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On the Invariance of the Stimulant Craving Questionnaire (STCQ) across Cocaine and Methamphetamine Users

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Abstract

Background—The rapid rise in the number of methamphetamine users, relative to cocaine users, has brought the number of each to nearly equal levels, making research on similarities and differences across these groups a needed area of exploration. Craving is postulated to play a significant role in relapse for both user types, yet group differences on observed scale scores have been reported without first assessing the prerequisite measurement equivalence (invariance) of the items, which is essential for meaningful group comparisons.

Methods/design—Baseline data from stimulant users in residential treatment (N=301; n=177 cocaine; n=124 methamphetamine) were used to assess the measurement invariance of the 10-item Stimulant Craving Questionnaire (STCQ), which was adapted from a cocaine-specific measure.

Results—The unifactorial STCQ demonstrated measurement invariance across cocaine and methamphetamine users for factor loadings (metric), common residual covariances between item pairs, and item intercepts (scalar), as determined by fit indices (RMSEA<0.05; CFI & TLI>0.95; SRMR<0.10). The latent mean, as well as 5 (out of 10) item means and the overall composite scale score, were significantly greater for methamphetamine users compared to cocaine users.

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Discussion—Results indicate the STCQ is an invariant tool for the assessment of stimulant craving across the two most prevalent user types. Methamphetamine users had significantly higher levels of observed and latent craving than cocaine users, demonstrating a potentially meaningful difference in craving between users of these two stimulants. Future research will determine if treatments and statistical models need to account for craving variations across methamphetamine and cocaine users.

Keywords

Cocaine; Methamphetamine; Stimulant; Craving; Invariance

1. Introduction

In the past decade the number of methamphetamine-dependent individuals has increased dramatically (NIDA, 2012; SAMHSA, 2005) nearly equaling cocaine-dependent users (NIDA, 2010). This trend has prompted the examination of clinical differences across these two stimulant user types. Stimulant-user differences have been explored for decades (e.g., Newmeyer, 1978) and recent findings highlight pharmacokinetic differences between stimulants. For example, methamphetamine takes longer than cocaine to clear the brain (Fowler et al., 2008). Despite physiological differences, other constructs related to both groups remain underexplored.

Craving is one factor often hypothesized to play a role in stimulant use and relapse following treatment (Robinson & Berridge, 1993; Volkow et al., 2006) and is critical to evaluate for dissimilarities across users. Despite possible differences in how craving is experienced by cocaine- and methamphetamine-dependent individuals (e.g., Hilburn et al., 2011), research often assumes the construct is measured equivalently (e.g., factor loadings are invariant). Measurement invariance exists when item content has the same meaning across groups, which allows score comparison. Without establishing invariance, observed differences may simply be mean differences on the same construct or the measure could capture different constructs across groups. Ideally, one instrument could be used to assess craving equivalently across stimulant users by removing non-invariant items (Cheung & Rensvold, 1999).

A brief practical measure of cocaine craving exists (i.e., the 10-item Cocaine Craving Questionnaire-Brief [CCQ-Brief]; Sussner et al., 2006); however, the data were collected over a decade ago at one site, excluded individuals under age 26 and individuals dependent on stimulants other than cocaine, and only 3% were female. The CCQ-Brief, reworded to include more stimulant types, is ideal for psychometric evaluation with a diverse stimulant-user population. Furthermore, the modifications underscore the need for additional evaluation. The aim of this research was to psychometrically assess a new tool, the Stimulant Craving Questionnaire (STCQ), by evaluating the measurement invariance across cocaine and methamphetamine users.

2. Methods

The STimulant Reduction Intervention using Dosed Exercise (STRIDE) study (conducted within the National Drug Abuse Treatment Clinical Trials Network) recruited from 9 Institutional Review Board-approved sites (Trivedi et al., 2011). Briefly, men and women (ages 18-65) who were admitted to residential treatment, used stimulants in the 30 days prior to admission, met DSM-IV criteria for stimulant abuse or dependence, and medically cleared to exercise, were eligible. Consented participants were randomized (N=302) to dosed cardiovascular exercise or health education in addition to treatment-as-usual. One participant not meeting inclusion criteria was removed from this baseline psychometric evaluation of 301 participants.

The Stimulant Craving Questionnaire-Brief (STCQ) was adapted from the 10-item unifactorial CCQ-Brief (Sussner, et al., 2006). “Cocaine” and “coke” from the CCQ-Brief were replaced with “cocaine, methamphetamine or other stimulants.” Participants were asked to indicate their feelings “right now” on a 0 (“Strongly Disagree”) to 6 (“Strongly Agree”) scale. A composite was generated by averaging all items (Table 1).

3. Statistical Analyses

A Confirmatory Factor Analysis (CFA) with Maximum Likelihood estimation and a mean-adjusted chi-square test (MLM) obtained standard errors and the Satorra Bentler chi-square test (χ^2_{SB}), which are robust to non-normality (Curran, West, & Finch, 1996; Muthen, 2009). The Comparative Fit Index (CFI; >0.95 considered good), Tucker-Lewis Index (TLI; >0.95 considered good), Root Mean Square Error of Approximation (RMSEA; ≤0.05 considered good), and Standardized Root Mean Residual (SRMR; <0.10 considered good) were also used to evaluate model fit (Kline, 2005).

Model fitting and invariance testing followed recommendations by Byrne (Chapters 4 & 7; 2012) for MPlus, version 7. Generally, invariance testing proceeded by freely estimating parameters for each group, then constraining them (i.e., factor loadings, shared residual covariances, intercepts, and latent means) sequentially to assess model-fit decrements as evidence of non-invariance. Specifically, we began with a CFA to test the hypothesized unifactorial validity for each group (cocaine and methamphetamine) and optimize the model for each group *separately* before invariance testing. Modification indices (Muthen & Muthen, 1998-2012) guided theoretically justified modifications. Invariance testing proceeded by estimating configural invariance (i.e., factor loadings' patterns), metric invariance (i.e., factor loadings' magnitudes), common residual covariance invariance, scalar invariance (i.e., items' intercepts), and finally latent means. The χ^2_{SB} difference test ($\Delta \chi^2_{SB}$) was used to compare nested models for each successive step following suitable mathematical calculations for MLM estimation (MPlus, 2014; Muthen & Muthen, 1998-2012). Stepwise evaluation of improvements (following modifications) were significant if the MLM-adjusted chi-square difference test value was ≥3.84 ($p<0.05$).

4. Results

Mean age was 39.0 years (SD=10.8) and 39.9% of the sample were female. The sample was 45.2% White, 43.2% Black, 10.3% Hispanic/Latino, and 4.0% Other. Fifty-nine percent (n=177) were cocaine dependent only, 30.6% (n=92) were methamphetamine dependent only, and 10.6% (n=32) were dependent on methamphetamine and one or more other stimulants (polystimulant group). The methamphetamine only and polystimulant groups were combined (n=124).

The entire sample's craving composite was <1.0 (Table 1), suggesting relatively low craving. The number of days since last stimulant use was not different (t=1.50, df=298, p=0.13) across the cocaine-only (M=17.3, SD=9.2) and methamphetamine groups (M=15.7, SD=8.7). Also, the correlation between days since last stimulant use and STCQ scores was not different from zero (r=-0.08, p=0.14), and therefore not included as a covariate. Chronbach's alpha (unstandardized) was 0.83, suggesting good internal consistency reliability.

Model Optimization

Each group's unifactorial model resulted in significant improvements by allowing residual covariances between items 1 and 2 and between items 3 and 9. The cocaine group model also allowed residual covariances between the two reverse-scored items (i.e., 4 and 7) and items 8 and 10. These modifications allowed the models to account for overlapping item content and similar methodology, as recommended by Byrne (p. 233; 2012). Model fit indices were generally excellent for the cocaine group (χ^2_{SB}=42.6, df=31, p=0.08; CFI=0.96; TLI=0.94; RMSEA=0.05; SRMR=0.05) and methamphetamine group (χ^2_{SB}=42.0, df=33, p=0.13; CFI=0.98; TLI=0.97; RMSEA=0.05; SRMR=0.04).

Invariance Testing

Excellent fit indices (χ^2_{SB}=84.9, df =64, p=0.04; CFI= 0.97; TLI=0.96; RMSEA=0.05; SRMR=0.05) for the configural invariance step demonstrated the factor loadings' pattern was invariant across groups. No model adjustments were made based on modification indices. Next, constraining factor loadings to test metric invariance did not result in a significant decrement to model fit, ($\Delta\chi^2_{SB}$=9.1, p=ns) and fit indices were excellent, with the exception of the SRMR (0.11), and no theoretically meaningful changes were suggested by the modification indices. The third step constrained residual covariances between item pairs 3 and 9 and items 1 and 2. The $\Delta\chi^2_{SB}$ value was not significant, no model changes were made, and all fit indices (except the SRMR=0.11) were excellent. This result implies that the method effects of these item pairs operate similarly across groups. Next, scalar invariance was assessed by constraining the item intercepts across groups. The $\Delta\chi^2_{SB}$ was not significant and the model fit indices remained in the excellent range with the exception of SRMR (0.12).

In the final step, the cocaine group's factor mean was fixed to zero and freely estimated in the methamphetamine group (for model identification; Byrne, 2012), which provides the factor mean for the methamphetamine group relative to the cocaine group. This final step

retained excellent fit indices (χ^2_{SB}=96.0, *df* =84, *p*=0.18; CFI= 0.98; TLI=0.98; RMSEA=0.03; SRMR=0.07). The standardized latent mean of +0.33 (*SE*=0.10) for the methamphetamine group was significant (*z*=3.34, *p* <0.01) and the $\Delta\chi^2_{SB}$ was significant (*p*<0.01). This result implies that individuals in the methamphetamine group (relative to the cocaine group) have higher levels of latent craving, which is supported by a scatter plot (fit with separate regression lines) of latent factor scores by observed STCQ composites (Figure 1) and the comparisons of observed individual item means and overall STCQ composite scores (Table 1). Specifically, 5 (of 10) item means and the STCQ composite were significantly higher for the methamphetamine group (1.0 vs. 0.7, *p*<0.01). The final model's standardized factor loadings, item intercepts, and residual covariances are provided (Table 1).

Post-Hoc Sensitivity Analysis

Consolidating 32 polystimulant and 92 methamphetamine users could have biased the findings in favor of invariance. The invariance analyses were repeated without the polystimulant users and the model fit indices for each step, individual parameters, and conclusions were highly similar. Therefore, the results including polystimulant users were retained.

5. Discussion

The STCQ demonstrated a high level of invariance across a relatively large residential-treatment sample composed of the two most prevalent stimulant-user groups. These results indicate cocaine and methamphetamine users respond similarly to individual craving items. The significantly higher latent mean for the methamphetamine group supports earlier work (Hilburn, et al., 2011) that this group experiences more intense craving. Latent mean differences are commonly found and still allow meaningful group comparisons.

One other difference stemmed from the cocaine group having two extra residual covariances estimated. This suggests cocaine users may have stronger method-related effects from these item pairs. However, these extra residual covariance estimations were unlikely to have substantively affected the results.

Using CFA to compare latent means (rather than composite [observed] scores), and knowing that latent means are not attenuated by measurement error (Vandenberg & Lance, 2000), offered robust statistical evidence of group differences. Despite methodological rigor, psychometric evaluations can be highly sample dependent; therefore, it is important to compare this study and work reported for the CCQ-Brief (Sussner, et al., 2006). The present sample was recruited from 9 U.S.-based residential treatment programs and included individuals under 26 years of age and significantly more females, which were absent or underrepresented in the single-site veterans treatment center sample. Further, with recent trends for significantly higher proportions of younger adults (18-25 years) to report methamphetamine and cocaine use (NIDA, 2010, 2012; SAMHSA, 2005) this sample may better reflect this growing population. Also, this study only excluded opioid-dependent patients, whereas Sussner et al. did not include individuals dependent on substances other

than cocaine. The heterogeneous stimulant-using population poses craving measurement challenges and invariant tools are necessary.

Limitations include an inadequate sample to allow for cross-validation, potentially increasing the capitalization on chance variation. Furthermore, merging polystimulant and methamphetamine users may have introduced a small amount of error, but the post-hoc sensitivity analyses suggested the consolidation was acceptable. The relatively low craving levels reported while this sample was in residential treatment might differ markedly from craving measured in an outpatient setting. Further, stimulant craving levels may change over time (Wang et al., 2013), which future work could assess.

6. Conclusion

Craving can persist up to one year after cessation, particularly for methamphetamine users (Wang, et al., 2013), and is critical to measure. The 10-item STCQ should be less prone to measurement error than single-item measures (Sayette et al., 2000) and more sensitive to change throughout treatment. Future research may determine whether craving is an accurate predictor of relapse as suggested by Sussner et al. (2006). Additional analyses with this measure may also demonstrate key differences across other stimulant user types, as higher levels of latent craving for individuals dependent on methamphetamine were detected. In closing, the STCQ is an invariant instrument for continued study with stimulant users. The clinical utility of this difference is unknown at this stage of research; however, it could be important to account for when designing interventions or performing statistical modeling with a heterogeneous stimulant-user population.

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References

Byrne, BM. Structural Equation Modeling with Mplus: Basic Concepts, Applications, and Programming. New York: Routledge; 2012.

Cheung GW, Rensvold RB. Testing factorial invariance across groups: A reconceptualization and proposed new method. Journal of Management. 1999; 25(1):1–27.10.1016/S0149-2063(99)80001-4

Curran PJ, West SG, Finch JF. The robustness of test statistics to nonnormality and specification error in confirmatory factor analysis. Psychological Methods. 1996; 1(1):16.10.1037//1082-989X.1.1.16

Fowler JS, Volkow ND, Logan J, Alexoff D, Telang F, Wang GJ, Apelskog K. Fast uptake and long-lasting binding of methamphetamine in the human brain: comparison with cocaine. Neuroimage. 2008; 43(4):756–763.10.1016/j.neuroimage.2008.07.020 [PubMed: 18708148]

Hilburn C, Nejtek VA, Underwood WA, Singh M, Patel G, Gangwani P, Forster MJ. Is serum brain-derived neurotrophic factor related to craving for or use of alcohol, cocaine, or methamphetamine? Neuropsychiatric disease and treatment. 2011; 7:357.10.2147/NDT.S18953 [PubMed: 21792305]

Kline, RB. Principles and Practice of Structural Equation Modeling. 2nd. New York: The Guilford Press; 2005.

MPlus. Chi-Square Difference Testing Using the Satorra-Bentler Scaled Chi-Square. 2014. Retrieved March 26th, 2014, from http://www.statmodel.com/chidiff.shtml

Muthen, LK. MLR Acronym?. 2009. Retrieved March 26th, 2014, from http://www.statmodel2.com/discussion/messages/11/2156.html?1176562358

Muthen, LK.; Muthen, BO. Mplus User's Guide. Sixth. Los Angeles, CA: Muthén & Muthén; 1998-2012.

Newmeyer JA. The Epidemiology of the Use of Amphetamine and Related Substances Journal of Psychoactive Drugs. 1978; 10(4):293–302.10.1080/02791072.1978.10471533

NIDA. Cocaine: What is the scope of cocaine use in the United States?. 2010. Retrieved March 26th, 2014, from http://www.drugabuse.gov/publications/research-reports/cocaine/what-scope-cocaine-use-in-united-states

NIDA. Methamphetamine. 2012. Retrieved March 26th, 2014, from http://www.drugabuse.gov/drugs-abuse/methamphetamine

Robinson TE, Berridge KC. The neural basis of drug craving: an incentive-sensitization theory of addiction. Brain Research Brain Research Reviews. 1993; 18(3):247–291.10.1016/0165-0173(93)90013-P [PubMed: 8401595]

SAMHSA. The NSDUH Report: Methamphetamine use, abuse, and dependence: 2002, 2003, and 2004. 2005. Retrieved March 26th, 2014, from http://www.samhsa.gov/data/2k5/meth/meth.htm

Sayette MA, Shiffman S, Tiffany ST, Niaura RS, Martin CS, Shadel WG. The measurement of drug craving. Addiction. 2000; 95 Suppl 2:S189–210.10.1046/j.1360-0443.95.8s2.8.x [PubMed: 11002914]

Sussner BD, Smelson DA, Rodrigues S, Kline A, Losonczy M, Ziedonis D. The validity and reliability of a brief measure of cocaine craving. Drug and Alcohol Dependence. 2006; 83(3):233–237.10.1016/j.drugalcdep.2005.11.022 [PubMed: 16384655]

Trivedi MH, Greer TL, Grannemann BD, Church TS, Somoza E, Blair SN, Nunes E. Stimulant reduction intervention using dosed exercise (STRIDE) - CTN 0037: study protocol for a randomized controlled trial. Trials. 2011; 12:206.10.1186/1745-6215-12-2061745-6215-12-206[pii] [PubMed: 21929768]

Vandenberg RJ, Lance CE. A review and synthesis of the measurement invariance literature: Suggestions, practices, and recommendations for organizational research. Organizational Research Methods. 2000; 3(1):4–69.10.1177/109442810031002

Volkow ND, Wang GJ, Telang F, Fowler JS, Logan J, Childress AR, Wong C. Cocaine cues and dopamine in dorsal striatum: mechanism of craving in cocaine addiction. Journal of Neuroscience. 2006; 26(24):6583–6588.10.1523/jneurosci.1544-06.2006 [PubMed: 16775146]

Wang G, Shi J, Chen N, Xu L, Li J, Li P, Lu L. Effects of length of abstinence on decision-making and craving in methamphetamine abusers. PLoS ONE. 2013; 8(7):e68791.10.1371/journal.pone.0068791 [PubMed: 23894345]

Highlights

- An invariant measure of craving is needed across methamphetamine and cocaine users.
- The Stimulant Craving Questionnaire demonstrated invariance across both user types.
- During residential treatment, methamphetamine users had greater latent craving.
- Future research will determine the clinical utility of these craving differences.

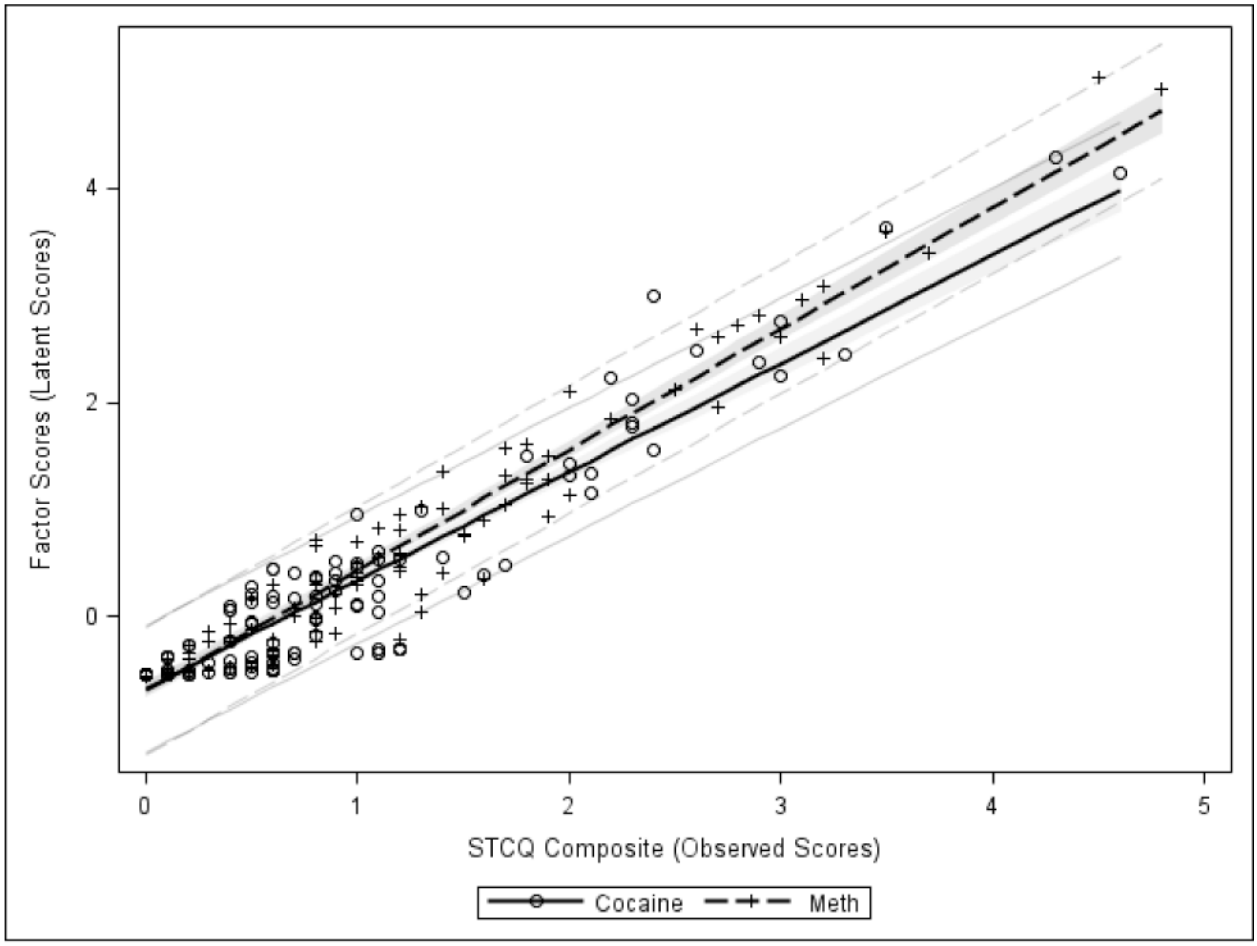

Figure 1.

Factor (latent) scores by STCQ composite (observed scores) fitted separately for cocaine and methamphetamine. The lines are linear regression fitlines with 95% confidence intervals and prediction limits by group.

Table 1

Standardized Factor Loadings, Item Intercepts, & Residual Covariances for the STCQ

	All (N=301)	Cocaine (N=177)			Methamphetamine (N=124)			Means Testing
Item	***M(SD)***	***M(SD)***	**FL(SE)***	***Intercept* (SE)***	***M(SD)***	**FL(SE)***	***Intercept* (SE)***	***p***
i1: I want [stimulants] so bad I can almost taste it	0.7(1.4)	0.6(1.4)	0.72(0.07)	0.44(0.04)	0.9(1.4)	0.84(0.04)	0.41(0.07)	0.06
i2: I have an urge for [stimulants]	1(1.6)	0.8(1.5)	0.77(0.06)	0.57(0.04)	1.4(1.7)	0.85(0.03)	0.51(0.07)	<0.01
i3: I am going to use [stimulants] as soon as possible	0.3(0.8)	0.2(0.7)	0.53(0.06)	0.26(0.04)	0.4(0.8)	0.55(0.08)	0.22(0.05)	<0.05
i4: I think that I could resist using [stimulants] now	1.5(2.0)	1.5(2.1)	0.21(0.06)	0.69(0.05)	1.6(1.9)	0.28(0.07)	0.76(0.06)	0.78
i5: I crave [stimulants] right now	0.9(1.6)	0.8(1.6)	0.74(0.08)	0.49(0.04)	1.2(1.6)	0.82(0.05)	0.44(0.07)	<0.05
i6: All I want to use now are [stimulants]	0.5(1.3)	0.4(1.2)	0.69(0.07)	0.31(0.04)	0.8(1.3)	0.85(0.04)	0.31(0.06)	<0.05
i7: I have no desire for [stimulants] right now	1.7(2.2)	1.5(2.2)	0.43(0.06)	0.67(0.05)	2.0(2.2)	0.56(0.06)	0.71(0.07)	0.12
i8: Using [stimulants] now would make things seem just perfect	0.5(1.4)	0.4(1.1)	0.56(0.08)	0.33(0.04)	0.8(1.6)	0.56(0.08)	0.26(0.05)	<0.01
i9: I will use [stimulants] as soon as I get the chance	0.3(0.9)	0.2(0.8)	0.42(0.11)	0.29(0.04)	0.4(1.0)	0.43(0.10)	0.24(0.05)	0.05
i10: Nothing would be better than using [stimulants] right now	0.3(1.0)	0.2(1.0)	0.62(0.10)	0.25(0.04)	0.5(1.2)	0.68(0.07)	0.22(0.05)	0.06
STCQ Composite	0.8(0.9)	0.7(0.9)	-	-	1.0(1.0)	-	-	<0.01

Residual Covariance	**Cocaine Estimates (SE)***	**Methamphetamine Estimates (SE)***
Item 3 with item 9	0.46(0.14)	0.33(0.10)
Item 1 with item 2	0.36(0.10)	0.46(0.10)
Item 4 with item 7**	0.30(0.09)	-
Item 8 with item 10**	0.39(0.12)	-

Note. Factor loadings and intercepts are provided for items 4 and 7 after reverse scoring. "Means testing" refers to *t* tests conducted for each individual item and the composite. "STCQ Composite" was computed using the CCQ-Brief scoring method of averaging the responses for all 10 items after reverse scoring items 4 and 7. [Stimulants] = cocaine, methamphetamine, or other stimulants; FL=factor loading; i=item.

* All factor loadings, intercepts, and residual covariances were significant at the $p<0.01$ level.

** Only included in the Cocaine group's model.