Behavioral Economic Measurement of Cigarette Demand:

A Descriptive Review of Published Approaches to the Cigarette Purchase Task

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Abstract

The Cigarette Purchase Task (CPT) is a behavioral economic method for assessing demand for cigarettes. Growing interest in behavioral correlates of tobacco use in clinical and general populations as well as empirical efforts to inform policy has seen an increase in published articles employing the CPT. Accordingly, an examination of the published methods and procedures for obtaining these behavioral economic metrics is timely. The purpose of this investigation was to provide a review of published approaches to using the CPT. We searched specific Boolean operators (["behavioral economic" AND "purchase task"] OR ["demand" AND "cigarette"]) and identified 49 empirical articles published through the year 2018 that reported administering a CPT. Articles were coded for participant characteristics (e.g., sample size, population type, age), CPT task structure (e.g., price framing, number and sequence of prices; vignettes, contextual factors), and data analytic approach (e.g., method of generating indices of cigarette demand). Results of this review indicate no standard approach to administering the CPT and underscore the need for replicability of these behavioral economic measures for the purpose of guiding clinical and policy decisions.

Keywords: behavioral economics, cigarettes, demand, nicotine, purchase task

Public significance statement: This systematic review describes wide variability in researchers' published accounts of cigarette purchase task structures for assessing behavioral economic demand for nicotine/tobacco. While standardized approaches to simulating cigarette purchasing is proposed, research on procedural variations identified in this review is warranted.

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The field of behavioral economics employs tools and concepts from microeconomics and operant psychology to study decision-making (Hursh & Roma, 2016; Reed, Kaplan, & Becirevic, 2015). Within behavioral economics, operant demand analyses provide a quantitative account of the degree to which both non-humans and humans will defend consumption of a commodity in the face of increasing constraints (Hursh, 1980, 1984, 2014). Over the past 40 years, behavioral pharmacologists have increasingly relied on operant frameworks to understand drug-seeking behavior (Aston & Cassidy, 2019; Bickel, Degrandpre, & Higgins, 1993; Hursh, 1991). When applied to substance abuse, operant demand provides a framework to understand drug consumption in the face of increasing operant responses, resource expenditure, or time, each of which can be conceptualized as price. These markers of demand conceptually map onto known behavioral indicators of substance use disorders (Amlung, Gray, & MacKillop, 2017; Bickel, Johnson, Koffarnus, MacKillop, & Murphy, 2014; Jarmolowicz, Reed, DiGennaro Reed, & Bickel, 2016; Zvorksy et al., 2019), where demand in these applications is defined as the quantity of a drug reinforcer consumed or purchased across a range of prices.

Behavioral economic tasks simulating purchasing behavior provide an efficient, ethical, and safe means of experimentally evaluating operant demand for addictive substances in humans (see discussions by Jacobs & Bickel, 1999; Roma, Reed, DiGennaro Reed, & Hursh, 2017) relative to actual drug delivery studies (see review by Carter & Griffiths, 2009). The Cigarette Purchase Task (CPT; González-Roz et al., 2019) is a behavioral economic simulation that asks individuals to report their estimated cigarette consumption across a range of hypothetical monetary costs and is an adapted complement to what can be time- and labor-intensive

procedures used in experimental drug self-administration studies (see review by Higgins, Bickel, & Hughes, 1993). Operant demand assays modeled under these conditions are valuable tools for assessing pharmacological abuse potential as well as the effectiveness of manipulations designed to reduce consumption of harmful addictive substances.

There is broad consensus and a dense literature base supporting economic constraints as a prominent means of tobacco control with respect to both in-vivo laboratory nicotine-administrations studies (Cassidy & Dallery, 2014; Higgins, Heil et al., 2017a; Higgins, Heil et al., 2017b; Madden & Bickel, 1999; Shahan, Bickel, Madden, & Badger, 1999) and as applied to policy (Chaloupka, Straif, Leon, & Working Group, International Agency for Research on Cancer, 2011; Chaloupka & Warner, 2000; Chaloupka, Yurekli, & Fong, 2012; Madden & Bickel, 1999). Purchase tasks typically involve reports of *estimated* consumption in simulated markets (Roma, Hursh, & Hudja, 2015); however, controlled research suggests equivalence between reported consumption for hypothetical cigarettes and demand assays producing real cigarettes (Wilson, Franck, Koffarnus, & Bickel, 2016). Moreover, the relationship between repeated administrations of the CPT appears to be robust (Few, Acker, Murphy, MacKillop, 2012), providing support for the temporal stability of the task. The efficacy of pricing manipulation to alter cigarette use thereby renders the CPT a promising behavioral economic tool for informing clinical and policy-level decisions (Hursh & Roma, 2013; MacKillop et al., 2012; Roma et al., 2017).

Demand metrics obtained from the CPT demand indices appear to be significantly related to clinically important variables and outcomes (see review of these relations in González-Roz et al., 2019 and Zvorsky et al., 2019), such as the Heaviness of Smoking Index (Higgins et al., 2018), nicotine dependence (Chase, MacKillop, & Hogarth, 2013), concurrent

psychiatric/psychological disorders (Secades-Villa et al., 2017), prospective use (Heckman et al., 2018), and cessation outcomes (MacKillop et al., 2016). Indeed, two recent meta-analyses examining published CPT studies indicates CPT indices – particularly, intensity, O_{max}, and elasticity – are significantly related to smoking (González-Roz et al., 2019; Zvorsky et al., 2019); it is thereby unsurprising that the Consortium on Methods Evaluating Tobacco has begun explicitly recommending the use of behavioral economic demand approaches – including purchase tasks – to inform US FDA regulations (Berman et al., 2018), and that Tobacco Centers of Regulatory Science (a collaborative research effort between NIH and FDA) use these approaches to guide their policy-informing research (Higgins et al., 2019; Perry et al., 2019).

The most common version of the CPT employs a *trait-based* approach (González-Roz et al., 2019), typically including a vignette asking participants to imagine a typical day in which they smoke or to make choices as though smoking according to their usual habits. The purpose of trait-based CPTs is to provide an overall measure of the reinforcing value of cigarettes to the individual while holding other contextual factors constant (Kaplan et al., 2018). Researchers and clinicians aiming to examine motivation to purchase cigarettes following an acute experimental manipulation may use *state-based* versions of the CPT that typically include instructions asking individuals to focus on the way they are currently feeling or to imagine they have access to their preferred brand of cigarettes at that moment. Metrics derived from a state-based approach are useful ways to measure constructs like craving, affect, and arousal (Kaplan et al., 2018).

The CPT and the analogous Alcohol Purchase Task (APT; Murphy & MacKillop, 2006; Kaplan et al., 2018) share numerous similarities across structural and methodological domains. Both the CPT and APT emerged as efficient tools to safely and accurately assess substance users' demand for commodities of abuse, and both tasks exhibit adequate psychometric

performance, both with respect to reliability and validity as indicated by relations to existing clinical tools or behavioral measurements (see González-Roz et al., 2019; Kaplan et al., 2018). An additional similarity is that numerous versions and iterations of these tasks presently exist in the literature, thereby complicating meta-analyses or comparative reviews across studies. While Kaplan et al. synthesized the APT literature and cataloged procedural differences, no such review of task variations presently exists for the CPT. Recent meta-analyses of CPT indices' relation to smoking identified a wide range of prices used in the CPT, as well as variability in the price densities and structure of the task (González-Roz et al., 2019; Zvorsky et al., 2019). Given the focus on clinical relations between CPT indices and smoking, these meta-analyses did not provide details on the CPT structural components, nor did they discuss other aspects of the CPT structure such as vignettes and their assumptions, as well as the unit price framing of the product.

It is well documented that structural components of a purchase task yield significantly different demand indices (see Kaplan et al., 2018; Roma et al. 2015, 2017). As discussed by Kaplan et al., structural components of the APT modulate demand indices and the heterogeneity of APT attributes potentially obfuscate meta-analytic findings (e.g., Kiselica, Webber, & Bornolova, 2016). Given recent meta-analytic attempts to understand relations between CPT demand indices and smoking (González-Roz et al., 2019; Zvorsky et al., 2019), as well as the growing number of published studies employing the CPT and recent proposals to use this approach to inform nicotine and tobacco regulations, there is a critical need to document the extent to which methods of administering this tool vary in systematic ways. Contemporary reviews of the CPT indicate wide variability in the task structure (González-Roz et al., 2019), but no such catalog or review detailing these differences presently exists. The purpose of this review was to provide a narrative evaluation of CPT procedures (i.e., vignette instructions and

assumptions, unit price densities/structures and framing) and to use such findings to inform the proposal of a standardized CPT protocol to better prepare data for meta-analytic evaluation or clinical comparisons between studies.

Methods

The research team registered this review with the international prospective register of systematic reviews (PROSPERO 2018 CRD42018085565) and conducted the review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations (Moher, Liberati, Tetzlaff, Altman, & Group, 2009).

Search Strategy

The search included the following literature databases in September 2019: PsycINFO (ProQuest), PubMed, and Web of Science. Publication dates were specified through the year 2018. Searching "cigarette purchase task" as a complete phrase (i.e. using quotation marks) eliminated relevant articles, so that search was not used. The final literature search included the following key terms and Boolean operators: (behavioral economic* AND purchase task*) OR (demand AND cigarette*).[1] The combined searches yielded 802 unique results after removing duplicates.

Criteria for study inclusion. The search included any peer-reviewed, original empirical study of any human population, using any intervention, exposure or descriptive study, regardless of experimental design in clinical, community, online, or academic settings as long as it included use of a CPT involving hypothetical outcomes. We excluded studies that solely used an experimental tobacco marketplace and those that only reanalyzed data from other studies. In addition, we excluded studies solely using non-cigarette purchase tasks (e.g. alcohol, cannabis, e-

[1] Note that a more thorough search strategy (see Supplemental Materials 1 document) yielded the same overall results; we thereby report the simplest search strategy for ease of replication.

cigarettes). The search included no limits to language of included studies, although the CPT is a relatively new measure, which limited the scope of published studies.

Coding categories. The second and third authors independently coded each article for procedural and structural characteristics of the CPT instrument (number of prices, prices specified, units assessed [e.g., per cigarette, per cigarette w/yoked pack, per puff], quantity purchased, and vignette and/or instructions). Inter-rater reliability was assessed for 33% of the articles, resulting in 96.8% agreement between raters. Discrepancies between coded items were resolved through discussion between the first, second, and third authors until reaching consensus.

Results

Meta-information

Year. Twelve articles were published between the years 2008 and 2013 and another 37 articles between 2014 and 2018. In sum, the number of articles featuring a CPT has more than tripled in each 5-year period since 2008.

Articles. Forty-nine articles met inclusion criteria. Articles featuring the CPT appeared most frequently in *Nicotine and Tobacco Research* (29%; *n* = 14), *Psychopharmacology* (18%; *n* = 9), *Experimental and Clinical Psychopharmacology* (10%; *n* = 5), and *Drug and Alcohol Dependence* (10%; *n* = 5). Other notable journals included *Addiction* (8%; *n* = 4), *Journal of the Experimental Analysis of Behavior* (4%; *n* = 2), and *Addictive Behaviors* (4%; *n* = 2). The following journals each featured article count of *n* = 1: *American Journal of Health and Behavior, JAMA Psychiatry, BMJ, Journal of Behavioral Medicine, Journal of Psychopharmacology, Scientific Reports, New Zealand Journal of Psychology,* and *Tobacco Control.*

Mode and Method of Administration

Forty-one percent (n = 20) of the articles reported solely providing a computer-delivered version of the CPT, with 16% (n = 8) of these articles using an online-crowdsourced sample (Amazon Mechanical Turk: 10%; n = 5; Online Global Market Insite, Inc: 6%; n = 3). Fourteen percent (n = 7) of the articles reported collecting written responses and one article collected both written and computer-rendered CPT responses (Higgins, Reed et al., 2017). A single article reported administering the CPT through MRI-compatible presentation goggles and a response box (Gray et al., 2017), while an additional article reported providing each participant a Personal Digital Assistant (PDA) to complete the CPT remotely (Schlienz et al., 2014). The remaining 39% (n = 19) articles did not explicitly report the mode of administering the CPT.

Seventy-one percent (n = 35) of the articles reported administering the CPT in person and 22% (n = 11) reported administering the task remotely. An additional article reported that some participants completed the CPT in an outpatient clinic while the remaining sample completed the task at home (Higgins, Reed et al., 2017) and another article (Schlienz et al., 2014) reported that participants completed the CPT from home each morning using an experimenter-provided PDA. A single article (González-Roz et al., 2018) did not report whether CPT completion occurred in person or remotely.

Structural Characteristics of the CPT

Vignette and instructions. Forty-seven percent (n = 23) of the articles reported using *trait-based* instructions (e.g., asking participants to make choices based on their typical smoking habits without explicitly referencing their current state or any experimentally imposed establishing operations), with 21 of these trait-based these articles beginning with a vignette asking participants to *"Imagine a typical day…*" and the remaining two articles beginning with "*If you were smoking today according to your typical habits…"* **(**Murphy et al., 2017), or asking

participants to "*respond based on your current smoking habits…*" (Koffarnus, Wilson, & Bickel, 2015). Twelve percent (*n* = 6) of articles reported priming participants with *state-based* instructions (i.e., a more present-focused method where participants are asked to choose based on their current mood or state of physiological arousal). One of these six state-based articles reported asking participants to *"Think about how you're feeling right now…*" and vignettes in the remaining five articles respectively asked participants to *"Imagine that you could smoke right now…*" (*n* = 3), "*Imagine that you could smoke your favorite cigarettes right now…*" (*n* = 1; MacKillop & Tidey, 2011), and "*The following questions ask how many cigarettes you would purchase at various prices, if they were offered to you right now*" (Hindocha, Lawn, Freeman, & Curran, 2017). Forty-three percent (*n* = 21) of articles did not explicitly report whether individuals were asked to respond to the items on the CPT as they would on a typical day (trait-based) or to first consider their present mood or level of craving before responding (state-based).

Assumptions. Forty-nine percent (*n* = 24) of articles provided participants with instructions to respond as though the cigarettes were their *favorite* (*n* = 19) or *preferred* (*n* = 5) brand, while 12% (*n* = 6) of articles instructed participants to respond as though the cigarettes were their *usual* (*n* = 5) or *typical* (*n* = 1) brand. One article (Wall et al., 2018) specified the brand was the session cigarette experienced by the participants prior to completing the CPT and the remaining 37% (*n* = 18) of articles reported no information about the quality of the cigarettes specified in the instructions. With respect to financial assumptions, 47% (*n* = 23) of articles specified participants in the purchasing scenario should respond based on their present income and/or savings, while 4% (*n* = 2) asked participants to consider their financial circumstances (Johnson et al., 2017), or to respond based on their existing resources (Tucker, Laugesen, & Grace, 2018). Four percent (*n* = 2) of the articles provided participants a $10 "tab" with which to

"purchase" cigarettes, and one article (Koffarnus, Wilson, & Bickel, 2015) assessed cigarette demand across four different income conditions. Forty-three percent (*n* = 21) of the articles did not report specifying any financial constraints to the participants. Fifty-three percent (*n* = 26) of the articles reported instructing participants to imagine that they could not access cigarettes or other nicotine products outside of the experimental context. One article specified that other cigarettes or tobacco were unavailable (Stein, Tegge, Turner, & Rush, 2018), and 8% (*n* = 4) of the articles specified only that other cigarettes (*n* = 5) or other sources of tobacco (*n* = 1; Tucker, Kivell, Laugesen, & Grace, 2017) were unavailable. For one article participants were informed that the prices listed were the same as all cigarettes available from any source (Madden & Kalman, 2010) and additional article told participants that "*You will be asked to only use cigarettes you purchase during this task for the next week…*" (Koffarnus, Wilson, & Bickel, 2015). Thirty-one percent (*n* = 15) of the articles did not report whether participants were instructed to imagine there would be no access to other forms of nicotine/tobacco. Thirty-three percent (*n* = 16) of the articles reported that all cigarettes purchased had to be smoked *on that* day, 10% (*n* = 5) of the articles indicated that purchases were for either *a single day* (*n* = 3)*, one day* (Wilson, Franck, Koffarnus, & Bickel, 2016), or that cigarettes must be smoked *within a day* (O'Connor, Bansal-Travers, Carter, & Cummings, 2012). An additional article reported asking participants how many cigarettes they would smoke *each day* (Madden & Kalman, 2010). Eight percent (*n* = 4) of the articles indicated *at this time*, 6% (*n* = 3) of the articles reported restricting the time frame to *a 3-h period*, 10% (*n* = 5) extended the time frame to *24 h*, and one article specified the cigarettes purchased were to be smoked *in the next week* (Koffarnus, Wilson, & Bickel, 2015). Thirty-one percent (*n* = 15) did not report specifying a time frame in which to consume cigarettes purchased in CPT. Fifty-nine percent of the articles (*n* = 29) explicitly stated

that cigarettes purchased could not be saved, stockpiled, or given away; 49% (*n* = 20) did not report whether participants were informed they could not save/stockpile/give away the cigarettes purchased.

Number of prices. Figure 2 depicts the prices assessed in published demonstrations of the CPT through the year 2018. The number of prices reported ranged from 4 (Koffarnus, Wilson, & Bickel, 2015) to 73 (Few, Acker, Murphy, & MacKillop, 2012; MacKillop, Few et al., 2012) and featured maximum prices ranging from $1.00 (e.g., Snider, Cummings, & Bickel, 2017) to $1,120 (e.g., Murphy et al., 2011). We coded price densities as low (< 9 prices; 6%; *n* = 3), medium (9 – 19 prices; 47%; *n* = 23) and high (> 19 prices; 45%; *n* = 22). Eighty-eight percent of the articles (*n* = 43) reported beginning the price sequence at $0.00 (thus, providing an empirical measure of demand when the commodity is free), 6% (*n* = 3) of the articles reported beginning the sequence at $0.01, one study at (£) 0.02 (Chase, MacKillop, & Hogarth, 2013), and another study at $0.12 (Koffarnus, Wilson, & Bickel, 2015). One article did not report the prices assessed (Higgins, Heil et al., 2017a).

Price structure. Fifty-seven percent (*n* = 27) of the articles reported exposing participants to prices in an ascending sequence, while a single article (Gray et al., 2017) arranged a quasirandom price sequence; this article along with six others presented each price on a single page. The remaining 43% (*n* = 21) of articles did not explicitly report whether prices were ascending, descending, or randomized.

Price framing. The majority of articles reported framing prices as either *per cigarette* (59%; *n* = 29) or *per cigarette* with the *yoked price per pack* (33%; *n* = 16). Four percent (*n* = 2) of articles used puffs as the units of consumption (per puff, Johnson et al., 2017; per 10 puffs, Wall et al., 2018), and the remaining 4% (*n* = 2) of the articles did not report price framing.

Seventy-eight percent of the articles (n = 38) reported a unique combination of structural parameters (e.g., vignettes, instructions/assumptions, number and type of prices, and response mode). We identified four versions of the CPT shared among the remaining articles and each variant differed with respect to the structural characteristics outlined in the preceding sections. We note, however, that the uniqueness of the CPT characteristics identified in this review are solely dependent upon information provided (or referenced) in the articles.

Conclusion

The purpose of the present review was to catalog the various methods employed when measuring cigarette demand using the CPT and to use these data to inform a standardized CPT task. Our data suggest that no standard approach has evolved with respect to administering this assessment, corroborating the recent review by González-Roz et al. (2019). The majority of studies we reviewed employed a close variant of the trait-based CPT used in MacKillop et al. (2008); however, differences in the hypothetical timeframe in which to smoke the cigarettes (e.g., "right now" or "on this day") and openness of economy (e.g., no availability of *any* alternative nicotine products versus only no availability of other cigarettes) could alter reported consumption. Published demonstrations of the CPT varied most notably in the number of prices assessed, with maximum prices across articles ranging from $1.00 - $1,200. Researchers and clinicians should be weary of ceiling effects when the maximum price is still relatively low. In addition, not only does cigarette price vary between states (and countries) due to factors such as excise taxes, if history is any indication cigarette price may very well increase in the future suggesting the use of CPT prices high enough to make longitudinal comparisons. Another challenge concerning price structure are the step sizes, where differential effects on reported consumption may occur as a function of a rapidly increasing price progression (Kaplan et al.,

2018). As researchers begin to meta-analyze CPT data and as policymakers begin to use CPT indices to inform regulations, these procedural differences potentially present major roadblocks in the generality of CPT findings.

Given the wide variability in published approaches to the CPT, we offer several recommendations that may provide consistency and aid in efforts to integrate and replicate findings. Beginning with the vignette, priming participants with state-based instructions may hinder efforts to replicate across populations, especially given the wide variability in samples recruited. State-based instructions may be useful, however, when administering the CPT following antecedent manipulations (e.g., episodic future thinking, priming). Toward this end, researchers and clinicians should consider whether their aims are to characterize the overall reinforcing value of cigarettes (trait-based) or to measure the effects of acute experimental manipulations like nicotine deprivation or satiation (state-based).

Several studies in the APT literature have found manipulating aspects of the vignette or instructions can produce changes in demand (Murphy et al., 2014; Teeters & Murphy, 2015). With respect to *openness of economy*, we recommend clearly stating there will be no access to other cigarettes or alternative sources of nicotine. The inferred availability of nicotine electronic cigarettes or nicotine replacement therapies (e.g., nicotine lozenges, gum, patches) in the choice scenario may differentially influence responses across individuals. Another important consideration is the *timeframe to consume* presented choice scenario. Several studies provided participants with potentially ambiguous temporal windows in which to consume the chosen cigarettes (*"at this time," "on that day"*). Toward this end, we recommend clearly specifying the number of hours in which participants are hypothetically permitted to consume and that they may not share, save, or stockpile the cigarettes they choose. See the Supplemental Materials 2

document associated with this article for examples of state- and trait-based CPT vignettes incorporating the aforementioned details.

In accordance with the procedures reported in this review, a sentence asking, "how many cigarettes would you purchase and consume at $0.00 (free)?" with an ascending price for each question should follow the vignette. With respect to the prices assessed in the CPT, evidence suggests low-density price structures (< 9 prices) are vulnerable to distortion insofar as generating less elasticity, and consequently higher essential value (Roma, Hursh, & Hudja, 2015). We note, however, that emerging evidence suggests that a 14-price CPT demonstrates adequate reliability and may be an efficient alternative (González-Roz, Secades-Villa, Weidberg, Muñiz, & MacKillop, 2019). We further note that 33% of articles contained yoked price per pack along with the per cigarette price. The inclusion of yoked price per pack may be beneficial for disadvantaged populations who may need to consider such pricing information within their budgetary constraints. To date, we are aware of no CPT studies comparing how inclusion of the yoked price per pack affects demand elasticity – such information seems critical for understanding the need or effects of yoked pricing. Collectively, the current paucity of research on price framing approaches (e.g., yoked price per pack) and specific pricing sequences or density variations, along with with the variability in pricing structures observed in this review (see Figure 1), underscores the need for further analyses of pricing influences on demand (cf. González-Roz et al.).

The present review and synthesis of the extant publications employing the CPT advances the literature in four distinct and important ways. First, this review was registered with PROSPERO and follows the 2009 PRISMA guidelines for preferred reporting items in systematic reviews. Approach this review in this manner is advantageous in that it reduces biased

reporting in the review through public provision of our planned methods, offsets duplicative efforts by other researchers interested in this topic, and ultimately enhances readers' confidence in our findings (see also Stewart, Moher, & Shekelle, 2012). Moreover, similar efforts by other researchers (González-Roz et al., 2019). and for other purchase tasks (Kaplan et al., 2018) share these attributes, rendering our review an objective complement to their findings.

Second, this review complements and extends the work of both González-Roz et al. (2019) and Zvorsky et al. (2019) to provide a thorough overview of CPT methods, approaches, and analyses. These existing reviews provide a comprehensive account of CPT analyses and conducted meta-analyses on the degree to which CPT demand indices related to smoking, but ultimately acknowledge that the heterogeneity of methods renders comparison difficult. While structural reviews of the CPT were outside the scope of these meta-analyses, these were the focus of our review. The information gleaned by our review provides researchers with a catalog of procedures used by other laboratories and for particular samples. Such information can be used to inform replication or extension studies, or to identify gaps in the literature (e.g., prices yet to be assessed, price framing manipulations yet to be used, vignette manipulations yet to be tested).

Third, the catalogued CPT methods and structures yielded by this review complements the APT review by Kaplan et al. (2018). Collectively, the APT and CPT are two of the most widely and commonly used purchase tasks in the behavioral economic literature (see Aston & Cassidy, 2019). However, purchase tasks are emerging for many other substances and behavioral addiction commodities, such as cannabis (e.g., Aston, Metrik, & MacKillop, 2015), pornography (Mulhauser, Short, & Weinstock, 2018), opioid medication (e.g., Schwartz et al., 2019), internet use (Acuff, MacKillop, & Murphy, 2018), food (Epstein, Dearing, & Roba, 2010) and ultraviolet

indoor tanning (Reed, Kaplan, Becirevic, Roma, & Hursh, 2016), as well as for issues such as sustainability (e.g., Kaplan, Gelino, & Reed, 2018) and medication adherence (e.g., Jarmolowicz et al., 2019a,b). Given the relatively large research corpora on APT and CPT – both with respect to procedural manipulation effects and psychometric performance – providing researchers with the extant catalog of these purchase task variations, structures, and forms may help spur the continued development and refinement of novel purchase tasks.

Finally, we believe the strongest contribution of this review is the proposal of standardized CPTs for both state- and trait-based inquiries of cigarette demand. The information gleaned from this review identified substantial overlap in many CPT attributes. Our proposed vignettes, assumptions, and price structuring are the synthesis of the most commonly used attributes, as well as promising but under-researched components (such as specifications of available substitutes, timeframes of consumption, or instructional prompts). These proposed CPTs would permit the most generality across existing studies and could standardize future cigarette demand studies across labs and populations. We also view these proposed tasks as potential templates for research focusing specifically on procedural manipulations to better understand the impact of particular components of the task (e.g., timeframe, openness of economy) on cigarette demand; such data would help elucidate the basic behavioral economic processes invoked in CPT studies and related to nicotine consumption.

We note several limitations that readers should consider regarding this review. First, our results contain only the information reported in the articles. Certain structural characteristics of the CPT (e.g., presenting the yoked price per pack) may have been present during the original investigation, yet not reported in the final manuscript. Second, we limited our review to combustible cigarettes only. As vaping continues to increase in prevalence among youth and

young adults (see Levy et al., 2018), researchers have begun developing and investigating e-cigarette demand using CPT-like tasks (e.g., Cassidy, Tidey, Colby, Long, & Higgins, 2017). A review of such procedures will be warranted as more e-cigarette tasks emerge in the literature. Second, this review specifically targeted *hypothetical* CPTs. Some paradigms exist in which actual cigarette smoking/demand is assessed across increasing effort requirements/prices and experienced outcomes (e.g., Heckman et al., 2017; Wilson et al., 2014), but these differ substantively from CPTs in both form and function – the differences are enough that they are inappropriate to aggregate in reviews such as this. Third, we did not meta-analyze these data to determine relative effects of CPT attributes on demand. The sheer variability in samples and procedures leaves insufficient power to explore nuanced influences of task components on demand; such inquiries are best left for specific experimentation. Moreover, the recent publication by González-Roz et al. (2019) already provides general meta-analytic data on the CPT's relation to smoking.

In sum, the CPT is useful and psychometrically sound tool to measure behavioral economic demand for combustible cigarettes (González-Roz et al., 2019; Zvorsky et al., 2019). The success of the CPT is evidenced in its widespread application and the increasing rate of CPT papers in the literature. However, much like its alcohol counterpart (i.e., the APT; Kaplan et al., 2018), there is substantive heterogeneity in the formal attributes of the CPT; such variations may hinder aggregation of studies or generality of study outcomes. This systematic review catalogs the differences in CPT structures in the extant literature and arrives at a proposed CPT to potentially standardize practices amongst labs. These findings will aid future research in the CPT, as well as other purchase tasks, and may subsequently advance our understanding of the behavioral economics underlying issues of societal concern.

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Table 1. *Structural Characteristics of the CPT*

Authors (year)	Price Framing	Number of Prices	Prices Specified ($USD/Cigarette unless specified)	Instructions/Assumptions	Mode of Administration
Chase, MacKillop, & Hogarth (2013)	Per cigarette with yoked pack price	39	£0.02, £0.04, £0.06, £0.08, £0.10, £0.12, £0.14, £0.16, £0.18, £0.20, £0.22, £0.24, £0.26, £0.28, £0.30, £0.32, £0.34, £0.36, £0.38, £0.40, £0.42, £0.44, £0.46, £0.48, £0.50, £0.52, £0.56, £0.58, £0.60, £0.70, £0.80, £0.90, £1, £1.50, £2, £2.50, £3, £4, and £5	• Imagine a TYPICAL DAY during which you smoke • TYPICAL BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed ON THAT DAY; cannot save/stockpile for a later date • Pay close attention to the prices and costs per pack because they change by different amounts	Paper/pencil; in person
Dahne, Murphy, & MacPherson (2017)	Per cigarette with yoked pack price	48	0.00 (Free), 0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55, 060, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1, 1.05, 1.10, 1.15, 1.20, 1.25, 1.30, 1.35, 1.40, 1.45, 1.50, 1.55, 1.60, 1.65, 1.70, 1.75, 1.80, 1.85, 1.90, 1.95, 2, 3, 4, 5, 6, 7, 8, and 9	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed ON THAT DAY; cannot save/stockpile for a later date • Be sure to consider each price increment carefully	NR; in person
Farris, et al. (2017a)	Per cigarette with yoked pack price	22	0.00, 0.01, 0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10	• Imagine you could smoke RIGHT NOW • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products	Computer; in person

				• Cigarettes must be consumed AT THIS TIME; cannot save/stockpile for a later date • Be sure to consider each price increment carefully	
Farris et al. (2017b)	Per cigarette with yoked pack price	22	0.00, 0.01, 0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10	• Imagine you could smoke RIGHT NOW • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed AT THIS TIME; cannot save/stockpile for a later date • Be sure to consider each price increment carefully	Computer; in person
Few, Acker, Murphy, & MacKillop (2012)	Per cigarette with yoked pack price	73	0.00 - 0.50 (increments of 0.01), 0.50 – 1 (increments of 0.04, with the exception of 0.98 – 1), 1 – 10 (increments of 1)	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed ON THAT DAY; cannot save/stockpile for a later date • Be sure to consider each price increment carefully	Paper/pencil; in person
González-Roz et al. (2018)	Per cigarette with yoked pack price	19	€0.00, €0.01, €0.02, €0.05, €0.10, €0.25, €0.50, €1, €2, €3, €4, €5, €10, €20, €50, €100, €250, €500, and €1,000.	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now	NR

				• No access to other cigarettes or nicotine products • Cigarettes must be consumed ON THAT DAY; cannot save/stockpile for a later date • Please respond to these questions honestly	
Grace, Kivell, & Laugesen (2015a)	Per cigarette with yoked pack price for factory-made cigarettes; yoked pouch (30 g or 50 g) for roll-your-own (RYO) cigarettes	64	Factory-made: NZ$0.00 – 2.50 (increments of 0.05); 2.50 – 4.90 (increments of 0.20); 4.90 – 5 (increment of 0.10) RYO: NZ$0.00 – 214 (30 g); NZ$0 – $357 (50 g)	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed ON THAT DAY; cannot save/stockpile for a later date • Be sure to consider each price increment carefully	NR; in person
Grace, Kivell, & Laugesen (2015b)	Per cigarette with yoked pack price for factory-made cigarettes; yoked pouch (30 g or 50 g) for roll-your-own (RYO) cigarettes	64	Factory-made: NZ$0.00 – 2.50 (increments of 0.05); 2.50 – 4.90 (increments of 0.20); 4.90 – 5 (increment of 0.10) RYO: NZ$0.00 – 214 (30 g); NZ$0 – $357 (50 g)	NR; adapted from MacKillop et al. (2008)	Paper/pencil; in person
Grace, Kivell, and Laugesen (2015c)	Per cigarette (yoked pack price not	64	Factory-made: NZ$0.00 – 2.50 (increments of 0.05); 2.50 – 4.90 (increments	NR; adapted from MacKillop et al. (2008); referred reader to Grace, Kivell, & Laugesen (2015a) for more information	Paper/pencil; in person

	explicitly reported)		of 0.20); 4.90 – 5 (increment of 0.10) RYO: NZ$0.00 – 214 (30 g); NZ$0 – $357 (50 g)		
Gray et al. (2017)	Per cigarette with yoked pack price	22	0.00, 0.01, 0.02, 0.03, 0.04, 0.05, 0.09, 0.10, 0.14, 0.15, 0.19, 0.20, 0.21, 0.22, 0.23, 0.24, 0.25, 0.26, 0.28, 0.29, 0.30, 0.34, 0.35, 0.40, 0.50, 1, 2, 2.50, 5, and 10; participants had a $10 cigarette "tab"	• $10 cigarette "tab" • PREFERRED BRAND • Each trial consisting of a 6-s "*Consider*" period and a ≥ 7-s "*Choose*" period • Moved green box to desired number of cigarettes with right hand and submitted response with left hand	MRI-compatible stimulus presentation system; choices made with MRI-compatible response box
Green & Ray (2018)	Per cigarette	25	0.00, 0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.60, 0.70, 0.80, 0.90, 1, 1.20, 1.40, 1.60, 1.80, 2, 4, 6, 8, and 10.	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed ON THAT DAY; cannot save/stockpile for a later date	NR; in person
Heckman et al. (2018)	Per cigarette	8	Average market price (0.30) × 0.00, 0.5, 1, 1.5, 2, 5, 10, and 20	• Imagine FOR THE NEXT 24 HOURS only ordinary factory-made cigarettes are available • No access to other nicotine products • Average price for an ordinary factory-made cigarette is [0.50 (CA)/ 0.30 (US)/ £0.40 (UK)/ 0.90 (AU)]	Computer; online

Higgins, Heil et al. (2017a)	NR	NR	NR	NR	Computer; in person
Higgins, Heil et al. (2017b)	Per cigarette with yoked pack price	20	0.00, 0.02, 0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 1, 2, 3, 4, 5, 10, 20, and 40	• Same income/savings you have now • No access to other cigarettes or nicotine products • Can smoke without restrictions for the next 24 hours • Cigarettes must be consumed AT THIS TIME; cannot save/stockpile for a later date	Computer; in person
Higgins, Reed et al. (2017)	Per cigarette with yoked pack price	19	0.00, 0.02, 0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 1, 2, 3, 4, 5, 10, and 20	• Think about how you are feeling RIGHT NOW • USUAL BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed WITHIN 24 HOURS; cannot save/stockpile for a later date • Can smoke without restrictions for the next 24 hours • Be sure to consider each price increment carefully	Computer; in person; paper/pencil when completed at participant's home
Hindocha, Lawn, Freeman, & Curran (2017)	Per cigarette	23	£0.00, £0.01, £0.02, £0.05, £0.10, £0.15, £0.20, £0.30, £0.40, £0.50, £0.75, £1, £1.50, £2, £2.50, £3, £3.50, £4, £5, £7.50, £10, £15, and £20	• How many cigarettes would you smoke if they were_____ each?" • Hypothetical cigarettes were to be "consumed" within the next 3 hours	NR; in person

Hitsman et al. (2008)	Per cigarette	16	£0.00, £0.01, £0.05, £0.13, £0.25, £0.50, £1, £3, £6, £11, £35, £70, £140, £280, £560, and £1,120	• Hypothetical cigarettes were to be "consumed" within the next 3 hours	NR; in person
Johnson, Johnson, Rass, & Pacek (2017)	Per puff	9	0.01, 0.03, 0.10, 0.30, 1, 3, 10, 30, and 100	• Participants asked to imagine a TYPICAL DAY in which they could use only the specified commodity • PREFERRED BRAND • Only form of nicotine/tobacco available for the next 24 hours • Consider your financial circumstances • Treat individual prices as separate 24-hour periods (puffs purchased must be "consumed" prior to purchasing puffs at a different price) • Puffs may not be saved or given away • All Puffs purchased must be consumed within a 24-hour period	Computer; online (MTurk)
Koffarnus, Franck, Stein, & Bickel (2015)	Per cigarette	9	0.00, 0.10, 1, 3, 10, 30, 100, 300, and 1,000	• How many cigarettes would you purchase and consume in A SINGLE DAY if the price per cigarette was…	Computer; online (MTurk)
Koffarnus, Wilson, & Bickel (2015)	Per cigarette	4	0.12, 0.25, 0.50, and 1	• Purchase enough cigarettes for THE NEXT WEEK based on your current smoking habits • PREFERRED BRAND • Four experimenter-provided income conditions • One purchasing scenario randomly selected as "real," whereby participants actually received the cigarettes chosen	Computer; in person

Lawn et al. (2018)	Per cigarette	22	£0.00, £0.01, £0.02, £0.05, £0.10, £0.15, £0.20, £0.25, £0.30, £0.35, £0.40, £0.45, £0.50, £0.60, £0.70, £0.80, £0.90, £1, £2, £3, £4, and £5	• Imagine you could smoke RIGHT NOW AND FOR THE NEXT 3 HOURS. • FAVORITE BRAND. • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes cannot be saved/stockpiled after 3 hours is up	NR; in person
Liao et al. (2013)	Per cigarette	19	0.00, 1, 5, 13, 25, 50, 1, 2, 3, 4, 5, 6, 11, 35, 70, 140, 280, 560, and 1,120	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed on THAT DAY; cannot save/stockpile for a later date	Computer; online
MacKillop et al. (2012a)	Per cigarette	22	0.00, 0.02, 0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10	• $10 cigarette “tab” • One response randomly selected randomly selected as “real,” whereby participants actually received the cigarettes chosen	Computer; in person
MacKillop et al. (2012b)	Per cigarette with yoked pack price	73	0.00 – 0.50 (increments of 0.01), 0.50 – 1 (increments of 0.10), 1.00 – 5.00 (increments of 0.01), 5.00 – 35.00 (increments of 5)	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products	Paper/pencil; in person

				• Cigarettes must be consumed on THAT DAY; cannot save/stockpile for a later date • Please respond to these questions honestly	
MacKillop, Murphy, Martin et al. (2016)	Per cigarette with yoked pack price	41	0.00 – 0.50 (increments of 0.02), 0.50 – 1 (increments of 0.10), 1 – 5 (increments of 1), 5 – 35 (increments of 5)	• NR; adapted from MacKillop et al. (2008)	NR; in person
MacKillop, Murphy, Ray et al. (2008)	Per cigarette	19	0.00, 0.01, 0.05, 0.13, 0.25, 0.50, 1, 2, 3, 4, 5, 6, 11, 35, 70, 140, 280, 560, and 1,120	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed on THAT DAY; cannot save/stockpile for a later date • Please respond to these questions honestly	Computer; in person
MacKillop & Tidey (2011)	Per cigarette	19	0.00, 0.01, 0.05, 0.13, 0.25, 0.50, 1, 2, 3, 4, 5, 6, 11, 35, 70, 140, 280, 560, and 1,120	• Imagine that you could smoke your FAVORITE cigarettes RIGHT NOW • Assume you would smoke every cigarette you request; cannot stockpile for a later date or bring home with you	NR; in person
Madden & Kalman (2010)	Per cigarette	26	0.00, 0.01, 0.05, 0.13, 0.15, 0.25, 0.35, 0.50, 1, 1.50, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 11, 35, 70, 140, 280, 560, and 1,120.	• Report the number of cigarettes [you] would smoke EACH DAY if a single cigarette cost… • Report only the cigarettes [you yourself] would smoke	NR; in person

				• Price listed is the same as all cigarettes available from any source	
McClure, Vandrey, Johnson, & Sitzer (2013)	Per cigarette	18	0.01, 0.05, 0.10, 0.3, 0.5, 1, 2, 3, 4, 5, 6, 11, 35, 70, 140, 280, 560, and 1,120	NR	NR; in person
Murphy, MacKillop, Martin et al. (2017)	Per cigarette	41	0.00 – 0.50 (increments of 0.02), 0.50 – 1 (increments of 0.10), 1 – 5 (increments of 1), 5 – 35 (increments of 5)	• If you were smoking today according to your typical habits, how many cigarettes would you smoke at the following prices? • FAVORITE BRAND • Assume that you have the same income/savings that you have now • No access to any cigarettes or nicotine products • Cigarettes must be consumed on THAT DAY; cannot save/stockpile for a later date	NR; in person
Murphy, MacKillop, Tidey, Brazil, & Colby (2011)	Per cigarette	26	0.00, 0.01, 0.05, 0.13, 0.25, 0.35, 0.50, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 11, 35, 70, 140, 280, 560, and 1,120	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed on THAT DAY; cannot save/stockpile for a later date • Please respond to these questions honestly	NR; in person

O'Connor, Bansal-Travers, Carter, & Cummings (2012)	Per cigarette	19	0 – 1,120 (no progression specified)	• Imagine a TYPICAL DAY • MENTHOL CIGARETTES • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed WITHIN A DAY; cannot save/stockpile for a later date • Asked to respond honestly *_Note_: Participant instructions reported only for menthol cigarettes	Computer; online (Global Market Insite)
O'Connor, Heckman et al. (2016)	Per cigarette	12	0.00, 0.01, 0.05, 0.13, 0.25, 1, 2, 3, 4, 5, 6, and 11	• USUAL BRAND • No access to other cigarettes • Cigarettes must be consumed OVER 24 HOURS	Computer; online (Global Market Insite/Lightspeed)
O'Connor, June et al. (2014)	Per cigarette	18	0.00, 0.01, 0.05, 0.13, 0.25, 1, 2, 3, 4, 5, 6, 11, 35, 70, 140, 280, 560, and 1,120	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed on THAT DAY; cannot save/stockpile for a later date • Please respond to these questions honestly	Computer; online (Global Market Insite)
Schlienz, Hawk, Tiffany, O'Connor, & Mahoney (2014)	Per cigarette	19	0.00, 0.01, 0.05, 0.13, 0.25, 0.50, 1, 2, 3, 4, 5, 6, 11, 35, 70, 140, 280, 560, and 1,120	NR; adapted from MacKillop et al. (2008)	Stylus pen on a Personal Digital Assistant; natural environment

Secades-Villa, Pericot-Valverde, & Weidberg (2016)	Per cigarette	19	€0.00, €0.01, €0.02, €0.05, €0.10, €0.25, €0.50, €1, €2, €3, €4, €5, €10, €20, €50, €100, €250, €500, and €1,000	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed on THAT DAY; cannot save/stockpile for a later date • Please respond to these questions honestly	NR; in person
Secades-Villa et al. (2018)	Per cigarette	19	€0.00, €0.01, €0.02, €0.05, €0.10, €0.25, €0.50, €1, €2, €3, €4, €5, €10, €20, €50, €100, €250, €500, and €1,000	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed on THAT DAY; cannot save/stockpile for a later date • Please respond to these questions honestly	NR; in person
Smith et al. (2017)	Per cigarette with yoked pack price	17	0.00, 0.02, 0.05, 0.10 – 1.00 (increments of 0.10), 1 – 5 (increments of 1)	• USUAL BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed WITHIN 24 HOURS; cannot save/stockpile for a later date • You can smoke without any restrictions for the next 24 hours	NR; in person

Smith et al. (2018)	Per cigarette	21	0.00, 0.01, 0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.60, 0.70, 0.80, 0.90, 1, 2, 3, 4, and 5	• TYPICAL DAY • No access to other cigarettes or nicotine products	NR; in person
Snider, Cummings, & Bickel (2017)	Per cigarette	5	0.00, 0.12, 0.25, 0.50, and 1	• Purchasing cigarettes for your own consumption • No access to other cigarettes • Cigarettes must be consumed WITHIN 24 HOURS • cannot stockpile or give away	Computer; online (MTurk)
Stein, Tegge, Turner, & Bickel (2018)	Per cigarette	13	0.00, 0.03, 0.06, 0.12, 0.25, 0.50, 1, 2, 4, 8, 16, 32, and 64	• USUAL BRAND • No access to other cigarettes or tobacco products • Cigarettes must be consumed WITHIN 24 HOURS; cannot give away	Computer; online (MTurk)
Strickland, Lile, Rush, & Stoops (2016)	Per cigarette	19	0 – 1,120 (no progression directly specified)	• Imagine a TYPICAL DAY during which you smoke • No access to other cigarettes • Cigarettes must be consumed in A SINGLE DAY	Paper/pencil; in person
Strickland & Stoops (2017)	Per cigarette	16	0.00, 0.01, 0.05, 0.13, 0.25, 0.50, 1, 2, 3, 4, 5, 6, 11, 35, 70, and 140	• Imagine a TYPICAL DAY *over the last month* during which you smoke • USUAL BRAND • No access to other cigarettes • Cigarettes must be consumed in A SINGLE DAY	Computer; online (MTurk)

Tucker, Kivell, Laugesen, & Grace (2017)	Per cigarette with yoked pack price for factory-made cigarettes; yoked pouch (30 g or 50 g) for roll-your-own (RYO) cigarettes	64	Factory-made: NZ$0.00 – 2.50 (increments of 0.05), 2.50 – 4.90 (increments of 0.20), and 5 RYO: NZ$0.00 – 214 (30 g); NZ$4 – $357 (50 g)	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed on THAT DAY; cannot save/stockpile for a later date Please respond to these questions honestly	Paper/pencil; in person
Tucker, Laugesen, & Grace (2018)	Per cigarette with yoked pack price for factory-made cigarettes; per pouch (30 g) for roll-your-own (RYO) cigarettes	20	Factory made: NZ$0.00 – 2 (increments of 0.20), 2 – 5 (increments of 1), 5 – 20 (increments of 2.5), and 25 RYO: NR	• TYPICAL DAY • Existing resources • No access to other sources of tobacco • No stockpiling	NR; in person
Wall et al. (2018)	Per 10 puffs	16	0.00, 0.01, 0.02, 0.04, 0.08, 0.16, 0.32, 0.64, 1.28, 2.56, 3.84, 5.12, 6.40, 7.68, 8.96, and 10.24	NR; adapted from Jacobs & Bickel (1999)	Computer; in person
Weidberg et al. (2018)	Per cigarette	19	€0.00, €0.01, €0.02, €0.05, €0.10, €0.25, €0.50, €1, €2, €3, €4, €5, €10, €20, €50, €100, €250, €500, and €1,000	• Imagine a TYPICAL DAY during which you smoke • FAVORITE BRAND • Same income/savings you have now • No access to other cigarettes or nicotine products • Cigarettes must be consumed ON THAT DAY; cannot save/stockpile for a later date	NR; in person

				• Please respond to these questions honestly	
Wilson, Franck, Koffarnus, & Bickel (2016)	Per cigarette	15	0.01, 0.05, 0.13, 0.2, 0.5, 1, 3, 6, 11, 35, 70, 140, 280, 560, and 1,120	• If individual cigarettes cost ____: How many would you buy for one day? • *After entering a response, the program would read:* *"You would buy [quantity] cigarettes for one day if they cost [$] each?"* • *Participant would then click "Yes" or "Change Answer" to continue.*	Computer; in person
Zhao et al. (2016)	NR	19	0.00, 0.01, 0.05, 0.13, 0.25, 0.50, 1, 2, 3, 4, 5, 6, 11, 35, 70, 140, 280, 560, and 1,120	*NR; adapted from Jacobs and Bickel (1999)	Computer; online

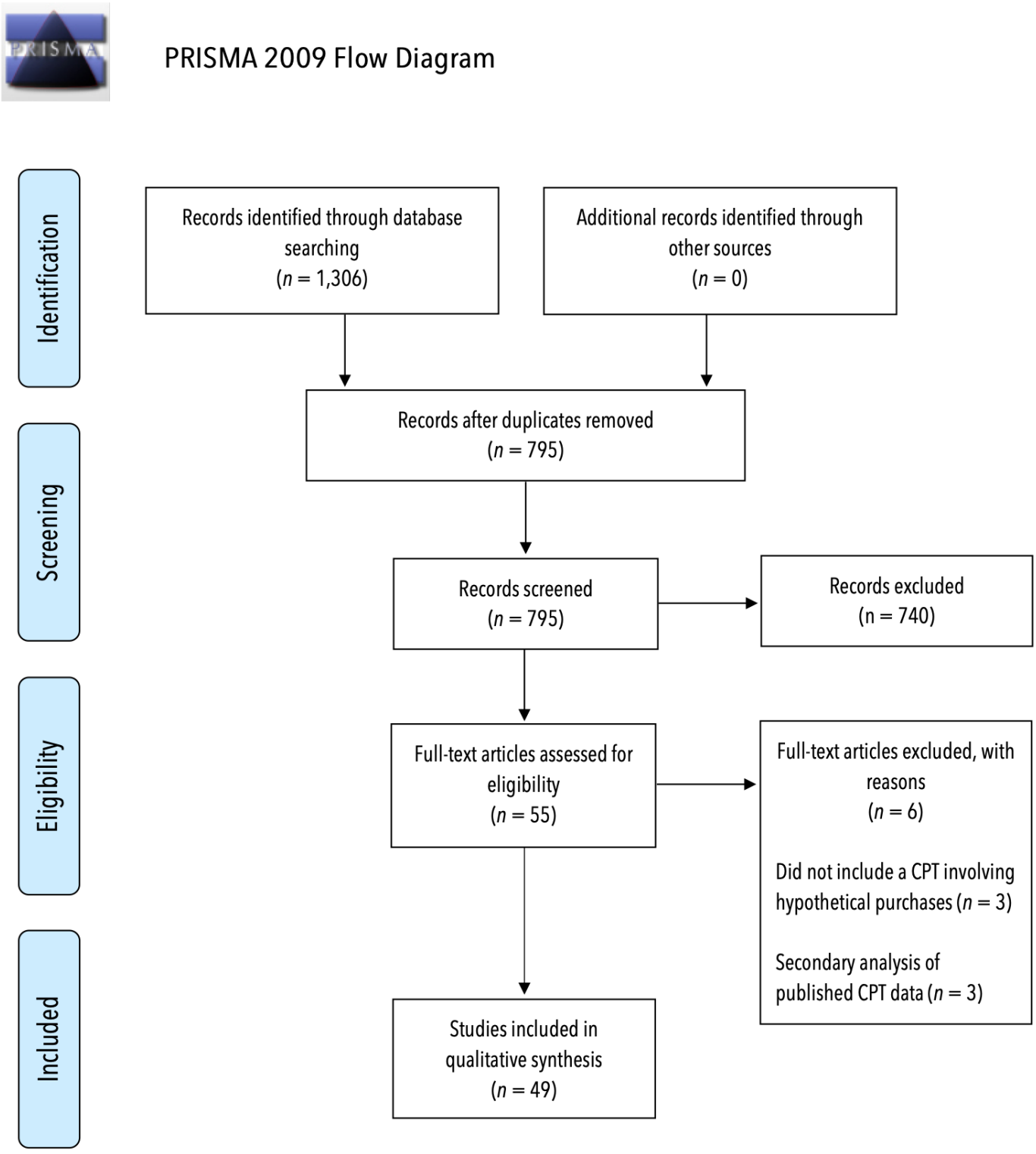

Figure 1. Preferred reporting items for systematic reviews and meta-analyses flow diagram.

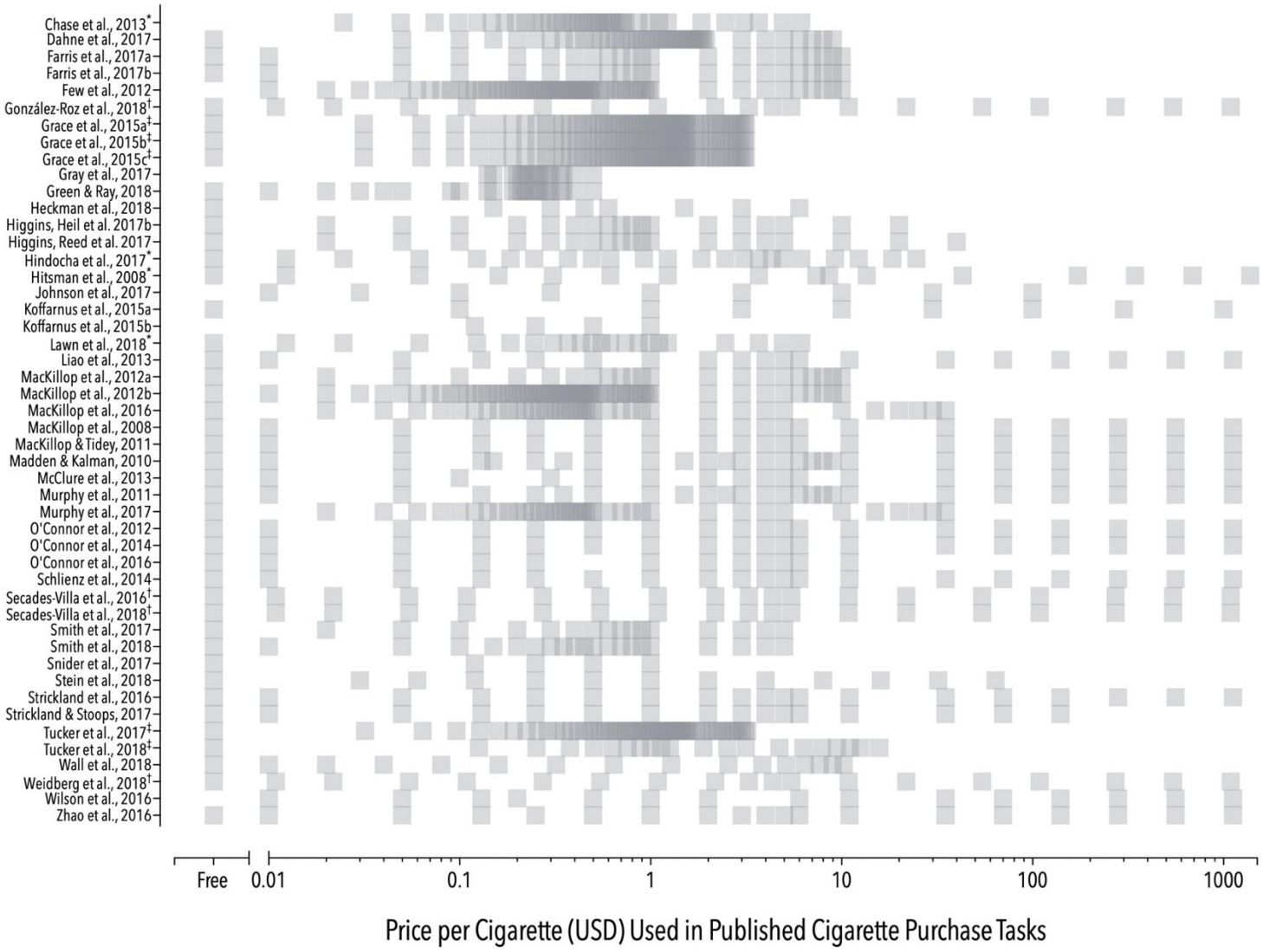

Figure 2. Distribution plot of prices (in USD; plotted along the x-axis on a logarithmic scale) assessed in each of the published CPTs included in this review (organized alphabetically along the y-axis). Semi-transparent gray boxes represent inclusion of associated prices in the CPT.
Note: * = converted from £; † = converted from €; ‡ = converted from NZ