Use Patterns, Beliefs, Experiences, and Behavioral Economic Demand of Indica and Sativa Cannabis: A Cross-Sectional Survey of Cannabis Users

Dennis J. Sholler[1], **Meghan B. Moran**[2], **Sean B. Dolan**[1], **Jacob T. Borodovsky**[3], **Fernanda Alonso**[2], **Ryan Vandrey**[1], **Tory R. Spindle**[1]

[1]Behavioral Pharmacology Research Unit, Johns Hopkins University School of Medicine

[2]Department of Health, Behavior and Society, Johns Hopkins University Bloomberg School of Public Health

[3]Department of Biomedical Data Science, Dartmouth Geisel School of Medicine

Abstract

Cannabis products available for retail purchase are often marketed based on purported plant species (e.g., "indica" or "sativa"). The cannabis industry frequently claims that indica versus sativa cannabis elicits unique effects and/or is useful for different therapeutic indications. Few studies have evaluated use patterns, beliefs, subjective experiences, and situations in which individuals use indica versus sativa. A convenience sample of cannabis users ($n = 179$) was surveyed via Amazon Mechanical Turk (mTurk). Participants were asked about their prior use of, subjective experiences with, and opinions on indica versus sativa cannabis and completed hypothetical purchasing tasks for both cannabis subtypes. Participants reported a greater preference to use indica in the evening and sativa in the morning and afternoon. Participants were more likely to perceive feeling "sleepy/tired" or "relaxed" after using indica and "alert," "energized," and "motivated" after using sativa. Respondents were more likely to endorse wanting to use indica if they were going to sleep soon but more likely to use sativa at a party. Hypothetical purchasing patterns (i.e., grams of cannabis purchased as a function of escalating price) did not differ between indica and sativa, suggesting that demand was similar. Taken together, cannabis users retrospectively report feeling different effects from indica and sativa; however, demand generally did not differ between cannabis subtypes, suggesting situational factors could influence whether someone uses indica or sativa. Placebo-controlled, blinded studies are needed to characterize the pharmacodynamics and chemical composition of indica and sativa cannabis and to determine whether user expectancies contribute to differences in perceived indica/sativa effects.

Keywords

cannabis; indica; sativa; cross-sectional survey; behavioral economics

Cannabis legalization has greatly expanded in recent years. In the U.S., cannabis is presently legal for medicinal purposes in 36 states and for nonmedicinal ("recreational") purposes in 15 states and the District of Columbia, and many countries beyond the U.S. have also legalized both medicinal and nonmedicinal cannabis use. Because of these changes and growing interest in the therapeutic use of cannabis, an expansive cannabis industry has emerged. The retail cannabis marketplace contains a diverse array of products that vary with respect to the intended route of administration, formulation, and/or chemical composition, such as the ratio of the two primary cannabis constituents: 9-tetrahydrocannabinol, THC, and cannabidiol, CBD (Spindle et al., 2019; Steigerwald et al., 2018).

Consumers and retailers commonly dichotomize cannabis products based on two species of the cannabis plant: "indica" and "sativa" (Hazekamp et al., 2016; Piper, 2018). Indica and sativa cannabis allegedly elicit different effects due to variations in classes of compounds found in cannabis (e.g., cannabinoids, terpenes, and flavonoids). There is some empirical evidence supporting that these two species do indeed contain different amounts of certain cannabis constituents. For example, various studies have analyzed commercially available cannabis labeled as "indica" or "sativa" and found that indica samples contained greater concentrations of myrcene and hydroxylated terpenes while sativa samples contained greater terpinolene, 3-carene, and several sesquiterpenes (Hazekamp et al., 2016), but indica and sativa samples generally contained similar concentrations of major cannabinoids (i.e., THC and CBD; Elzinga et al., 2015; Fischedick et al., 2010; Hazekamp & Fischedick, 2012; Hazekamp et al., 2016). Though these few studies suggest some indica and sativa products may be distinguishable by terpene content, there is presently no consensus, operational definition of "indica" or "sativa" based on chemical composition. Moreover, scientific commentaries (Piomelli & Russo, 2016) have called into question whether the indica/sativa nomenclature meaningfully distinguishes retail cannabis products given rampant "cross-breeding" between the plant species and general lack of standardization in the cannabis industry. Despite skepticism from the scientific community, cannabis retailers and marketing communications often allege that these two species will elicit different therapeutic and/or nontherapeutic effects. For example, sativa products are said to produce an energizing or uplifting "high" and are more likely to be recommended for depression or to stimulate appetite (Haug et al., 2016; Piper, 2018). Conversely, indica products are thought to elicit sedative and relaxing effects and are more likely to be recommended or used for anxiety, pain, and insomnia (Cohen et al., 2016; Haug et al., 2016; Piper, 2018).

Despite the ubiquity of the indica and sativa nomenclature, virtually all prior survey studies of cannabis users have inquired about the use of cannabis broadly without specifying species, with only a few exceptions. Three studies that surveyed medicinal cannabis users inquired about indica versus sativa use (Cohen et al., 2016; Pearce et al., 2014; Piper, 2018). Pearce et al. (2014) recruited 95 medicinal cannabis users for a web-based survey regarding health symptoms, conditions, and purpose for using indica and sativa. Indica was

preferred for pain management, sedation, and sleep while sativa was preferred for euphoria and enhancing energy (Pearce et al., 2014). Cohen et al. (2016) recruited 163 medicinal cannabis users from a dispensary in California who were using cannabis specifically for either chronic pain or other common indications (e.g., anxiety and insomnia); individuals who used cannabis for chronic pain were more likely to use indica over sativa (Cohen et al., 2016). Piper (2018) surveyed 455 medicinal cannabis patients from New England to quantify the number of unique cannabis strains available and to determine if certain strains were preferred for specific health conditions. Qualitative responses revealed that many participants preferred using sativa during the day and indica at night, specifically for improving sleep (Piper, 2018). Beyond medicinal cannabis users, one survey study of recreational cannabis users assessed whether respondents preferred to use cannabis during various leisure activities. Cannabis species was associated with leisure interests involving social activity and physical activity; the percent of respondents endorsing indica versus sativa use during social activity did not differ, but the majority of respondents endorsing physical activity consumed sativa while none consumed indica (Gould et al., 2019).

Collectively, these prior studies provided some insight as to what situations individuals may elect to use one cannabis type over another (e.g., to alleviate symptoms of a health condition; indica was preferred at night to improve sleep). Despite this, there is still presently little understanding as to whether the use of indica/sativa impacts: How people use cannabis (e.g., the typical amount used, the preferred route of administration, etc.), the likelihood of using under other specific scenarios (e.g., before driving), the acute subjective effects users typically feel after use, behavioral economic measures of individualized indica/sativa value (i.e., demand; Aston & Meshesha, 2020), and many other outcomes. Moreover, these prior studies were also limited by enrolling participants from single geographic locations (e.g., from one U.S. state in which cannabis was legalized). The present study sought to extend these prior studies by surveying a convenience sample of past 90-day cannabis users (from a mix of U.S. states with varying degrees of cannabis legality) with a more comprehensive set of questions/instruments to determine use patterns, experiences, and beliefs associated with indica and sativa cannabis. Outcomes of the present study could inform whether common marketing claims associated with indica/sativa are in line with cannabis users' self-reported prior experiences using these two types of cannabis, which may or may not be related to the chemical composition of indica and sativa.

Materials and Methods

Participants and Procedure

Survey respondents were recruited via Amazon Mechanical Turk (mTurk), an online crowdsourcing platform. To be eligible, participants were required to: (a) be ≥ 21 years of age, (b) have used cannabis at least once in the last 90 days, (c) currently reside in the U.S., (d) read/write in English fluently, (e) have an mTurk approval rating of ≥ 95%, and (f) have completed at least 100 prior mTurk tasks (i.e., "HITs"; Strickland & Stoops, 2019). Prior to completing the survey, respondents provided informed consent. The study procedures were approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board (#00009796). Participants completed the survey through Qualtrics (Provo,

UT). The mean (*SD*) duration to complete the survey was 17.5 (13.8) min among all survey completers. Participants who completed the full study were paid $1.00 USD, regardless of the quality of their responses. Those who completed the survey and passed the embedded attention check were paid an additional bonus of $3.00 USD. The attention check, used to deter the use of autonomous programs (i.e., "bots") for survey completion, asked: "which of the following is not round?" and responses included "a basketball," "a frisbee," "a brick," or "a wheel." Those who selected an answer other than "brick" (*n* = 11) were not included in data analyses. The final data set consisted of *n* = 179 survey respondents.

Measures

Demographics and General Substance Use—Participants provided basic demographic information (Table 1) including age, gender, race/ethnicity, employment status, education, and state of residence. State residence was subcategorized into three groups according to cannabis legality as of May 2019: States where (a) cannabis is illegal for any use, (b) legal for medicinal use only, and (c) legal for any adult use (i.e., "recreational"). Participants provided past 30-day use of tobacco and alcohol, past 90-day use of cannabis, age of first cannabis use, and completed the eight-item Cannabis Use Disorders Identification Test-Revised (CUDIT-R) as a measure of cannabis misuse. Each CUDIT-R item is scored on a scale of 0–4; thus, the maximum possible score on the CUDIT-R is 32 (Adamson et al., 2010).

Knowledge and Beliefs About Indica/Sativa Cannabis—Participants reported how familiar they were with indica/sativa cannabis by selecting one of the following choices: "I have heard of it [either indica or sativa] and used it before," I have heard of it, but have not used it," "I have heard of it, but am not sure if I have used it," "I have never heard of it," or "Not sure." Additionally, participants were asked to respond (Yes/No/Not sure) to the question "Do you believe that indica and sativa cannabis produce different effects?" Participants reported how confident they were in their ability to tell the difference between indica versus sativa cannabis effects using a 5-point Likert scale (1 = *not confident at all*; 5 = *extremely confident*) and also indicated all of the ways in which they learned about the effects of indica versus sativa cannabis (e.g., friends, internet, etc.).

Preferred Methods for Using Indica/Sativa Cannabis—Participants reported their primary method for using indica/sativa cannabis. Possible methods included: "joints," "blunts," "pipe/bowl," "bong," "hookah," "vaporizer (e.g., vape pen)," "edibles/beverages," "oil/tincture (not to inhale)," "dab rig," "spliffs (tobacco and cannabis together)," "topical/transdermal (e.g., patch, lotion, cream)," or "suppository." Next, participants reported their preferred form of indica/sativa cannabis. Possible cannabis forms included: "cannabis flowers (dried plant material)," "cannabis oil/Liquid (for inhalation with vape pen or similar device)," "cannabis oil liquid (in tincture form; NOT for inhalation)," "cannabis concentrates (e.g., hash, wax, shatter, dabs)," "edibles (cannabis-infused foods or beverages)," "topical/transdermal (e.g., patch, lotion, cream)," or "suppository."

Participants who reported (i.e., endorsed) using cannabis flowers were shown a reference image depicting various quantities of dried cannabis (Cuttler & Spradlin, 2017; see

Supplemental Materials, Supplemental Protocol 1). Participants indicated how many grams of indica/sativa cannabis that they personally use: (a) during a typical cannabis-use session and (b) on a typical day in which they use cannabis. Reference images depicting different cannabis amounts may enhance reporting accuracy with respect to the consumption of dried cannabis flowers (Goodman et al., 2019) since cannabis users may overestimate the quantity of cannabis flower used (Prince et al., 2018).

Preferred Time of Day for Using Indica/Sativa Cannabis—Participants reported the time of day that they preferred to use indica/sativa cannabis. Participants selected one of the answers from the following choices: "first thing when I wake up (wake and bake)," "middle of my day," "end of my day," or "not sure/no specific preference."

Self-Reported Subjective Effects of Indica/Sativa Cannabis—Participants reported how consistent their experience is when they use indica/sativa cannabis in their usual way using a 5-point Likert scale (1 = *the effects are rarely the same*; 5 = *the effects are always the same*). Additionally, participants selected all of the effects that they typically feel after using indica/sativa cannabis from a list of common cannabis-related effects (see Table 2).

Likelihood of Using Indica/Sativa Cannabis in Different Scenarios—Participants reported the likelihood that they would use indica and sativa cannabis in hypothetical scenarios using a 5-point Likert scale (1 = *not very likely*, 5 = *extremely likely*). Participants were asked how likely they were to use indica/sativa cannabis "if you were going to have to drive in the next 30 min," "if you were going to have to go to work in the next 30 min," "if you were at a party," "if you were going to be going to sleep in the next 30 min," and "if you were drinking alcohol."

Hypothetical Purchasing of Indica/Sativa Cannabis—A hypothetical cannabis purchasing task was used to evaluate potential differences in the relative perceived demand for indica and sativa cannabis. Demand curve analysis, which can be applied to hypothetical purchasing task responses, provides a multidimensional assessment of drug demand (Bickel et al., 2014; Johnson & Bickel, 2006; Strickland et al., 2020) and has been validated and applied widely in research on cannabis use behaviors (Aston & Meshesha, 2020). Participants read a brief set of instructions that asked them to imagine a typical week when they would use cannabis and to consider the following: The cannabis was of their normal quality; they could not get cannabis elsewhere; they could not use cannabis saved from previous use episodes; they could not spend more money than they actually had; they would consume all of the purchased cannabis in the next week; and they should consider each price individually. Participants completed two separate purchasing tasks, one specific to indica and one specific to sativa. Participants endorsed how many grams of each they would purchase for 1 week at the following prices: $1.00, $2.50, $5.00, $10.00, $25.00, $50.00, and $100.00 per g (USD). Grams purchased as a function of price were used to generate a demand curve, and regression analyses of these curves can produce two variables to provide a multidimensional assessment of drug demand: Intensity (purchasing at prices approaching 0) and elasticity (price-sensitivity). Six individuals provided nonsystematic responses on the indica purchasing task and eight responded nonsystematically on the sativa task, yielding *n*

= 94 and n = 92 data sets for indica and sativa demand analysis, respectively. For technical details, see Supplemental Materials, Supplemental Protocol 2.

Data Analysis

Descriptive statistics, chi-squares tests of independence, and Mann–Whitney U-tests were used to summarize participant demographics, cannabis use characteristics, and knowledge and beliefs about indica/sativa, where applicable. McNemar's test (for matched-pairs data) was used to examine differences in a subset of participants (n = 100) who endorsed "I have heard of it and have used it before" for both indica and sativa cannabis for the following measures: Preferred methods for using cannabis, forms of cannabis (e.g., flowers, oils, etc.), cannabinoid content, preferred time of day to use, and self-reported subjective effects. In the same subset of n = 100 participants, paired-samples t-tests (for parametric data) or Wilcoxon matched-pairs signed rank test (for nonparametric data as determined by the Shapiro–Wilk test of normality) were used to examine differences in a typical number of grams of cannabis used and the likelihood of using indica/sativa cannabis in different scenarios. Demand intensity and elasticity were compared between sativa and indica cannabis using paired-samples t-tests (for a complete description of hypothetical purchasing data analysis, see Supplemental Methods).

Results

Participant Demographics

Participants (n = 179) were predominantly White (73.7%) and male (64.8%), had a mean (SD) age of 34.9 (10.1), and were from an approximately even mix of states where cannabis was illegal (29.6%), available for medicinal use only (40.2%), and available for recreational use (30.2%). The mean (SD) age of first cannabis use was 19.2 (6.9). The mean (SD) number of cannabis using days in the past 30 days was 11.7 (10.9). The mean (SD) CUDIT-R score was 10.0 (6.7); a mean score of 10 indicates that, generally, the sample may engage in hazardous cannabis use but does not exhibit characteristics of severe Cannabis Use Disorder (Adamson et al., 2010; Table 1).

Knowledge and Beliefs About Indica/Sativa Cannabis

Most participants endorsed "I have heard of it and have used it before" for *either* indica (64.3%) *or* sativa (59.8%) cannabis. 55.9% of participants endorsed "I have heard of it and have used it before" for *both* indica and sativa cannabis. For indica and sativa cannabis, respectively, other responses included: "I have heard of it, but have not used it" (9.5% and 15.6%), "I have heard of it, but am not sure if I have used it" (12.3% and 15.1%), "I have never heard of it" (11.7% and 7.3%), and "Not sure" (2.2% and 2.2%). Overall, prior knowledge (or lack of knowledge) of indica and sativa cannabis did not differ as a function of state legality (i.e., illicit, medicinal-only, recreational): Indica [$\chi^2(8.0, n = 179) = 12.8, p = .12$]; sativa [$\chi^2(8.0, n = 179) = 14.8, p = .06$].

Most participants who had heard of both indica and sativa believed that there were unique effects common to use of one subtype of cannabis versus the other (64.2%), although some did not (10.1%), and others were not sure (25.7%). On a 5-point Likert scale, 55.3% of

participants were confident (4/5) or extremely confident (5/5) in their ability to tell the difference between the effects of indica versus sativa cannabis; 29.1% reported little (2/5) to no confidence (1/5).

Common ways in which participants learned about the effects of indica versus sativa cannabis included: "used both and know from experience" (49.7%), "friend" (34.1%), "comments from others on the internet" (30.2%), "written article on the internet" (25.1%), "a dispensary employee or 'budtender'" (19.6%), "information from cannabis retailers on the internet" (14.5%), "written information at a cannabis dispensary" (12.8%), "video on the internet" (11.7%), "advertisements" (6.7%), "information on cannabis packaging" (6.1%), and "podcasts" (5.0%).

From this point forward, we characterize use patterns, self-reported subjective effects, likelihood to use in hypothetical scenarios, and hypothetical purchasing patterns for indica/sativa cannabis among the subset of participants ($n = 100$) who endorsed "I have heard of it and have used it before" for both indica and sativa cannabis. When comparing participants who endorsed "I have heard of it and have used it before" for both indica and sativa cannabis ($n = 100$) to the total sample ($n = 179$), there were no statistically significant differences in age, gender, residence by state legality, race/ethnicity, employment status, education, age of first cannabis use, CUDIT-R score, or past 30-day tobacco or alcohol use. However, a Mann–Whitney U test revealed that participants who endorsed "I have heard of it and have used it before" for both indica and sativa cannabis ($n = 100$) reported greater past 30-day [15.1 (11.7) days, $U = 7,510$, $p < .05$] and past 90-day cannabis use [44.0 (36.4) days, $U = 7,590$, $p < .05$] relative to the total sample ($n = 179$).

Use Patterns of Indica/Sativa Cannabis

Among individuals who endorsed having "heard of and used" both indica and sativa cannabis ($n = 100$), there was no difference [mean (*SD*)] in the number of grams (g) used in a typical smoking session between indica [.52 g (.32)] versus sativa [.45 g (.49)] cannabis [$U = 2,803$, $p = .58$] or in the number of grams used per day between indica [.88 g (.83)] versus sativa [.79 g (.71)] cannabis [$U = 2,740$, $p = .43$]. Participants who selected "not sure" for these questions were excluded from these analyses.

Generally, the preferred method for using cannabis was not significantly different between indica and sativa. For indica versus sativa cannabis, preferred methods included pipes/bowls (39% vs. 36%), joints (15% vs. 13%), vaporizers (15% vs. 17%), blunts (9% vs. 12%), edibles/beverages (9% vs. 9%), bongs (9% vs. 9%), dab rigs (1% vs. 1%), and other methods (3% vs. 3%). Similarly, participants' preferred form of cannabis did not differ between indica and sativa. For indica versus sativa cannabis, preferred forms included flowers (79% vs. 73%), oils/Liquids for inhalation (10% vs. 11%), edibles/beverages (10% vs. 11%), and other forms (1% vs. 5%).

For each form of cannabis that participants endorsed having used, they were asked to report the average % THC content and the primary THC:CBD ratio that they used (if known). However, low endorsement and lack of participant knowledge on these items prevented a powered assessment for most forms of cannabis with the exception of flowers. There was no

difference in average % THC content [mean (*SD*), *n*] between indica [15.9% (8.0), *n* = 47] versus sativa flowers [16.7% (8.2), *n* = 42, *t*(87) = .52, *p* = .61].

Preferred Time of Day for Using Indica/Sativa Cannabis

Participants (*n* = 100; prior users of indica and sativa) were asked to report one time of day that they preferred most to use indica/sativa cannabis. Participants were more likely to prefer indica (62%) versus sativa (18%) cannabis at the end of the day (*p* < .01). Conversely, these participants preferred using sativa versus indica in the morning (19% vs. 6%, *p* < .01) and middle of the day (30% vs. 8%, *p* < .01). A sizeable subset of participants had no preference for the time of day to use indica or sativa cannabis (24% vs. 33%).

Self-Reported Subjective Effects of Indica/Sativa Cannabis

Self-reported experiences using indica and sativa cannabis were compared in a subset of participants (*n* = 100) who endorsed "I have heard of it and have used it before" for both indica and sativa cannabis (Table 2). Participants reported how consistent their experience is when they use indica/sativa in their usual way using a 5-point Likert scale. For both indica (73%) and sativa (63%), a majority of participants reported a 4/5 or 5/5, indicating that the effects are often or always the same. Some participants reported a 3/5, suggesting that the effects are sometimes the same for indica (25%) and sativa (32%). For both indica (2%) and sativa (5%), very few participants reported a score of 1 or 2, indicating that the effects are seldom or never the same. There was no difference in the consistency of experience between indica and sativa [X^2 (4.0, *n* = 100) = 4.4, *p* = .35].

After using indica (vs. sativa) cannabis, participants were more likely to report having felt "Relaxed" (85% vs. 28%) and "Sleepy/Feel Tired" (72% vs. 13%) as well as report "Difficulty Performing Routine Tasks" (16% vs. 7%; although endorsement for this outcome was low for both groups). After using sativa (vs. indica) cannabis, participants were more likely to report having felt "Happy/Euphoric" (66% vs. 37%), "Focused" (55% vs. 10%), "Motivated" (52% vs. 9%), "Alert" (54% vs. 7%), "Energized" (54% vs. 3%), and "Paranoid/Anxious" (21% vs. 10%). Endorsement of having felt "Hungry/Have Munchies" (64% vs. 57%) and "Trouble with Memory" (14% vs. 9%) following cannabis use did not differ between indica and sativa.

Likelihood of Using Indica/Sativa Cannabis in Different Scenarios

Participants were more likely to use indica over sativa cannabis if they were going to sleep in 30 min (*p* < .01), but they were more likely to use sativa if they were at a party (*p* < .01) (Figure 1). There was no difference in the likelihood to use indica versus sativa cannabis while drinking alcohol (*p* = .29). Participants were more likely to use sativa over indica cannabis if they were going to drive in the next 30 min (*p* < .001) or go to work in the next 30 min (*p* < .01), though it should be noted that, overall, participants did not report a high likelihood that they would use cannabis (regardless of the species) in these two scenarios (see Figure 1).

Hypothetical Purchasing of Indica/Sativa Cannabis

Purchasing patterns were generally orderly; in other words, the demand for cannabis was robust at lower prices (median = 10 g purchased at a price of $1.00/g) but became elastic at higher prices (Figure 2a). The mean (*SD*) square-root transformed demand intensity for indica cannabis [4.18 (3.41)] did not differ from that of sativa cannabis [(4.05 (3.47); $t(91)$ = 1.609, p = .11] (Figure 2 b). The mean (*SD*) natural-log transformed demand elasticity for indica cannabis [−6.68 (1.26)] did not differ significantly from that of sativa cannabis [−6.64 (1.33); $t(87)$ = 1.679, p = .10] (Figure 2c).

Discussion

Cannabis products are often categorized based on plant species, with "indica" and "sativa" being the two most common monikers. The cannabis industry often asserts that the acute effects of cannabis differ between indica and sativa strains, and cannabis dispensary employees may recommend that consumers use indica or sativa based on their desired therapeutic/nontherapeutic effects (Haug et al., 2016; Piper, 2018). However, empirical evidence is generally lacking to support or refute whether cannabis effects differ based on these plant species designations, and researchers have called into question the usefulness of the indica/sativa nomenclature (Piomelli & Russo, 2016). In the present study, cannabis users completed a cross-sectional survey with questions asking about their use patterns, beliefs, past experiences, and hypothetical purchasing patterns associated with indica and sativa cannabis. This research represents a critical first step toward delineating whether there are meaningful perceived differences between indica and sativa cannabis and informing whether cannabis products should be permitted to continue being marketed using this terminology.

The vast majority (>88%) of participants had heard of both indica and sativa cannabis. This finding aligns with the common notion that the indica/sativa nomenclature is pervasive in the cannabis-using community, including in locations that do not have a legal cannabis infrastructure. Moreover, 64% of respondents believed that these two types of cannabis produce different effects. Sources of participants' knowledge on indica and sativa included: Prior use of both indica/sativa, friends, various internet sources (e.g., articles, retailer websites, and blog posts), cannabis dispensary employees, and various other means (e.g., product packaging and advertisements). Thus, people appear to learn about indica and sativa in many ways that may not be reputable, including through sources directly related to the cannabis industry.

Participants were more likely to report having felt "Relaxed" and "Sleepy/Feel Tired" after previously using indica compared with sativa cannabis. Conversely, participants were more likely to report having felt "Happy/Euphoric," "Alert," "Energized," "Focused," Motivated," and "Paranoid/Anxious" after previously using sativa cannabis compared with indica. Intriguingly, respondents were also more likely to use indica or sativa in different scenarios that were in accordance with the observed differences in subjective experiences. For example, participants were more likely to use indica over sativa cannabis if they planned to go to sleep in 30 min and preferred using indica at the end of the day. Conversely, participants were more likely to use sativa over indica in the morning/daytime and if they

were at a party. Taken together, these data suggest that cannabis users often perceive that indica and sativa produce different effects, and as a result, the situation and context (e.g., time of day, interacting with others vs. going to sleep) may dictate the choice of cannabis type. These findings are generally consistent with the few prior surveys of medicinal cannabis patients regarding the use of indica/sativa in which respondents were more likely to report using sativa for "enhanced energy" and indica for "sleep" and "sedation" (Cohen et al., 2016; Pearce et al., 2014).

Prior studies that have conducted analytical testing on commercial indica and sativa cannabis products for cannabinoid and terpene content (Elzinga et al., 2015; Fischedick et al., 2010; Hazekamp & Fischedick, 2012; Hazekamp et al., 2016) may provide insight into the differences in perceived effects of indica and sativa observed in the present study. These studies have shown that cannabis labeled as "indica" contains similar concentrations of major cannabinoids (i.e., THC and CBD) to cannabis labeled as "sativa" (Elzinga et al., 2015; Hazekamp et al., 2016). Interestingly, however, these analytical studies have revealed that cannabis products labeled as "sativa" or "indica" often contain markedly different concentrations of terpenes, which are theorized to influence the acute effects of cannabis (Russo, 2011). For example, in one study, indica cannabis samples contained greater myrcene and hydroxylated terpenes while sativa contained greater terpinolene, 3-carene, and several sesquiterpenes (Hazekamp et al., 2016). In the present study, self-reporting of typical THC-to-CBD ratios was low across indica and sativa, and participants were not asked to report specific terpene profiles of their products. An alternative, parsimonious explanation is that the perceived effects of indica and sativa are linked to individuals' expectancy effects and/or time of day the cannabis is used. The present study found that cannabis users often have prior expectations that indica/sativa will produce different effects; it is important to understand how this knowledge may influence the context in which an individual decides to consume cannabis as well as how that person experiences the effects, feels after cannabis use, and retrospectively reports on those subjective experiences.

Thus, controlled research whereby cannabis type (i.e., indica versus sativa) and participant expectancies (i.e., an expectation of indica versus sativa versus no expectation) are both systematically manipulated is needed. Such research may determine whether perceived differences in effects of indica and sativa cannabis stem from expectancy effects, differences in the chemical composition of these two species (e.g., terpene content), or a combination of both factors. A notable challenge to such future research, however, is that there presently are no consensus, operational definitions for "indica" and "sativa" based on chemical composition. Thus, any future controlled studies that include "indica" and "sativa" products should conduct detailed chemical testing and analysis on the products used and publish these results, as this may assist with interpretation of study findings and facilitate comparisons across other future studies.

Another goal of this study was to evaluate the relative demand for indica and sativa cannabis via hypothetical purchasing tasks. Despite the observed differences between indica and sativa regarding prior subjective effects and scenarios in which participants would use cannabis, neither demand metric (intensity or elasticity) differed between indica and sativa cannabis. This finding suggests that participants valued the two types of cannabis equally

in the hypothetical purchasing scenario, or in other words, that demand for indica and sativa were similar overall to these individuals when consumed in their typical context/ setting or for their typical activity-based purpose. Although demand metrics did not differ between cannabis types, the robust hypothetical purchasing observed across prices indicated demand for cannabis in general. Of note, the instructional set asked participants to estimate how much cannabis they would purchase for a typical week of cannabis use but did not specify the specific scenarios under which they would be using that cannabis. Given that participants' cannabis-use preferences differed across several hypothetical scenarios presented (e.g., before bed, at a party), it is likely indica/sativa demand may be sensitive to the context in which purchasing decisions are made, as has been observed across substances (e.g., Amlung et al., 2019; Schwartz et al., 2019; Skidmore & Murphy, 2011); this is a target for future studies. Additionally, an examination of hypothetical scenarios in which both strains are concurrently available, such as simple-preference or substitution tasks, may better model real-world purchasing and allow greater insight into constraints governing strain preference.

This study had several limitations. First, the study included a relatively small convenience sample recruited from mTurk. The use of mTurk may have yielded a sample biased toward technologically adept and/or younger individuals (Strickland & Victor, 2020). Additionally, the majority of mTurk users are White, and the number of mTurk users who belong to other racial/ethnic groups (particularly Black/African-American and Hispanic/Latino) may be lower than the general population (Paolacci & Chandler, 2014). Future studies should consider over-recruiting such minority racial/ethnic groups if using mTurk or employ other recruitment strategies (such as community-based recruitment or Facebook advertisement (Borodovsky et al., 2018)) to yield more diverse and representative samples. Second, the survey was cross-sectional and respondents retrospectively reported on their experiences with indica/sativa cannabis in addition to other outcomes (e.g., source of knowledge on indica/sativa effects, etc.). Thus, some individuals may have misremembered their subjective experiences after using indica/sativa cannabis, how they learned about indica/ sativa, etc. Third, this study only inquired about the use of indica and sativa products, yet commercial cannabis products may also be labeled as "hybrid." However, the term "hybrid" is ambiguous, as this sometimes refers to products that are a blend of indica and sativa cannabis (e.g., "sativa-dominant," "indica-dominant," or "balanced") or products that contain both THC and CBD in roughly equal proportions. For these reasons, hybrid cannabis is difficult to query via self-report, and products labeled as "hybrid" may be especially confusing to consumers. Future studies targeted toward the use patterns, beliefs, experiences associated with hybrid cannabis strains are warranted given the diversity of products within this category.

In conclusion, cannabis users in our sample were largely aware of indica and sativa cannabis and learned about the purported differences between these two cannabis species through a variety of sources. Study participants retrospectively reported drastically different acute effects from indica/sativa cannabis, and situational or contextual factors influenced the likelihood that participants would use sativa versus indica cannabis. However, indica and sativa demand were comparable according to demand curve analysis. Controlled laboratory studies are needed to confirm whether indica and sativa cannabis does indeed elicit different

acute effects and to clarify the role of user expectancies on altering the perceived effects of these 2 types of cannabis. Taken together, these steps may inform future regulatory decisions around using the indica/sativa nomenclature.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

References

Adamson SJ, Kay-Lambkin FJ, Baker AL, Lewin TJ, Thornton L, Kelly BJ, & Sellman JD (2010). An improved brief measure of cannabis misuse: The cannabis use disorders identification test-revised (CUDIT-R). Drug and Alcohol Dependence, 110(1–2), 137–143. 10.1016/j.drugalcdep.2010.02.017 [PubMed: 20347232]

Amlung M, Reed DD, Morris V, Aston ER, Metrik J, & MacKillop J (2019). Price elasticity of illegal versus legal cannabis: A behavioral economic substitutability analysis. Addiction, 114(1), 112–118. 10.1111/add.14437 [PubMed: 30194789]

Aston ER, & Meshesha LZ (2020). Assessing Cannabis Demand: A Comprehensive Review of the Marijuana Purchase Task. Neurotherapeutics, 17(1), 87–99. 10.1007/s13311-019-00819-z [PubMed: 31916237]

Bickel WK, Johnson MW, Koffarnus MN, MacKillop J, & Murphy JG (2014). The behavioral economics of substance use disorders: Reinforcement pathologies and their repair. Annual Review of Clinical Psychology, 10, 641–677. 10.1146/annurev-clinpsy-032813-153724

Borodovsky JT, Marsch LA, & Budney AJ (2018). Studying cannabis use behaviors with facebook and web surveys: Methods and insights. JMIR Public Health and Surveillance, 4(2), Article e48. 10.2196/publichealth.9408

Bruner NR, & Johnson MW (2014). Demand curves for hypothetical cocaine in cocaine-dependent individuals. Psychopharmacology, 231(5), 889–897. 10.1007/s00213-013-3312-5 [PubMed: 24217899]

Cohen NL, Heinz AJ, Ilgen M, & Bonn-Miller MO (2016). Pain, cannabis species, and cannabis use disorders. Journal of Studies on Alcohol and Drugs, 77(3), 515–520. 10.15288/jsad.2016.77.515 [PubMed: 27172585]

Cuttler C, & Spradlin A (2017). Measuring cannabis consumption: Psychometric properties of the daily sessions, frequency, age of onset, and quantity of cannabis use inventory (DFAQ-CU). PLOS ONE, 12(5), Article e0178194. 10.1371/journal.pone.0178194

Elzinga SFJ, Podkolinski R, & Raber JC (2015). Cannabinoids and terpenes as chemotaxonomic markers in cannabis. Natural Products Chemistry & Research, 3(4), 1–9. 10.4172/2329-6836.100018

Fischedick JT, Hazekamp A, Erkelens T, Choi YH, & Verpoorte R (2010). Metabolic fingerprinting of Cannabis sativa L., cannabinoids and terpenoids for chemotaxonomic and drug standardization purposes. Phytochemistry, 71(17–18), 2058–2073. 10.1016/j.phytochem.2010.10.001 [PubMed: 21040939]

Goodman S, Leos-Toro C, & Hammond D (2019). Methods to assess cannabis consumption in population surveys: Results of cognitive interviewing. Qualitative Health Research, 29(10), 1474–1482. 10.1177/1049732318820523 [PubMed: 30600773]

Gould J, Donnelly R, & Innacchione B (2019). Turning over a new leaf in Colorado: An exploration of legalized recreational marijuana preferences, leisure interests, and leisure motivations in a sample of young adults. World Leisure Journal, 61(2), 113–130. 10.1080/16078055.2018.1521866

Haug NA, Kieschnick D, Sottile JE, Babson KA, Vandrey R, & Bonn-Miller MO (2016). Training and practices of cannabis dispensary staff. Cannabis and Cannabinoid Research, 1(1), 244–251. 10.1089/can.2016.0024 [PubMed: 28861496]

Hazekamp A, & Fischedick JT (2012). Cannabis – from cultivar to chemovar. Drug Testing and Analysis, 4(7–8), 660–667. 10.1002/dta.407 [PubMed: 22362625]

Hazekamp A, Tejkalová K, & Papadimitriou S (2016). Cannabis: From cultivar to chemovar II—a metabolomics approach to Cannabis classification. Cannabis and Cannabinoid Research, 1(1), 202–215. 10.1089/can.2016.0017

Hursh SR, & Silberberg A (2008). Economic demand and essential value. Psychological Review, 115(1), 186–198. 10.1037/0033-295X.115.1.186 [PubMed: 18211190]

Johnson MW, & Bickel WK (2006). Replacing relative reinforcing efficacy with behavioral economic demand curves. Journal of the Experimental Analysis of Behavior, 85(1), 73–93. 10.1901/jeab.2006.102-04 [PubMed: 16602377]

Johnson MW, Johnson PS, Rass O, & Pacek LR (2017). Behavioral economic substitutability of e-cigarettes, tobacco cigarettes, and nicotine gum. Journal of Psychopharmacology (Oxford, England), 31(7), 851–860. 10.1177/0269881117711921

MacKillop J, Few LR, Murphy JG, Wier LM, Acker J, Murphy C, Stojek M, Carrigan M, & Chaloupka F (2012). High-Resolution behavioral economic analysis of cigarette demand to inform tax policy. Addiction, 107(12), 2191–2200. 10.1111/j.1360-0443.2012.03991.x [PubMed: 22845784]

Paolacci G, & Chandler J (2014). Inside the Turk: Understanding mechanical Turk as a participant pool. Current Directions in Psychological Science, 23(3), 184–188. 10.1177/0963721414531598

Pearce DD, Mitsouras K, & Irizarry KJ (2014). Discriminating the effects of Cannabis sativa and Cannabis indica: A web survey of medical cannabis users. Journal of Alternative and Complementary Medicine (New York, N.Y.), 20(10), 787–791. 10.1089/acm.2013.0190

Piomelli D, & Russo EB (2016). The Cannabis sativa versus Cannabis indica debate: An interview with Ethan Russo, MD. Cannabis and Cannabinoid Research, 1(1), 44–46. 10.1089/can.2015.29003.ebr [PubMed: 28861479]

Piper BJ (2018). Mother of Berries, ACDC, or Chocolope: Examination of the strains used by medical cannabis patients in New England. Journal of Psychoactive Drugs, 50(2), 95–104. 10.1080/02791072.2017.1390179 [PubMed: 29064777]

Prince MA, Conner BT, & Pearson MR (2018). Quantifying cannabis: A field study of marijuana quantity estimation. Psychology of Addictive Behaviors, 32(4), 426–433. 10.1037/adb0000370 [PubMed: 29771542]

Russo EB (2011). Taming THC: Potential cannabis synergy and phytocannabinoid-terpenoid entourage effects. British Journal of Pharmacology, 163(7), 1344–1364. 10.1111/j.1476-5381.2011.01238.x [PubMed: 21749363]

Schwartz LP, Roma PG, Henningfield JE, Hursh SR, Cone EJ, Buchhalter AR, Fant RV, & Schnoll SH (2019). Behavioral economic demand metrics for abuse deterrent and abuse potential quantification. Drug and Alcohol Dependence, 198, 13–20. 10.1016/j.drugalcdep.2019.01.022 [PubMed: 30861390]

Skidmore JR, & Murphy JG (2011). The effect of drink price and next-day responsibilities on college student drinking: A behavioral economic analysis. Psychology of Addictive Behaviors, 25(1), 57–68. 10.1037/a0021118 [PubMed: 21142332]

Spindle TR, Bonn-Miller MO, & Vandrey R (2019). Changing landscape of cannabis: Novel products, formulations, and methods of administration. Current Opinion in Psychology, 30, 98–102. 10.1016/j.copsyc.2019.04.002 [PubMed: 31071592]

Steigerwald S, Wong PO, Khorasani A, & Keyhani S (2018). The form and content of cannabis products in the United States. Journal of General Internal Medicine, 33(9), 1426–1428. 10.1007/s11606-018-4480-0 [PubMed: 29770952]

Stein JS, Koffarnus MN, Snider SE, Quisenberry AJ, & Bickel WK (2015). Identification and management of nonsystematic purchase task data: Toward best practice. Experimental and Clinical Psychopharmacology, 23(5), 377–386. 10.1037/pha0000020 [PubMed: 26147181]

Strickland JC, Campbell EM, Lile JA, & Stoops WW (2020). Utilizing the commodity purchase task to evaluate behavioral economic demand for illicit substances: A review and meta-analysis. Addiction, 115(3), 393–406. 10.1111/add.14792 [PubMed: 31454109]

Strickland JC, & Stoops WW (2019). The use of crowdsourcing in addiction science research: Amazon mechanical Turk. Experimental and Clinical Psychopharmacology, 27(1), 1. 10.1037/pha0000235 [PubMed: 30489114]

Strickland JC, & Victor GA (2020). Leveraging crowdsourcing methods to collect qualitative data in addiction science: Narratives of non-medical prescription opioid, heroin, and fentanyl use. The International Journal on Drug Policy, 75, Article 102587. 10.1016/j.drugpo.2019.10.013

Public Health Significance

Cannabis users retrospectively reported feeling different effects from indica versus sativa cannabis; however, demand for the two cannabis subtypes was similar on hypothetical purchasing tasks, suggesting situational factors could influence whether someone uses indica or sativa. Controlled laboratory studies are needed to confirm whether indica and sativa cannabis does indeed elicit different subjective effects and to clarify the role of user expectancies on altering the perceived effects of these two types of cannabis. Taken together, these steps may inform future regulatory decisions regarding cannabis-related marketing nomenclatures like indica and sativa.
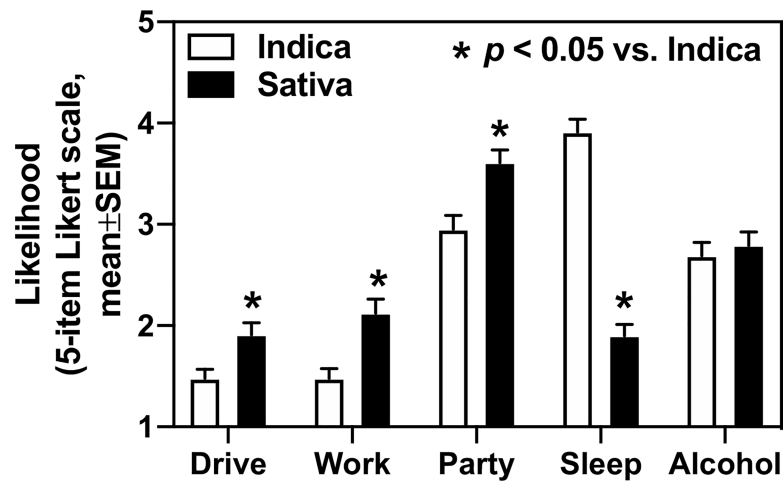
Figure 1.
Likelihood of Using Indica/Sativa Cannabis in Different Scenarios
Note. Participants reported likelihood to use indica (open bars) or sativa (closed bars) cannabis in hypothetical scenarios using a 5-point Likert scale (1 = *not very likely*; 5 = *extremely likely*, *y*-axis). Participants were asked how likely (mean ± SEM) they were to use indica/sativa cannabis in five hypothetical scenarios (*x*-axis, bolded): "if you were going to have to drive in the next 30 min," "if you were going to have to go to work in the next 30 min," "if you were at a party," "if you were going to be going to sleep in the next 30 min," and "if you were drinking alcohol."
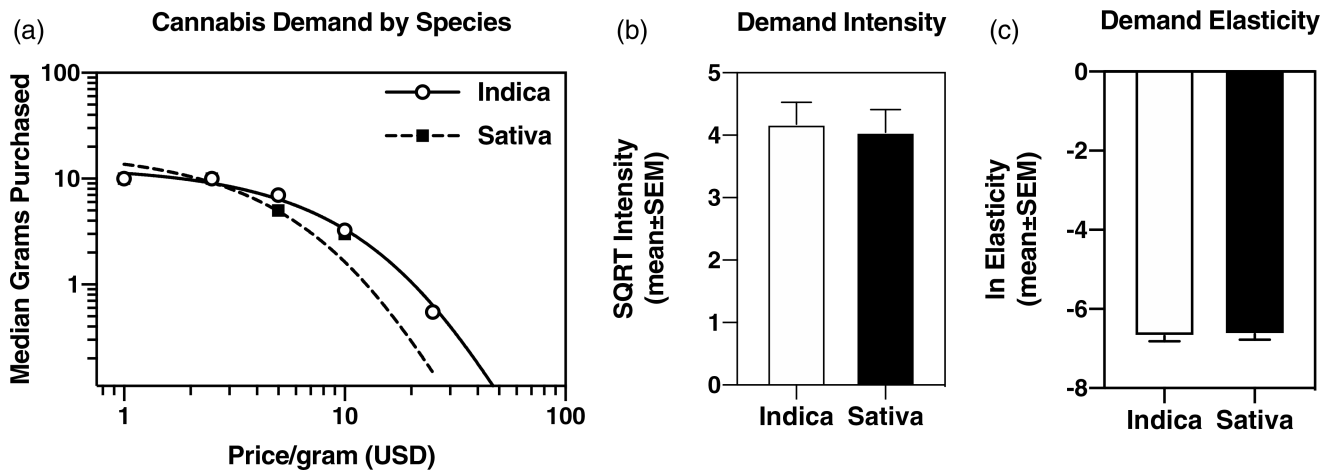
Figure 2.
Hypothetical Purchasing of Indica/Sativa Cannabis

Note. (a) Demand curves illustrating median grams of indica cannabis ($n = 94$, open circles, solid line) and sativa cannabis ($n = 92$, closed squares, dashed line) purchased in the hypothetical purchasing tasks. (b) The mean (±SEM) square-root (SQRT) transformed demand intensity (*y*-axis) for indica (open bars) and sativa (closed bars) cannabis are shown. (c) The mean (±SEM) natural-log (ln) transformed demand elasticity (*y*-axis) for indica (open bars) and sativa (close bars) cannabis are shown. No differences were observed between indica and sativa for demand intensity nor elasticity.

Table 1

Demographics for (a) All Participants and (b) Participants Reporting Lifetime Use of Indica and Sativa Cannabis

Demographic (*p < .05; all participants vs. past use of indica and sativa)		All participants (n = 179)	Past use of indica and sativa (n = 100)
Age	Mean (*SD*)	34.9 (10.1)	34.5 (9.3)
	Range	21–70	21–65
Gender [n, (%)]	Male	116 (64.8)	65 (65.0)
	Female	63 (35.2)	35 (35.0)
Residence by Cannabis State Legality [n, (%)]	Illicit	53 (29.6)	26 (26.0)
	Medicinal	72 (40.2)	38 (38.0)
	Recreational	54 (30.2)	36 (36.0)
Race/Ethnicity [n, (%)]	American Indian/Alaska Native	1 (.6)	1 (1.0)
	Asian	11 (6.1)	5 (5.0)
	Black/African-American	22 (12.3)	7 (7.0)
	Hispanic/Latino	6 (3.4)	3 (3.0)
	Native Hawaiian/Pacific Islander	0 (.0)	0 (.0)
	White/Caucasian	132 (73.7)	80 (80.0)
	More than one race	6 (3.4)	4 (4.0)
	Other	1 (.6)	0 (.0)
Employment status [n, (%)]	Full-time employment	149 (83.2)	79 (79.0)
	Part-time employment	16 (8.9)	10 (10.0)
	Unemployed; looking for work	4 (2.2)	4 (4.0)
	Unemployed; not looking for work	4 (2.2)	4 (4.0)
	Retired	2 (1.1)	0 (.0)
	Student	1 (.6)	0 (.0)
	Disabled	3 (1.7)	3 (3.0)
Education [n, (%)]	Some high school	0 (.0)	0 (.0)
	High school graduate/GED	23 (12.8)	13 (13.0)
	Some college	29 (16.2)	19 (19.0)
	Trade/technical/vocational training	8 (4.7)	4 (4.0)
	Associate's degree	19 (10.6)	9 (9.0)
	Bachelor's degree	79 (44.1)	47 (47.0)

Demographic (*p < .05; all participants vs. past use of indica and sativa*)		All participants (*n* = 179)	Past use of indica and sativa (*n* = 100)
	Master's degree	19 (10.6)	7 (7.0)
	Doctoral/Professional degree	2 (1.1)	1 (1.0)
Past 90-day cannabis use*	Number of days [Mean (*SD*)]	34.5 (33.8)	44.0 (36.4)
Past 30-day cannabis use*	Number of days [Mean (*SD*)]	11.7 (10.9)	15.1 (11.7)
Age of first cannabis use	Mean (*SD*)	19.2 (6.9)	18.2 (6.8)
CUDIT-R Score	Mean (*SD*)	10.0 (6.7)	8.7 (4.8)
Past 30-day tobacco use	*n*, (%)	57 (31.8)	30 (30.0)
Past 30-day alcohol use	*n*, (%)	64 (35.8)	38 (38.0)

Table 2

Self-Reported Subjective Responses Typically Felt After Using Indica/Sativa Cannabis

Subjective effect	Indica	Sativa	p value*
	(% Endorsing)		
Happy/euphoric	37	66	<.001
Relaxed	85	28	<.001
Sleepy/feel tired	72	13	<.001
Focused	10	55	<.001
Motivated	9	52	<.001
Alert	7	54	<.001
Energized	3	54	<.001
Paranoid/anxious	10	21	<.05
Hungry/have munchies	64	57	=.31
Trouble with memory	14	9	=.18
Difficulty performing routine tasks	16	7	<.05

Note. $n = 100$ respondents endorsed using both sativa/indica cannabis.

*
Results of McNemar's test.