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Development and Initial Psychometric Validation of the Brief-Caffeine Expectancy Questionnaire (B-CaffEQ)

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Abstract

Caffeine is the most widely available and consumed psychoactive substance in the United States. Extant work indicates that across substances, use expectancies play a marked role in the development and maintenance of consumption patterns. Despite a burgeoning line of etiological and intervention-oriented research focused on expectancies (e.g., alcohol), there is a limited literature regarding caffeine use effect expectancies, specifically. To facilitate this work, the Caffeine Expectancy Questionnaire (CaffEQ) was developed and psychometrically validated; however, the length of the CaffEQ (i.e., 47 items) may hinder widespread adoption of this tool. As such, the current study provides an initial psychometric validation of a brief, 20-item version—the Brief-Caffeine Expectancy Questionnaire (B-CaffEQ)—in a multiethnic sample of undergraduate students (N = 975). Results showed that the B-CaffEQ replicated the 7-factor structure of the original CaffEQ using both constrained (confirmatory factor analysis) and less constrained (exploratory structural equation modeling) structural models and evidenced good internal consistency across subscales. The B-CaffEQ also demonstrated concurrent validity with caffeine use frequency indices, replicated and extended convergent validity between caffeine expectancy subscales and related behavioral and psychological constructs, and demonstrated discriminant validity with other related, but notably distinct, stimulant use metrics (e.g., cocaine, Ritalin). Lastly, the B-CaffEQ appears to provide an invariant measure of expectancies across types of caffeine users. These findings indicate that the B-CaffEQ is a reliable assessment of caffeine use effect expectancies, with acceptable-to-good psychometric properties—comparable in length to

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other substance use expectancies measures—that may be more readily incorporated into research and clinical settings.

Keywords

caffeine; expectancy; substance use; psychometrics; assessment

Caffeine is the most widely available and consumed psychoactive substance in the United States (Fulgoni, Keast, & Lieberman, 2015; Knight, Knight, & Mitchell, 2006; Mitchell, Knight, Hockenberry, Teplansky, & Hartman, 2014). Caffeine is produced naturally in a variety of plant species (e.g., cocoa, tea) and is typically consumed via caffeinated beverages —the most common being coffee and tea, depending on geographic location (Frary, Johnson, & Wang, 2005; Knight et al., 2006; Lachenmeier et al., 2013). Recent estimates indicate that 85–89% of the population consume at least one caffeinated beverage per day, with caffeine intake increasing over the past decade (Fulgoni et al., 2015; Mitchell et al., 2014). Further, caffeine use has garnered increasing attention in the substance use literature with the growing popularity of energy drinks (Fulgoni et al., 2015; Reissig, Strain, & Griffiths, 2009; Seifert, Schaechter, Hershorin, & Lipshultz, 2011) and concern regarding the mixing of caffeine with alcohol (Attwood, 2012; Marczinski, 2011).

Among healthy adults, low-to-moderate caffeine consumption (i.e., under 200 mg/day) may yield positive perceived effects regarding mood (e.g., positive affect), sociability, cognition (e.g., alertness, concentration, memory), and fatigue, as well as objective physiological effects, such as weight loss and improved athletic performance (e.g., Ganio, Klau, Casa, Armstrong, & Maresh, 2009; Heckman, Weil, & de Mejia, 2010; Juliano, Anderson, & Griffiths, 2011). Moderate caffeine consumption also has been noted as a potential protective factor against certain neurological diseases and health conditions (e.g., reduced risk of Type II diabetes, Parkinson's disease, cancer; Butt & Sultan, 2011; Mitchell et al., 2014; Sinha et al., 2012). However, there are no specified recommendations from the Food and Drug Administration concerning "safe" caffeine consumption, and extant research suggests that higher doses of caffeine (e.g., >400 mg per day; Juliano & Griffiths, 2004) may result in negative perceived psychological symptoms (e.g., nervousness, anxiety; Heckman et al., 2010; Lieberman et al., 2012) and worsened cognition (e.g., loss of concentration; Vilarim, Rocha Araujo, & Nardi, 2011), as well as increases in physical symptoms (e.g., headaches, nausea, restlessness; Lieberman et al., 2012) and sleep disturbances (e.g., insomnia, worsened quality of sleep; Snel & Lorist, 2011).

Although the side effects of stopping caffeine after extended use are typically mild and temporary (e.g., headache, drowsiness; Heckman et al., 2010; Nawrot et al., 2003), some research indicates that excessive caffeine use can produce symptomatology indicative of substance dependency and withdrawal (see Addicott, 2014 for review). For example, caffeine users have reported failures in attempts to reduce or cut down on caffeine use (Juliano et al., 2011), exacerbation of physical problems (e.g., cardiovascular problems; Mesas, Leon-Muñoz, Rodriguez-Artalejo, & Lopez-Garcia, 2011), and evidence of increased tolerance (Juliano & Griffiths, 2004) and withdrawal (e.g., migraine; Budney,

Brown, Griffiths, Hughes, & Juliano, 2013). However, despite evidence of the potentially addictive qualities, as well as widespread use and availability of caffeine across age groups (Addicott, 2014; Mitchell et al., 2014), limited work has been conducted to understand mechanisms that may underlie the development of problematic caffeine use.

Drawing from outcome expectancy theory and social learning frameworks (Bandura, 1977; Rotter, Chance, & Phares, 1972), over the past few decades, substance use researchers have explored the influence of outcome expectancies in predicting subsequent substance use behaviors. Expectancies regarding the effects of substance use are formed from various sources, including personal experiences, social modeling, and verbal transmission. These expectancies can influence motivations to use, or refrain from using, a substance within a given context, which may partially explain consumption patterns (e.g., Cox & Klinger, 1988; Jones, Corbin, & Fromme, 2001). This work was pioneered within the alcohol use literature, culminating in research that has aided in both developmental modeling and prevention efforts (e.g., prediction of future drinking; see Monk & Heim, 2013, for review), as well as empirically supported interventions for reducing alcohol use (e.g., expectancy challenge techniques; see Scott-Sheldon Terry, Carey, Garey, & Carey, 2012, for reviews). Indeed, use expectancies are indicated as an important variable in modeling a variety of substance use patterns (e.g., cannabis; Buckner & Schmidt, 2008; Hayaki et al., 2010; Stacy, 1997). Importantly, although initial findings from a few studies indicate that caffeine expectancies (e.g., caffeine will improve mood) are meaningfully associated with caffeine consumption (Bradley & Petree, 1990; Heinz, Kassel, & Smith, 2009; Huntley & Juliano, 2012), the literature directly examining the relationship between caffeine use expectancies and patterns of caffeine use is fairly limited.

Ultimately, our foundational understanding and continued expansion of the literature regarding substance use expectancies is reliant on the use of psychometrically validated assessments of these constructs, such as the Comprehensive Effects of Alcohol (CEOA; Fromme, Stroot, & Kaplan, 1993) and subsequent Brief-Comprehensive Effects of Alcohol questionnaires (B-CEOA; Ham, Stewart, Norton, & Hope, 2005). Unfortunately, the handful of proposed measures of caffeine use expectancies in the literature—two nonpsychometrically validated surveys (Greden, Victor, Fontaine, & Lubetsky, 1980; Page & Goldberg, 1986) and the Caffeine Expectancy Questionnaire (CEQ; Heinz et al., 2009)—have been plagued by methodological (e.g., small sample) and structural (e.g., limited scope caffeine effects; limited to “drinking” caffeine) shortcomings (see Huntley & Juliano, 2012 for detailed overview). To account for these limitations, Huntley and Juliano (2012) developed a new Caffeine Expectancy Questionnaire (CaffEQ). The measure consists of 47 items comprising seven subscales that assess both positively and negatively valenced expectancies from caffeine use: (a) withdrawal/dependence, (b) energy/work enhancement, (c) appetite suppression, (d) social/mood enhancement, (e) physical performance enhancement, (f) anxiety/negative physical effects, and (g) sleep disturbances. The psychometric assessment of the CaffEQ—using large samples (n_{range} = 655 to 1,711) of adults (M_{range} = 26.6 to 30.4 years old) with varying levels of caffeine exposure (i.e., 41.0–59.5% endorsed daily caffeine use)—indicated a psychometrically strong factor structure, good 2-week test–retest reliability, concurrent validity with caffeine use and caffeine withdrawal symptoms, and convergent validity with other related psychological and

behavioral effects (e.g., anxiety, sleep; Huntley & Juliano, 2012). Given these results, the CaffEQ provides researchers with a promising, psychometrically sound assessment of caffeine use expectancies.

Study Aims and Rationale

Although the CaffEQ rectified many of the shortcomings of the existing caffeine expectancies measures, more widespread adoption of this tool may be hindered simply by the length of the measure (i.e., 47 questions). Experimental studies and meta-analyses examining the potential influence of participant burden have empirically demonstrated a negative association between questionnaire length and response rate (e.g., Sharp & Frankel, 1983; Rolstad, Adler, & Rydén, 2011). Moreover, given the complexity of modeling substance use and polysubstance outcomes, including lengthier questionnaires within larger assessment batteries may not be feasible for clinical or research purposes (Ham et al., 2005). As a result, many established measures within the substance use literature have culminated in “brief” or “short form” versions, which include, but are not limited to, measures of consumption (Bush, Kivlahan, McDonell, Fihn, & Bradley, 1998), substance use consequences (Kahler, Strong, & Read, 2005), and, importantly, expectancies for both cannabis (Torrealday et al., 2008) and alcohol (Ham et al., 2005) use. As such, the current study aims to balance comprehensiveness and efficiency in assessing caffeine use expectancies among a variety of caffeine users (e.g., in primary caffeine type [coffee, tea, etc.]; consumption amount [infrequent, daily, etc.]) by examining the psychometric properties of a brief version of the CaffEQ (B-CaffEQ). More specifically, the current study will (a) examine the factor structure of the B-CaffEQ using confirmatory factor analysis (CFA); (b) replicate that factor structure using exploratory structural equation modeling (ESEM); (c) assess the internal consistency, concurrent, convergent, and discriminant validities; (d) assess measurement invariance of the B-CaffEQ between types of caffeine users; and, finally, (e) descriptively compare and contrast the psychometric properties of the B-CaffEQ to those described in the original validation of the full CaffEQ.

Method

Participants and Procedure

The total sample consisted of 975 participants (M_{age} = 20.84, SD_{age} = 3.04; 71.0% female) who completed an online survey examining substance use and psychological well-being. Participants were recruited from a general undergraduate subject pool (49.2% psychology majors) at a large, Southwestern university. Data were collected from November 2016 through May 2017. All procedures were approved by the Institutional Review Board at the University of North Texas. The plurality of participants identified as White (43.7%), followed by Hispanic (20.2%), African American (15.1%), multiracial (10.1%), Asian (8.5%), and other (2.4%). The sample was nearly evenly split, in terms of daily caffeine use, with 49.3% endorsing daily caffeine consumption. Full information regarding the sample can be found in Table 1.

Measures

Caffeine expectancies.—The CaffEQ (Huntley & Juliano, 2012) is a 47-item assessment of caffeine use outcome expectancies. For the current study, participants completed all 47 items, which asked them to rate how they expected caffeine to affect them, basing their responses off of a singular (primary) caffeine consumption choice: coffee, energy and soft drinks, tea, caffeine-related medications (e.g., Excedrin No-Doz), caffeine in general (i.e., individuals who regularly used multiple caffeine-containing vehicles), or "other." Rating are assessed on a 6-point Likert-type ranging from 1 (*very unlikely*) to 6 (*very likely*). Items on the measure are matched to a subscale and summed to comprise seven total subscales: (a) withdrawal/dependence, (b) energy/work enhancement, (c) appetite suppression, (d) social/mood enhancement, (e) physical performance enhancement, (f) anxiety/negative physical effects, and (g) sleep disturbances. There is no total global score for the CaffEQ; each subscale is theoretically orthogonal. Higher scores on each of the subscales indicate greater expectancies. Following item reduction procedures detailed in the validation of the B-CEOA (Ham et al., 2005), the items used for the B-CaffEQ were chosen based strictly on the highest factor loadings on each of the seven expectancies subscale from the originally published factor structure (see Huntley & Juliano, 2012). The resulting 21 items included three items on each of the seven subscales (see Figure 1)—an a priori determination aimed at (a) maintaining content coverage (i.e., comprehensiveness) of the measure and consistency with the original CaffEQ (as noted in Smith, McCarthy, & Anderson, 2000) while (b) meaningfully reducing the number of items in the measure. See the Appendix in online supplementary material for B-CaffEQ instructions, questions, scaling, and scoring.

Substance use history.—A self-report measure of substance use—based on a structured interview detailed in Barrett, Darredeau, and Pihl (2006)—was used to assess past year use frequency (i.e., 12 months) and past month use frequency (i.e., 30 days), regarding caffeine, alcohol mixed with energy drinks (AmED), cocaine, and recreational/nonmedical use (i.e., use to get "high, drunk, stoned, buzzed, or intoxicated") of Ritalin and Adderall. Excessive or "binge" use (i.e., five or more uses in a single day) over the past 2 weeks was assessed for caffeine and AmEDs.

Regarding caffeine use participants also were asked to report their primary route of caffeine consumption (e.g., coffee, tea, energy/soft drinks) and how frequently they had consumed caffeine within a specified timeframe (i.e., past year, past month), with possible responses of (a) not at all, (b) less than one time per day, (c) one or two times per day, (d) three or four times per day, or (e) five or more times per day. Given general estimates for caffeine content (i.e., typically less than 100 mg/8 fl oz.; Mitchell et al., 2014) and some empirical work demonstrating limited adverse health effects for consumption of ≤400 mg/day for healthy adults (e.g., Heckman et al., 2010; Mitchell et al., 2014; Nawrot et al., 2003), excessive use was operationally defined as ingesting caffeine on five or more occasions (i.e., ~>400 mg/day) within a single day. As such, to assess for excessive caffeine use, participants were asked in a separate question how many times they ingested caffeine on "five or more occasions within a single day" over the past 2 weeks, with possible responses ranging from 1 (*none*) to 6 (*10 or more times*).

Comparison measures.—For assessment of convergent validity, participants completed measures of anxiety symptoms, sleep quality, and change in appetite. Specifically, the Anxiety Sensitivity Index-3 (ASI; Taylor et al., 2007) is an 18-item measure rated on a 0 (*very little*) to 4 (*very much*) scale (possible score range = 0–72), with higher total scores reflecting higher anxiety sensitivity (e.g., "It scares me when my heart beats rapidly"). The ASI evidences acceptable psychometric properties including internal reliability (α = .95), replicated factor structures, and criterion validity (Taylor et al., 2007). The Social Interaction Anxiety Scale (SIAS; Heimberg, Mueller, Holt, Hope, & Liebowitz, 1992) is a 20-item measure rated on a 0 (*not at all*) to 4 (*extremely*) scale (possible score range = 0–80) reflecting the degree to which each characteristic is true of the participant (e.g., "I have difficulty talking with other people"). The SIAS evidences acceptable psychometric properties including internal reliability (α= .94), replicated factor structures, and discrimination between individuals with social anxiety disorder, persons with other anxiety disorders, and community volunteers (Brown et al., 1997; Heimberg et al., 1992; Mattick & Clarke, 1998).

The Pittsburgh Sleep Quality Index (PSQI) is a 1-month retrospective measure of sleep quality and disturbance (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The PSQI consists of 19 items assessing a range of factors influencing sleep quality (e.g., sleep latency, frequency/severity of specific sleep problems) used to produce a global sleep quality score (possible score range = 0–21), with higher total scores reflecting worse sleep quality. The PSQI evidences acceptable psychometric properties including internal reliability (α= .80), replicated factor structures, and convergent validity (Buysse et al., 1989; Carpenter & Andrykowski, 1998). A single item was drawn from the nine-item depression module of the Patient Health Questionnaire (PHQ-9) to assess past-two week change in appetite ("poor appetite or overeating"; Löwe, Kroenke, Herzog, & Gräfe, 2004). The item was rated on a 0 (*not at all*) to 3 (*nearly every day*) scale reflecting the extent to which their poor appetite bothered them during the previous two weeks.

Data Analytic Plan

After confirming the original factor structure, the primary analytic plan for the B-CaffEQ consisted of three steps. The first two steps were to confirm and validate the structure of the B-CaffEQ—derived a priori from the highest loading items in the original seven-factor CaffEQ. For this, the full sample was randomly divided into two samples: a confirmatory sample (Sample 1; n = 487) and a validation sample (Sample 2; n = 488). Importantly, the two samples did not statistically significantly differ on any sociodemographic characteristics (e.g., age, biological sex, race/ethnicity) or on any caffeine use variables (i.e., caffeine use, primary caffeine use type; see Table 1 for more detail). The final step was to evaluate the psychometric properties of the B-CaffEQ. Consistent with the original validation of the CaffEQ, the entire sample (n = 975) was used for the final step (Huntley & Juliano, 2012).

Confirming factor structure.—A CFA was fitted to Sample 1 to confirm the hypothesized 21-item, seven-factor structure of the B-CaffEQ. Given that measurement scale on each of the B-CaffEQ items comprised more than five categories, the data were considered intervally scaled for analyses. Model fit was determined by examining:

confirmatory fit index (CFI; > 0.95, Hu & Bentler, 1999), root mean square error of approximation (RMSEA; < .06, Hu & Bentler, 1999) and standardized root mean square residual (SRMR; < 0.08, Hu & Bentler, 1999). The parenthetical values listed above indicate good model fit based on CFI and SRMR. Generally, RMSEA less than 0.06 indicates good fit, whereas RMSEA above that threshold, but less than 0.08, indicates medium but acceptable fit (Browne & Cudeck, 1993).

Validating factor structure.—CFA is commonly used to validate factor structure (Brown, 2014; Thompson, 2004). Of note, in CFA, each item is allowed to indicate only one factor and at least two items are used to indicate a factor. The CFA is a restrictive model because it constrains the direct relationships between items and other factors to zero. However, in reality, items may have small direct relationships to factors that they do not indicate. Therefore, the less restrictive ESEM was fitted to Sample 2. ESEM allows for testing of the hypothesized model while allowing for small cross-loadings (Asparouhov & Muthén, 2009; Marsh et al., 2009; Marsh et al., 2010; Marsh, Morin, Parker, & Kaur, 2014). Cross-loadings are the direct relationships between items and the factors they do not indicate. In the ESEM framework, the cross-loadings are freely estimated but are expected to be small (e.g., close to zero). By allowing this relationship to fluctuate slightly from zero, the ESEM model can control the inflation of true population latent factor correlations that can occur in CFA models (Asparouhov & Muthén, 2009). This is particularly salient in psychological research, where most items have some relationship to the other factors or constructs. The CFA model and a schematic diagram of the ESEM are shown in Figures 1 and 2.

Reliability and validity.—The full sample (N = 975) was used to assess the internal consistency of the B-CaffEQ subscales. Further, consistent with the original validation of the CaffEQ (Huntley & Juliano, 2012), the full sample was used to demonstrate concurrent, convergent, and discriminant validities of the final B-CaffEQ. For concurrent validity, Pearson correlation coefficients were used to assess associations between the seven sub-scales of the B-CaffEQ and past-year caffeine use, past month-caffeine use, and excessive caffeine use (i.e., consumption of five or more caffeinated beverages in a single day). Based on findings from the original CaffEQ, it was expected that the five positively valenced subscales would be associated with an increase in caffeine use, whereas the two negatively valenced subscales would be associated with a decrease in caffeine use. To assess convergent validity, as well as replicate and extend analyses from the validation of the full CaffEQ (Huntley & Juliano, 2012), a series of analyses were conducted to demonstrate associations between specific B-CaffEQ subscales and related physiological and psychological constructs. More specifically, partial correlation coefficients (i.e., controlling for daily caffeine use frequency) examined the associations between (a) the sleep disturbances subscale and a global index of sleep (via PSQI); (b) the anxiety/negative physical effects subscale and anxiety sensitivity (via the ASI-3) and social interaction anxiety (via SIAS); and (c) the appetite suppression subscale and a single-item metric of change in appetite (via PHQ-9). Lastly, correlation coefficients were used to compare the B-CaffEQ subscale to several related, but notably distinct, assessments of substance use to assess discriminant validity. More specifically, partial correlation coefficients (i.e., controlling for daily caffeine

use frequency) were used to examine the association between the B-CaffEQ and past year (a) alcohol mixed with energy drink use (AmED; general use and binge use); and (b) other stimulant use (i.e., cocaine, Ritalin, Adderall use).

Measurement invariance.—Measurement invariance of the instrument was examined between primary caffeine use groups. Participants were asked to choose which type of caffeine substance was their primary route of consumption (i.e., how they "typically" consume caffeine): coffee, energy and soft drinks, tea, caffeine-related medications (e.g., Excedrin No-Doz), caffeine in general (i.e., individuals who regularly used multiple caffeine-containing vehicles), or "Other." Participants were informed that if they use many types of caffeinated products, they should either choose just one to base their responses on or that they could choose to base their responses on "caffeine in general." Regarding the B-CaffEQ, invariance assessed whether the different types of caffeine users vary in how they perceived the items on the instrument. More specifically, measurement invariance helps establish if the same factors for different groups (e.g., coffee vs. tea) are comparable and if any of the items are biased toward certain groups (Jöreskog & Sörbom, 1979; Meredith, 1993). Multigroup ESEM was conducted and the 13 models suggested by Marsh et al. (2014) were fitted to evaluate a series of measurement invariance models. These models differ from each other based on the parameters that are constrained to be equal across the groups. For instance, the configural invariance model tests if the same factor structure fits the groups well, while allowing all parameters to be freely estimated. The metric or factorial invariance model tests if, given the same factor structure, the factor coefficients or loadings are the same across the groups. The scalar invariance model fixes both the factor coefficients and the intercepts to be the same across the groups for the same factor structure. The error variance invariance model fixes factor structure and coefficients, intercepts, and error variances to be the same across groups. All these invariances need to hold true for measurement invariance to be established (Chen, 2007; Cheung & Rensvold, 2002; Meredith, 1993). There are several additional models that restrict combinations of factor coefficients, intercepts, and error variances, as listed in Table 2. Each of these represent a different level of invariance. The aim is to find a factor structure with as many coefficients identical across groups as possible in order to establish measurement invariance. The ESEM extension of measurement invariance is based on this same idea, but tests many more models as outlined in Marsh and colleagues (2014).

Although there are model comparison criteria for retaining the best fitting level of measurement invariance in CFAs (e.g., Chen, 2007), there are no such guidelines for ESEM measurement invariance. Instead, Marsh et al. (2009) suggest comparing CFI, RMSEA, SRMR, and the three information criteria (Akaike information criteria (AIC), Bayesian information criteria (BIC), and sample-adjusted AIC [SA-AIC]) holistically. Smaller values on SRMR, RMSEA, AIC, BIC, and SA-AIC criteria and larger values on CFI indicate better fit when all else are held equal. Because of small sample sizes in the caffeine-related medications ($n = 3$) and "other" ($n = 17$) groups, only the coffee, energy and soft drinks, tea, and caffeine in general groups were included in the comparative analyses.

Software and data management.—Analyses in the split samples (i.e., CFA and ESEM) and measurement invariance were conducted using MPlus. Descriptive statistics, reliability, and validity analyses in the full sample were conducted using SPSS (Version 22.0). Zero-order (*r*) and partial correlation coefficients (pr) and *p* values were interpreted for significance and effect size in the convergent and discriminant validity analyses. Assumptions for each statistical analysis were checked and met (e.g., normality). Less than 0.03% of the data were missing. Therefore, the default MPlus option of missing at random for maximum likelihood was used to handle missing data.

Results

Confirming Factor Structure

The initial 21-item model was nonpositive definite because Item 38 (“Using caffeine late in the day disrupts my sleep”) was severely multicollinear (i.e., >.90) with Item 28 (“I have difficulty sleeping after having caffeine”). Given the high correlation between Items 28 and 38, deleting either item would provide the same results (e.g., CFA, ESEM); as such, Item 28 was retained to broaden the scope of the sleep disturbance subscale (i.e., less overlap with the other item on the subscale), resulting in a two-item sleep disturbance factor. After dropping Item 38, the CFA evidenced adequate fit to be retained as a reasonable model, including strong factor loading for each of the items in each of the seven subscales (min = . 70). Only Item 46 (“Caffeine decreases my appetite”) shared more than 81% of the variance with the factor. Although larger factor pattern coefficients are desirable, unusually large factor pattern coefficients (i.e., >.90) indicate that the item can essentially replace the factor. Although 81% is not unusually high, it borders on the rather large side. Full model fit indices for the CFA model can be found in Table 2. Factor structure and loadings for the CFA model can be found in Table 3. Correlations between subscales on the B-CaffEQ from the CFA are presented in Table 4.

Validating Factor Structure

Based on the CFA model that was retained in Sample 1, an ESEM model was fit to Sample 2. That is, in addition to the relationships in the CFA model, the items were allowed to cross-load with the factors they did not indicate. The software program automatically specifies the cross-loadings to be small. As shown in Table 2, the ESEM model fit the data better than the CFA model. Some of the cross-loadings were as large as 0.21 indicating that restricting these values to be zero as in the CFA model would not reasonably indicate actual associations between items and factors. Importantly, the cross-loadings (range =−0.17 to 0.21) were always substantially smaller than the factor loadings (0.5 to 0.98). Further, as expected, the factor correlations from the ESEM are smaller than those from CFA (see Table 3). In general, both CFA and ESEM analyses support the seven-factor structure of the B-CaffEQ. Full model fit indices for the ESEM model can be found in Table 2. Factor structure and loadings for the ESEM model can be found in Table 3. Correlations between subscales on the B-CaffEQ from the ESEM are presented in Table 4.

Reliability and Validity

Given results from both the CFA in the confirmatory sample and the ESEM in the validation sample, the 20-item B-CaffEQ was assessed for internal consistency, concurrent validity, convergent validity, discriminant validity, and measurement invariance using the full sample (N = 975).

Internal consistency.—Internal consistency was assessed using Cronbach's alpha for each of the seven factors on the B-CaffEQ. Internal consistencies for the B-CaffEQ were good, with alphas on the subscales ranging from .81 to .90. Although full scale scores should not be interpreted, the internal consistency of the full B-CaffEQ was .93. Overall, internal consistency appears to be good on the brief version of the measure. See Table 4 for full results of internal consistency coefficients.

Concurrent validity.—Results of the concurrent validity analyses demonstrated statistically significant positive associations between all positively valenced B-CaffEQ subscales (i.e., withdrawal/dependence, energy/work enhancement, appetite suppression, social/mood enhancement, physical performance enhancement) and all caffeine use indices (rs = .08 to .44). The associations between negatively valenced subscales (i.e., anxiety/negative physical effects, sleep disturbances) and caffeine use indices were not statistically significant (r = .00 to .04). Full results of the concurrent validity analyses can be found in Table 5.

Convergent validity.—Results of the convergent validity analyses showed a statistically significant association between the sleep disturbances subscale of the B-CaffEQ and global sleep index on the PSQI (r = .10); statistically significant associations between the anxiety/negative physical effects subscale on the B-CaffEQ and anxiety sensitivity on the ASI-3 (r = .27) and social interaction anxiety on the SIAS (r = .19); and a statistically significant association between the appetite suppression subscale on the B-CaffEQ and the "poor appetite" item from the PHQ-9 (r = .17). Although these associations were relatively weak, these findings replicate the strength and direction of associations found in the original validation of the CaffEQ (Huntley & Juliano, 2012) between sleep disturbances and sleep quality (r = .08) and anxiety/negative physical effects and anxiety (r = .22). Full results of the convergent validity analyses can be found in Table 6.

Discriminant validity.—Results of the discriminant validity analyses indicated that, aside from the physical performance enhancement subscale, the remaining B-CaffEQ subscales were not statistically significantly associated with AmED use, AmED binge use, cocaine use, Ritalin use, or Adderall use. See Table 5 for full results regarding discriminant validity analyses.

Measurement invariance.—Measurement invariance of the seven-factor structure was assessed between the groups that consumed one of the four types of caffeine: general, coffee, energy and soft drinks, and tea. The ESEM model fitted only three of the four groups, as seen in Table 2. For the "caffeine in general" group, negative error variance was obtained for Item 42 on the social/mood enhancement subscale; therefore, "the caffeine in

general" group was not included in the measurement invariance analysis. Next configural invariance—multigroup ESEM with none of the parameters constrained—was tested for the three remaining groups. The list of all models in this series and their fit indices are given in Table 2. Based on CFI, RMSEA, SRMR, AIC, BIC, and SABIC, the metric, scalar, and error variance invariance models were retained. Latent and manifest mean invariances, and complete factorial invariance models were not retained because their SRMRs, AICs, BIC, and SABICs were much higher than the metric, scalar, and error variance invariance models.

Although invariance could not be established for the factor means, variances, and covariances, the instrument showed the four levels of invariance required for comparing latent means across the groups. Therefore, standardized mean difference effect sizes were computed between each of the seven factors for the three groups (Cohen, 1988). The factor means and variances for the coffee user group was fixed to be zero and one, respectively. Therefore, the mean values in Table 7 for the comparison groups are referenced at zero (i.e., the distance between that group's average from the coffee group's average). Results showed that coffee drinkers tended to have larger expectations that drinking caffeine would give them energy (*d*s =−0.79; −1.06) and enhance their mood (*d*s =−0.49; −0.61), in comparison to energy/soft drink and tea groups, respectively. All other comparisons showed small-to-medium effects (*d*s =−0.40 to −0.09).

Discussion

A burgeoning line of research demonstrates the impact that substance use expectancies can have on understanding subsequent substance use behavior, which has led to improvements in both prevention and intervention efforts. The original CaffEQ was designed to identify these expectations for caffeine use, resulting in a reliable and psychometrically valid measure that improved upon several previously established assessments of caffeine use expectancies (Huntley & Juliano, 2012). However, the number of items on the original measure (i.e., 47 items) limits the utility of the CaffEQ. As such, the current study sought to validate the B-CaffEQ.

Evaluation of the factor structure of the B-CaffEQ indicated acceptable to good model fit across indices in the CFA. This structure was confirmed using ESEM, with results indicating an improvement in overall model fit. Further, subscales on the B-CaffEQ evidenced moderate-to-strong correlations, and no two subscales evidenced troublingly strong correlations (e.g., >.90). Importantly, these model fit indices were comparable to results from the psychometric evaluation of the original CaffEQ (RMSEA = .06, CFI = .98, SRMR = .08; Huntley & Juliano, 2012). Notably, because of the removal of one item that evidenced high multicollinearity with other items in the measure (resulting in the final 20-item measure), the Sleep Disturbance subscale of the B-CaffEQ retained only two-items. However, importantly, the remaining two items on the subscale (i.e., "I have difficulty sleeping after having caffeine" and "Caffeine late in the day gives me insomnia") were face-valid and unique assessments of expectations that caffeine would disturb sleep, were not highly correlated with any items on other subscales in the B-CaffEQ, and, taken together, evidenced good internal consistency as a subscale. Notably, two-item subscales are not uncommon (e.g., Zamboanga et al., 2018), particularly on brief or short-form measures, such

as the Brief COPE (Carver, 1997), B-CEOA (Ham et al., 2005), and Short-Form Health Survey (Ware, Kosinski, & Keller, 1996); however, future work may consider development and examination of other question(s) that might uniquely expand on the current Sleep Disturbances caffeine use effect expectancies subscale Overall, the B-CaffEQ was able to replicate the seven-factor structure of the original CaffEQ while drastically reducing the number of items in the overall measure.

All seven of the subscales on the B-CaffEQ showed good internal consistency and were generally comparable to results from the full CaffEQ. Although internal consistency on several of the subscales were slightly reduced, the most notable differences occurred on subscales where there was a drastic reduction in number of items on the subscale from the original measure (e.g., nine-item CaffEQ [$\alpha = .91$] to three-item B-CaffEQ [$\alpha = .81$] on the anxiety/negative physical effects subscale). This decrease in alpha values is expected given that the number of items influences alpha coefficients (Cortina, 1993); in general, longer tests have larger alpha values compared to shorter tests, when all other information and conditions are held constant. Overall, the B-CaffEQ subscales evidenced good internal consistency, similar to those on the full CaffEQ.

Regarding concurrent validity, the majority of subscales on the B-CaffEQ were positively correlated with past-year daily caffeine use frequency, past-month daily caffeine use frequency, and excessive caffeine use. Among those subscales, withdrawal/dependence, energy/work enhancement, and social/mood enhancement were most strongly associated with increases in daily caffeine use. These findings replicate those detailed in the original validation of the CaffEQ (Huntley & Juliano, 2012) and are consistent the larger substance use expectancy literature (e.g., alcohol, tobacco) indicating that drug expectancies can discriminate between varying patterns of drug use (Buckner & Schmidt, 2008; Looby & Earley-wine, 2010; Ham et al., 2005; Schafer & Brown, 1991). More specifically, increased expectations that (a) participants need caffeine or that failure to use caffeine would result in withdrawal symptoms; (b) caffeine would provide energy and alertness; (c) caffeine would suppress feelings of hunger; (d) caffeine would improve mood and sociability; and (e) caffeine would enhance physical performance were associated with actual increases in caffeine use. Notably, unlike the initial psychometric validation of the full CaffEQ, the anxiety/negative physical effects and sleep disturbance subscales were not statistically significantly associated with any of the caffeine use indices. However, evaluation of these subscales and caffeine use in the original CaffEQ publication were relatively low (i.e., −.11 and −.08, respectively) and were examined in a larger sample ($N = 1,711$), which can increase the likelihood of finding statistically significant results. Several minor, but notable methodological differences between the original psychometric validation of the CaffEQ and the current study also may partially explain these disparities. First, in the original CaffEQ psychometric evaluation, caffeine exposure was assessed via estimates of average daily caffeine consumption in milligrams, whereas in the current study, caffeine use was assessed via average number to times caffeine (e.g., a cup of tea, can of soda) was ingested per day. Second, the original CaffEQ analyses were examined in a community sample that was notably older than the undergraduate student sample used in the current study. Given these disparate findings, it may be that there are important age or developmentally related differences in caffeine use effect expectancies across populations. For example, extant

alcohol research has demonstrated that type and strength of use expectancies differ with age and developmental context (Leigh & Stacy, 2004). Exploratory analyses using an older subsample support the assertion that there may be age-related differences in caffeine use expectancies across populations[1] and, importantly, suggest that the disparate findings with the negatively valenced expectancies were likely unrelated to the reduction in number of items on the brief measure.[2] However, future work is needed to examine associations between these caffeine use expectancies and caffeine use in the B-CaffEQ across contextually and developmentally distinct populations.

Evaluations of convergent validity showed significant associations between various B-CaffEQ subscales and theoretically associated constructs. More specifically, results showed associations between the anxiety/negative physical effects and anxiety sensitivity and social interaction anxiety; sleep disturbance subscale and a measure of global sleep; and appetite suppression and a measure of general appetite change. As suggested by Huntley and Juliano (2012) in their original CaffEQ validation, the associations between (a) the anxiety/negative physical effects subscale and increases in both anxiety-related constructs, (b) the sleep disturbances subscale and diminished sleep quality, and (c) the appetite suppression subscale and increases in appetite change may be due to increased awareness of these specific consequences of caffeine consumption based on past personal experience (e.g., using caffeine actually reduced their appetite, use of caffeine late in the day led to insomnia, etc.). This increased awareness, in turn, may facilitate the modification or strengthening of future expectations about caffeine use—as purported by outcome expectancy theory and social learning frameworks (Bandura, 1977; Rotter et al., 1972). These results replicate and extend findings from the original CaffEQ (Huntley & Juliano, 2012) and highlight the potential utility of these various subscales in understanding related behavioral (e.g., sleep) and psychological (e.g., anxiety) functioning.

Although not assessed in the original psychometric evaluation of the CaffEQ, the B-CaffEQ also demonstrated discriminant validity against measures of related, but notably distinct, substance use indices. For example, none of the B-CaffEQ subscales were associated with AmED use frequency or binge use, with the exception of a weak correlation between physical performance enhancement and AmED binge drinking. Similarly, none of the B-CaffEQ subscales were associated with other stimulant use frequency (i.e., cocaine, Ritalin, Adderall), with the exception of a weak-to-moderate correlation between physical performance enhancement and Adderall use frequency. Overall, the subscales on the B-CaffEQ demonstrate convergent validity with theoretically related behavioral and psychological constructs—replicating results from the original CaffEQ—as well as discriminant validity with measures of AmED and other stimulant use frequency.

[1]Exploratory analyses using an older subsample of participants ($n = 31$; $M_{age} = 32.81$, $SD = 4.45$) evidenced results more similar to the original CaffEQ regarding the Anxiety/Negative Physical Effects ($r = -.08$) and Sleep Disturbances ($r = -.08$) subscales and caffeine use; however, these analyses were underpowered to detect significant effects due to small sample size. Notably, the association between the Anxiety/Negative Physical Effects and Sleep Disturbances subscales in the original CaffEQ psychometric validation were −.11 and −.08, respectively.

[2]Examination of bivariate associations between the full CaffEQ Anxiety/Negative Physical Effects and Sleep Disturbances subscales and caffeine use frequency in the current sample mirrored the non-significant findings from the B-CaffEQ analyses in the current sample. This suggests that the lack of replicating significance on the B-CaffEQ was likely not related to the reduction in the number of items on the measure.

Regarding measurement invariance, results indicated that coffee drinkers, generally, endorsed greater expectancies on all B-CaffEQ seven subscales than individuals who endorsed soft/energy drinks and tea as their primary route of consumption. However, these differences were notably very small (M_{diff} =−1.15 to −0.20), and evidenced mostly small-to-medium effects. These results suggest that the B-CaffEQ is generally measuring the same constructs across the various groups. This finding adds to the validity of the items and the factor structure because it performs reasonably similar irrespective of caffeine user group. Although Huntley and Juliano's (2012) psychometric evaluation of the CaffEQ did not directly assess measurement invariance, comparisons between primary consumption groups using analyses of variance similarly found that coffee drinkers generally reported greater caffeine use expectancies across subscales, with only small-to-medium differences between groups.

Limitations

Some limitations in the present study should be noted. First, although the current study used a similar administration methodology as the original validation of the CaffEQ (i.e., web-based survey), the present sample was comprised entirely of undergraduate students that differed in age and other demographic characteristics (i.e., race/ethnicity). Although it is promising that the majority of findings from the original CaffEQ evaluation were readily replicated in the B-CaffEQ analyses, sampling differences may have contributed to the handful of disparate findings. Further, findings regarding convergent validity may be partially limited by the use of a single-item measure for change in appetite. Future work is needed to replicate this initial psychometric assessment of B-CaffEQ in a larger, nationally representative sample using more detailed assessment of caffeine use (e.g., by caffeine type, in milligrams) and caffeine expectancy-related constructs. Future research also should consider differential assessment of caffeine use expectancies in various developmentally distinct populations (e.g., adolescents, emerging adults), as extant work focused on other substances (e.g., alcohol) has demonstrated that type and strength of use expectancies differ with age and developmental context (Leigh & Stacy, 2004).

Second, the cross-sectional nature of the findings did not allow for examination of test–retest reliability. Future work should consider use of a short-term, prospective and/or experience sampling method to expand on the psychometric properties of the B-CaffEQ, as well as evaluate if, and to what extent, caffeine use effect expectancies fluctuate with each instance of consumption. Third, although the current study measured several indices of caffeine use frequency and related-substance use frequency, there was no assessment for caffeine dependence-related symptoms. Given the strong relationships between the original CaffEQ subscales and various caffeine dependence symptoms in the original validation article, future work evaluating the B-CaffEQ should incorporate the proposed *DSM–5* Section III: Caffeine Use Disorder symptoms (including dependence-related symptoms) into their analytic plan (American Psychiatric Association, 2013).

Fourth, there are mixed opinions on how to appropriately select items for development of shortened questionnaires (e.g., Smith et al., 2000). Exploratory factor analyses conducted on the present study sample (not detailed in current article) evidenced subtly different highest

factor loadings on each of the seven subscales. However, replicating item reduction methodology outlined by Ham and colleagues (2005) in their psychometric evaluation of a brief measure of alcohol use expectancies (B-CEOA), the current study chose to use the highest factor loadings from the original factor structure of the CaffEQ (Huntley & Juliano, 2012) to generate the final 20-items in the B-CaffEQ. Importantly, this strategy may result in greater similarity across instrument versions and improve reliability of the B-CaffEQ; however, future work with the B-CaffEQ should consider this methodological decision. Further, the B-CaffEQ was purposefully designed to mirror the comprehensive factor structure of the original CaffEQ, (i.e., evaluating all seven caffeine use effect expectancies), while focusing primarily on reducing the overall number of items on the measure. However, given strong correlations between some B-CaffEQ sub-scales and the limited number of items on each factor, future work might also consider evaluating more parsimonious models and/or a higher-order factor model. Notably, exploratory analyses of a higher-order factor structure in the current data did not improve fit (i.e., over the current CFA or ESEM models), [3] although replication is needed in other developmentally and/or contextually distinct populations.

Fifth, the assessment of measurement invariance in the current study did not allow comparisons to the “caffeine in general” group. Future work with larger samples of individuals who use “caffeine in general”—or multiple vehicles of primary consumption of caffeine—as well as individuals who primarily use less common forms of caffeine (e.g., 5-hr Energy) are needed to evaluate measurement invariance of the B-CaffEQ across other types of caffeine users. Future research should also consider expanding the list of possible caffeine use types; for example, separating soft drinks from energy drinks, given that these beverages tend to vary in milligrams of caffeine per serving (Frary et al., 2005; Mitchell et al., 2014).

Last, the aim of the current study was to conduct an initial psychometric evaluation of the B-CaffEQ with the intent of providing researchers and clinicians with a substantively shorter form of the full CaffEQ (i.e., with similar items, subscale structure, and psychometric properties). As such, no modifications were made to the wording of the instructions and individual items or to the scaling and scoring of the responses; further, no new items were developed or evaluated. Future work should consider not only replicating and extending findings from this initial psychometric evaluation of the B-CaffEQ (e.g., test–retest reliability), but also consider improving the measure through revision (e.g., incorporate reversed-polarity items to control and/or identify acquiescence response bias; Herche & Engelland, 1996) and expansion (e.g., developing a third unique item for sleep disturbances subscale) of the B-CaffEQ items. Future work should also consider addressing relevant recommendation by Smith and colleagues (2000) for short-form measurement development that were not examined in the current study (e.g., evaluating overlapping variance with the full form measure using independent administrations).

[3] A higher-order CFA model with all factors loading onto a single higher-order factor was fitted. Results produced model fit indices (i.e., RMSEA [.079], CFI [.928], SRMR [.068], AIC [28052], BIC [28247], and SABIC [28012]) which were notably worse than both the original CFA and ESEM models (see Table 2).

Conclusions

The present study attempted to improve the utility of the CaffEQ—a well-designed and psychometrically valid assessment of caffeine use effect expectancies—by evaluating the psychometric properties of a briefer, 20-item version of the original measure. Although future work is needed to replicate and extend this initial psychometric evaluation, the results of the current study indicate that the B-CaffEQ is a reliable assessment of caffeine use effect expectancies, with acceptable-to-good psychometric properties, comparable in length to other brief measures of substance use expectancies (i.e., B-CEOA has 15 items; Ham et al., 2005), that may be more readily incorporated into both research and clinical settings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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These data/research appearing in the manuscript have not been previously disseminated. This article has not been previously published and has not been submitted elsewhere for publication.

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Public Significance Statement

Caffeine is the most widely used psychoactive substance in the United States, prompting the need for well-validated caffeine assessment instruments. Results of this initial psychometric evaluation indicate that the Brief-Caffeine Expectancy Questionnaire (B-CaffEQ) is a reliable and valid assessment of caffeine use effect expectancies that may be more readily incorporated into research focused on understanding patterns of caffeine consumption. Given extant work indicating the influence of substance use effect expectancies on the development and maintenance of consumption patterns, the B-CaffEQ may be a useful tool in future etiological and intervention-oriented, caffeine-focused research.

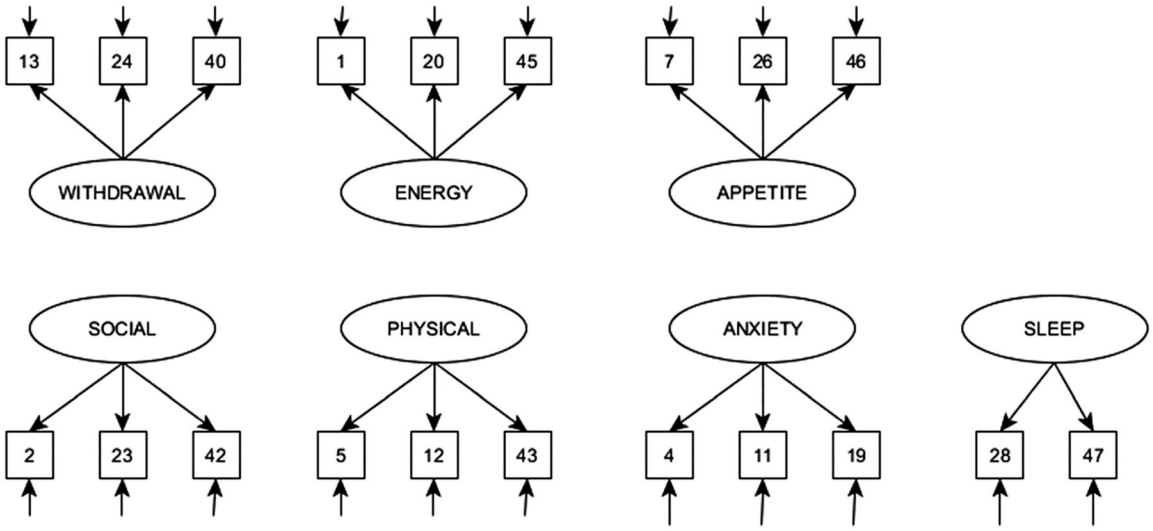

Figure 1.

Schematic of confirmatory factor analyses (CFA) seven-factor model. Factor correlations are not shown. All factors are correlated.

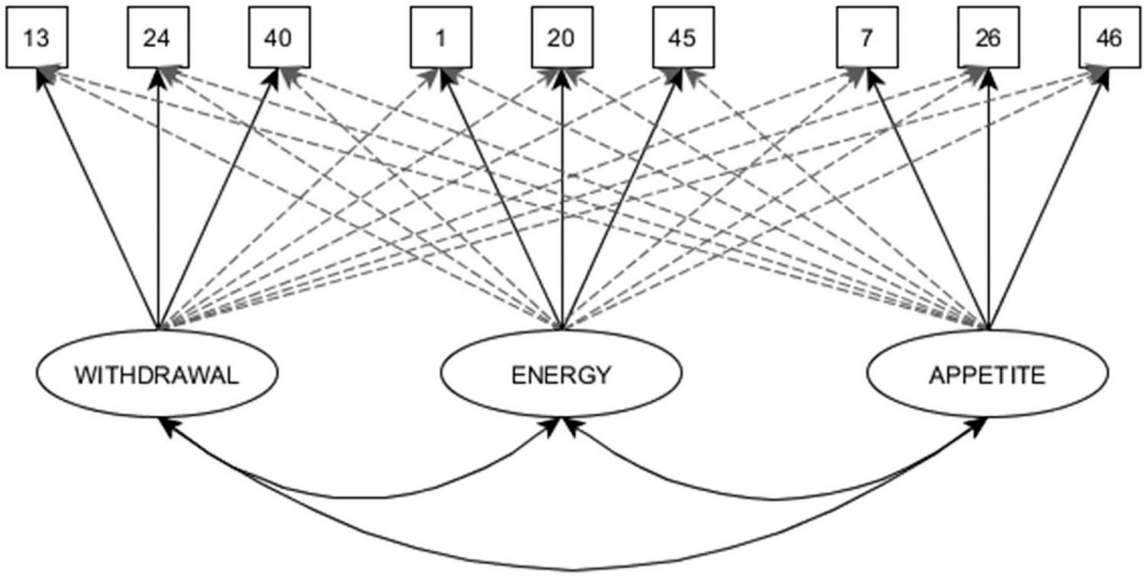

Figure 2.
Schematic of the exploratory structural equation model (ESEM) for three factors. This abbreviated three-factor model is shown for illustrative purposes only.

Table 1

Descriptive Statistics for Total Sample, Confirmatory Sample (1) and Validation Sample (2)

Variable	Total sample (*n* = 975)	Sample 1 (*n* = 488)	Sample 2 (*n* = 487)	*t*	χ^2	*p*
Age	20.84 ± 3.04	20.83 ± 3.05	20.84 ± 3.04	−.061		.951
Biological sex					.01	.927
Male	283 (29.0%)	141 (28.9%)	142 (29.2%)			
Female	692 (71.0%)	347 (71.1%)	345 (70.8%)			
Race/ethnicity[a]					6.45	.265
Asian	83 (8.5%)	32 (6.6%)	51 (10.5%)			
African American	147 (15.1%)	81 (16.6%)	66 (13.6%)			
White	425 (43.7%)	213 (43.7%)	212 (43.7%)			
Hispanic	196 (20.2%)	97 (19.9%)	99 (20.4%)			
Other	23 (2.4%)	13 (2.7%)	10 (2.1%)			
Multiracial	98 (10.1%)	51 (10.5%)	47 (9.7%)			
Caffeine Uuse[b]					.02	.897
Daily	479 (49.3%)	241 (49.5%)	238 (49.1%)			
Less than daily	493 (50.7%)	246 (50.5%)	247 (50.9%)			
Primary caffeine type[c]					3.87	.276
Coffee	377 (39.6%)	183 (38.0%)	194 (41.2%)			
Energy/soft drink	265 (27.8%)	145 (30.1%)	120 (25.5%)			
Tea	122 (12.5%)	65 (13.5%)	57 (12.1%)			
Caffeine in general	188 (19.3%)	88 (18.3%)	100 (21.2%)			

[a]Data not available for three participants.

[b]Data not available for two participants. Participants were considered “Daily” if they endorsed use of caffeine at least once daily over the past month; “Less than daily” if they endorsed use of caffeine “less than one time per day” or “not at all” over the past month.

[c]Data not available for three participants; 20 participants endorsing “Caffeine-containing medication” or “Other” as their primary caffeine type were excluded from the analyses of sample differences (in Table). Examination of full primary caffeine type (*n* = 972) revealed no significant association between sample and type (χ^2 = 7.60, *p* = .269).

Table 2

CFA and ESEM Model Fit Indices and Invariance Model Fit Indices

Model	Parameters constrained	*n*	*df*	χ^2	RMSEA	CFI	SRMR	AIC	BIC	SABIC
Factor structure										
CFA	NA	487	149	469.29	.066 [.060, .072]	.953	.040	29234	29573	29316
ESEM	NA	488	71	162.53	.051 [.041, .062]	.987	.012	29067	29733	29228
Invariance										
General caffeine	NA	Non positive-definite matrix								
Coffee	NA	377	71	194.77	.068 [.057, .08]	.975	.015	22862	23487	22983
Drinks	NA	265	71	140.04	.061 [.046, .075]	.980	.016	15568	16137	15633
Tea	NA	122	71	108.76	.066 [.039, .09]	.980	.017	7051	7497	6994
1	None (configural invariance)	764	213	443.57	.065 [.057, .074]	.978	.016	45483	47695	46181
2	***Factor loadings (FL) [1] (metric invariance)***	***764***	***395***	***696.10***	***.055 [.048, .061]***	***.961***	***.034***	***45454***	***46823***	***45886***
3	FL uniquenesses (uniq) [1, 2]	764	435	705.62	.049 [.043, .056]	.965	.036	45453	46636	45826
4	FL, factor variance-covariances (FVCV) [1, 2]	764	451	806.04	.056 [.049, .062]	.954	.071	45497	46606	45847
5	***FL, intercepts (inter) [1, 2] (scalar invariance)***	***764***	***421***	***734.61***	***.054 [.048, .061]***	***.959***	***.035***	***45439***	***46687***	***45833***
6	FL, uniq, FVCV [1, 2, 3, 4]	764	491	826.52	.052 [.046, .058]	.957	.077	45508	46431	45800
7	***FL, uniq, inter [1, 2, 3, 5] (error variance invariance)***	***764***	***461***	***743.32***	***.049 [.042, .055]***	***.963***	***.037***	***45435***	***46497***	***45771***
8	FL, FVCV, inter [1, 2, 4, 5]	764	477	844.74	.055 [.049, .061]	.952	.072	45481	46469	45794
9	FL, uniq, FVCV, inter [1–8]	764	517	864.09	.051 [.045, .057]	.955	.077	45490	46293	45744
10	FL, inter, factor means (FMn) [1, 2, 5] (latent mean invariance)	764	435	845.61	.061 [.055, .067]	.947	.072	45536	46719	45910
11	FL, uniq, inter, FMn [1, 2, 3, 5, 7, 10] (manifest mean invariance)	764	475	847.47	.055 [.049, .062]	.952	.073	45533	46530	45848
12	FL, FVCV, inter, FMn [1, 2, 4, 5, 6, 8, 10]	764	491	954.61	.061 [.055, .067]	.940	.102	45577	46500	45868
13	FL, uniq, FVCV, inter, FMn [1–12] (complete factorial invariance)	764	531	968.13	.057 [.051, .063]	.943	.105	45585	46323	45818

Note. CFA = confirmatory factor analysis; ESEM = exploratory structural equation mod; RMSEA = root mean square error of approximation; CFI = comparative fit index. Models within brackets were compared; for example, [1,2] means models 1 and 2 were compared. Models with best fit are in bold italics. None of the analyses were statistically significant at the $p < .05$ level.

Table 3

Factor Pattern Coefficients of CFA and ESEM Estimates

Factor	Item	Question	CFA f/p	ESEM						
				1	2	3	4	5	6	7
1. Withdrawal/dependence	13	I would experience caffeine withdrawal if I went without caffeine	.89	**.90**	−.01	−.08	−.01	.03	.10	−.06
	24	I need to have caffeine every day	.83	**.77**	.06	.10	.05	−.03	−.07	−.01
	40	I would get a headache if I went without caffeine	.88	**.91**	−.03	.00	−.01	.00	−.04	.05
2. Energy/work enhancement	1	Caffeine picks me up when I am feeling tired	.79	.07	**.87**	.00	−.10	.04	.07	−.08
	20	Caffeine makes me feel more alert	.87	−.01	**.65**	−.02	.18	.04	.05	.12
	45	Caffeine makes me feel more energetic	.87	.04	**.64**	.09	.18	.03	−.17	.17
3. Appetite suppression	7	Caffeine suppresses feelings of hunger	.83	−.07	.09	**.83**	.01	.01	.07	−.13
	26	Caffeine allows me to skip meals	.82	.07	−.12	**.82**	.00	.01	.07	.00
	46	Caffeine decreases my appetite	.92	.01	.02	**.91**	−.01	.01	−.07	.11
4. Social/mood enhancement	2	Conversations are better when using caffeine	.82	.05	.21	−.01	**.61**	.02	.15	−.14
	23	Caffeine makes me friendlier	.88	.01	.00	.01	**.85**	.03	.07	−.06
	42	I feel more sociable after having caffeine	.92	.03	−.02	.04	**.89**	.03	−.07	.10
5. Physical performance enhancement	5	Caffeine improves my athletic performance	.79	−.01	.09	.05	.04	**.68**	.09	−.08
	12	Workouts are better after having caffeine	.90	−.01	.01	−.03	−.10	**.98**	.03	−.04
	43	I can exercise longer if I have caffeine	.90	.01	−.07	.01	.09	**.87**	−.11	.09
6. Anxiety/negative physical effects	4	I am easily stressed after having caffeine	.77	.02	.01	.06	.06	−.04	**.74**	.04
	11	Caffeine makes me jittery	.70	.02	.17	.12	−.03	.04	**.50**	.09
	19	Caffeine makes me feel nervous	.82	.02	−.14	−.03	.08	.06	**.74**	.13
7. Sleep disturbance	28	I have difficulty sleeping after having caffeine	.77	.02	.16	−.02	−.09	.05	.14	**.69**
	47	Caffeine late in the day gives me insomnia	.79	.02	.01	.06	.03	.01	.11	**.73**

Note. CFA = confirmatory factor analysis; ESEM = exploratory structural equation mod. Item numbers in the table denote the item number from the original Caffeine Expectancy Questionnaire. Bold text indicates factor loadings for items on each subscale.

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Table 4

CFA and ESEM Factor Correlations for Samples 1 and 2 and Alpha for Brief Caffeine Expectancy Questionnaire Subscales

Factor	1	2	3	4	5	6	7	α
1. Withdrawal/dependence		.55	.40	.64	.46	.36	.30	.898
2. Energy/work enhancement	.48		.52	.81	.61	.46	.53	.873
3. Appetite suppression	.39	.42		.58	.49	.48	.39	.894
4. Social/mood enhancement	.61	.70	.54		.65	.44	.34	.888
5. Physical performance enhancement	.45	.54	.47	.62		.40	.36	.888
6. Anxiety/negative physical effects	.28	.33	.38	.30	.32		.75	.813
7. Sleep disturbance	.23	.36	.33	.23	.32	.45		.857

Note. CFA = confirmatory factor analysis; ESEM = exploratory structural equation mod. CFA factor correlations are above the diagonal; ESEM factor correlations are below the diagonal.

Table 5

Correlation Between Brief-Caffeine Expectancy Questionnaire Subscales, Caffeine Use Frequency, and Other Substance Use Frequency (N = 975)

Substance use	Withdrawal/ dependence	Energy/work enhancement	Appetite suppression	Social/mood enhancement	Physical performance enhancement	Anxiety/negative physical effects	Sleep disturbance
Caffeine use frequency	.44**	.30**	.15**	.30**	.16**	.03	.00
Caffeine use frequency (month)	.44**	.28**	.16**	.31**	.17**	.01	.00
Excessive caffeine use (2 weeks)	.24**	.10**	.08*	.16**	.11**	.04	.00
AmED use frequency	−.03	.02	.06	.02	.05	−.02	.06
AmED binge drinking	.03	.05	.06	.05	.07*	.05	.03
Cocaine use frequency	−.13	.08	−.01	−.01	−.01	.04	.04
Ritalin use frequency	.10	−.05	−.17	−.01	.08	−.10	−.13
Adderall use frequency	−.13	.05	−.06	.02	.25**	.02	.02

Note. AmED = alcohol mixed with energy drinks. Use frequency is past year, unless otherwise specified. Excessive and binge use is past two weeks. Excessive caffeine use is an ordinal outcome (none, once, twice, three to five, six to nine, 10 or more). All caffeine use frequency coefficients are zero-order correlations; all other substance use frequency coefficients are partial correlations, controlling for daily caffeine use frequency in past 30 days.

* $p < .05$.

** $p < .01$.

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Table 6

Partial Correlations Between Brief-Caffeine Expectancy Questionnaire Subscales and Theoretical Associated Measures

Subscale	Global Sleep (PSQI)	Anxiety Sensitivity (ASI)	Social Interaction Anxiety (SIAS)	Change in Appetite (PHQ)
Withdrawal/dependence	.06	.19**	.17**	.05
Energy/work enhancement	.04	.09	.06*	.06
Appetite suppression	.08	.21**	.17**	.17**
Social/mood enhancement	.03	.22**	.16**	.11*
Physical performance enhancement	.01	.12**	.06*	.02
Anxiety/negative physical effects	.11*	.27**	.19**	.18**
Sleep disturbance	.10*	.11**	.06*	.11*

Note. PSQI = Pittsburgh Sleep Quality Index; ASI = Anxiety Sensitivity Index-3; SIAS = Social Interaction Anxiety Scale; PHQ = Patient Health Questionnaire. All coefficients are partial correlation coefficients, controlling for daily caffeine use frequency in past 30 days.

* $p < .05$.

** $p < .01$.

Table 7

Factor Means, Variances, and Standardized Mean Differences

	M		Variance		Effect size[a]	
Subscale	**Energy**	**Tea**	**Energy**	**Tea**	**Energy**	**Tea**
Withdrawal/dependence	−.21	−.32	.94	.82	−.21	−.32
Energy/work enhancement	−.87	−1.15	1.54	1.69	−.79	−1.06
Appetite suppression	−.34	−.39	.68	.76	−.37	−.40
Social/mood enhancement	−.47	−.59	.80	.71	−.49	−.61
Physical performance enhancement	−.31	−.25	.73	.79	−.33	−.26
Anxiety/negative physical effects	−.31	−.20	.75	1.14	−.33	−.19
Sleep disturbance	−.26	−.24	.80	1.02	−.27	−.24

Note. Means and variances are in comparison to individuals that denoted coffee as their primary consumption vehicle.

[a]Effect size is the standardized mean difference between the group and coffee.