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Psychometric Validation of the Four Factor Situational Temptations for Smoking Inventory in Adult Smokers

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PSYCHOMETRIC VALIDATION OF THE FOUR FACTOR SITUATIONAL TEMPTATIONS FOR SMOKING INVENTORY IN ADULT SMOKERS

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ABSTRACT

The situational temptations for smoking inventory assesses the degree of temptation a person might feel to smoke across a variety of situations found to be important for smoking cessation. The temptations measure with four subscales, Positive/Social (PS), Habit Strength (HS), Negative/Affective (NA), and Weight Concerns (WC), was previously validated among adolescent smokers. The measure that has been validated in adults includes only the PS, HS, and NA subscales, although weight concerns are also salient to adults who smoke and have been negatively associated with smoking cessation. This study examines the psychometric validity of the temptations measure with the addition of the WC subscale, including stability of the measurement model, using a population-based sample of adults who reported being current smokers (N = 2921, age range 18–82 years, 68.6% white, 55.3% female). Participants in the sample had complete data for the measure, and those with extreme response patterns were deleted. Confirmatory factor analyses (CFA) showed that theoretically based four-factor (PS, HS, NA, WC) models fit the measure well (CFI: .967, RMSEA: .052), with moderate to high internal consistency for all subscales (α .55 – .91). Multiple sample CFA established that the factor structure of the temptations measure was invariant across population subgroups defined by gender, age, racial identity, ethnicity, stage of change for smoking cessation, baseline smoking severity, and weight status. Measurement invariance testing using multiple sample analyses of mean and covariance structures showed that the invariance models fit well across stage of change, racial identity, ethnicity, and weight status at the level of strong measurement invariance. These results indicate a consistent relationship between the four factors (PS, HS, NA, WC) of the situational temptations for smoking measure, and the twelve items that serve as their measured indicators, confirming the internal validity of the measure in adult smokers. Multivariate analysis of variance revealed a small but significant effect of stage of change on the temptations subscale scores, demonstrating that the temptations measure can differentiate between adult smokers in the early stages of change for cessation.

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CHAPTER 1

INTRODUCTION

Smoking is the single most preventable cause of premature death and chronic disease in the United States. It causes heart and pulmonary diseases, multiple types of cancer, and exacerbates other chronic health conditions (USDHHS, 2010). Each year in the United States, smoking accounts for at least 443,000 premature deaths, and approximately $96 billion in direct medical costs and $97 billion in lost productivity (CDC, 2008). Nonetheless, approximately 19% (43.8 million) of all adults in the United States continue to smoke (CDC, 2012). Even though the prevalence of smoking has declined slightly since 2005 (CDC, 2011), the current estimated smoking rate is still much higher than the *Healthy People 2020* target of less than 12% (USDHHS). Smoking rates still vary widely across racial or ethnic groups, with the highest prevalence found among American Indians/Alaska Natives, African Americans and non-Hispanic whites (CDC, 2011; Caraballo, Yee, Gfroerer & Mizra, 2008), and most subgroups would be unable to meet the *Healthy People* target if the current trend continues. Increasing cessation rates among those who currently smoke and preventing smoking in the population remain important public health goals.

Behavioral interventions for smoking cessation using tailored health communications based on the Transtheoretical Model of behavior change have been developed and implemented, and have demonstrated significant impacts (e.g., Prochaska, DiClemente, Velicer & Rossi, 1993; Velicer & Prochaska, 1999; Velicer, Prochaska, Fava, Laforge & Rossi, 1999; Prochaska et al., 2004, 2005). The Transtheoretical Model (TTM; Prochaska & Velicer, 1997; Velicer et al., 2000) is an integrative model of intentional behavior change underlying numerous effective interventions. Empirically based tailoring is especially relevant

in population-based interventions when not everyone is prepared to change their risk behavior immediately (Velicer et al., 1993), for example, less than 20% of all smokers in the United States are prepared to quit smoking in the next month (Velicer et al., 1995).

The concept of self-efficacy refers to an individual's perceived ability or confidence to perform a task, which in turn mediates performance on future tasks (Bandura, 1977); it is also one of the core constructs integrated within the TTM framework. Temptation to smoke is conceptualized to be inversely related to confidence/self-efficacy in remaining abstinent from smoking, and reflects how tempted people are to smoke in different situations rather than how confident they are to avoid smoking in those situations (Velicer, DiClemente, Rossi & Prochaska, 1990). The theoretical relationship between self-efficacy/temptations and progress through the stages of change (i.e., readiness to change) has been documented (Velicer et al., 1990; Fava, Velicer & Prochaska, 1995; Velicer, Rossi, Prochaska & DiClemente, 1996), and incorporated into TTM-tailored intervention programs.

Appropriately operationalizing theoretical constructs into psychometrically sound measures is critical for testing and implementing a theoretical model. Several TTM-based smoking cessation measures have been tested in adult smokers and demonstrated good psychometric validity (e.g., O'Connor, Carbonari, & DiClemente, 1996; Ward, Velicer, Rossi, Fava & Prochaska, 2004). The situational temptations for smoking inventory with the original three subscales (Positive/Social, Habit Strength, Negative/Affective) has been used in a number of applications (e.g. Prochaska et al., 2004, 2005), however, no study to date has evaluated the psychometric properties of this version of the Temptations measure including the additional (fourth) Weight Concerns subscale in an adult population. Smoking-specific weight concerns are salient to both women and men who smoke, and are equally important among adult African American and Caucasian smokers, and weight concerns and body image have been associated with lower rates of smoking cessation and relapse (White, McKee & O'Malley, 2007; Clark et al., 2004; Pomerleau, Zucker, Namenek Brouwer, Pomerleau &

Stewart, 2001; Sanchez-Johnson, Carpentier & King, 2011; Klesges & Klesges, 1988; Meyers, et al., 1997; USDHHS, 2001). The situational temptations subscale relating to Weight Concerns should therefore be evaluated for inclusion in the temptations measure, in order to be used in assessment and interventions.

The aim of this study is to assess the internal and external validity and measurement stability of the temptations measure with the addition of the fourth Weight Concerns subscale, including confirming the factorial invariance of the measure. Factorial invariance is central to establishing the internal validity and reliability of a measure, as it indicates whether a set of items measures the same theoretical constructs consistently across population subgroups, allowing legitimate comparisons between groups on the measure of interest (Meredith, 1993; Meredith & Teresi, 2006). Meaningful group comparisons can be assumed when a measure has demonstrated factorial (measurement) invariance. To investigate the psychometric validity of the temptations inventory (Table 1), the following specific hypotheses were examined:

Hypothesis 1: The data from a large sample of adult smokers should represent four correlated latent factors: Positive/Social, Habit Strength, Negative/Affective, and Weight Concerns (see Figure 1), to demonstrate that the temptations inventory is reliably measuring four constructs.

a. Items 1 to 3 should have primary, non-zero loadings on the first factor (i.e. Positive/Social; see Figure 1) to demonstrate that these three items are reliably measuring positive or social situations where a person may feel tempted to smoke.

b. Items 4 to 6 should have primary, non-zero loadings on the second factor (i.e. Habit Strength; see Figure 1) to demonstrate that these three items are reliably measuring situations related to smoking habits when a person may feel tempted to smoke.

c. Items 7 to 9 should have primary, non-zero loadings on the third factor (i.e. Negative/Affective; see Figure 1) to demonstrate that these three items are reliably measuring negative/affective situations when a person may feel tempted to smoke.

d. Items 10 to 12 should have primary, non-zero loadings on the fourth factor (i.e. Weight Concerns; see Figure 1) to demonstrate that these three items are reliably measuring situations when a person may feel tempted to smoke due to weight concerns.

Hypothesis 2: The final correlated four factor model for temptations should provide an adequate fit to the data, with CFI > .90 and RMSEA < .08. This would demonstrate that the four-factor temptations measurement model fits well in a large sample of adult smokers.

Hypothesis 3: The final correlated four factor model for temptations should also have the potential for one higher order factor (i.e. Temptations), to demonstrate replication of the hierarchical factor structure found previously in other samples (Velicer et al., 1990; Plummer et al., 2001).

Hypothesis 4: The final temptations measurement model should have the same correlated four factor structure (configural invariance) and similar factor loading parameter matrices (i.e. metric invariance) across the three stages of change at baseline (i.e., Precontemplation, Contemplation, and Preparation). This hypothesis assesses the stability of temptations across stage.

Hypothesis 5: The final temptations measurement model should have a similar correlated four factor structure (configural invariance) and similar factor loading parameter matrices (i.e. metric invariance) in data from adult male and female smokers. This hypothesis assesses the stability of temptations across gender.

Hypothesis 6: The final temptations measurement model should have the same correlated four factor structure (configural invariance) and similar factor loading parameter matrices (i.e. metric invariance) in subsamples of the data defined by racial identity (i.e., White, Black, American Indian/Alaskan Native). This hypothesis assesses the stability of temptations across racial groups.

Hypothesis 7: The final temptations measurement model should have a similar correlated four factor structure (configural invariance) and similar factor loading parameter matrices (i.e.

metric invariance) in subsamples of the data defined by ethnicity (i.e., Hispanic, Non-Hispanic). This hypothesis assesses the stability of temptations across ethnicity.

Hypothesis 8: The final temptations measurement model should have a similar correlated four factor structure (configural invariance) and similar factor loading parameter matrices (i.e. metric invariance) in subsamples of the data defined by age (e.g., 34 years or younger, 35-49 years old, and 50 years and older). This hypothesis assesses the stability of temptations across age groups.

Hypothesis 9: The final temptations measurement model should have a similar correlated four factor structure (configural invariance) and similar factor loading parameter matrices (i.e. pattern identity invariance) in subsamples of the data defined by smoking volume (i.e., Light smoker, Medium smoker, and Heavy smoker). This hypothesis assesses the stability of temptations across smoking problem severity groups.

Hypothesis 10: Scores on the temptations inventory should show significant mean differences across the three stages of change at baseline (i.e., Precontemplation, Contemplation, and Preparation) to demonstrate that the temptations measure has "known groups" validity (Redding et al., 2006). The effect size for stage of change is expected to be relatively small because the baseline sample is restricted to current smokers (i.e., those in Precontemplation, Contemplation, and Preparation to quit smoking), whereas the Temptations/Self-efficacy construct is theorized to be more important during the later stages within the Transtheoretical model framework.

CHAPTER 2

METHOD

Participants

This study involved secondary analyses of primary data from a large population-based smoking cessation intervention study (Redding et al., 2012). All procedures were approved by the Institutional Review Board at the University of Rhode Island. The study was a randomized-controlled trial with four separate treatment arms in which TTM-tailored CTIs were applied, and one assessment-only comparison arm. Participants were recruited from a population of smokers who had been proactively recruited via a national list-assisted telephone survey. Participants provided informed consent, and were then randomly assigned to one of the four intervention conditions or to the control arm. Randomization was stratified by stage of change for smoking cessation.

Data from all participants were collected at each assessment time point by telephone interview conducted according to an established protocol. Participants in the control group were assessed at baseline, 12, and 24 months. Participants in each of the four intervention groups completed assessments at baseline, 6, and 12 months for intervention purposes; printed intervention materials were mailed to them immediately upon completion of the telephone surveys. Participants in the intervention groups also completed a final follow-up assessment at 24 months. Participants in the four intervention groups were assessed and treated at baseline, 6, and 12 months; those in the control group completed assessments at baseline and 12 months. All participants completed a follow-up assessment at 24 months. This psychometric validation study for the situational temptations for smoking inventory was conducted using baseline data combined across all five intervention and control groups.

A large sample of 3006 current smokers participated in the population-based study. All participants were between 18-82 years old (mean 41.95 years, SD 13.44 years); 44.5% were male and 55.5% were female. Of the participants that reported racial identity, 68.5% were non-Hispanic White, 12.7% were non-Hispanic Black, 9.4% were American Indian/Alaskan Native, 5.3% responded Other, 1.0% were Asian, 0.5% were Pacific Islanders, and 2.7% reported identifying with a combination of two or more races. Only 7.1% of participants who responded to the question about ethnicity identified as Hispanic. All participants reported being current smokers at baseline; based on the Transtheoretical Model (TTM) stages of change scale for smoking cessation, 32.3% were least ready to quit smoking (i.e. Precontemplation stage for smoking cessation), 45.7% were in the Contemplation stage, and 22.0% were in the Preparation stage. After excluding (*N*=85) participants with missing or extreme response patterns (i.e., responded with only 1's or only 5's) on the 12-item temptations measure, 2921 participants remained. The overall summary of the characteristics for the final sample of *N*=2921 participants is presented in Table 2.

Instruments

This study focused on demographic questionnaires, the situational temptations for smoking inventory, and the Transtheoretical model (TTM) stage of change scale for smoking cessation, from the baseline assessment. Demographic variables were not analyzed directly with respect to smoking behavior or the outcomes of the intervention study, but were assessed and reported as they relate to the internal and external validity of this psychometric assessment study. There was adequate racial-ethnic heterogeneity among participants in this large sample of adult smokers to allow assessment of the stability of the temptations measure across different population subgroups defined by gender, racial identity, ethnicity, age, stage of change for cessation, smoking problem severity, and weight status.

The situational temptations for smoking inventory assesses the degree of temptation a person feels to smoke across different situations. The version of the measure being evaluated

consists of four subscales: Positive/Social (PS), Habit Strength (HS), Negative/Affect (NA), and Weight Concerns (WC), with three items for each subscale. For each item, participants are asked to rate *how tempted* they may be to smoke in each of the situations described using a 5-point Likert scale (5=Extremely tempted, 4=Very tempted, 3=Moderately tempted, 2=Not very tempted, 1=Not at all tempted), a response format that has been preferred by several researchers (e.g. Redding et al., 2006). Table 1 shows the list of 12 items for the four factor temptations measure. A hierarchical three factor model, without the Weight Concerns subscale, has been demonstrated among adult smokers (Velicer et al., 1990), and extensively used. A hierarchical four factor measurement structure with all four subscales (PS, HS, NA, WC) was previously tested in a large sample of adolescent smokers and ex-smokers in the United States, and subsequently validated in a sample of Bulgarian adolescent smokers (Plummer et al., 2001; Anatchkova, Redding, & Rossi, 2006). In the present study, an alternative measurement model with four correlated subscales (see Figure 1) was assessed in measurement invariance analyses using data from the baseline assessment.

Stage of change was measured using an algorithm assessing readiness to quit smoking based on the following criteria: Precontemplation (not intending to quit in the next 6 months), Contemplation (intending to quit in the next 6 months), Preparation (intending to quit in the next 30 days, and has attempted to quit for at least 24 hours one or more times within the past year), Action (quit for less than 6 months), and Maintenance (quit for 6 months or more). The reliability, utility, and predictive validity of this algorithm have been demonstrated (DiClemente et al., 1991; Prochaska & DiClemente, 1983; Velicer et al., 2007). In addition to the discrete stage measure, the average number of cigarettes smoked per day is a quantitative measure of smoking behavior that permits participants to be categorized into groups by baseline severity according to the following criteria: Light smoker (not more than 15 cigarettes per day), Moderate smoker (16 to 29 cigarettes per day), and Heavy smoker (30 or more cigarettes per day). These cutoff points were selected so as to be reasonably consistent with

previous studies of light and heavy smokers (Rossi, Prochaska & DiClemente, 1988). Body mass index (BMI, kg/m^2) was computed for each participant based on their self-reported weight and height, this allowed participants to be categorized into weight status categories according to current public health criteria (CDC, 2011): Underweight (BMI 18.5 or less), Normal weight (BMI 18.6 to 24.9), Overweight (BMI 25.0 to 29.9), and Obese (BMI 30.0 or greater). BMI could only be computed for 2811 participants in the sample; the remaining 110 participants had missing responses on weight or height. The number of participants categorized as underweight (i.e. BMI 18.4 or less) was too low (*N*=73, 2.5% of sample) to support the multiple sample confirmatory factor analysis procedure used for assessment of measurement invariance. The underweight and normal weight (i.e. BMI 18.5 to 24.9; *N*=981) categories were therefore collapsed to form a single weight status category (BMI 24.9 or less) that was used in the measurement invariance analyses.

Analyses

To assess the psychometric properties and validity of the situational temptations for smoking inventory, this study utilized several psychometric procedures including principal components analysis (PCA), confirmatory factor analysis (CFA), multiple sample nested invariance model comparisons, and multivariate analysis of variance (MANOVA). Some of these psychometric procedures are included within the structural equation modeling (SEM) framework. All SEM procedures in this study were conducted using EQS 6.2 (Bentler, 2007) and the results were replicated using the lavaan software package (Rosseel, 2012) in the R statistical computing environment. Other analytic procedures, such as calculating descriptive statistics, PCA, and MANOVA, were conducted using SPSS 19.

The initial phase for the analyses utilized a "split-half cross validation" approach to validate the factor structure of the measurement model for the temptations inventory. The overall baseline sample was randomly divided into two subsamples to form an exploratory half and a confirmatory half. This procedure was conducted using SPSS 19. Participants'

characteristics were compared between the two subsamples, and the summary is presented in Table 3.

The goal of these analyses was to validate the temptations instrument with the additional (fourth) Weight Concerns subscale in adult smokers, instead of improving the scale as in a traditional measure development study. The cross-validation approach was applied only to the PCA and assessment of the measure's internal consistency (i.e., coefficient alpha; Cronbach, 1951); these procedures were therefore conducted in both the exploratory and confirmatory samples to verify replication of the results. Analytic procedures to validate the temptations measure were performed using the full sample, including CFA to assess the measurement model and MANOVA to test discriminant or "known groups" validity based on the TTM (Redding et al, 2006).

PCA was conducted to examine the model structure and how the 12 measured items relate to the latent factors in the temptations measure. The Varimax with Kaiser normalization rotation method was used to interpret the factor structure resulting from the PCAs. The factor structure among manifest and latent variables was compared to the model that had been validated in adolescents (Plummer et al., 2001) and also to the original three factor model that was validated and has been extensively used in adult populations (Velicer et al., 1990). Internal consistency estimates (Cronbach's coefficient alpha) were computed for each of the four subscales in both subsamples.

After cross-validation of the factor structure, CFA was used to test the fit of the hypothesized four factor temptations measurement model (Figure 1) using data for the full baseline sample (N=2921). Normal distribution theory maximum likelihood (ML) and robust maximum likelihood (MLM) estimation methods were used. Multiple macro fit indices based on normal ML estimation were evaluated, including model χ^2 value, comparative fit index (CFI; Bentler, 1990), and the root mean square error of approximation (RMSEA). Manifest indicators that are ordinal variables may pose a challenge to the assumption of multivariate

normality underlying normal theory ML estimation. However, for ordinal variables with five or more levels (e.g. assessed on a 5-point Likert scale as in the temptations measure), corrected test statistics computed based on robust standard errors using MLM estimation were found to be reliable for evaluating mean and covariance structures (MACS) based models (Curran, West, & Finch, 1995; Rhemtulla, Brosseau-Liard, & Savalei, 2012). Additional fit indices based on MLM estimation such as the Satorra-Bentler (1988) corrected χ^2, and robust versions of the CFI and RMSEA were also assessed. For CFI, values of .80 to .89 indicate adequate fit, whereas values of .90 and greater indicate good or excellent fit (Hu & Bentler, 1999). For the RMSEA, values below .06 indicate excellent fit (Kline, 2011). In addition, the individual items factor loadings were examined, with adequate factor loadings expected to be above .40. Five alternative comparison models for temptations including a single factor model, and a hierarchical model that includes one higher order factor in addition to the four first-order factors (PS, HS, NA, WC; Hypothesis 3), were also assessed using CFA in the full sample.

This study also investigated the stability of the final, best-fitting measurement model for temptations (Figure 1) across population subgroups defined by stage, gender, racial identity, ethnicity, age, baseline smoking severity, and weight status. For the series of measurement invariance analyses, the baseline sample was split into subsamples for testing of the measurement model, for example, into male and female subsamples to test measurement invariance across gender. The four factor temptations model was first assessed for good fit to the data in each subgroup category separately. Next, multiple sample CFA based on the analysis of mean and covariance structures (MACS) was used to evaluate invariance of the final temptations measurement model (Figure 1) across population subgroups simultaneously (e.g., across male and female subsamples). Based on analyses of mean and covariance structures, four levels of measurement invariance were tested using a stepwise procedure, progressing from the least to the most restrictive: (1) Equal form (also referred to as configural invariance) with the same factor pattern but unconstrained factor loadings; (2) Equal factor

loadings (or metric invariance) with factor loadings for like items constrained to be equal across groups; (3) Equal indicator intercepts (strong factorial invariance) with both factor loadings and indicator intercepts (item means) constrained to be equal across groups; and (4) Equal indicator error variances (strict measurement invariance) with equal factor loadings, indicator intercepts, and item error variances across subgroups. Model fit was assessed using several fit indices, including model χ^2 value, CFI, and RMSEA based on both ML and MLM estimation. Measurement invariance was tested by examining the change in fit index values between a less restrictive model and the more constrained model. The χ^2-difference test was included to assess decrement in fit for the nested invariance models, even though χ^2 statistics are very sensitive to large sample sizes (Kline, 2011), as in this study. Alternative fit indices that are not affected by sample size such as CFI, McDonald's Non-Centrality Index (NCI; 1989), and gamma-hat (Steiger, 1989), have been suggested for testing of measurement invariance (Cheung & Rensvold, 2002; Meade, Johnson & Braddy, 2008), and these were also assessed. The difference between the fit index values between the less restricted and more constrained models were computed and evaluated. This difference represents the deterioration in the fit of the model to the data as additional across-subgroup equality constraints are imposed, for example, the difference (ΔCFI) when CFI for the equal factor loading model is subtracted from the equal form model. Cheung and Rensvold (2002) have suggested that ΔCFI greater than .01, ΔNCI greater than .02, and ΔGamma-hat above .001indicate that the more constrained model provides a significantly worse fit to the data (i.e., does not support invariance with the additional constraints), and the less restrictive model should be retained. Chen (2007) showed that an alternative cut-off value between .005 to .008 for ΔGamma-hat was more consistent in terms of sensitivity to invariance with the ΔCFI and ΔNCI guidelines previously suggested by Cheung and Rensvold (2002).

Last but not least, the external or "known groups" validity of the temptations measure was examined in the full sample (Redding et al., 2006). Multivariate analysis of variance

(MANOVA) was conducted to simultaneously test for differences in the four temptations subscale (i.e., PS, HS, NA, WC) mean scores across the three baseline stages of Precontemplation, Contemplation, and Preparation. Although the 12 items in the temptations measure are ordinal variables with up to five response levels, the mean of three item scores computed for each subscale is a continuous variable that can be used in analytic methods based on the General Linear Model (GLM) such as ANOVA and MANOVA. Means, standard deviations, skewness, and kurtosis values for the four subscale mean scores were examined to assess departure from normality. Four independent ANOVAs were conducted as a follow-up procedure to the MANOVA to examine which of the four subscale scores showed significant mean differences across the three baseline stage of change groups. Follow-up Tukey tests for multiple pairwise comparisons were conducted for each significant ANOVA. Effect sizes were also computed for each model, including a multivariate η^2 for the MANOVA, and univariate η^2 for each ANOVA.

CHAPTER 3

RESULTS

Comparison of cross-validation samples

The baseline sample of 2921 participants was randomly split into two cross-validation subsamples to form an "exploratory" half (Sample 1) and a "confirmatory" half (Sample 2). A comparison of the demographic and smoking-related characteristics for participants in both samples found no meaningful differences. The summary of the main characteristics for participants in each of the two samples is presented in Table 3. In addition to the principal components analysis procedures, assessment of the temptation measure's internal consistency was performed in each cross-validation sample.

Principal Components Analysis (PCA)

The purpose of these analyses was to examine the model structure and the relationship between the 12 measured items and the underlying constructs (components) in the temptations measure. PCA was conducted on each of the two cross-validation samples separately. The Varimax with Kaiser normalization rotation method was used to interpret the resulting factor structure. PCAs were performed initially without *a priori* specification of the number of components to be retained. The minimum average partial method (MAP; Velicer, 1976; O'Connor, 2000) was used to determine the number of underlying components to be extracted given the 12 measured temptations items. MAP analysis conducted on Sample 1 suggested that two components should be retained; the same result was obtained when MAP was applied to Sample 2. PCA was then performed for Sample 1 in which two components were extracted, and the two component solution was shown to account for 48.5% of the variance in the temptations item scores. Examination of the component matrix rotated using the Varimax with

Kaiser Normalization method revealed that all nine items associated with the three constructs of Positive/Social, Habit Strength, and Negative/Affective from the original Temptations for smoking measure (Velicer et al., 1990) loaded onto the first component, while the three items related to Weight Concerns loaded onto component 2. These results were similar when PCA with a two component solution was conducted on Sample 2. The two components accounted for 50.02% of the variance, and once again, the nine items from the previous measure loaded onto the same component and the three Weight Concern items loaded onto the second component.

Next, a second series of PCAs was performed in which a four component solution was specified based on the proposed temptations model. The rotated component matrix with a four factor solution for Sample 1 is presented in Table 4. The proportion of variance explained by the 4 components increased to 66.41%, and with the exception of item 2 "Over coffee while talking and relaxing," all the 11 remaining items loaded highly (i.e. loading > .50) onto their expected components. Item 2 did not load highly on the Positive/Social component, and loaded more highly on the Habit Strength component instead. A fourth PCA was performed on Sample 2 in which a four factor solution was specified, the four components were found to account for 67.95% of the variance in the temptations item scores. The rotated component matrix for the four factor solution for Sample 2 is shown in Table 5. The same factor structure among measured items and latent factors was replicated in Sample 2, as before, 11 items loaded highly on their theorized factors, except for Item 2 which loaded highly on the Habit Strength component but much lower on the Positive/Social component.

Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis was conducted to assess the fit of the temptations measurement model to the data based on the full sample of 2921 participants. Five alternative models besides the null model were compared: (1) a one factor model, (2) an uncorrelated four-factor model with three theoretically based indicators per factor (Table 1), (3) a four-

factor correlated model suggested by results of the four component PCA solution, (4) a four-factor correlated model based on theory (Hypothesis 2), and (5) a four-factor hierarchical model (Hypothesis 3). Model fit based on normal theory ML and robust MLM estimation for the comparison models is presented in Table 6. The Likelihood Ratio χ^2 test is based on the central χ^2 distribution and tests the null hypothesis that the sample variance-covariance matrix is equal to the predicted variance-covariance matrix produced by the specified model. It has also been shown to be inflated by sample size, so that even negligible discrepancies between the sample and predicted matrices can result in large and significant χ^2 values with large sample sizes (Brown, 2006; Kline, 2011). Alternative fit indices that are less sensitive to large Ns were examined for all CFA procedures, and generally given more weight than the χ^2 in assessment of model fit. All the model χ^2 obtained in this study were statistically significant because of the large sample size, even when alternative fit indices indicated otherwise good model fit. The model fit statistics based on robust ML estimation are reported, the normal theory ML statistics are also presented in Table 6 for reference.

First, a one factor model in which all 12 measured indicators loaded onto a single latent variable was tested. As expected, the model scaled χ^2 was very large and significant, S-B $\chi^2(54) = 4518.65$, $p < .001$, indicating that the one factor model fit the data poorly. For the one factor model, the robust Comparative Fit Index (*CFI) was only .61, and the robust root mean square error of approximation (*RMSEA) was .168, confirming that the one factor model provided a poor fit to the data.

The next model assessed had four orthogonal factors; the three items associated with each subscale served as measured indicators for each factor (refer to Table 1). The uncorrelated four factor model also did not provide a good fit to the data, S-B$\chi^2(54) = 1994.28$, $p < .001$, *CFI=.83, and *RMSEA=.111.

The third model assessed had four correlated latent factors specified by the factor structure revealed through the four component PCA solution. This model had one factor with

four indicators (items 2, 4, 5, and 6), a second factor with only 2 indicators (items 1 and 3), and the two remaining factors each had three indicators loading on them that were consistent with the theoretical model. This model had a significant S-B $\chi^2(48)=389.78$, $p < .001$, however, the *CFI=.970, and *RMSEA=.049 indicated that the PCA-driven model provided a very good fit to the sample data.

The hypothesized measurement model for temptations with four correlated latent factors representing Positive/Social, Habit Strength, Negative/Affective and Weight Concerns (Plummer et al., 2001; Velicer et al., 1990) was examined next. This theory-based model was specified with three indicators loading onto each factor (Figure 1). The CFA results showed that the model χ^2 was significant S-B $\chi^2(48)=422.16$, $p < .001$, although both *CFI=.967 and *RMSEA=.052 demonstrated that this model also provided an excellent fit to the data. The confirmatory model for temptations is presented in Figure 2 with standardized parameter estimates for the full baseline sample. Because the objective of this study was to validate the existing temptations measurement model (Figure 1), the theory-based model was therefore retained over the PCA-driven model, especially as Model 3 is only an ad hoc model, and used as the main model for testing of measurement invariance and external (known groups) validity.

The fifth and final model assessed in the full baseline sample was an alternative hierarchical model that included one higher order "Temptations" factor in addition to the four first-order factors (PS, HS, NA, WC); the higher-order factor was implied by the significant correlations between the four first-order factors in Model 4 (see Fig. 2). The factor structure specified for each first-order factor had the same three indicators loading on them as in Models 2 and 4, and in turn, all four first-order factors served as indicators for a single higher order factor. The hierarchical model χ^2 was significant, S-B $\chi^2(50)=429.00$, $p < .001$, although review of other fit indices revealed that the hierarchical model also provided a very good fit to the data, *CFI=.967, *RMSEA=.051. The hierarchical model with standardized parameter

estimates for the full baseline sample is shown in Figure 3. In the hierarchical model, the Habit Strength factor was found to be extremely strongly related to the higher order factor for this sample (standardized γ coefficient=1.0). The hierarchical model was confirmed, but was also not retained for subsequent testing in this study.

Internal consistency was assessed for (i) each of the four subscales, and (ii) the complete instrument with 12-items, in both cross-validation samples based on the final temptations measurement model; the computed coefficient alpha values are presented in Table 7 for each cross-validation sample and the full (*N*=2921) sample. The coefficient alpha estimates were comparable in both Sample 1 and Sample 2. The 3-item subscales showed moderate to high internal consistency with alpha values from 0.55 (Habit Strength) to 0.91 (Weight Concerns). The internal consistency of the full measure was high (α=0.80) across 12-items.

Measurement Invariance (Multiple-sample CFA)

The purpose of these analyses was to examine the invariance (stability) of the final temptations measurement model (Figure 1) over population subgroups defined by gender, racial identity, ethnicity, age, TTM-stage of change for cessation, baseline smoking (problem) severity, and weight status. The baseline sample was split into subgroups for testing of the measurement model. Sample sizes associated with each category for all seven subgroups are presented in Table 8.

As a first step, (single sample) CFA was used to test the fit of the correlated four factor measurement model to the data in each subgroup category separately. For each subsample category assessed, the temptations model demonstrated a very good to excellent fit to the data as shown by CFI > .90 and RMSEA < .08. The overall model fit statistics for each subgroup are presented in Table 9.1 (based on normal theory ML estimation) and Table 9.2 (robust ML estimation).

After the fit of the baseline measurement model was confirmed in each subgroup, multiple-sample CFA of mean and covariance structures (MACS) was performed to test for

invariance of the correlated four factor temptations model across all categories within the population subgroup. Four invariance models (i.e., Equal form, Equal factor loadings, Equal indicator intercepts, and Equal indicator error variances) were tested for each of the seven population subgroups. The χ^2-difference test results for the (nested) invariance models are presented by population subgroups in Table 10.1 (normal ML estimation) and Table 10.2 (robust ML estimation). Because the χ^2 statistic is known to be inflated by large Ns, it was not surprising that all of the models had statistically significant χ^2, and most of the $\Delta\chi^2$ computed for nested model comparisons were also significant. The model χ^2 and $\Delta\chi^2$ were therefore given much lower weight in assessment of fit compared to other fit indices (e.g. CFI). Alternative fit indices used to assess model fit and test for invariance were robust versions of the CFI (*CFI), and Gamma-hat (*Gamma-hat), and the uncorrected McDonald's Noncentrality Index (NCI), these are presented in Table 11.1 (normal ML estimation) and Table 11.2 (robust ML) for each invariance model by population subgroup.

Gender: Sample sizes were adequate to test the models across subsamples of men and women. Equal form invariance of the temptations model was confirmed for gender, S-B$\chi^2(96) = 475.78$, $p < .001$, *CFI=.961, *RMSEA=.052. When the model was constrained to have equal factor loadings, ΔS-B$\chi^2(12)=211.28$, $p < .001$, Δ^*CFI=.019, Δ^*Gamma-hat=.011, and ΔNCI=.035, suggesting there were some differences in factor loadings between men and women. Examination of the model modification indices and individual factor loading estimates revealed statistically significant differences in loadings for item 7 "When I am very anxious and stressed" (λ coefficient .706 in women compared to .742 in men) and item 12 "When I am concerned about managing my weight" (λ .953 in women versus .904 in men), however, the magnitude of the differences was small and judged to be not meaningful. When equal indicator intercepts constraints were imposed on the model, ΔS-B$\chi^2(8) = 115.75$,

$p < .001$, Δ^*CFI=.009, Δ^*Gamma-hat=.005, and ΔNCI=.015, indicating invariance in the measurement model. The equal indicator intercepts (strong) measurement invariance model provided a good fit for gender, S-B$\chi^2(116)=786.11$, $p < .001$, *CFI=.936, *RMSEA=.053.

Racial Identity: Sample sizes were adequate to test the model across subsamples of participants who identified as White, Black and native American/Alaskan native. Equal form invariance was confirmed for racial identity, S-B$\chi^2(144)=498.40$, $p < .001$, *CFI=.966, *RMSEA=.053. Equal factor loadings, equal indicator intercepts, and equal indicator error variances constraints were imposed upon the model hierarchically without substantial deterioration in model fit. The equal indicator error variance (strict measurement invariance) model provided an excellent fit for racial identity, S-B$\chi^2(128)=631.18$, $p < .001$, *CFI=.960, *RMSEA=.048.

Ethnicity: Sample sizes were just adequate to test the model across subsamples of participants who identified as Hispanic and non-Hispanic. Equal form invariance was confirmed for ethnicity, S-B$\chi^2(96)=473.37$, $p < .001$, *CFI=.968, *RMSEA=.052. Equal factor loadings, equal indicator intercepts, and equal indicator error variances constraints were imposed upon the model hierarchically without substantial deterioration in model fit. The equal indicator error variances measurement model provided an excellent fit for ethnicity, S-B$\chi^2(128)=653.18$, $p < .001$, *CFI=.955, *RMSEA=.053.

Age: Sample sizes were adequate to test the model across three age group subsamples based on approximate tertiles: 18-34 years old, 35-49 years old, 50-82 years old. Equal form invariance was confirmed for age, S-B$\chi^2(144)=453.35$, $p < .001$, *CFI=.973, *RMSEA=.047. Equal factor loadings constraints were imposed upon the model without substantial deterioration in model fit, Δ^*CFI=.005, Δ^*Gamma-hat=.003, and ΔNCI=.011, even though the ΔS-B$\chi^2(24)=80.96$ was significant, $p < .001$. When the model was constrained to have equal indicator intercepts, ΔS-B$\chi^2(16)=405.49$, $p < .001$, Δ^*CFI=.024, Δ^*Gamma-hat=.015, and ΔNCI=.045, suggesting some differences in indicator intercepts (item means) across age

groups, although the overall model fit showed that the equal indicator intercepts model still provided a good fit for age, S-Bχ^2(184)=824.56, $p < .001$, *CFI=.943, *RMSEA=.060. Review of the model modification indices revealed several localized areas of strain in the model at the intercepts for four items (items 1, 2, 6, and 8). Four separate ANOVAs confirmed that the means were significantly different across age-groups for item 1 "with friends at a party," item 2 "over coffee while talking and relaxing," item 6 "when I realize I haven't smoked for a while," and item 8 "when I am very angry about something or someone." The ANOVA and follow-up Tukey test results for these four items are shown in Table 12.

TTM-Stage of change: Sample sizes were adequate to test the model across subsamples of participants in the Precontemplation, Contemplation, and Preparation stages of change for cessation. Equal form invariance was confirmed for stage, S-Bχ^2(144) = 515.92, $p < .001$, *CFI=.968, *RMSEA=.052. Equal factor loadings constraints were imposed upon the model without substantial deterioration in model fit, ΔS-Bχ^2(24)=35.32, $p = .064$, Δ^*CFI=.002, Δ^*Gamma-hat=.001, and ΔNCI=.003. Equal indicator intercepts, and equal indicator error variances constraints were next imposed upon the model sequentially without substantial deterioration in model fit. The equal indicator error variances measurement model provided an excellent fit for stage of change, S-Bχ^2(208)=622.36, $p < .001$, *CFI=.964, *RMSEA=.045.

Smoking problem severity: Sample sizes were adequate to test the model across three subsamples of Light, Medium and Heavy smokers. Equal form invariance was confirmed for smoking severity, S-Bχ^2(144)=471.41, $p < .001$, *CFI=.970, *RMSEA=.048. Equal factor loadings constraints were imposed upon the model with small but acceptable reduction in model fit, Δ^*CFI=.004, Δ^*Gamma-hat=.003, ΔNCI=.009, ΔS-Bχ^2(24)=67.26, $p < .001$. When the model was constrained to have equal indicator intercepts, ΔS-Bχ^2(16)=240.36, $p < .001$, Δ^*CFI=.016, Δ^*Gamma-hat=.009, and ΔNCI=.028, suggesting possible differences in indicator intercepts (item means) across smoking severity subsamples. It should be noted that the overall model fit showed that the equal indicator intercepts model still provided a good fit

for age, S-Bχ^2(184)=724.06, $p < .001$, *CFI=.950, *RMSEA=.055. Examination of the model modification indices revealed several localized areas of strain in the model at the intercepts for three items: Item 2 "over coffee while talking and relaxing," item 4 "when I first get up in the morning," and item 5 "when I feel I need a lift." Follow-up ANOVAs confirmed that the intercepts were significantly different across smoking severity groups for those three items; the ANOVA and follow-up Tukey test results are shown in Table 13.

Weight status: Sample sizes were adequate to test the model across three weight status subsamples (BMI 24.9 or less, BMI 25.0-29.9, BMI 30.0 or more). Equal form invariance was confirmed for weight status, S-Bχ^2(144)=493.23, $p < .001$, *CFI=.968, *RMSEA=.051. Equal factor loadings constraints were imposed upon the model with only minor and no significant reduction in model fit, ΔS-Bχ^2(24)=30.59, $p= .166$, Δ*CFI=.001, Δ*Gamma-hat=.001, and ΔNCI=.001. Constraining indicator intercepts to be equal across the three subsample reduced the model fit only marginally, ΔS-Bχ^2(16)=22.71, $p= .122$, Δ*CFI=.001, Δ*Gamma-hat=.001, and ΔNCI=.001. When equal indicator error variances constraints were imposed, ΔS-Bχ^2(24)=104.78, $p < .001$, Δ*CFI=.009, Δ*Gamma-hat=.006, and ΔNCI=.028, revealing some incongruence across the alternative fit indices. The equal indicator error variances measurement model also provided an excellent fit for weight status, S-Bχ^2(208)=673.04, $p < .001$, *CFI=.957, *RMSEA=.049.

External (Known groups) Validity

The purpose of these analyses was to assess the external (or "known groups") validity of the four factor temptations measure by testing whether the scores on the measure could differentiate between the different stages of change in adult smokers. The internal validity and measurement stability of the four-factor temptations measure was established through CFA, and measurement invariance testing. Therefore, it was reasonable to compute composite (unweighted mean) scores for each of the four subscales.

Table 14 shows the descriptive statistics for the 12 items and the computed subscale mean scores for the Positive/Social (PS), Habit Strength (HS), Negative/Affective (NA), and Weight Concerns (WC) subscales in the full sample ($N = 2921$). The minimum and maximum mean scores were 1.00 and 5.00 respectively, because all items used the same Likert scale response format with a range of 1 to 5. The mean scores ranged from 2.09 for the weight concerns subscale, well below the "theoretical" midpoint of 3.0 on the 1-5 scale, to 4.12 (negative/affective), which was much higher than the midpoint. The standard deviations were less than the mean score for each of the four subscales, with the WC subscale showing the most variability (SD=1.28) while the standard deviations for the other three subscale means were just under 1.00. None of the subscale mean scores showed excessive skewness, skewness for the NA subscale was -1.12, and the PS, HS, and WC subscales had skewness < |1.00|. However, it should be noted that the WC subscale scores were positively skewed (0.96), whereas the other subscale scores were negatively skewed. Kurtosis for all four subscales was acceptable (all were < |0.80|). Overall, the distribution of the four subscale mean scores for the full sample appeared to be fairly normally distributed. Finally, correlations between the four subscale means were assessed. All Pearson correlation coefficients were low to moderate, with the lowest correlation observed between PS and WC subscale scores ($r = .206$), and the highest correlation was between HS and NA ($r = .453$), indicating that the risk of multi-collinearity would be low.

Multivariate analysis of variance (MANOVA) revealed significant differences for the four subscale mean scores across the three stages of change (Precontemplation, Contemplation, Preparation), $F(8,5830) = 5.46$, $p < .001$, Wilks' $\Lambda = .985$. The multivariate effect size η^2 was .02, and represents the overall effect of the three stages assessed (i.e. Precontemplation, Contemplation, and Preparation) on the variance observed in the four temptations subscale scores.

Follow-up ANOVAs indicated significant between-stage differences on the Negative/Affective subscale mean, $F(2,2918) = 7.70$, $p < .001$, $\eta^2 = .005$, Habit Strength subscale, $F(2,2918) = 4.18$, $p < .05$, $\eta^2 = .003$, and Weight Concerns subscale, $F(2,2918) = 3.02$, $p < .05$, $\eta^2 = .002$. Table 15 shows the ANOVA and Tukey test results for the four temptations subscale means across stage. Follow-up Tukey tests revealed that smokers in Contemplation reported being significantly more tempted in Negative/Affective situations compared to those in Precontemplation, and smokers in Preparation were significantly more tempted in situations linked to Habit Strength compared to those in either Precontemplation or Contemplation. Figure 3 shows that both Positive/Social and Habit Strength subscales had similar patterns of slight decrease across stage subgroups, however, the Weight Concerns subscale showed a pattern of increase across the same stage subgroups, and the Habit Strength subscale showed a nonlinear pattern with the peak at Contemplation. Finally, Table 15 also shows that the Negative/Affect subscale was generally more highly endorsed at each stage of change, while the Weight Concerns subscale was endorsed most weakly at each stage.

CHAPTER 4

DISCUSSION

This study validated the four-factor situational temptations for smoking inventory in a large population based sample of current smokers ($N = 2921$) using multiple psychometric procedures. Confirmatory analyses for the temptations measure, including an additional fourth weight concerns factor, demonstrated factor structures consistent with those found in adolescent samples (Plummer et al., 2001) and indicated excellent model fit in this adult sample. Results from this comparison and evaluation of alternative structural models suggested that the structure of the four factor temptations measure was confirmed in this adult sample. The four factor measurement model demonstrated invariance across multiple population subgroups. In addition, the measures showed good internal validity and adequate external validity. This study established initial validation of the four-factor situational temptations for smoking inventory including a fourth weight concerns factor in adult smokers.

Component structure

Two sets of principal components analysis (PCA) were performed in each of the cross-validation split-half samples with similar results. The first PCA was performed without *a priori* specification of the number of components, resulting in a solution that retained two orthogonal factors. The two-factor solution suggested that the nine items on the positive/social, habit strength and negative/affective subscales that comprise the three-factor temptations measure (Velicer et al., 1990) should make up the first component, with the second component including the three items on the weight concerns subscale. This suggests that the first three subscales are very highly inter-correlated, especially when assessed in this sample of current smokers, and the fourth weight concerns subscale is less highly correlated

with the first three subscales. The second PCA that was performed specified a four component solution based on the theoretical model for this measure. The four-factor PCA solutions (Tables 4 and 5) showed a component structure for the temptations measure that was very close to the theoretical model. The only exception was that item 2: "over coffee while talking and relaxing" had a primary, non-zero loading on the next component together with the three habit strength items, and a much lower (< .40) loading on its expected component. This result indicates that item 2 has the potential to be a complex item, and suggests that the pairing of smoking with coffee described in item 2 might be associated more with habitual situations than with the social situations. However, post-hoc modification of the measure based strictly on the PCA suggestion is not recommended, because it would result in an unbalanced number of items across factors. Reducing the number of indicators for the positive/social subscale to just two would decrease the internal consistency and measurement reliability for that factor. Future measure modification or refinement attempts should involve psychometric assessment of a pool of alternative items that may replace the current item 2. Results of the two and four component solutions replicated in the second split-half sample, demonstrating that the component pattern for the 12 items of this measure are fairly stable.

Confirmatory model

Confirmatory factor analyses (CFA) using the full sample (N = 2921) compared five competing measurement models for temptations. The theory-based measurement model with four correlated factors, each with three measured indicators (Figure 1), demonstrated an excellent fit to the data. All factor loadings were adequate to high, the highest loadings (> .80) were for the three weight concerns items and also item 9: "when things are not going my way and I am frustrated." The item with the lowest loading was item 5: "when I feel I need a lift" (λ = .44), review of the Lagrange Multiplier indices suggest that adding a path between item 5 and the weight concerns factor would significantly improve model fit even more than adding another suggested path between item 2 and the habit strength factor would. This indicates that

item 5 was quite likely to be another complex item. All correlations among the four factors were significant, the highest correlation was between the positive social and habit strength factor ($\varphi = .74$), which may reflect some impact of the complex-loading for item 2. The correlations between the weight concerns factor and the other three factors were much lower (φ .26 to .42), which had been suggested by the results of the unrestricted PCAs. A hierarchical four factor model (Figure 3) also provided a very good fit to the data, confirming the higher order temptations construct implied by the four correlated factors. However, the estimated loading for the habit strength factor was extremely high in this model, suggesting that in a sample comprising only current smokers, the strength of the relationship between habit strength and overall temptations may overwhelm those for other situations. It is quite likely that the results for the hierarchical model also reflect some artifacts of the complex-loadings for items 2 and 5; both loaded onto habit strength and one other factor. Unsurprisingly, the factor structure suggested by the four component PCA solution also fit the data very well. However, for reasons discussed, even though the fit of the PCA-derived model looked to be marginally better based on comparison of the Akaike Information Criteria (AIC) values for both models, post-hoc modification of the measurement model based strictly on the PCA solution but not on theory was not a preferred option in this study. Overall, the CFA results replicated the underlying structure for temptations with four correlated factors, and also suggest that several items on the temptations measure could be further improved.

Cronbach's coefficient alphas computed for each three-item subscale showed that the weight concerns subscale had the highest internal consistency. The unweighted mean score in the full sample for weight concerns was well below the theoretical midpoint for the 5-point response scale (i.e. 2.09 compared to 3.00), and the distribution of the scores was positively skewed, suggesting that weight concerns were not highly endorsed by a high proportion of the sample. The negative/affective subscale also showed fairly high internal consistency, but the mean score was much higher than the scale midpoint and the distribution was negatively

skewed. Temptations to smoke in response to stress or anxiety can hamper attempts to quit smoking, and could benefit from tailored interventions that address this barrier. Finally, the estimates of coefficient alpha indicated that the internal consistency of the positive/social and habit strength subscales were only moderate, and lower than found in previous samples. Once again, these results probably reveal some effect of the cross-loading for item 2. Internal consistency for the positive/social subscale was re-assessed after excluding item 2; the computed coefficient alpha for 2-items of .56 was exactly the same as the previous 3-item alpha, indicating that inclusion of a poor item did not contribute to subscale performance.

Measurement invariance

This study confirmed the invariance of the temptations measurement model with four correlated subscales across multiple population subgroups in a large sample of adult smokers. The strong factorial invariance model constrained factor loadings and item intercepts in the model to be equal across comparison groups, and provided a very good fit across gender, racial identity, ethnicity, age, stage of change for cessation, smoking problem severity, and BMI status, based on CFI values around .95 and RMSEA values below .08. Results of these analyses indicate a consistent relationship between the four factors (PS, HS, NA, and WC subscales), and the twelve items that serve as measured indicators for the factors.

Although the CFI and RMSEA values for the strong factorial invariance (i.e. equal factor loadings and item intercepts) models indicated good to excellent fits across all subgroups tested, it should be noted that the ΔCFI, ΔGamma-hat, and ΔNCI values computed to compare nested invariance models were slightly less consistent for comparisons across gender, age and smoking severity subgroups. For gender, ΔCFI= .019, ΔGamma-hat= .011 and ΔNCI=.035 were all above the suggested cut-offs of ΔCFI= .010, ΔGamma-hat= .001 and ΔNCI=.020 (Cheung & Rensvold, 2002), or even the alternative ΔGamma-hat range of .005 to .008 proposed by Chen (2007), when factor loadings were constrained to be equal. This suggests some slight differences in the factor loadings between men and women, specifically on item 7:

"when I am very anxious and stressed," and item 12: "when I am concerned about managing my weight." However, further examination of the discrepant loadings indicate that even though the difference in absolute values were statistically significant, the magnitude of the difference represented only a small effect for item 7, Cohen's $q = |0.18|$ (Cohen, 1988), and for item 12, the suggested effect appeared larger than the real difference showed (λ_{women}: .95 vs. λ_{men}: .90, not a meaningful difference) as an artifact of being at the extreme tails of the distribution. When equal indicator intercepts were constrained for comparisons across age subgroups, ΔCFI= .024, ΔGamma-hat= .045 and ΔNCI=.015, suggesting some lack of invariance. Review of the modification indices revealed that four items associated with the decrease in model fit were item 1 "with friends at a party," item 2 "over coffee while talking and relaxing,' item 6 "when I realize I haven't smoked in a while," and item 8 "when I am very angry about something or someone." When equal indicator intercepts were constrained for comparisons across smoking problem severity subgroups, ΔCFI= .016, ΔGamma-hat= .028 and ΔNCI=.009, suggesting again possible invariance in some indicator intercepts. Examination of the modification indices showed that the three items with intercepts (means) that were not invariant across smoking severity subgroups were item 2 "over coffee while talking and relaxing," item 4 "when I first get up in the morning," and item 5 "when I feel I need a lift." Items 4 and 5, and possibly item 2 as suggested by the PCA results, are all related to smoking habit strength, so it is not surprising that groups means for these specific items were different across light, medium and heavy smokers. It is also possible that these results indicate a possible interaction between the effects of age and smoking severity. However, the noted decrement in model fit when cross-group equality constraints were imposed do not invalidate the high degree of fit for the strong invariance model as indicated by the macro model fit indices such as CFI and RMSEA values.

These results demonstrate that the measurement model of four correlated factors for situational temptations for smoking have a consistent relationship across subgroups and

provide empirical support for the internal validity of the measure. The four subscales have demonstrated invariance in factor loadings and indicator intercepts, and even indicator error variances (for subgroups defined by racial identity, ethnicity, stage of change and weight status), across multiple subgroups assessed, and allow meaningful comparisons of the measured constructs to be made across different samples in the target population.

External validity

Multivariate analysis of variance showed that temptations varied slightly across the first three stage of change although the overall η^2 of .02 would be interpreted as a small multivariate effect size (i.e., < .02; Cohen, 1992). This is consistent with TTM predictions because the Temptations/Self-efficacy construct is theorized to be more important during the later stages of Action and Maintenance (Rossi & Redding, 2001). As expected, participants' temptation to smoke in positive/social and habit strength situations were highest in Precontemplation and lower among those in Preparation, replicating previous studies in adults and adolescents (Hoeppner et al., 2012; Redding et al., 2013; Velicer et al, 1990). The largest increase on the negative/affective subscale was observed between smokers in Contemplation compared to those in Precontemplation, before decreasing again for those in the Preparation stage. The η^2 of .005 indicates a small effect of the three early stages of change on variance in negative/affective scores (Rossi, 2012). Negative affect was also more highly endorsed than the other subscales. Interestingly, weight concerns showed a pattern of increase across stage groups, which was in the opposite direction compared to the other subscales, although this was also a very small effect. Weight Concerns were endorsed much lower than the other subscales, indicating that it was not as important across all participants in the sample. However, smokers for whom weight concerns may be a barrier to cessation may benefit from individually tailored intervention attention. These results support the use of this measure for both assessing temptations to smoke and for tailored intervention purposes in this sample of adult smokers.

LIMITATIONS

Findings from this study are based on data from a large population-based sample. However, one major limitation of this study was the restricted range because the sample consisted entirely of current smokers. This low variability in the sample was also indicated by the low values of the determinants for the data matrix. If possible, a sample that includes a mix of both current and former smokers (e.g. from a follow-up assessment) should be selected for future analyses, which would provide greater variance in responses on these measures, and also a wider range in terms of stages of change (i.e. a sample with smokers who have quit smoking would allow assessments to include the Action and Maintenance stages). The reduced variability in a sample that included only smokers in the pre-Action stages (i.e. Precontemplation, Contemplation, and Preparation) may also have reduced the estimates of internal consistency for some subscales, which were lower compared to previously reported estimates.

Another limitation of the current sample relates to the racial and ethnic demographics. A sample that is more diverse in terms of racial identity, with adequate numbers of other racial groups besides white and black, would allow more comprehensive assessment of the measure across more racial groups. The sample sizes used in the analyses were highly unbalanced across racial and ethnic groups, although the invariance models were still indicative of good fit. This sample also had too few participants who were classified as underweight (i.e. BMI below 18.5), so that underweight participants had to be combined with those of normal weight (i.e., BMI 18.5–24.9). This resulted in greater heterogeneity in weight status among participants in that subsample for measurement invariance testing. It also meant that the measure could not be assessed specifically in a sample of underweight adult smokers; it would

have been especially interesting to investigate whether the fourth Weight Concerns factor was equally stable in underweight adults who smoke.

Finally, the cross-sectional nature of the data used was another limitation of this validation study. This measure would benefit from longitudinal analyses, for example, assessing the predictive validity of the four factor inventory. Also, establishing measurement invariance over time would satisfy a fundamental assumption of any analyses designed to investigate temporal change in the construct.

CHAPTER 5

CONCLUSION

The results of this study confirmed the internal and external validity of the four factor situational temptations of smoking inventory in a large national sample of adult smokers. The underlying factor structure of situational temptations with four factors, including weight concerns, replicated what was found in previous studies of smoking temptations in other samples (Hoeppner, 2012; Plummer et al, 2001). The fourth factor, weight concerns, had high factor loadings and high internal consistency (coefficient α .91). The internal consistency for the negative/affective subscale was high (α .79), although lower than expected for both remaining subscales (positive/social α .56; habit strength α .55).

In addition, these study results provide strong support for the stability of the four factor measurement model across population subgroups defined by stage of change for cessation, gender, racial identity, ethnicity, age, smoking problem severity, and weight status. These findings confirmed that the four factors and the set of 12 items that serve as their measured indicators have a consistent relationship across population subgroups, and provide empirical support for the internal validity of the measure. The four factor measurement model demonstrated invariance in factor loadings and indicator intercepts, allowing meaningful group comparisons to be made on these constructs.

Finally, temptations varied slightly across the first three stage of change consistent with TTM predictions (Rossi & Redding, 2001), although only the habit strength and positive/social subscales replicated previous findings in adults and adolescents (Hoeppner et al., 2012; Plummer et al., 2001; Redding et al., 2013; Velicer et al., 1990). As expected, participants' temptations to smoke in positive/social and habit strength situations were highest

in Precontemplation and lower among those in Preparation. The negative/affective subscale items were endorsed more highly than the other subscales. Interestingly, the weight concerns subscale showed a slight increasing pattern across stage of change, and was endorsed lower than the other subscales. This relationship is worth further investigation, and may indicate that weight concerns may be salient only to some but not all smokers. Overall, these results support the use of this measure for both assessing temptations to smoke and for tailored intervention purposes in adult smokers.

APPENDICES

Tables

Table 1. Four Factor Situational Temptations for Smoking Inventory.

Subscale 1 – Positive/Social	
01.	With friends at a party
02.	Over coffee while talking and relaxing
03.	With my spouse or close friend who is smoking
Subscale 2 – Habit Strength	
04.	When I first get up in the morning
05.	When I feel I need a lift
06.	When I realize I haven't smoked in a while
Subscale 3 – Negative/Affective	
07.	When I am very anxious and stressed
08.	When I am very angry about something or someone
09.	When things are not going my way and I am frustrated
Subscale 4 – Weight Concerns	
10.	When I am afraid I might gain weight
11.	When I want to lose weight
12.	When I am concerned about managing my weight

Table 2. Overall characteristics of participants ($N = 2921$).

Characteristic	Mean	(Standard Deviation)
Age (years)	41.9	(13.4)
Height (inches)	67.2	(4.2)
Weight (pounds)	178.4	(46.4)
BMI (kg/m^2)	27.6	(6.5)
Education (years)	13.2	(2.5)
	% with characteristic	
Female	55.3	
White	68.6	
Hispanic	7.1	
Employed	48.5	
Married	40.6	
General health = "Good" or better	69.9	
Smoking-related characteristics	% with characteristic	
TTM-Stage of change for cessation		
Precontemplation	32.0	
Contemplaton	46.0	
Preparation	22.0	
Smoking severity		
Light smoker (0–15 cigarettes/day)	59.4	
Medium smoker (16–29 cigarettes/day)	30.5	
Heavy smoker (30 or more cigarettes/day)	10.2	
	Mean	(Standard Deviation)
Average number of cigarettes per day	15.5	(12.1)
Fagerstrom test of nicotine dependence score	3.5	(2.3)

Table 3. Characteristics of two cross-validation samples.

	Sample 1 (N = 1433)		Sample 2 (N = 1488)	
Characteristic	Mean	(SD)	Mean	(SD)
Age (years)	41.9	(13.2)	41.8	(13.6)
Height (inches)	67.2	(4.1)	67.3	(4.2)
Weight (pounds)	177.0	(46.6)	179.8	(46.1)
BMI (kg/m^2)	27.5	(6.5)	27.8	(6.5)
Education (years)	13.1	(2.4)	13.2	(2.6)
	% with characteristic		% with characteristic	
Female	55.1		55.4	
White	68.5		68.6	
Hispanic	6.9		7.3	
Employed	41.7		39.6	
Married	47.6		49.4	
General health = "Good" or better	69.0		70.8	
Smoking-related characteristics	% with characteristic		% with characteristic	
TTM-Stage of change for cessation				
Precontemplation	32.6		31.4	
Contemplaton	46.4		45.6	
Preparation	21.0		23.0	
Smoking severity				
Light smoker (0–15 cigarettes/day)	57.8		60.9	
Medium smoker (16–29 cigarettes/day)	31.7		29.3	
Heavy smoker (30 or more cigarettes/day)	10.5		9.8	
	Mean	(SD)	Mean	(SD)
Average number of cigarettes per day	15.8	(12.3)	15.2	(11.9)
Fagerstrom test of nicotine dependence score	3.5	(2.4)	3.5	(2.3)

Table 4. Rotated component matrix for sample 1 with four components solution.

	Components			
Item	Positive/ Social	Habit Strength	Negative/ Affective	Weight Concerns
01. With friends at a party	0.792			
02. Over coffee while talking and relaxing	(0.380)	0.523		
03. With my spouse or close friend who is smoking	0.784			
04. When I first get up in the morning		0.787		
05. When I feel I need a lift		0.530		
06. When I realize I haven't smoked in a while		0.609		
07. When I am very anxious and stressed			0.762	
08. When I am very angry about something or someone			0.841	
09. When things are not going my way and I am frustrated			0.801	
10. When I am afraid I might gain weight				0.885
11. When I want to lose weight				0.914
12. When I am concerned about managing my weight				0.927

66.41% of variance explained
Note: Low loadings for items identified as belonging to a specific component based on previous study are shown in parentheses.

Table 5. Rotated component matrix for sample 2 with four components solution.

	Components			
Item	Positive/ Social	Habit Strength	Negative/ Affective	Weight Concerns
01. With friends at a party	0.831			
02. Over coffee while talking and relaxing	(0.295)	0.710		
03. With my spouse or close friend who is smoking	0.729			
04. When I first get up in the morning		0.774		
05. When I feel I need a lift		0.496		
06. When I realize I haven't smoked in a while		0.496		
07. When I am very anxious and stressed			0.757	
08. When I am very angry about something or someone			0.846	
09. When things are not going my way and I am frustrated			0.828	
10. When I am afraid I might gain weight				0.875
11. When I want to lose weight				0.911
12. When I am concerned about managing my weight				0.932

67.95% of variance explained
Note: Low loadings for items identified as belonging to a specific component based on previous study are shown in parentheses.

Table 6. Goodness-of-fit statistics for five alternative measurement models assessed with full sample (N = 2921)

Measurement model	χ^2	***df***	**CFI**	**RMSEA**	**[90% CI]**	**AIC**
Normal ML estimation						
Null model	12707.91**	66	--	--	--	12575.91
One factor model	5223.48**	54	.591	.181	[.177, .185]	5115.48
Uncorrelated four factors model	2217.36**	54	.829	.117	[.113, .121]	2109.36
PCA-based correlated four factors model	452.75**	48	.968	.054	[.049, .058]	356.75
Correlated four factors model (Fig. 1)	488.43**	48	.965	.056	[.052, .061]	392.43
Hierarchical four factors model (Fig. 2)	494.05**	50	.965	.055	[.051, .060]	394.05

Measurement model	**S-B χ^2**	***df***	***CFI**	***RMSEA**	**[90% CI]**	***AIC**
Robust ML estimation						
Null model	11481.38**	66	--	--	--	11349.38
One factor model	4518.65**	54	.609	.168	[.164, .172]	4410.46
Uncorrelated four factors model	1994.28**	54	.830	.111	[.107, .115]	1886.29
PCA-based correlated four factors model	389.78**	48	.970	.049	[.045, .054]	293.78
Correlated four factors model (Fig. 1)	422.16**	48	.967	.052	[.047, .056]	326.15
Hierarchical four factors model (Fig. 2)	429.00**	50	.967	.051	[.047, .055]	329.00

Note: CFI=Comparative Fit Index
RMSEA=Root mean square error of approximation
AIC=Akaike's Information Criteria
S-B χ^2=Satorra-Bentler scaled χ^2 statistic
* denotes robust versions of CFI, RMSEA and AIC
** $p < .001$ for χ^2

Table 7. Cronbach's coefficient alpha for four subscales and full scale in 2 samples.

		Coefficient Alpha		
Subscale	**Number of Items**	Sample 1 (N = 1433)	Sample 2 (N = 1488)	Full Sample (N = 2921)
Positive/ Social	3	0.57	0.56	0.56
Habit Strength	3	0.53	0.56	0.55
Negative/ Affective	3	0.78	0.81	0.79
Weight Concerns	3	0.91	0.91	0.91
Temptations	12	0.79	0.81	0.80

Table 8. Sample size by category for each population subgroup.

Subgroup	Category	*N*
Gender		
	Female	1614
	Male	1307
Racial Identity[a]		
	White	2000
	Black/African American	370
	American Indian/Alaskan Native	272
Ethnicity		
	Hispanic	207
	Non-Hispanic	2708
Age		
	18 – 34 years old	985
	35 – 49 years old	1060
	50 – 82 years old	875
TTM-Stage of Change for Cessation		
	Precontemplation	934
	Contemplation	1344
	Preparation	643
Smoking Severity		
	Light smoker (0–15 cigarettes/day)	1734
	Medium smoker (16–29 cigarettes/day)	890
	Heavy smoker (30 or more cigarettes/day)	297
Weight Status		
	BMI 24.9 or less[b]	1054
	BMI 25.0 – 29.9	945
	BMI 30.0 or more	812

[a] Does not include participants who selected more than one race.
[b] Category includes *N*=73 underweight (i.e. BMI 18.4 or less) combined with *N*=981 normal weight (i.e. BMI 18.5–24.9) participants.

Table 9.1. Summary of baseline measurement model fit by subgroup (normal ML estimation).

Subgroup	χ^2	*df*	CFI	RMSEA	[90% CI]
Gender					
Females	344.67	48	.956	.062	[.056, .068]
Males	210.92	48	.968	.051	[.044, .058]
Racial identity					
White	335.26	48	.968	.055	[.049, .060]
Black	133.29	48	.940	.069	[.055, .083]
American Indian/Alaskan Native	78.91	48	.975	.049	[.028, .067]
Ethnicity					
Hispanic	75.50	48	.975	.052	[.027, .074]
Non-Hispanic	437.80	48	.966	.055	[.050, .059]
Age					
34 years and under	154.36	48	.973	.047	[.039, .056]
35 – 49 years	222.44	48	.965	.059	[.051, .066]
50 years or more	150.15	48	.972	.049	[.040, .058]
Stage of Change					
Precontemplation	162.43	48	.974	.051	[.042, .059]
Contemplation	221.02	48	.967	.052	[.045, .059]
Preparation	210.39	48	.947	.073	[.063, .083]
Smoking severity					
Light smoker (0–15 cigarettes/day)	297.02	48	.965	.055	[.049, .061]
Medium smoker (16–29 cigarettes/day)	163.09	48	.970	.052	[.043, .061]
Heavy smoker (30 or more cigarettes/day)	100.17	48	.960	.060	[.043, .077]
Weight status					
BMI 24.9 or less	175.02	48	.973	.050	[.042, .058]
BMI 25.0 – 29.9	209.84	48	.961	.060	[.052, .068]
BMI 30.0 or more	182.57	48	.957	.059	[.050, .068]

Note: CFI=Comparative Fit Index
RMSEA=Root mean square error of approximation

Table 9.2. Summary of baseline measurement model fit by subgroup (robust ML estimation).

Subgroup	S-B χ^2	*df*	*CFI	*RMSEA	[90% CI]
Gender					
Females	297.81	48	.958	.057	[.051, .063]
Males	179.03	48	.970	.046	[.039, .052]
Racial identity					
White	287.31	48	.970	.050	[.045, .055]
Black	123.20	48	.942	.065	[.052, .079]
American Indian/Alaskan Native	75.38	48	.976	.046	[.025, .064]
Ethnicity					
Hispanic	75.38	48	.973	.052	[.028, .074]
Non-Hispanic	375.11	48	.969	.050	[.046, .055]
Age					
34 years and under	138.66	48	.974	.044	[.036, .052]
35 – 49 years	186.35	48	.969	.052	[.045, .059]
50 years or more	127.23	48	.976	.043	[.035, .052]
Stage of Change					
Precontemplation	138.38	48	.977	.045	[.037, .053]
Contemplation	189.23	48	.970	.047	[.040, .053]
Preparation	181.31	48	.949	.068	[.058, .077]
Smoking severity					
Light smoker (0–15 cigarettes/day)	258.98	48	.968	.050	[.045, .056]
Medium smoker (16–29 cigarettes/day)	140.66	48	.973	.047	[.038, .055]
Heavy smoker (30 or more cigarettes/day)	79.55	48	.971	.047	[.030, .063]
Weight status					
BMI 24.9 or less	155.05	48	.975	.046	[.038, .054]
BMI 25.0 – 29.9	181.51	48	.965	.054	[.047, .062]
BMI 30.0 or more	156.52	48	.961	.053	[.044, .061]

Note: S-B χ^2=Satorra-Bentler scaled χ^2 statistic
*CFI=Robust CFI
*RMSEA=Robust RMSEA

Table 10.1. Measurement invariance model fit by subgroup (normal ML estimation).

	χ^2	*df*	$\Delta\chi^2$	Δdf	RMSEA	[90% CI]
Gender						
Equal form	555.60	96	--	--	.057	[.044, .058]
Equal factor loadings*	792.65	108	237.05	12	.066	[.062, .070]
Equal indicator intercepts*	902.35	116	109.70	8	.068	[.064, .072]
Equal indicator error variances*	1086.81	128	184.46	12	.072	[.068, .076]
Racial identity						
Equal form	547.62	144	--	--	.056	[.051, .061]
Equal factor loadings*	603.51	168	55.90	24	.054	[.050, .059]
Equal indicator intercepts*	651.29	184	47.78	16	.054	[.049, .058]
Equal indicator error variances*	786.12	208	134.83	24	.056	[.052, .060]
Ethnicity						
Equal form	513.30	96	--	--	.055	[.050, .059]
Equal factor loadings	529.28	108	15.99	12	.052	[.047, .056]
Equal indicator intercepts*	577.11	116	47.83	8	.052	[.048, .057]
Equal indicator error variances*	663.97	128	86.86	12	.054	[.050, .058]
Age						
Equal form	526.95	144	--	--	.052	[.048, .057]
Equal factor loadings*	617.93	168	90.98	24	.052	[.048, .057]
Equal indicator intercepts*	925.28	184	307.35	16	.064	[.060, .068]
Equal indicator error variances*	1125.08	208	199.80	24	.067	[.063, .071]
Stage of Change						
Equal form*	593.84	144	--	--	.057	[.052, .061]
Equal factor loadings*	633.70	168	39.86	24	.053	[.049, .058]
Equal indicator intercepts*	676.41	184	42.71	16	.052	[.048, .057]
Equal indicator error variances	742.42	208	66.01	24	.051	[.047, .055]
Smoking severity						
Equal form	560.28	144	--	--	.054	[.050, .059]
Equal factor loadings*	639.36	168	79.08	24	.054	[.049, .058]
Equal indicator intercepts*	836.02	184	196.67	16	.060	[.056, .065]
Equal indicator error variances*	1015.15	208	179.13	24	.063	[.059, .067]
Weight status						
Equal form	567.43	144	--	--	.056	[.051, .061]
Equal factor loadings	601.94	168	34.51	24	.053	[.048, .057]
Equal indicator intercepts	624.41	184	22.47	16	.051	[.046, .055]
Equal indicator error variances*	819.37	208	194.97	24	.056	[.052, .060]

Note: RMSEA=Root mean square error of approximation
*$p < .05$ for $\Delta\chi^2$

Table 10.2. Measurement invariance model fit by subgroup (robust ML estimation).

	S-Bχ^2	*df*	ΔS-Bχ^2	Δ*df*	*RMSEA	[90% CI]
Gender						
Equal form	475.78	96	--	--	.052	[.048, .056]
Equal factor loadings*	681.74	108	211.28	12	.060	[.056, .064]
Equal indicator intercepts*	786.11	116	115.75	8	.063	[.059, .067]
Equal indicator error variances*	907.88	128	110.26	12	.065	[.061, .068]
Racial identity						
Equal form	498.40	144	--	--	.053	[.048, .058]
Equal factor loadings*	544.99	168	48.22	24	.050	[.046, .055]
Equal indicator intercepts*	597.66	184	52.83	16	.051	[.046, .055]
Equal indicator error variances*	631.20	208	55.28	24	.048	[.044, .052]
Ethnicity						
Equal form	473.37	96	--	--	.052	[.047, .056]
Equal factor loadings	492.17	108	15.92	12	.049	[.045, .054]
Equal indicator intercepts*	550.18	116	69.13	8	.051	[.047, .055]
Equal indicator error variances*	653.18	128	123.55	12	.053	[.049, .057]
Age						
Equal form	453.35	144	--	--	.047	[.042, .052]
Equal factor loadings*	534.15	168	80.96	24	.047	[.043, .052]
Equal indicator intercepts*	824.56	184	405.49	16	.060	[.056, .064]
Equal indicator error variances*	936.16	208	110.24	24	.060	[.056, .064]
Stage of Change						
Equal form	515.92	144	--	--	.052	[.047, .056]
Equal factor loadings	552.09	168	35.32	24	.048	[.044, .053]
Equal indicator intercepts*	598.01	184	44.69	16	.048	[.044, .052]
Equal indicator error variances*	622.36	208	39.60	24	.045	[.042, .049]
Smoking severity						
Equal form	471.41	144	--	--	.048	[.044, .053]
Equal factor loadings*	538.78	168	67.26	24	.048	[.044, .052]
Equal indicator intercepts*	724.06	184	240.36	16	.055	[.051, .059]
Equal indicator error variances*	870.33	208	142.55	24	.057	[.054, .061]
Weight status						
Equal form	493.23	144	--	--	.051	[.046, .055]
Equal factor loadings	524.68	168	30.59	24	.048	[.043, .052]
Equal indicator intercepts	550.85	184	22.71	16	.046	[.042, .050]
Equal indicator error variances*	673.04	208	104.78	24	.049	[.045, .053]

Note: S-B χ^2=Satorra-Bentler scaled χ^2 statistic
*RMSEA=Robust RMSEA
* $p < .05$ for ΔS-Bχ^2

Table 11.1. Alternative fit indices for measurement invariance models by subgroup (normal ML estimation).

	CFI	ΔCFI	NCI	ΔNCI	G-h	Δ G-h
Gender						
Equal form	.961	--	.924	--	.974	--
Equal factor loadings	.942	.019	.889	.035	.962	.012
Equal indicator intercepts	.934	.009	.874	.015	.957	.005
Equal indicator error variances	.919	.015	.849	.025	.948	.009
Racial identity						
Equal form	.965	--	.926	--	.975	--
Equal factor loadings	.962	.003	.921	.005	.973	.002
Equal indicator intercepts	.960	.003	.915	.006	.971	.002
Equal indicator error variances	.950	.010	.896	.019	.965	.006
Ethnicity						
Equal form	.967	--	.931	--	.977	--
Equal factor loadings	.967	0	.930	.001	.976	.001
Equal indicator intercepts	.964	.003	.924	.006	.974	.002
Equal indicator error variances	.958	.006	.912	.012	.970	.004
Age						
Equal form	.970	--	.937	--	.979	--
Equal factor loadings	.964	.006	.926	.011	.975	.004
Equal indicator intercepts	.941	.023	.881	.045	.959	.016
Equal indicator error variances	.927	.042	.855	.026	.950	.009
Stage of Change						
Equal form	.965	--	.926	--	.975	--
Equal factor loadings	.963	.002	.923	.003	.974	.001
Equal indicator intercepts	.961	.002	.919	.004	.973	.001
Equal indicator error variances	.958	.003	.913	.006	.970	.003
Smoking severity						
Equal form	.966	--	.931	--	.977	--
Equal factor loadings	.962	.004	.922	.009	.974	.003
Equal indicator intercepts	.947	.015	.894	.028	.964	.010
Equal indicator error variances	.935	.013	.871	.023	.956	.008
Weight status						
Equal form	.965	--	.927	--	.976	--
Equal factor loadings	.964	.001	.926	.001	.975	.001
Equal indicator intercepts	.964	.001	.925	.001	.975	.001
Equal indicator error variances	.949	.014	.897	.028	.965	.010

Note: CFI-Comparative Fit Index
NCI=McDonald's Noncentrality Index
G-h=Gamma-hat

Table 11.2. Alternative fit indices for measurement invariance models by subgroup (robust ML estimation).

	*CFI	Δ*CFI	NCI	ΔNCI	*G-h	Δ*G-h
Gender						
Equal form	.964	--	.924	--	.979	--
Equal factor loadings	.945	.019	.889	.035	.968	.011
Equal indicator intercepts	.936	.009	.874	.015	.963	.005
Equal indicator error variances	.925	.011	.849	.025	.957	.006
Racial identity						
Equal form	.966	--	.926	--	.978	--
Equal factor loadings	.964	.002	.921	.005	.977	.001
Equal indicator intercepts	.961	.003	.915	.006	.975	.002
Equal indicator error variances	.960	.001	.896	.019	.974	.001
Ethnicity						
Equal form	.968	--	.931	--	.979	--
Equal factor loadings	.967	.001	.930	.001	.978	.001
Equal indicator intercepts	.963	.004	.924	.006	.976	.002
Equal indicator error variances	.955	.008	.912	.012	.971	.005
Age						
Equal form	.973	--	.937	--	.983	--
Equal factor loadings	.968	.005	.926	.011	.980	.003
Equal indicator intercepts	.943	.024	.881	.045	.965	.015
Equal indicator error variances	.935	.008	.855	.026	.960	.005
Stage of Change						
Equal form	.968	--	.926	--	.979	--
Equal factor loadings	.966	.002	.923	.003	.978	.001
Equal indicator intercepts	.964	.002	.919	.004	.977	.001
Equal indicator error variances	.964	.001	.913	.006	.977	.001
Smoking severity						
Equal form	.970	--	.931	--	.982	--
Equal factor loadings	.966	.004	.922	.009	.979	.003
Equal indicator intercepts	.950	.016	.894	.028	.970	.009
Equal indicator error variances	.939	.011	.871	.023	.964	.006
Weight status						
Equal form	.968	--	.927	--	.980	--
Equal factor loadings	.967	.001	.926	.001	.979	.001
Equal indicator intercepts	.966	.001	.925	.001	.979	.001
Equal indicator error variances	.957	.009	.897	.028	.973	.006

Note: *CFI=Robust CFI
NCI=McDonald's Noncentrality Index
*G-h=Robust Gamma-hat

Table 12. ANOVA & Tukey test results for non-invariant item intercepts by age group.

	Mean (SD)				
	18 – 34 yrs	35 – 49 yrs	50 – 82 yrs		
Item	(*N*=985)	(*N*=1060)	(*N*=875)	***F*(2,2917)**	**Tukey test**
1	4.06	3.95	3.66	27.41**	18-49 yrs > 50-82 yrs
	(1.14)	(1.16)	(1.28)		
2	3.13	3.46	3.65	36.15**	50-82 yrs > 35-49 yrs > 18-34 yrs
	(1.39)	(1.35)	(1.28)		
6	2.95	2.87	2.74	5.86*	18-34 yrs > 50-82 yrs
	(1.38)	(1.31)	(1.24)		
8	4.34	4.15	3.79	51.73**	18-34 yrs > 35-49 yrs > 50-82 yrs
	(0.99)	(1.18)	(1.38)		

*$p < .01$; **$p < .001$

Table 13. ANOVA & Tukey test results for non-invariant item intercepts by smoking severity group.

	Mean (SD)				
	Light smokers	Medium smokers	Heavy smokers		
Item	(*N*=1734)	(*N*=890)	(*N*=297)	***F*(2,2918)**	**Tukey test**
2	3.19	3.68	3.85	56.76**	Heavy, Medium > Light
	(1.36)	(1.28)	(1.29)		
4	3.35	4.20	4.26	147.99**	Heavy, Medium > Light
	(1.48)	(1.07)	(1.08)		
5	2.45	2.84	2.67	27.64**	Heavy, Medium > Light
	(1.29)	(1.33)	(1.36)		

**$p < .001$

Table 14. Descriptive statistics for four Temptations subscales and 12 items in full sample.

	Mean[a]	Standard Deviation	Min	Max	Skewness	Kurtosis
Positive/Social subscale	3.61	0.94	1.00	5.00	−0.48	−0.27
Item 1	3.90	1.20	1	5	−0.91	−0.08
Item 2	3.41	1.36	1	5	−0.45	−0.93
Item 3	3.52	1.31	1	5	−0.56	−0.73
Habit Strength subscale	3.05	0.97	1.00	5.00	−0.14	−0.59
Item 4	3.70	1.40	1	5	−0.71	−0.81
Item 5	2.59	1.32	1	5	0.32	−1.02
Item 6	2.86	1.32	1	5	0.09	−1.04
Negative/Affective subscale	4.12	0.94	1.00	5.00	−1.12	0.73
Item 7	4.33	0.96	1	5	−1.51	1.91
Item 8	4.10	1.21	1	5	−1.28	0.62
Item 9	3.93	1.17	1	5	−0.96	0.06
Weight Concerns subscale	2.09	1.28	1.00	5.00	0.96	−0.32
Item 10	2.27	1.49	1	5	0.76	−0.90
Item 11	1.98	1.35	1	5	1.13	−0.06
Item 12	2.01	1.33	1	5	1.07	−0.16
Temptations	3.22	0.72	1.08	4.92	−0.07	−0.25

[a] Sub-scale totals divided by number of items before calculating means and standard deviations.

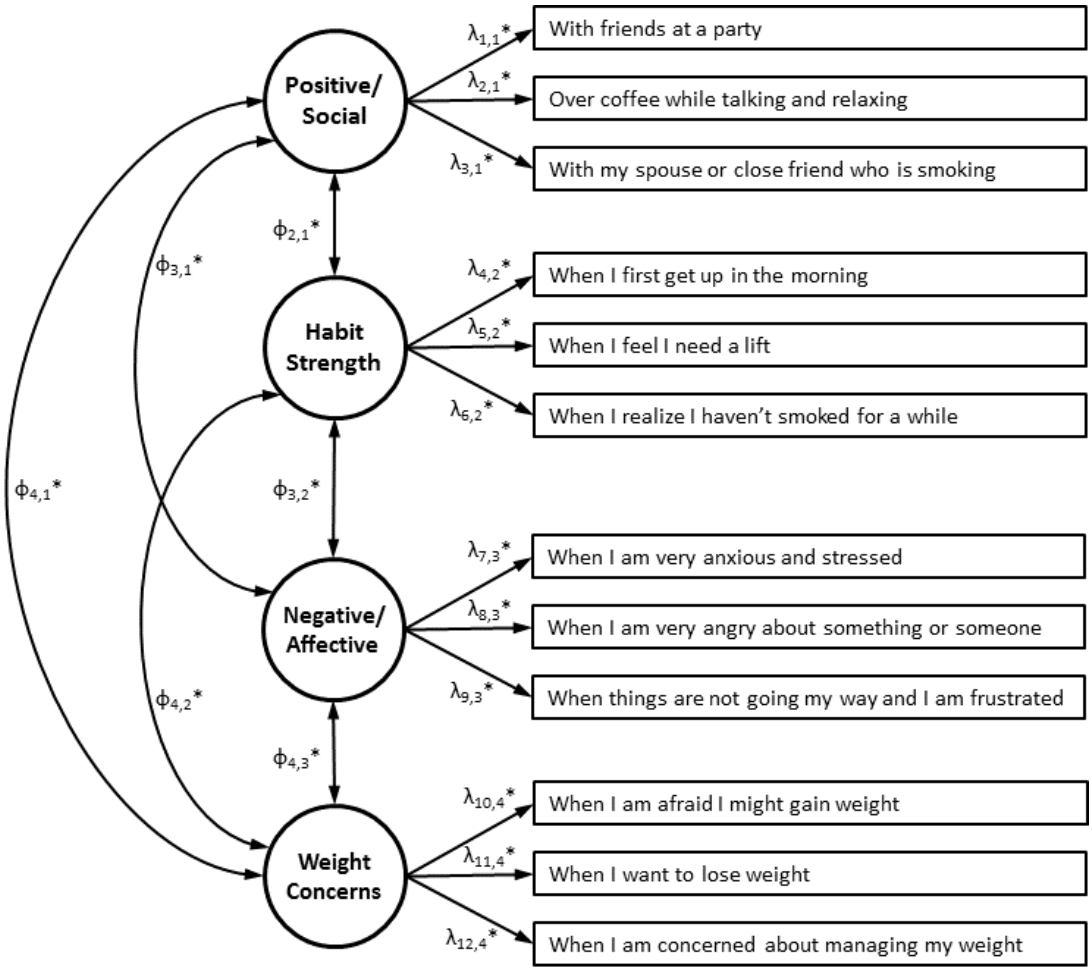
Table 15. ANOVA & Tukey test results for Temptations subscale means by stage of change.

	Mean (SD)					
Factor	PC (*N*=934)	C (*N*=1344)	PR (*N*=643)	***F*(2,2918)**	**η^2**	**Tukey test**
Positive/Social	3.64 (0.94)	3.63 (0.93)	3.53 (0.98)	2.94	.001	
Habit Strength	3.08 (0.98)	3.08 (0.96)	2.95 (1.00)	4.18*	.002	PC, C > PR
Negative/Affective	4.02 (1.01)	4.18 (0.89)	4.14 (0.94)	7.70**	.005	C > PC
Weight Concerns	2.01 (1.27)	2.11 (1.27)	2.16 (1.32)	3.02*	.001	

*$p < .05$; **$p < .001$

FIGURES.

Figure 1. Hypothesized correlated four factor measurement model for Temptations.



* Indicate parameters to be estimated.

Figure 2. Correlated four factor measurement model for Temptations with standardized parameter estimates for full baseline sample ($N = 2921$).

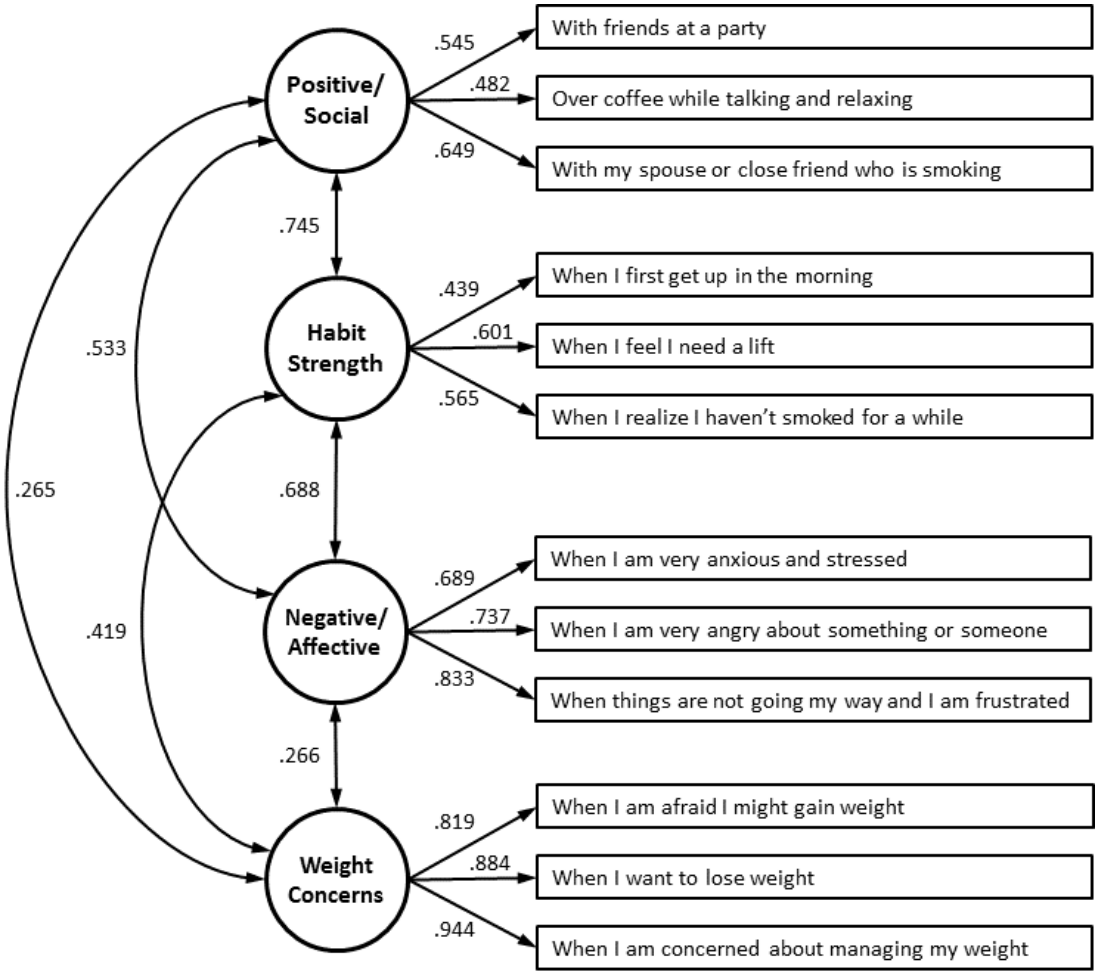


Figure 3. Hierarchical four factor measurement model for Temptations with standardized parameter estimates for full baseline sample (N = 2921).

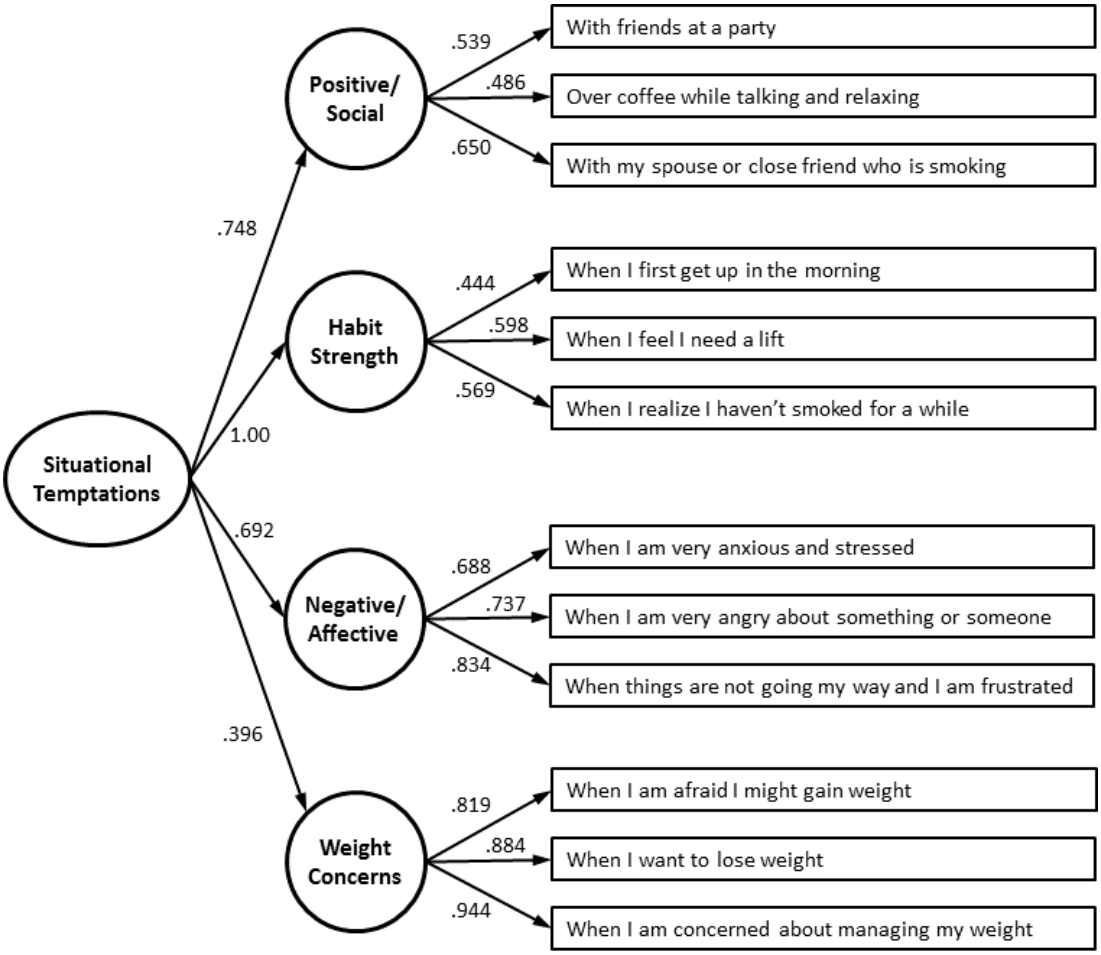
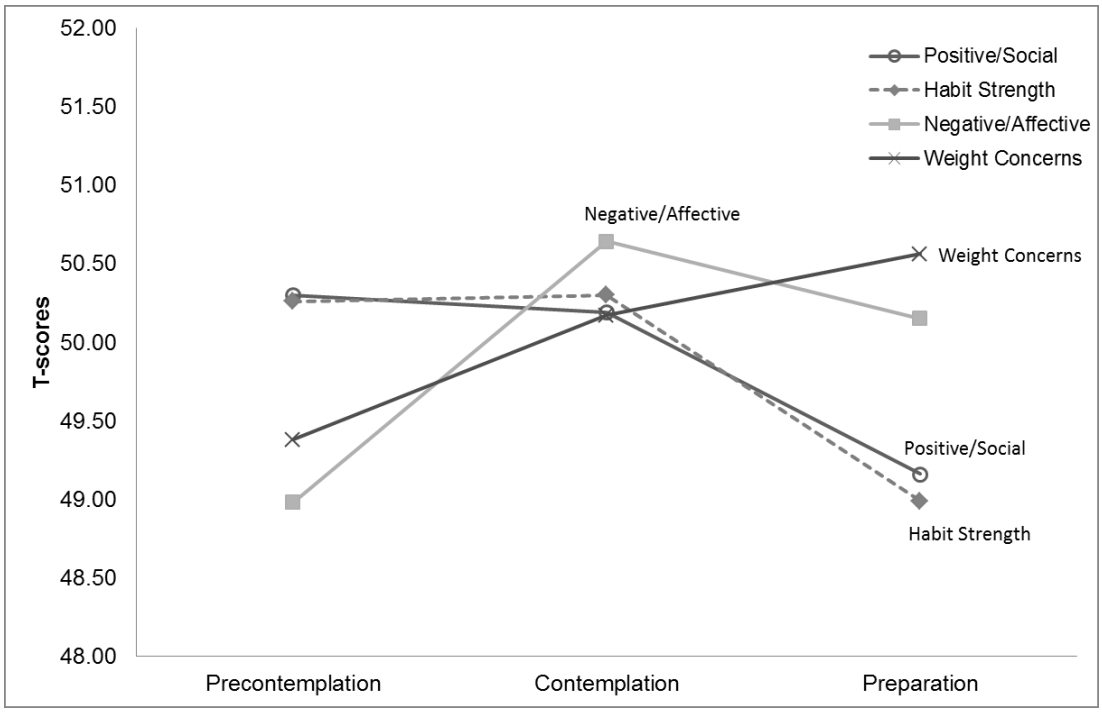


Figure 4. Temptations subscale scores across pre-action stages of change.



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