The Yale Craving Scale: Development and psychometric properties

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Abstract

Introduction—The current study presents a psychometric evaluation of the Yale Craving Scale (YCS), a novel measure of craving for cigarettes and alcohol, respectively. The YCS is the first

craving measure to use a generalized Labeled Magnitude Scale (gLMS) as the scoring format, which facilitates between-group comparisons of subjective craving and eliminates ceiling effects by assessing the full range of imaginable sensation intensities.

Methods—Psychometric evaluations of the YCS for use with cigarettes (YCS Smoking) and alcohol (YCS Drinking) included assessments of latent factor structure, internal consistency, ceiling effects, and test-criterion relationships. Study samples included 493 treatment-seeking smokers and 213 heavy drinkers.

Results—Factor analyses of the 5-item YCS Smoking and Drinking scores confirmed a 1-factor scale. The YCS Smoking and Drinking scores evidenced: (1) good internal consistency, (2) scalar measurement invariance within several subgroups (e.g., smoking/drinking status; nicotine/alcohol dependence), (3) convergent relationships with extant craving measures, and (4) concurrent relationships with smoking/drinking outcomes.

Conclusions—These results suggest that the YCS represents a psychometrically sound scale for assessing smoking and drinking urges in dependent populations.

1. Introduction

Craving, which has been defined as "subjective experience of wanting to use a drug" (Tiffany and Wray, 2012), is a well-documented phenomenon in addictive behaviors. Research has suggested two types of craving: tonic and phasic (Tiffany and Wray, 2012). Tonic craving refers to a desire for a substance that is relatively stable over time and is elicited by substance withdrawal, while phasic craving is characterized by acute, intense episodes of craving that are elicited by exposure to stimuli that are associated with substance use (e.g., stress, presence of other users, etc.). Indeed, there is a relationship between craving intensity and the number of substance- and individual-specific cues, and craving intensity predicts increases in later substance use (Fatseas et al, 2015). In addition, a recent review evaluating ecological momentary assessment data across multiple substances of abuse demonstrated a positive relationship between craving and concurrent and prospective substance use (Serre et al., 2015). An assessment of craving may aid researchers or clinicians in understanding an individual's craving in specific contexts, between group differences in craving, or, possibly, the risk of relapse. The field would benefit from a single, psychometrically sound measure that can be used to assess craving across multiple substances; extant craving measures largely are substance specific (e.g., Questionnaire on Smoking Urges [QSU; Tiffany and Drobes, 1991]; the Obsessive Compulsive Drinking Scale [Anton et al., 1995], the Alcohol Urge Questionnaire [AUQ; Bohn et al., 1995]). Similarly, a measure that could be used to assess craving in across several conditions known to elicit strong craving would maximize its utility.

To address these gaps in the literature, we created the Yale Craving Scale (YCS), a novel craving measure for use in clinical and research settings that provides a global index of craving over the past week by assessing craving at the present moment, and in 4 situations

over the prior week: (1) during the strongest craving experienced (Sayette and Tiffany, 2013), (2) when trying to avoid the substance (Dunbar et al., 2010), (3) when using the substance (Jarvik et al., 2000), and (4) when in a stressful situation (Sinha, 2001). A central strength, the YCS was designed to assess the perceived intensities of cravings for cigarettes (YCS Smoking) and for alcohol (YCS Drinking). A second unique feature, the YCS uses a generalized version of the Labeled Magnitude Scale (LMS). The LMS is based on the concept of the "category-ratio scale" (Borg, 1982), in which semantic scaling is used to empirically determine the spacing of scale response categories (i.e., barely detectable, weak, moderate, strong, very strong, and strongest imaginable). Due to the quasi-logarithmic spacing of the semantic labels on the LMS, LMS scales have been found to produce ratio-level data as opposed to the ordinal or interval-level data produced by equal-interval Likert-type scales (Green et al., 1993; Stevens, 1971). The LMS initially was created to improve comparisons of individual differences in oral sensations of taste, temperature, and chemesthesis (Green et al., 1993), but subsequently was validated for broader use within and between perceptual domains in which the strongest imaginable sensations are painful (Green et al., 1996). Bartoshuk and colleagues later generalized the LMS (gLMS) by changing its top label to "strongest imaginable sensation *of any kind"* (Bartoshuk et al., 2004). As a result, the gLMS allows modality matching (in this case, drug cravings to be compared against the strongest imaginable sensation of any kind) and, thereby, encompasses the full range of possible cravings that can be experienced.

Finally, the YCS has two features designed to increase the accuracy of participants' responses. Prior to completing the YCS craving items, all participants complete a brief training exercise that is designed to familiarize them with the gLMS. Second, the YCS instructs participants to recall and record a specific situation prior to making each retrospective craving rating for the past week (i.e., items 2–5). For example, prior to rating craving intensity for a cigarette while stressed (YCS item 5), participants first recall and record the most stressful event that occurred during the past week (e.g., having an argument, financial stress). This approach mirrors methods used in Timeline Follow-Back reports of substance use in which individuals are encouraged to recall each day's events so as to enhance accurate recall of drug use (Sobell and Sobell, 1992).

The current study presents a psychometric evaluation of the YCS. In building evidence for its psychometric properties, we employed a tiered approach such that establishing evidence for "basic" psychometric properties of the YCS (e.g., a stable latent structure, measurement invariance [MI], internal consistency) was a prerequisite for conducting advanced psychometric evaluations (e.g., test-criterion validity). Thus, we first present results from a range of "first tier" psychometric analyses (e.g., Confirmatory Factor Analyses; internal consistency, MI for subgroups of interest [e.g., sex; dependence severity], evaluation of ceiling effects). We then present evidence for second tier psychometric properties of the YCS Scores (i.e., convergent relationships with alternative measures of craving and test-criterion relationships with smoking and drinking outcomes).

We hypothesize that the YCS Smoking and Drinking scores will evidence a single latent factor structure, MI across a number of subgroups of interest (e.g., YCS Smoking: sex, number of cigarettes smoked per day; nicotine dependence severity; YCS Drinking: sex,

family history of alcoholism, alcohol dependence severity), and sufficient internal consistency. Based on the gLMS format, we anticipate that the YCS Smoking and Drinking Scores will not suffer from ceiling effects, a problem that has been noted with measures that utilize visual analog scales or Likert scales (Lishner et al., 2008). Finally, we predict that the YCS Smoking and Drinking Scores will demonstrate test-criterion relationships with extant craving measures and with substance use variables of interest (e.g., alcohol use; alcohol dependence; cigarette smoking; nicotine dependence).

2. Methods

2.1. Participants and procedure

The YCS smoking was administered to participants in two smoking cessation trials (i.e., the Message Framing Study and the Naltrexone + Patch Study). Details on the study procedures have been published previously (O'Malley et al., 2006; Toll et al., 2007). However, we briefly review information that is relevant to the current study below. The Message Framing Study (N= 198) was designed to investigate the impact of varying smoking messages in promoting smoking cessation among participants treated with sustained-release (SR) bupropion (Toll et al., 2007). The Naltrexone + Patch Study (N= 295) investigated whether varying doses of naltrexone improved rates of smoking cessation among participants receiving nicotine replacement therapy (i.e., a 21-mg nicotine patch; O'Malley et al., 2006). In the current study, we analyzed baseline YCS data, which was collected prior to the administration of any medication.

The YCS Drinking was administered to participants in two separate laboratory studies. Again, details on the study procedures have been published previously (Krishnan-Sarin et al., 2007, 2015). The first trial, the Naltrexone Study (N=102), was an investigation of the interactive effects of family history of alcoholism and naltrexone dose on alcohol consumption in nontreatment-seeking individuals with alcohol dependence (Krishnan-Sarin et al., 2007). The second trial, the Mementine Study (N= 111), examined the effects of memantine dosage (on drinking and craving behavior in non-treatment seeking alcohol dependent participants who were either family history positive or negative for alcohol dependence (Krishnan-Sarin et al., 2015). Again, current analyses focused on baseline ratings of craving, which were collected prior to the administration of any medication. The four parent studies were approved by the Institutional Review Board (IRB) of the Yale University School of Medicine. The Naltrexone + Patch Study also was approved by the IRBs of the University of Connecticut and the Veterans Affairs Connecticut Healthcare System. Table 1 presents demographics for all four studies.

2.2. Materials

2.2.1. The Yale Craving Scale (YCS; see supplementary material)—The first three pages of the YCS represent a training exercise that is designed to familiarize participants with the scoring method and orient them to the scaling. A research assistant reviewed the instructions with all participants and administered the training exercise. Participants then rated their craving associated with the following prompts: "(1) Please rate your desire for a cigarette/a drink right now;" (2) "Please rate the intensity of your strongest desire to smoke/

drink that you experienced last week;" (3) "Please rate the intensity of your desire when you tried to refrain from smoking/drinking last week;" (4) "Please rate the intensity of your desire to smoke/drink after you had that first cigarette/drink;" (5) "Please rate the intensity of your desire to smoke/drink during that stressful situation." Prior to rating items 2–5, participants were first asked to recall and record the situation upon which they based their rating (e.g., the most stressful situation during the past week). Participants were instructed to make a vertical mark along the 112 mm gLMS scale to indicate their level of craving. Each item was scored by measuring the distance from "experiencing no sensation at all" (0) to the point where the participant placed the mark. The YCS items were summed to create a global index of craving.

2.2.2. Timeline follow-back (TLFB; Brown et al., 1998; Sobell and Sobell, 1992)

—The TLFB is designed to collect reports of daily tobacco and alcohol consumption using a calendar to aid in the recall of past drinking and smoking. TLFB data were used to establish the average number of cigarettes smoked per day and the total number of drinks consumed over the past month.

2.2.3. The Fagerström test for nicotine dependence (FTND; Heatherton et al., 1991)—The FTND is a six item self-report questionnaire used to assess nicotine dependence. Scores can range from 0 to 10, with higher scores reflecting greater dependence.

2.2.4. The Questionnaire on Smoking Urges-Brief (QSU-Brief; Toll et al., 2006)

—The QSU-Brief is a self-report measure that asks respondents to indicate how strongly they agree or disagree "right now" with five craving-related items using a scale from 1 (strongly disagree) to 7 (strongly agree). Responses are best classified into two factors: Desire to smoke (2 items) and Desire to smoke to relieve negative affect (3 items).

2.2.5. The psychiatric family history by interview (FHAM; Rice etal., 1995)—

TheFHAM was used to determine parental family history of alcoholism status based on the DSM-IV diagnostic criteria. The FHAM is a reliable method for obtaining family history information and has good specificity and sensitivity diagnosing substance dependence.

2.2.6. Obsessive Compulsive Drinking Scale (OCDS; Roberts et al., 1999)—The OCDS is a 14 item, self-report measure of obsessive thoughts about and compulsive behaviors toward drinking. A three-factor model was selected for the present analyses reflecting: resistance/control impairment, obsession, and interference.

2.2.7. Alcohol Urge Questionnaire (AUQ; Bohn et al, 1995)—The AUQ is an 8-item, single factor measure of self-reported alcohol urges that asks respondents to indicate how strongly they agree or disagree "right now" with each item using a scale from 1 (strongly disagree) to 7 (strongly agree).

2.2.8. Alcohol Dependence Scale (ADS; Skinner and Allen, 1982)—The ADS is a 25 item self-report questionnaire that assesses alcohol dependence (e.g., impaired control

over alcohol use, tolerance). Total scores range from 0 to 40, with higher scores indicating greater dependence.

3. Data analysis

3.1. Evaluating the effectiveness of the YCS training

Using SPSS 22 (IBM, 2013), paired samples *t*-tests were conducted to ensure that participants rated experiences designed to be stronger in intensity as more intense (i.e., brightness of high beams >brightness of a well lit room; loudness of a fire engine >loudness of a normal conversation; desire to eat after skipping breakfast and lunch >desire to eat after finishing dinner). We also evaluated whether participants rated the intensity of the strongest experience they recalled ever having as stronger than the ratings of the other training experiences and the responses for each YCS item.

3.2. Confirming the latent structure of the proposed interpretation of YCS scores

Using MPLUS 7.0 (Muthén and Muthén, 1998), CFA models for YCS Smoking and Drinking scores were specified using robust maximum likelihood estimation, as it is robust to non-normality and produces model fit indices. Full Information Maximum Likelihood was specified to process missing data. We used the following indices as indicators of acceptable model fit: Root Mean Square Error of Approximation (RMSEA) <.07 (Steiger, 2007), Bentler's Comparative Fit (CFI) >.95 (Hu and Bentler, 1999), Standardized Root Mean Square Residual (SRMR) <.08 (Hu and Bentler, 1999).

3.3. Evaluating internal consistency of the proposed interpretation of YCS scores

Using SPSS 22 (IBM, 2013), Cronbach's alpha (α) values were calculated for the YCS scores. Values .70 indicate adequate reliability.

3.4. Evaluating measurement invariance of the proposed interpretation of YCS scores

Based on the procedures outlined by Cheung and Lau (2012), we employed a multi-group CFA approach using MPLUS 7.0 (Muthén and Muthén, 1998), in which bias-corrected bootstrap confidence intervals were used to evaluate item-level MI across subgroups of interest at baseline (YCS Smoking scores: sex, number of cigarettes smoked per day, nicotine dependence, drinking status; YCS Drinking scores: sex, family history, total alcohol consumed in the past month, daily binge drinking status; level of self-reported alcohol dependence symptoms, cigarette smoking status). Among other strengths, using this procedure solves the traditional multi-group CFA problem of selecting the most appropriate item referent by simultaneously testing all possible item combinations within a single model. This approach also is considered superior to other alternatives for evaluating measurement invariance such as Multiple Indicators Multiple Causes (MIMIC) modeling, which is insensitive to detecting when variance is present in factor loadings (e.g., Kim et al., 2012).

We first evaluated configural invariance (i.e., latent structure invariance) to determine if the conceptual framework of the YCS (i.e., 1 factor with 5 items) was invariant across groups. Configural invariance was established if all items loaded significantly onto a single factor and model fit was acceptable.

For all models in which configural invariance was established, we evaluated metric invariance (i.e., factor loading invariance) to determine if the magnitudes of the relationships between the latent factor and the YCS Smoking or Drinking items were similar across groups. Metric invariance was confirmed for all items for which zero fell inside of the bootstrapped confidence interval (1000 samples). For all items in which metric invariance was established, we evaluated scalar invariance (i.e., intercept invariance) to establish whether mean responses for corresponding YCS Smoking or YCS Drinking items were similar across groups. If any items were identified as non-scalar invariant (i.e., zero falls outside of the 95% confidence interval using 1000 samples), we employed a list-and-delete approach to identify item sets that were scalar invariant according to the procedure outlined by Cheung and Lau (2012). In Step 1 of this process, all possible item combinations are generated. In Step 2, for any items that were not invariant, all combinations are eliminated that contain both the problem item and the associated referent. For example, if item 3 is not invariant when item 1 is used as the referent, these two items cannot appear together in the final set of invariant items. Thus, all possible combinations that include both 1 and 3 are deleted. In Step 3, the solution comprising the greatest number of invariant items is selected. Evidence for scalar or partial scalar invariance (i.e., the majority of items are scalar invariant) must be present before mean-level comparisons across groups can be interpreted in a statistically meaningful way (e.g., Chen, 2008).

3.5. Evaluating ceiling effects for the proposed interpretation of YCS scores

Using SPSS 22 (IBM Corp, 2013), distributions of YCS Smoking Q and Drinking scores were examined to determine whether ceiling or floor effects were present.

3.6. Evaluating test-criterion relationships between YCS scores and alternative measures of craving and substance use using MPLUS 7.0 (Muthén and Muthén, 1998)

3.6.1. Convergent evidence—We conducted bivariate correlations between the YCS Smoking Scores and the QSU-Brief and between the YCS Drinking Scores and both the OCDS and the AUQ. Positive, significant relationships were expected between the YCS scores and the extant craving measures.

3.6.2. Concurrent evidence—We conducted bivariate correlations between the YCS Smoking Scores and both the average number cigarettes smoked daily and nicotine dependence at baseline. We also examined correlations between the YCS Drinking Scores and both past month alcohol use and alcohol dependence at baseline. Positive relationships between the YCS Drinking scores and these variables were expected. Finally, we conducted univariate general linear modeling to examine whether baseline YCS Scores (Smoking and Drinking) predicted the aforementioned substance use outcomes after accounting for participant sex, age, race and family history status (for the alcohol models only). For the models predicting dependence, baseline cigarette smoking or baseline total drinks per month were included in the respective models.

4. Results

4.1. Evaluating the effectiveness of YCS training and gLMS

The results of paired samples *t*-tests indicated that training was effective. Participants rated all experiences intended to be stronger in intensity accordingly, including rating the strongest sensation they had ever experienced as being more intense than each of the training items and YCS items (Smoking and Drinking; all *p*-values <.001; see Table 2). Participants mostly commonly listed the following experiences as the strongest sensations ever experienced: medical/surgical pain ($n = 218$; e.g., kidney stones, shoulder surgery), accidents ($n = 186$; e.g., car accident, dog bite), childbirth ($n = 104$; e.g., labor, C-section), emotional pain ($n = 64$; e.g., death of a loved one, divorce), and joy/excitement ($n = 30$; skydiving, birth of a grandchild).

4.2. Confirming the latent structure of the proposed interpretation of YCS scores

For both YCS Smoking and Drinking scores, a single factor, 5-item solution fit the data well (Smoking: $\chi^2(5) = 5.29$, $p = .38$, RMSEA = .011, CFI = .990, SRMR=.018; Drinking: $\chi^2(5) = 7.33$, $p = .20$, RMSEA = .047, CFI = .989, SRMR = .030). For both substances, factor loadings for each item were statistically significant (see Table 3) and no modification indices were present.

4.3. Evidence for the internal consistency of the proposed interpretation of YCS scores

The YCS scores demonstrated adequate internal consistency (Smoking: $\alpha = .76$; Drinking: $\alpha = .78$).

4.4. Evidence for measurement invariance of the proposed interpretation of YCS scores

A thorough description of the process for evaluating MI of the YCS Smoking scores based on number of cigarettes smoked per day (i.e., median split at 20 cigarettes per day) is presented below. We used the same procedure to evaluate MI of the YCS Smoking and Drinking scores across each of the remaining subgroups of interest. Thus, results of the remaining analyses are mentioned in brief within the text accompanied by references to the associated tables.

4.4.1. Configural invariance by number of cigarettes smoked per day—The multigroup CFA model for the YCS Smoking evidenced good fit (RMSEA =.001, CFI = .99, SRMR =.019), suggesting that a single factor latent structure comprising five items was invariant for smokers who smoked less than and greater than one pack of cigarettes per day (see Table 4).

4.4.2. Metric invariance by number of cigarettes smoked per day—Model constraints were specified such that differences in factor loadings across groups could be evaluated using bootstrap confidence intervals. For example, the difference in factor loadings for Item 2 (when the referent was Item 1) were specified as (Factor Loading for Item 2 [20 cigarettes/day] – Factor Loading for Item 2 [>20 cigarettes/day]). Based on the factor-ratio test, differences in item factor loadings were evaluated using each item as the referent. To this end, 10 unique tests were specified (i.e., 5 items × [5 – 1]/2). As shown in Table 5

(column labeled "Cigarettes per Day"), the confidence intervals for each parameter contained zero, suggesting factor that the factor loadings of the YCS Smoking items were invariant irrespective of the item used as the referent.

4.4.3. Scalar invariance by number of cigarettes smoked per day—Model constraints were specified such that differences in intercepts across groups could be evaluated using bootstrap confidence intervals. Again, based on the factor-ratio tests, differences in intercepts were evaluated using each item as the referent. As shown in Table 5 (column labeled "Cigarettes per Day"), the confidence intervals for each parameter contained zero, suggesting that the intercepts for all YCS Smoking items were invariant across irrespective of the item used as a referent.

4.4.4. Remaining invariance analyses—Using the same approach described above, configural, metric, and scalar MI were also evaluated for (1) YCS Smoking Scores by sex, nicotine dependence, and alcohol use status (see Table 4 for a summary of fit indices of models testing configural invariance and Table 5 for Metric and Scalar MI analyses) and (2) for the YCS Drinking Scores by sex, family history, past month alcohol use, daily binge drinking status, self-reported alcohol dependence, and cigarette smoking status (see Table 4 for configural invariance and Table 6 for a summary of Metric and Scalar MI analyses). For both YCS Smoking and Drinking Scores, configural and metric invariance were established for all subgroups assessed. Full scalar invariance was established for all subgroups with the exception of sex (YCS Smoking Scores). Invariant YCS Smoking items for sex subsequently were identified using the List-and-Delete method. The intercepts for YCS Smoking Items 2 and 5 (when Item 1 was the referent) were not invariant. After eliminating combinations including both 1 and 2 and 1 and 5 (and lower order combinations), the following item set was identified as invariant: 2, 3, 4, and 5, establishing partial scalar invariance for the YCS Smoking scores by sex.

4.5. Evaluating ceiling effects for the proposed interpretation of YCS scores

The distributions of YCS Scores approximated normality (Smoking: Skewness = .81, Kurtosis = .62; and Drinking: Skewness = 1.03, Kurtosis = 1.03), and there was no evidence of ceiling or floor effects (see Fig. 1).

4.6. Evidence for the validity of the proposed interpretation of YCS scores based on relations with other variables

4.6.1. Convergent evidence—Positive significant relationships were observed between the YCS Smoking scores and the QSU-Brief subscales (Desire to smoke, r=.32; Negative affect relief, $r = .24$) and between the YCS Drinking scores and the AUQ(r= .53) and the OCDS subscales (Resistance, r=.36; Obsession, $r = .57$; Interference, $r = .37$; all p-values <. 001).

4.6.2. Concurrent evidence (bivariate correlations)—Positive, significant correlations were observed between the YCS Smoking scores and both the number of cigarettes smoked per day ($r = .16$, $p < .001$) and nicotine dependence ($r = .32$, $p < .001$). A very similar pattern emerged for alcohol; significant positive correlations were observed

between the YCS Drinking scores and self-reported total number of drinks consumed in the past month (r=.17, p = .02) as well as with self-reported alcohol dependence at baseline (r=.31, p<.001).

4.6.3. Concurrent evidence (univariate general linear modeling)—After accounting for participant sex, race, and age, baseline YCS Smoking Scores accounted for 3.3% of the variance in the number of cigarettes smoked per day and 6.5% of the variance in nicotine dependence (p-values <.001; see Table 7), and YCS Drinking Scores accounted for 4.6% of the variance in the total number of drinks consumed and 4.8% of the variance in alcohol dependence (p-values <.01; see Table 7).

5. Discussion

The present results revealed that the Yale Craving Scale (YCS) has strong psychometric properties when used to assess craving for cigarettes and alcohol, respectively, across several situations previously shown to elicit phasic craving (e.g., when feeling stressed; Higley et al., 2011; McKee et al, 2011). Indicating that the YCS provides a meaningful global index of craving, confirmatory factor analyses demonstrated that the YCS is a 1-factor measure for use with both substances. Of central importance, the YCS Smoking and Drinking scores were scalar or partially scalar invariant for all subgroups of interest, ensuring our ability to make statistically meaningful comparisons of YCS scores across subgroups of interest and to include YCS scores in more complex models (e.g., univariate general linear models). Finally, the YCS Smoking and Drinking scores were internally consistent and there was evidence for test-criterion relationships with extant craving measures and smoking and drinking outcomes.

While some researchers disagree regarding the advantages of using category-ratio scales (Schifferstein, 2012), the benefits of using the gLMS as a response format in the context of assessing craving using the YCS were notable. In particular, the ratio nature of the scale permitted quantitative comparisons to be made across groups for which MI is established (e.g., nicotine dependent smokers experience twice as much craving as non-dependent smokers). Responses to the YCS also could be compared within individuals over time. Craving is a dynamic process (as is relapse), and may change over the course of time. Assessing craving at multiple time points may aid a clinician in gauging relapse risk or in designing treatment plans. Furthermore, the training component of the YCS was effective, and the quality of participant responses may have been enhanced by the use of a TLFB approach, although this could not be evaluated directly in the current study.

The study findings must be noted in light of several limitations. First, the findings are dependent on participant self-report, and therefore are limited by participants' willingness and ability to report on their substance use reliably. Second, the study findings are cross-sectional in nature and only speak to the psychometric properties of the YCS before dependent individuals receive treatment. Thus, longitudinal studies are needed to evaluate the extent to which the psychometric properties of the YCS are maintained over the course of treatment, whether the YCS is able to detect changes in craving over time reliably, and whether YCS scores predict substance use outcomes overtime including relapse.Third, we

evaluated the utility of the YCS for use with populations who are dependent on cigarettes or alcohol only; future research is needed to evaluate the extent to which the current findings generalize to cravings for other types of substances within both dependent and non-dependent samples. Relatedly, we were unable to evaluate measurement invariance of the YCS by substance given that participants in the current study completed either the YCS Smoking or the YCS Drinking. Future research is needed to evaluate whether the YCS is, in fact, invariant across different substances, which would permit meaningful comparisons of cravings across different substances to be made. Further, we were unable to control for other drugs of abuse in the present analyses because current drug use (other than alcohol and tobacco) was an exclusion criterion in the primary studies. Fifth, the training and TLFB components of the YCS may increase participant burden relative to existing craving measures. However, the results of the current study indicate that the added time needed to complete the measure is a worthwhile investment.

In spite of the study limitations, the YCS is a psychometrically sound measure that reliably assesses cravings for cigarettes and alcohol using a novel gLMS scoring format. The YCS Smoking and Drinking scores evidenced: (1) good internal consistency, (2) scalar measurement invariance within several subgroups (e.g., smoking/drinking status; nicotine/alcohol dependence), (3) convergent relationships with extant craving measures, and 4) concurrent relationships with smoking/drinking outcomes. Given the relative brevity of this questionnaire and its strong psychometric properties, researchers are encouraged to consider using the YCS.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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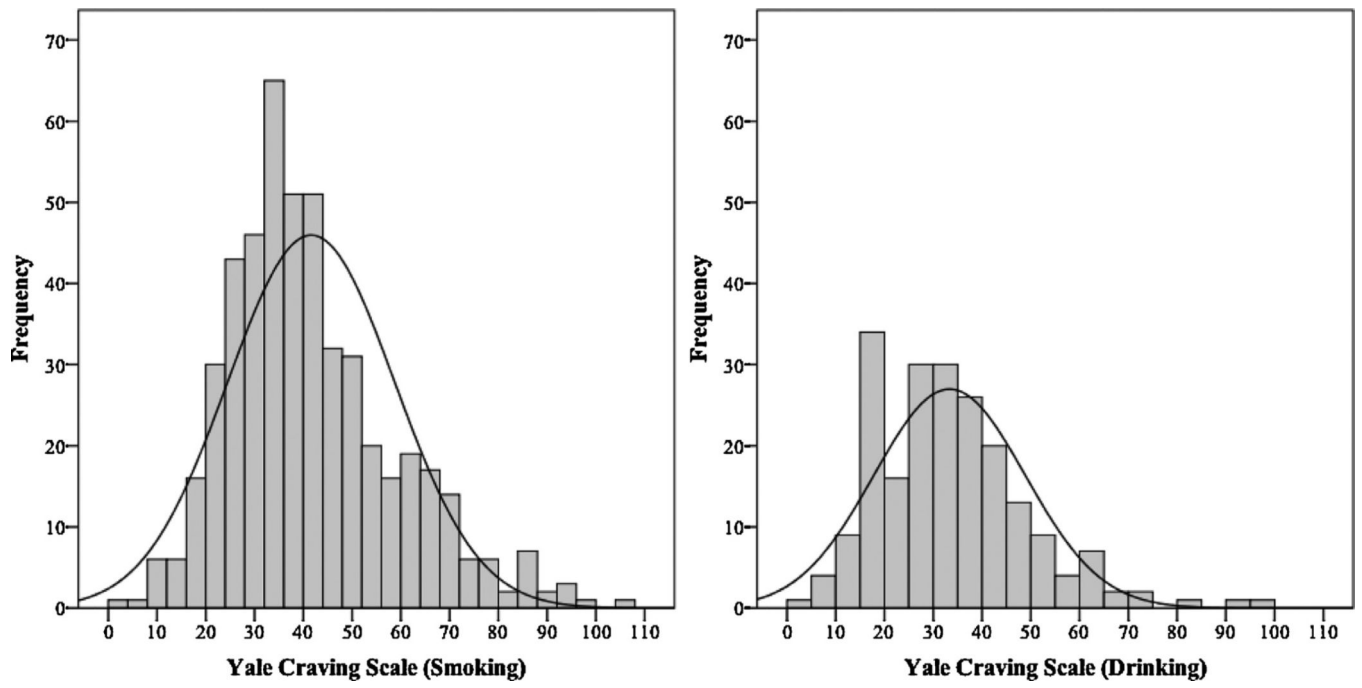
Fig. 1.
Distributions of YCS Smoking and Drinking Scores.

Table 1

Participant demographics.

	Smoking		
	Smoking total N = 493	Naltrexone + patch N = 295	Message framing N = 100
Age	43.98 (11.15)	45.05 (11.09)	42.38 (11.07)
Sex (*n* male)	251	151	100
Race (*n* white)	422	257	165
Drinking status in the past 60 days (*n* drinkers)	368	218	150
Cigarettes per day	25.48 (10.25)	27.59 (10.26)	22.35 (9.43)
Fagerstrom test of nicotine dependence	5.94 (2.13)	6.36 (2.07)	5.31 (2.07)
Brief Questionnaire of Smoking Urges Desire	8.73 (3.43)	8.95 (3.33)	8.40 (3.67)
Brief Questionnaire of Smoking Urges Negative Affect	7.32 (4.25)	7.97 (4.36)	6.31 (3.87)
Yale Craving Scale (baseline)	41.60 (17.11)	41.58 (17.55)	41.64 (16.49)
Yale Craving Scale (end of treatment)	23.82 (15.93)	22.03 (15.28)	26.39 (16.55)
	Drinking		
	Alcohol total N = 213	Memantine N = 111	Naltrexone N = 102
Age	31.42 (9.51)	31.01 (8.58)	31.87 (10.47)
Sex (*n* male)	153	75	78
Race (*n* white)	151	76	75
Cigarette smoking status (*n* smokers)	93	52	41
Family history of alcoholism (*n* positive)	100	58	42
Binge status (*n* binge drinkers)	164	85	79
Total drinks (past month)	159.15 (48.16)	165.02 (55.14)	152.70 (38.34)
Alcohol dependence (ADS)	10.85 (5.22)	11.29 (5.54)	10.37 (4.83)
Obessive Compulsive Drinking Scale (OCDS resistance)	10.81 (3.11)	11.04 (3.10)	10.56 (3.11)
Obessive Compulsive Drinking Scale (OCDS obsession)	5.39 (2.84)	5.49 (2.88)	5.29 (2.81)
Obessive Compulsive Drinking Scale (OCDS interference)	1.54 (1.62)	1.41 (1.52)	1.68 (1.73)
Alcohol Urge Questionnaire (AUQ)	–	–	21.32 (11.75)
Yale Craving Scale (baseline)	33.33 (15.53)	33.22 (15.39)	33.46 (15.76)
Yale Craving Scale (preceding alcohol administration)	28.47 (17.84)	30.43 (19.00)	26.49 (16.50)

Note. Continuous variables are presented as mean (standard deviation). Dichotomous variables are presented as follows: sex (the number of males); race (the number of Caucasian individuals); FamHX (the number of family history positive individuals); binge status (the number of participants whose alcohol consumption on atypical drinking day exceeds the binge drinking cutoff of 4 or more drinks for women or 5 or more drinks for men). – denotes that data were not available.

Table 2

Demonstrating effectiveness of the YCS training.

		Smoking		Alcohol	
		Mean	SD	Mean	SD
Training items					
Pair1 ***	Brightness of high beam headlights at night	38.01	21.90	32.48	19.14
	Brightness of a well lit room	24.31	18.14	19.75	15.35
Pair 2 ***	Sound of a fire engine, close up	40.11	25.50	37.29	22.38
	Sound of normal conversation	13.85	11.95	10.55	9.26
Pair 3 ***	Desire to eat after skipping breakfast and lunch	42.91	26.03	44.29	25.02
	Desire to eat after finishing dinner	8.92	12.92	7.42	10.75
YCS items					
Pair1 ***	1. Desire for a cigarette/drink right now	24.08	20.84	12.42	15.74
Pair 2 ***	2. Strongest desire to smoke/drink in the last week	60.60	23.13	53.23	19.98
Pair 3 ***	3. Desire to smoke/drink when you made an effort to avoid/refrain from smoking.	41.03	23.33	25.96	21.69
Pair 4 ***	4. Desire to smoke/drink after having first cigarette/drink	28.78	24.40	40.08	19.30
Pair 5 ***	5. Desire to smoke/drink when in a stressful situation	53.23	26.36	35.72	27.40
***	**Strongest experienced sensation (lifetime)**	**81.50**	**23.80**	**77.17**	**25.06**

*** denotes that paired samples *t*-tests were significant at *p*<.001. For training items, participants consistently rated experiences that were intended to be stronger in intensity as such (e.g., brightness of high beams >brightness of a well lit room). YCS items were each compared to the strongest imaginable sensation. Bolded font denotes that participant ratings of the strongest experienced sensation (lifetime) were significantly stronger than all other sensations (training items and YCS items).

Table 3

Confirmatory factor analytic indicator loadings for the 5-Item Yale Craving Scale (Smoking and Drinking).

YCS items	YCS smoking			YCS drinking		
	Standardized indicator loadings					
	StdYX	S.E.	Est./S.E.	StdYX	S.E.	Est./S.E.
YCS items						
1. Desire for a cigarette/drink right now	.54 ***	0.05	11.16	.67 ***	0.07	9.47
2. Strongest desire to smoke/drink in the last week	.79 ***	0.03	23.73	.80 ***	0.04	19.89
3. Desire to smoke/drink when you made an effort to avoid/refrain from smoking.	.59 ***	0.05	12.6	.59 ***	0.07	8.07
4. Desire to smoke/drink after having first cigarette/drink	.60 ***	0.04	14.58	.64 ***	0.06	11.38
5. Desire to smoke/drink when in a stressful situation.	.64 ***	0.04	15.39	.66 ***	0.05	12.96

***
p<.001;

StdXY=standardized factor loading; S.E. = standard error; Est./S.E. = a ratio of the factor estimate and the standard error.

Table 4

Fit indices for models testing configural invariance.

| | Configural invariance | | |
	RMSEA	CFI	SRMR
YCS smoking			
Sex (male vs. female)	.018	.998	.021
Cigarettes per day (<20/day vs 20/day)	.001	.990	.019
Nicotine dependence (<6 vs 6)	.044	.990	.026
Drinking status in past 60 days (yes vs. no)	.001	1.000	.021
YCS drinking			
Sex (male vs. female)	.035	.995	.029
Family history of alcoholism (yes vs. no)	.053	.990	.037
Total drinks (<148.5 vs. 148.5 drinks)	.054	.989	.031
Binge status (yes vs. no)	.079	.972	.039
Alcohol dependence (13 vs > 13)	.131	.952	.050
Current smoking status (Yes; No)	.076	.958	.035

CIGARETTES PER DAY reflects a median split of self-reported total number of cigarettes smoked per day at baseline [median = 20]; NICTONE DEPENDENCE reflects a median split of Fagerstrom Nicotine Dependence Scores a baseline [median = 6.00]; TOTAL DRINKS reflects a median split of self-reported total number of drinks consumed over the past month alcohol was consumed [median = 148.50]; BINGE STATUS reflects whether participants alcohol consumption on a typical drinking day exceeds the binge drinking cutoff of 4 or more drinks for women or 5 or more drinks for men; and ALCOHOL DEPENDENCE reflects a split based on a cutoff of 13 on the Alcohol Dependence Scale [13 indicates brief counseling or less is required; >13 indicates that level of alcohol use requires formal treatment].

Table 5

Metric and scalar invariance of the YCS smoking items by sex, cigarettes smoked per day nicotine dependence at baseline, and alcohol use status.

	Sex 99% CI		Cigs per day 99% CI		Nicotine dependence 99% CI		Drinking status 99% CI	
Item factor loadings								
Loading item 2 (referent @ 1)	−1.71	0.86	−1.32	1.63	−0.82	2.50	−0.52	3.19
Loading item 3 (referent @ 1)	−1.07	0.62	−0.35	1.40	−0.57	1.77	−0.79	1.29
Loading item 4 (referent @ 1)	−1.01	0.92	−1.44	0.72	−1.14	1.71	−0.67	2.42
Loading item 5 (referent @ 1)	−1.27	1.08	−1.15	1.20	−0.98	2.55	−0.33	3.44
Loading item 3 (referent @ 2)	−0.95	0.76	−1.39	0.45	−0.88	1.20	−0.27	2.91
Loading item 4 (referent @ 2)	−1.19	0.54	−0.45	1.46	−0.55	1.56	−0.59	1.20
Loading item 5 (referent @ 2)	−0.74	0.36	−0.45	0.73	−0.57	0.60	−0.55	0.55
Loading item 4 (referent @ 3)	−0.82	0.48	−0.21	1.60	−0.53	1.28	−0.88	0.73
Loading item 5 (referent @ 3)	−0.81	0.39	−0.27	1.05	−0.57	0.78	−0.91	0.12
Loading item 5 (referent @ 4)	−0.60	0.50	−0.68	0.43	−0.79	0.47	−0.79	0.26
	All invariant		All invariant		All invariant		All invariant	
Item intercepts								
Intercept item 2 (referent @ 1)	**0.06**	**17.30**	−11.15	4.82	−7.56	7.97	−8.05	12.43
Intercept item 3 (referent @ 1)	−2.05	11.78	−12.05	1.62	−8.01	5.36	−6.73	10.43
Intercept item 4 (referent @ 1)	−4.06	10.25	−4.92	10.95	−7.15	8.01	−5.57	13.88
Intercept item 5 (referent @ 1)	**1.28**	**16.54**	−11.07	5.70	−12.43	4.33	−5.08	14.71
Intercept item 3 (referent @ 2)	−10.29	3.57	−8.37	4.62	−6.75	4.47	−6.08	7.64
Intercept item 4 (referent @ 2)	−13.92	1.45	−0.36	10.72	−6.16	5.71	−4.82	9.53
Intercept item 5 (referent @ 2)	−0.06	18.90	−10.84	4.56	−8.36	7.03	−8.36	12.81
Intercept item 4 (referent @ 3)	−2.25	16.88	−9.57	1.40	−8.38	6.71	−9.29	20.35
Intercept item 5 (referent @ 3)	−2.50	17.00	−13.81	2.10	−11.10	7.50	−11.64	25.05
Intercept item 5 (referent @ 4)	−3.97	12.56	−6.41	21.26	−9.62	13.73	−7.14	24.48
	Invariant items: 2345		All invariant		All invariant		All invariant	

Note. This table depicts bias-corrected bootstrap confidence intervals (99%) used to evaluate metric and scalar measurement invariance of the YCS Smoking items across subgroups of interest. All groups are dichotomous in nature (i.e., SEX reflects men versus women; CIGS PER DAY reflects a median split of self-reported numberof cigarettes smoked per day at baseline [median = 20 cigarettes/day; NICTONE DEPENDENCE reflects a median split of Fagerstrom Nicotine Dependence Scores a baseline [median = 6.00]; DRINKING STATUS reflects whether participants reported consuming alcohol in the 60 days prior to entering the study [drinkers vs abstainers]). Confidence intervals containing zero reflect invariance. Bolded font denotes variant items. A summary of metric and scalar invariant items is provided for each subgroup. For sex, the invariant item sets were derived using the List-and-Delete method.

Table 6

Metric and scalar invariance for the YCS drinking items by sex, family history of alcoholism, alcohol use, binge drinking status, alcohol dependence, and cigarette smoking status.

	Sex 99% CI		FamHx 99% CI		Total drinks 99% CI		Binge status 99% CI		Alcohol dependence 99% CI		Smoking status 99% CI	
Item factor loadings												
Loading item 2 (referent @ 1)	-3.57	2.42	-0.07	12.32	-3.26	2.74	-2.81	8.61	-2.33	17.13	-2.47	2.85
Loading item 3 (referent @ 1)	-0.72	2.80	-1.39	2.47	-1.24	1.58	-10.25	9.85	-0.71	5.82	-1.94	1.30
Loading item 4 (referent @ 1)	-2.42	1.91	-0.61	5.03	-1.53	2.53	-1.87	8.77	-1.44	8.98	-2.26	2.40
Loading item 5 (referent @ 1)	-2.37	2.07	-1.00	4.98	-2.60	1.95	-2.06	11.43	-1.57	12.36	-3.27	2.97
Loading item 3 (referent @ 2)	-4.06	0.91	-0.34	17.58	-3.07	2.42	-3.64	0.31	-6.75	3.39	-2.22	2.33
Loading item 4 (referent @ 2)	-0.99	0.88	-0.34	1.96	-1.26	0.41	-1.05	0.47	-1.64	2.09	-1.23	0.64
Loading item 5 (referent @ 2)	-1.04	0.70	-1.80	2.97	-0.85	1.77	-1.23	0.22	-1.71	1.10	-0.86	0.82
Loading item 4 (referent @ 3)	-0.38	1.80	-1.42	0.60	-0.87	0.77	-0.60	1.18	-1.29	5.93	-1.51	0.72
Loading item 5 (referent @ 3)	-0.27	0.98	-0.91	0.28	-0.25	0.67	-0.46	0.64	-0.52	1.60	-0.70	0.48
Loading item 5 (referent @ 4)	-0.83	0.61	-0.58	1.35	-0.43	1.65	-0.83	0.43	-1.14	1.26	-0.69	0.87
	All invariant		All invariant		All invariant		All invariant		All invariant		All invariant	
Item intercepts												
Intercept item 2 (referent @ 1)	-7.48	32.85	-11.50	2.66	-12.74	9.59	-7.77	28.95	-19.30	7.29	-10.44	9.99
Intercept item 3 (referent @ 1)	-15.63	6.57	-10.17	4.55	-4.19	11.25	-10.17	14.39	-11.47	6.04	-6.27	12.10
Intercept item 4 (referent @ 1)	-7.65	22.92	-9.99	5.54	-13.22	4.21	-4.26	23.34	-10.21	9.61	-11.14	8.42
Intercept item 5 (referent @ 1)	-14.52	21.24	-7.71	12.22	-10.04	12.13	-9.27	24.76	-11.10	10.13	-2.23	22.03
Intercept item 3 (referent @ 2)	-34.95	1.88	-8.23	4.95	-4.40	13.18	-27.06	5.16	-11.74	13.99	-5.96	10.56
Intercept item 4 (referent @ 2)	-12.42	8.24	-5.95	7.15	-10.96	3.96	-11.72	9.96	-8.04	13.19	-8.45	5.47
Intercept item 5 (referent @ 2)	-9.14	37.60	-9.87	1.89	-14.79	11.98	-13.04	39.07	-16.10	8.25	-13.94	12.03
Intercept item 4 (referent @ 3)	-15.77	6.30	-45.01	15.01	-5.86	24.87	-9.48	14.66	-14.55	9.93	-8.64	16.27
Intercept item 5 (referent @ 3)	-20.56	7.72	-49.59	13.45	-6.47	20.99	-13.60	27.34	-20.94	9.10	-11.75	19.12
Intercept item 5 (referent @ 4)	-8.94	41.38	-11.76	7.86	-17.72	5.24	-5.66	43.26	-14.19	18.33	-14.11	11.69
	All invariant		All invariant		All invariant		All invariant		All invariant		All invariant	

Note. This table depicts bias-corrected bootstrap confidence intervals (99%) used to evaluate metric and scalar measurement invariance of the YCS Drinking items across subgroups of interest. All groups are dichotomous in nature (i.e., SEX reflects men versus women; FamHX reflects family history of alcoholism status; TOTAL DRINKS reflects a median split of self-reported total number of drinks consumed over the past month alcohol was consumed [median = 148.50]; BINGE STATUS reflects whether participants alcohol consumption on a typical drinking day exceeds the binge drinking cutoff of 4 or more drinks for women or 5 or more drinks for men]; ALCOHOL DEPENDENCE reflects a split based on a cutoff of 13 on the Alcohol Dependence Scale [13 indicates brief counseling is required;

>13 indicates that level of alcohol use requires formal treatment); SMOKING STATUS reflects cigarette smoking status (i.e., smoker, non-smoker). Note that invariance analyses for alcohol dependence were conducted within the memantine sample only; data were not available for participants in the naltrexone trial. Confidence intervals containing zero reflect invariance.

Table 7

YCS Smoking and Drinking scores predict substance use outcomes.

Smoking outcomes

	Cigarettes per day			Fagerstrom test of nicotine dependence		
	F	df	η_p^2	F	df	η_p^2
Corrected model	10.18	(4, 487)	.08 ***	65.58	(5, 464)	.40 ***
Sex	−16.74		.03 ***	−12.24		.03 **
Race	3.34		.01	3.89		.01 *
Age	6.30		.01	1.02		.00
# Cigs/day	—			225.85		.33 ***
YCS smoking	16.63		.03 ***	32.16		.07 ***

Drinking outcomes

	Total drinks (past month)			Alcohol dependence		
	F	df	η_p^2	F	df	η_p^2
Corrected model	3.89	(5,175)	.10 **	3.77	(6,173)	.12 **
Sex	11.67		.06 **	1.63		.01
Race	0.04		.00	5.83		.03 *
Age	1.49		.01	1.26		.01
Family history	0.24		.00	3.81		.02
Total drinks	—			0.86		.01
YCS drinking	8.51		.05 **	8.77		.05 **

*
$p<.05$.

**
$p<.01$.

***
$p<.001$.

− denotes a variable was not included in the model. Reference groups for categorical variables are: sex (female); Race (non-Caucasian); family History (negative family history of alcoholism).