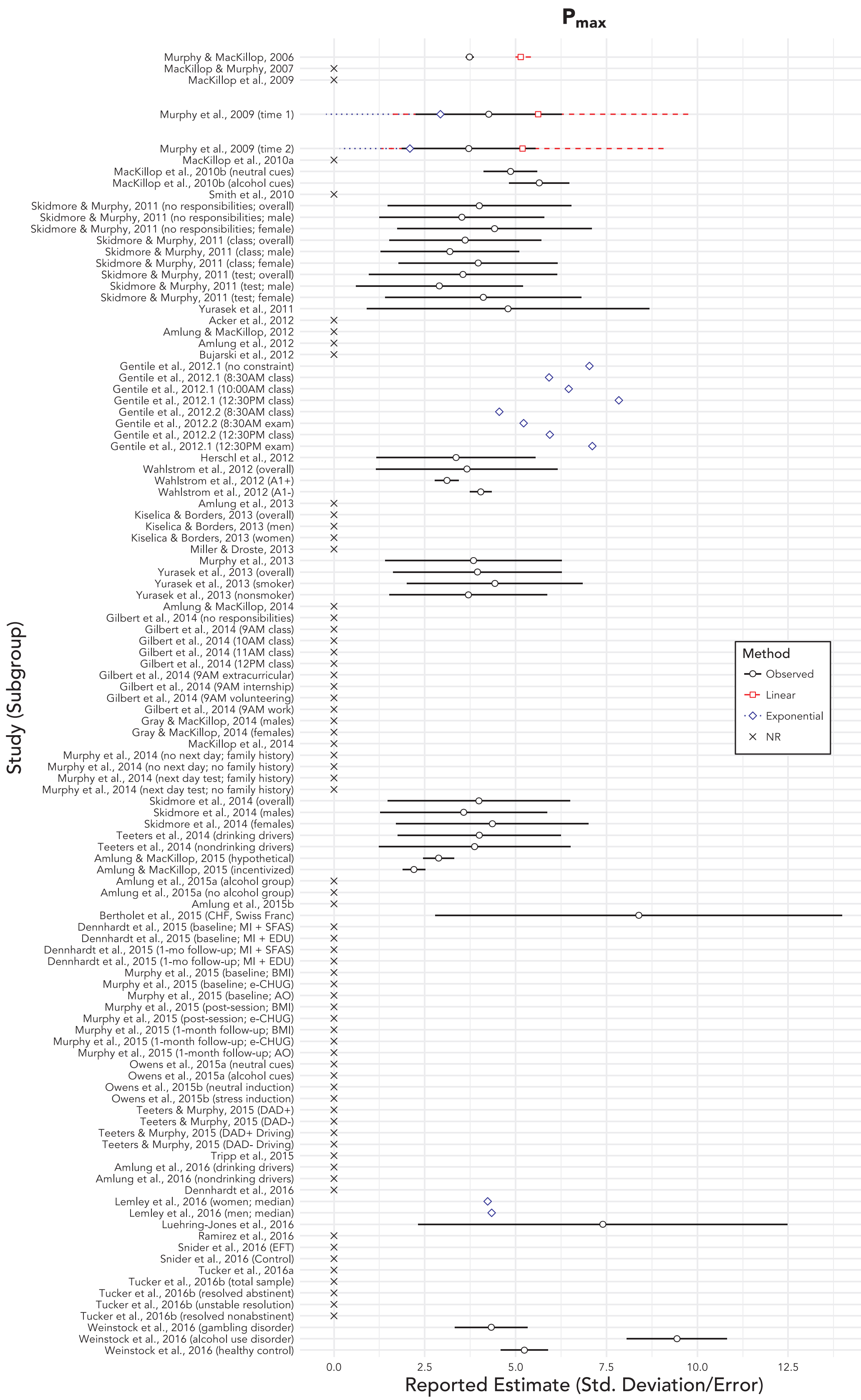

Fig. 5. Estimates of P_{max} across studies and subgroups depicted by method of obtaining values. Circles denote observed; squares denote Hursh et al.'s (1988) linear elasticity equation; diamonds denote Hursh and Silberberg's (2008) exponential equation; Xs denote instances that were not reported.

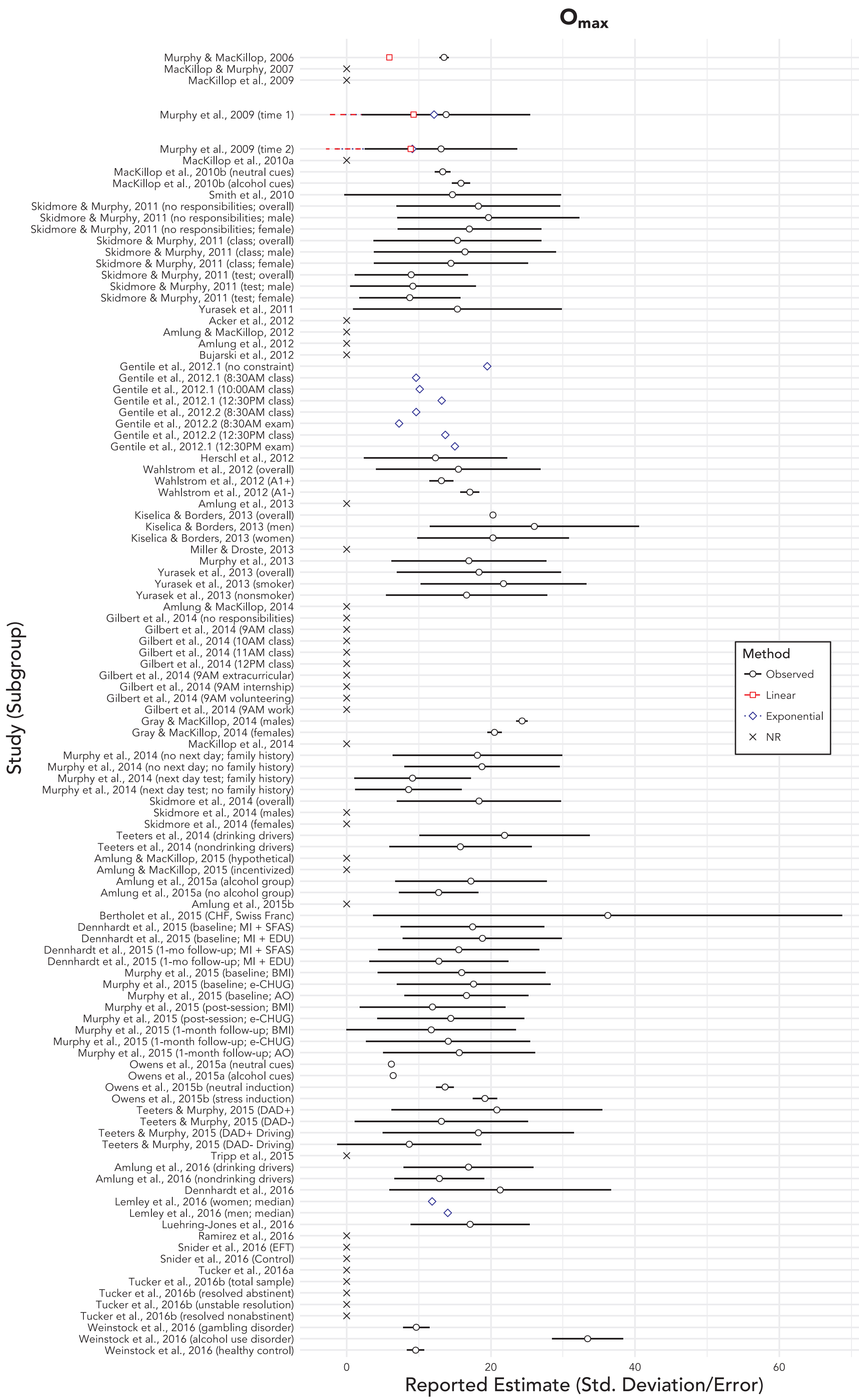

Fig. 6. Estimates of O_{max} across studies and subgroups depicted by method of obtaining values. Circles denote observed; squares denote Hursh et al.'s (1988) linear elasticity equation; diamonds denote Hursh and Silberberg's (2008) exponential equation; Xs denote instances that were not reported.

Table 3
Characteristics of Data Analyses.

Authors (year)	Changes to 0s	*k* (method of obtaining)	Use of Exponential Equation?
Acker et al. (2012)	NR	2.9 (best-fitting *k* from overall mean performance)	Yes
Amlung et al. (2012)	NR	4 (best-fitting *k* from overall mean performance)	Yes
Amlung et al. (2013)	NR	4 (best-fitting *k* from overall mean performance)	Yes
Amlung and MacKillop (2012)	NR	NR	Yes
Amlung and MacKillop (2014)	NR	3 (NR)	Yes
Amlung and MacKillop (2015)	NR	4 (best-fitting *k* from overall mean performance)	Yes
Amlung et al. (2015a)	NR	NR	No
Amlung et al. (2016)	NR	NR	Yes
Amlung et al. (2015b)	Removed	2.6 (best-fitting *k* from overall mean performance)	Yes
Bertholet et al. (2015)	0 - > 0.01	3.5 (NR)	Yes
Bujarski et al. (2012)	NR	NR	Yes
Dennhardt et al. (2015)	NR	NR	Yes
Dennhardt et al. (2016)	NR	4 (shared between all datasets constrained between 0-10)	Yes
Gentile et al. (2012)	$0 - > $0.01	1.482 (IBR's iterative solver and added 0.5)	Yes
Gentile et al. (2012)	$0 - > $0.01	1.822 (IBR's iterative solver)	Yes
Gilbert et al. (2014)	NR	NR	No
Gray and MacKillop (2014)	NR	3.0 (best-fitting *k* from overall mean performance)	Yes
Herschl et al. (2012)	NR	1 (NR)	Yes
Kiselica and Borders (2013)	NR	NR	Yes
Lemley et al. (2016)	NR	1.9 (dividing maximum mean by minimum mean)	Yes
Luehring-Jones et al. (2016)	NR	NR	Unclear
MacKillop et al. (2014)	NR	NR	No
MacKillop et al. (2010a)	Intensity - > 0.001; 0 - > 0.001	NR	No
MacKillop and Murphy (2007)	0 - > 0.01	NR	No; linear
MacKillop et al. (2009)	0 - > 0.01	NR	No
MacKillop et al. (2010b)	0 - > 0.01; $0.00 - > $0.001	NR	No; linear
Miller and Droste (2013)	NR	NR	No
Murphy et al. (2015)	NR	NR	No
Murphy and MacKillop (2006)	0 - > 0.01	NR	No; linear
Murphy et al. (2009)	0 - > 0.01	3.8 (NR)	Yes; and linear
Murphy et al. (2013)	0 - > 0.01	2.834 (derived from mean sample)	Yes
Murphy et al. (2014)	NR	NR	Yes
Owens et al. (2015a)	NR	NR	No
Owens et al. (2015b)	NR	3 (NR; "denotes range of consumption values across individuals")	Yes
Ramirez et al. (2016)	NR	NR	Yes
Skidmore and Murphy (2011)	0 - > 0.01	2.834 (based on average)	Yes
Skidmore et al. (2014)	Removed	2.834 (best-fitting *k* from sample mean)	Yes
Smith et al. (2010)	NR	NR	No
Snider et al. (2016)	NR	NR	No; exponentiated
Teeters and Murphy (2015)	Removed	2.6 (NR)	Yes
Teeters et al. (2014)	Removed	2.6 (NR)	Yes
Tripp et al. (2015)	Removed	2.6 (NR)	Yes
Tucker et al. (2016a)	NR	NR	Yes
Tucker et al. (2016b)	NR	NR	Yes
Wahlstrom et al. (2012)	No BP - > $9	1 (NR; "constant across individuals that denotes range of consumption values in log powers of ten")	Yes
Weinstock et al. (2016)	NR	NR	Unclear
Yurasek et al. (2013)	NR	NR	Yes
Yurasek et al. (2011)	NR	NR	No

Note: NR = Not Reported.
IBR = Institutes for Behavior Resources, Inc.
BP = Breakpoint.

prices increased. The highest price assessed was $1120 as reported by five studies; however, two of these reported analyzing prices up to $70 (e.g., Gray and MacKillop, 2014; Owens et al., 2015b; b).

3.4.3. Vignette

Columns 5–10 in Table 2 detail specific aspects of the vignettes as reported in the studies. In order, study vignettes were categorized as to whether a state or trait vignette was used, the specified situation, how and what drinks were specified, what drinking restrictions were specified, if the study used a vignette manipulation, and if details about a budget were specified. We found the vast majority of studies used a trait-based vignette with most trait-based APTs containing common elements such as specifying the available drinks (e.g., standard size beer [12 oz], wine [5 oz], shots of hard liquor [1.5 oz], or mixed drinks with one shot of liquor), being at a party/bar at night for several hours, and that alcohol was not consumed before and will not be available after leaving the party/bar.

3.5. Data analyses

Figs. 3–6 visually display the reported estimates and associated variability of intensity, elasticity, P_{max}, and O_{max}, respectively, across all studies (including subgroups when reported) reviewed in this paper (see Supplemental Information[1] for all values and R code used to generate the figures). As depicted, the vast majority of demand indices reported were obtained via the observed method and few studies reported indices using multiple methods. For values of intensity, derived measures ($M_{Linear} = 15.13$, $SD_{Linear} = 1.49$,

[1] Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:...

$n_{Linear} = 3$; $M_{Exponential} = 8.29$, $SD_{Exponential} = 3.75$, $n_{Exponential} = 10$; $M_{Exponentiated} = 18.80$, $SD_{Exponentiated} = 3.90$, $n_{Exponentiated} = 2$, $M_{NS} = 7.77$, $n_{NS} = 1$) tended to be higher than those observed ($M_{Observed} = 7.57$, $SD_{Observed} = 2.31$, $n_{Observed} = 86$; except Gentile et al., 2012). We found 14 instances in which intensity was not reported. For elasticity, 58 instances did not report the associated metric. The most common elasticity measure was α derived from the Hursh and Silberberg (2008) exponential demand equation ($M_{Exponential} = 0.015$, $SD_{Exponential} = 0.014$, $n_{Exponential} = 44$). Only two instances reported α from Koffarnus et al.'s (2015a) exponentiated demand equation ($M_{Exponentiated} = 0.012$, $SD_{Exponentiated} = 0.0007$, $n_{Exponentiated} = 2$). Four instances each reported elasticity derived from Hursh et al.'s (1988) linear elasticity equation ($M_{Linear} = -1.24$, $SD_{Linear} = 0.61$, $n_{Linear} = 4$) or did not specify (NS) the equation used ($M_{NS} = 0.0198$, $SD_{NS} = 0.020$, $n_{NS} = 4$).

In terms of P_{max}, we found 65 instances in which the metric was not reported. Observed measures tended be slightly lower ($M_{Observed} = 4.29$, $SD_{Observed} = 1.46$, $n_{Observed} = 35$) compared to derived measures ($M_{Linear} = 5.32$, $SD_{Linear} = 0.26$, $n_{Linear} = 3$; $M_{Exponential} = 5.31$, $SD_{Exponential} = 1.74$, $n_{Exponential} = 12$). For O_{max}, 34 instances did not report this metric and unlike intensity and P_{max}, observed measures tended to be higher ($M_{Observed} = 16.02$, $SD_{Observed} = 5.33$, $n_{Observed} = 66$) than derived ($M_{Linear} = 8.03$, $SD_{Linear} = 1.84$, $n_{Linear} = 3$; $M_{Exponential} = 12.10$, $SD_{Exponential} = 3.29$, $n_{Exponential} = 12$). The discrepancy between certain metrics being reported and others not may be unsurprising as some demand measures tend to be relatively highly correlated (O_{max} and P_{max}; e.g., MacKillop et al., 2009) and, thus, may lead researchers to omit redundant measures in order to reduce risk of Type 1 error. Nonetheless, the values we report here are not restricted to those statistical analyses reported in the studies that could be subject to Type 1 error. That is, we identified and report values here even if the studies used them in a purely descriptive manner (e.g., in a descriptive table).

Table 3 displays information related to data analyses, including modifications to zero values, values of and methods of obtaining the k parameter in the exponential demand equation, and whether the exponential demand equation was used. The k parameter in demand analyses (not to be confused with the k value in delay discounting analyses) denotes the range of consumption in logarithmic units and is intimately tied with the measure of elasticity. Importantly, k can be determined in a number of different ways, such as from the observed range of the data or as a fitted regression parameter.

3.5.1. Software[2]

Eighteen studies did not report any software used. Of the studies that did report software used, many reported using GraphPad Prism (GraphPad Software, La Jolla California USA, www.graphpad.com; $n = 13$). Several reported using either a calculator from or a template from the Institutes for Behavior Resources, Inc. website ($n = 11$; www.ibrinc.org). Other software reported included AMOS, JMP, Mplus, SAS, and SPSS.

3.5.2. Changes to zero values[3]

Thirty-two of the 47 articles did not report any changes to zero values. Five articles reported removing zero values completely. Seven articles reported replacing zero values with .01. One article reported replacing zero values with .001. Three articles explicitly reported changing free price (i.e., $0.00) to either .01 or .001.

3.5.3. Use of exponential equation and k values[4]

Thirty articles reported using the exponential equation (Hursh and Silberberg, 2008). The remaining articles used the linear elasticity model (Hursh et al., 1988), the recent, exponentiated version (Koffarnus et al., 2015a) of the exponential model, or did not use/report a quantitative equation. The following is with respect to aspects of the exponential model. Values of k ranged from 1-4. Nine of the 30 articles using the exponential equation did not report the value of k nor the method of obtaining it. Nine articles reported a k value but did not report the method of obtaining it. The most common method of obtaining k was by finding the best-fit value from the overall mean curve. One article (Gentile et al., 2012) explicitly reported using an iterative solver available from the Institutes for Behavior Resources, Inc. (www.ibrinc.org).

3.5.4. Outliers[1]

Seventeen articles did not report criteria to identify outlying data. Twenty-nine articles specified identifying outliers based on Tabachnick and Fidell's (2001) recommendation of a threshold z-score; 26 of these specified z > = 3.29 SDs and three specified z > = 4.00 SDs.

3.5.5. Exclusions[1]

Twenty-four articles did not describe exclusion criteria for data analysis. Of the remaining articles, exclusion criteria varied greatly. Among the most common criterion was for individual curve fits that resulted in an R^2 less than 0.30, which most commonly was applied to only the elasticity analysis. Other criteria included no consumption (i.e., all zeros), inconsistent responding (e.g., increases in consumption with increases in price), and few responses (e.g., less than five consumption values). Recently, formal methods for identifying nonsystematic purchase task data have been proposed by Stein et al. (2015). Identification is judged against three criteria quantifying trend (i.e., a global reduction in responding), bounce (i.e., threshold for price-to-price increases in responding), and reversals from zero (i.e., any positive number after zeros are reported). These criteria integrate some of the more common exclusion criteria just described; however, do so quantitatively. Given the recency of these criteria, we identified only one study (Snider et al., 2016) that implemented them.

4. Discussion

Results of the current review suggest substantial heterogeneity in APT demographics, methods, and analyses. In terms of demographics, nearly 60% of the articles reviewed used college-aged students as the target demographic. As such, it is unsurprising that the YAACQ was one of the more widely used measures. Additionally, criteria for inclusion and classification of heavy drinking varied (e.g., past-month alcohol use, 5+/4+ drinks/occasion for men/women). In terms of methods, there does not appear to be a standardized vignette nor standardized price sequence. Vignettes varied in their specificity and type, with most being trait-like (e.g., "Imagine that you and your friends are at a bar from 9 p.m. to 2 a.m.") as opposed to state-like (e.g., "Right now"), and

[2] Additional information related to software used and outlier and exclusionary criteria are available from the first author upon request.

[3] Several of the proposed equations (e.g., Hursh et al., 1988; Hursh and Silberberg, 2008) to model demand curve data require logarithmic transformations. Given that the logarithm of zero is undefined, there have been different, but no agreed upon, methods for dealing with these values. Recently developed exponentiated transformations of these aforementioned equations (e.g., Koffarnus et al., 2015a) do not require changing zero values.

[4] As discussed earlier in this paper, there have been a number of proposed equations to quantify the demand curve analyses (Ho et al., 2016; Hursh et al., 1988; Hursh and Silberberg, 2008; Koffarnus et al., 2015a; Liao et al., 2013; Yu et al., 2014; Zhao et al., 2016), with many of these being modifications to the Hursh and Silberberg exponential equation. However, the behavioral economic field has made progress converging on generally accepted methods of quantification and given the dates of the articles reviewed, we chose the exponential equation as the quantitative method to code. For a more comprehensive discussion, we recommend readers consult Hursh and Silberberg (2008).

price sequences and progression sizes varied, with the highest prices between $9 and $1120 per drink. In terms of analyses, there does not appear to be a standardized approach to changing zero values, obtaining *k* values, or using equations. When reported, zero values were changed to 0.01 and 0.001, which represents a difference of an entire log unit. Values of *k* in the exponential equation varied not only in terms of absolute values, but also in the ways they were obtained (e.g., using an iterative solver, based on a best-fit).

With respect to the meta-analysis by Kiselica et al. (2016), our findings suggest their results should be interpreted within the broader context of the variations in methodology, analyses, and demographic samples among the APT articles. One major finding of Kiselica et al. was that 11 of the 20 studies they reviewed demonstrated significant statistical heterogeneity, or the degree of variation in study outcomes between studies that is due to heterogeneity, rather than chance. Our results are consistent with this notion and suggest that reducing variability in methodology and data analysis may reduce statistical heterogeneity, and thus revealing more consistent relations between behavioral economic and alcohol-related measures. Nevertheless, findings from Kiselica et al. suggest the APT demonstrates adequate construct validity by way of its consistent relations with alcohol-related outcomes and more research using the task should be conducted. Moreover, several studies that were not included in their review suggest that APT values uniquely predict change in drinking over time (Dennhardt et al., 2015; Murphy et al., 2015), and drinking and driving (Teeters et al., 2014; Teeters and Murphy, 2015), providing key support for the predictive and clinical validity of alcohol demand.

4.1. Considerations and recommendations

Based on the results of our descriptive review, we provide considerations and recommendations regarding methodological and analytical aspects.

Studies that explicitly provided the vignette description most commonly described the situation as being at a party or a bar with friends at night where standard sized drinks were available for purchase. Vignettes typically included assumptions such as having not drank before the party, that all drinks were for the participant's consumption only, and that drinks were not available elsewhere. However, a number of the studies we identified provided nonspecific descriptions of the task (e.g., "Standard instructions based on previous studies") or did not report any information related to the vignette.

Emerging evidence from the APT literature suggests researchers should take precautions when choosing vignettes. For instance, several studies (Gentile et al., 2012; Gilbert et al., 2014; Skidmore and Murphy, 2011) have found that instruction manipulations that included specifications of next-day activities (i.e., activities the day after the night out drinking; e.g., class, job) altered various measures of demand, including intensity and elasticity (see also Kaplan et al., 2017;Kaplan & Reed, 2018). Additionally, Teeters and Murphy (2015) manipulated whether or not the participant had to drive following a drinking scenario and found individuals who reported a history of driving after drinking reduced their demand under this scenario significantly less than those without a history. Furthermore, referencing a bar or party as the context may not be an ideal scenario for solitary or socially anxious drinkers. Researchers may want to use a modified scenario congruent with an individual's typical drinking context, or experimentally manipulate context in order to quantify its influence (e.g., Murphy et al., 2014). In addition, relatively few studies used state-based vignettes suggesting more research should be conducted examining acute manipulations on alcohol reinforcement. Thus, we recommend, when possible, that researchers report vignettes in their entirety (either in text or in an appendix/supplemental materials) and match vignettes based on the participant population and experimental design.

Towards the goal of standardizing vignette administration, we propose two vignettes (state and trait; see Supplemental Information[5]) for use. We have pulled aspects from various vignettes used in articles reviewed in this paper, as well as from Roma et al. (2016) and believe these vignettes provide good specification (e.g., Imagine that you do not have any obligations the next day), while also being sufficiently generalizable (e.g., Imagine you are in a situation in which you usually drink alcohol). Both vignettes are similar in structure and form but include key aspects relevant to their intended purposes. Finally, we believe including a bulleted list of the main assumptions at the end of the vignette is helpful for reminding the participant of the situation to which they are responding.

Most APTs contained at least 11 prices ranging from free ($0.00) to at least $9.00 and prices were presented in ascending order. Recent research has investigated the effects of different price densities and price progressions on responses on the APT and other purchase tasks generally (Amlung and MacKillop, 2012; Reed et al., 2014; Roma et al., 2016). Mentioned previously, Amlung and MacKillop (2012) found relatively good correspondence between sequential and pseudo-randomized orders of prices. Reed et al. (2014) and Roma et al. (2016) found mixed findings with regard to density of prices in Hypothetical Purchase Tasks. In the former study, Reed and colleagues compared three different price progressions in a hypothetical purchase task for recreational driving. The price progressions consisted of $0.25, $0.50, and $1.00 increments, starting at $0.00 and escalating in ascending order until $15.00. Results indicated neither elasticity (i.e., a), P_{max}, nor breakpoint values differed across the three progression sizes when using all prices in all sequences, and the highest progression size (i.e., $0.25 increments) yielded the smallest variability in the compared demand measures. Roma and colleagues compared three price densities consisting of 5, 9, and 17 prices (i.e., low, medium, high) in a series of Hypothetical Purchase Tasks for commodities including small-ticket (e.g., hamburger/sandwich, roll of toilet paper) and big-ticket (e.g., fine-dining restaurant meal, refrigerator) items. Their results indicated no statistically significant differences in elasticity for all but one of the small-ticket items, yet differences were observed for all of the big-ticket items. To note, lower density prices can yield orderly and very informative demand data (e.g., 4 prices; Koffarnus et al., 2015b).

Within the articles we reviewed, several studies used a doubling response requirement that led to very large non-market prices (e.g., $1120) and found markedly reduced variability or no purchasing at these higher prices. Although consistent with the non-human animal operant paradigms (e.g., progressive-ratio schedules), strict adherence to such price progressions may render an unnecessarily narrow scope. On the other hand, we found some studies used an upper limit of $9 per drink, which may be viable in low cost of living areas, but may result in ceiling effects in more expensive cost of living areas. Thus, in accordance with suggestions by Roma et al. (2016), we recommend that when possible, at least 9 and preferably 17 prices be used when constructing a purchase task, as this will also provide more accurate curve-fitting results. This recommendation closely aligns with the current trends in APT research reviewed here, as we found that the average and most frequently observed number of prices assessed was 17.13 and 17, respectively. In addition, specific prices and price sequences should be balanced to allow for sufficient resolution at and around market price and to avoid potential ceiling effects. Therefore, based on our review of the literature, the findings from Roma et al. (2016), and the considerations posed above, we propose three price sequences to use that range in terms of the number of prices (9, 17, 33; see Table 4).

We recommend displaying these prices in ascending order (as to reduce a potential source of unsystematic variation); however, their presentation could be randomized in studies that require repeated administrations as such procedures may result in rote responding. We note

[5] Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:…

Table 4
Suggested Price Densities.

	Minimal (9 prices)	Ideal (17 prices)	High-resolution (33 prices)
	$0.00	$0.00	$0.00
			$0.01
		$0.05	$0.05
			$0.07
	$0.10	$0.10	$0.10
			$0.20
		$0.25	$0.25
			$0.33
	$0.50	$0.50	$0.50
			$0.75
		$1	$1
			$1.25
	$1.50	$1.50	$1.50
			$1.75
		$2	$2
			$2.50
Median →	$3	$3	$3
			$3.50
		$4	$4
			$4.50
	$5	$5	$5
			$5.50
		$6	$6
			$7
	$8	$8	$8
			$9
		$10	$10
			$12.50
	$15	$15	$15
			$17.50
		$20	$20
			$25
	$30	$30	$30

the middle price sequence (9 prices) is preferred but provide the additional price sequences because we understand there may be different constraints in a research study. For example, if the APT is to be embedded within a larger battery of tasks and participant fatigue or attention is a concern, the shorter price sequence may be preferred. On the other hand, if task length is not a relevant factor or if the research question necessitates a relatively high-resolution analysis (e.g., MacKillop et al., 2012), the longer price sequence may be optimal. Given the suggested trait vignette (also in Supplemental Information[6]) is worded to refer to a typical drinking situation, rather than specifically at a bar where drink prices may be higher, we chose to construct the three progressions around a median price of $3.00 per drink (akin to Roma et al., 2016), which roughly approximates the mean drink price across both retail establishments (e.g., bars) and liquor stores (including online retailers)[7]. We believe these price sequences provide sufficient resolution to capture the full range of demand dynamics.

We raise a final consideration with respect to APT construction. With greater ease and availability of administering the APT via computer (or tablet), as opposed to using paper and pencil, presenting the full price sequence to participants may not be necessary. Although in our review we did not find any studies that explicitly described the following approach, a dynamic APT may be constructed such that the task ends after a participant reports one or two consecutive zeros. Whereas a dynamic APT may serve beneficial to reduce participant burden whilst resulting in similar patterns of responding, this approach may have limitations in terms of complicated programming and reliance on computerized administration. Regardless of approach, a price sequence must be specified *a priori* and at the present time, we are not aware of any research that has compared these two approaches.

For studies that used the exponential demand equation, analyses consisted of replacing zero values with .01 and k was determined by finding the best-fit value from the overall mean curve. In recent years, several equations have been offered to better characterize demand curve data (Ho et al., 2016; Koffarnus et al., 2015a; Liao et al., 2013; Zhao et al., 2016) without the need for certain data transformations (e.g., removing or replacing zero values). In our review, we found only one study (Snider et al., 2016) that used one of these equations (e.g., Koffarnus et al., 2015a; that we found only one instance is in part due to our article search criteria restricting results using the APT and published through the year 2016). The tradeoffs between using these various approaches is an active question in the field and clearly reporting analytic techniques and, preferably, utilizing multiple methods (e.g., Kaplan and Reed, 2018; Strickland et al., 2016) will help further this area of inquiry. Regardless of approach, it is known that values of α (i.e., rate of change in elasticity) in the exponential equation (Hursh and Silberberg, 2008), and derivatives thereof, should not be compared when the k parameter differs (see work by Hursh, 2014; Hursh and Roma, 2016 attempting to remedy this issue). As a result, when k values are not reported, cross-study comparisons such as those in meta-analyses cannot be attempted.

Until recently, rationale and methods for excluding nonsystematic datasets varied including no consumption (i.e., all zeros), inconsistent responding (e.g., increases in consumption with increases in price), and few responses (e.g., less than five consumption values). The recent criteria set forth by Stein et al. (2015) integrate some of these criteria but do so in a quantitative way. We encourage researchers to utilize Stein and colleagues' criteria during initial examination of their data and to report the specific values used (if different from those recommended). Quantification using established criteria may shed insight into state and trait differences (e.g., are underage participants or participants under the influence of alcohol more likely to provide inconsistent data?) and will help future meta-analyses uncover potential sources of reporting bias.

In sum, we recommend researchers carefully consider their analytic techniques, the potential impact they have on the resulting data and ultimately the conclusions, and to report key details regarding the analyses. Such key details would include data transformations, statistical software, equation, k value, and methods by which demand indices are calculated. These demand metrics are most commonly referred to as "observed"/"empirical" and "derived," as mentioned earlier in this paper. Recall that observed measures are computed directly from the participant's responses, and certain metrics (e.g., breakpoint; P_{max}) may be influenced by procedural aspects such as the price progression. Unlike observed measures, derived measures are influenced by analytical aspects such as the equation chosen (and relatedly, the values of certain parameters such as k), modification of zero values, and even relatively nuanced considerations including starting values and regression algorithms. Being clear in how these metrics are computed are of vital importance if one is to compare within or even across studies.

4.2. Limitations

Although this review documented a number of aspects of the APT, several potential sources of bias exist, as well as the field's understanding of the factors affecting alcohol demand. The current review only included studies published in peer-reviewed journals and given the potential utility of the APT in clinical settings, there may be additional outlets that may not have been captured. The seminal article using the APT (i.e., Murphy and MacKillop, 2006) was published 12 years ago

[6] Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:…

[7] Based on findings by DiLoreto et al., (2012), in which they catalogued alcohol prices from physical and online stores across the United States, we determined the average price per drink to be approximately $1.25. We also examined cost of living estimates in various parts of the United States, where price per drink at a retail establishment was reported to be approximately $5 - $6.

and the current review only includes articles through its 10-year anniversary. With more studies utilizing the APT in recent years, there could be even greater variability in the categories we chose to code that is not captured here. We were unable to conduct a formal analysis on the influence of vignette content on resulting metrics because a number of articles did not report the full vignette used (i.e., characterizing an aspect of the vignette as not being used is not the same as an aspect not being reported). As more studies provide the full vignettes used, including vignette manipulations, future research could begin to identify the influence of specific aspects on resulting demand metrics (e.g., sentiment analysis). Relatedly, the research on price progressions did not assess alcohol specifically, so future research may benefit from a within-subject analysis directly testing price progressions using alcohol as the commodity.

As mentioned earlier, we found only one study (Snider et al., 2016) that used an equation (exponentiated; e.g., Koffarnus et al., 2015a) other than the linear or exponential. More research directly comparing the adequacy of these different equations, especially within the context of alcohol, is needed to fully understand how demand measures may be systematically affected. Similarly, we found a little less than half the studies reported software used for analysis and of those studies that did contain this information, none reported using open source software. Given parameter estimates derived from nonlinear regression techniques are sensitive to aspects such as fitting algorithms, starting values, and convergence criteria (Bates and Watts, 1988), it may be possible that biases in demand metrics exist as a result of different software used. Reporting software used and utilizing open source software packages (e.g., Kaplan, 2018; Gilroy et al. (accepted)) will enhance transparency and may allow for identification of such biases if they exist. Finally, we chose to restrict the review to purchase tasks specifically using alcohol as the commodity. This in and of itself is a source of bias, given the numerous other variations of the purchase task (e.g., cigarettes, marijuana).

5. Conclusions

Use of the APT continues to increase and we have provided a systematic review of the procedures thus far. Our goal is not to make definitive statements with respect to how variations in procedures and analyses affect relations with alcohol-related outcomes. Rather, the goal is to elucidate the various ways in which the APT has been administered and its responses analyzed. We hope this review is helpful in guiding researchers using or considering to use the APT in their research. In addition, this review may serve beneficial as the field aims to decide on standardized APT construction approaches. Such a task would require additional methodological research on the influence of APT characteristics such as vignette framing and demand analytic considerations such as zero values modifications and quantification (i.e., demand models). There also appears to be relatively minimal research using community-based samples as most of the research to date has relied predominately on university students. Additional insight into relations between demand indices and clinically-relevant outcomes may be gleaned with greater focus on more diverse participant samples. For purposes of reproducibility, general advancement of the field, and examining APT relations with alcohol-use measures, we urge researchers to clearly report even nuanced details regarding the experimental arrangement, especially as it applies to implementation of the APT.

Contributors

Brent Kaplan and Derek Reed contributed to the design of this project. Brent Kaplan and Rachel Foster were involved in data collection and analysis. All authors participated in manuscript preparation, and all authors have approved the final version of the manuscript.

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Conflict of interest

No conflict declared.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2018.06.029.

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