RESEARCH REPORT

Marijuana Craving Questionnaire: development and initial validation of a self-report instrument

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Abstract

Aims. *To develop and validate a multi-dimensional questionnaire on marijuana craving.* **Design and measurements.** *Current marijuana smokers (n = 217) not seeking treatment completed a 47-item Marijuana Craving Questionnaire (MCQ) and forms assessing demographics, drug use history, marijuana quit attempts and current mood.* **Findings.** *Exploratory and confirmatory factor analyses indicated that a four-factor solution best described the item structure. Factor subscales derived from the 17 items with significant loadings had respectable internal consistencies and were stable across settings and subgroups. The subscales exhibited low to moderate, positive intercorrelations and were significantly correlated with marijuana use history and a wide range of single-item measures of craving.* **Conclusions.** *Findings suggested that four specific constructs characterize craving for marijuana: (1)* compulsivity, *an inability to control marijuana use; (2)* emotionality, *use of marijuana in anticipation of relief from withdrawal or negative mood; (3)* expectancy, *anticipation of positive outcomes from smoking marijuana; and (4)* purposefulness, *intention and planning to use marijuana for positive outcomes. These data indicate that the MCQ is a valid and reliable instrument for assessing marijuana craving in individuals not seeking drug abuse treatment and that marijuana craving can be measured in the absence of withdrawal.*

Introduction

Drug craving has been variously conceptualized as wanting to re-experience drug effects, strong subjective desires, irresistible urges, obsessive thoughts, relief from unpleasant withdrawal symptoms, the incentive motivation to self-administer a drug, expectation of positive outcomes and non-automatic cognitive processes (Tiffany, 1990; Robinson & Berridge, 1993; American Psychiatric Association, 1994; Verheul, van den Brink & Geerlings, 1999). Despite a lack of consensus regarding the concept of craving among the scientific community (Pickens & Johanson, 1992), craving is widely accepted by clinicians and addicts as relevant to the addiction process, and self-reported craving has been doc-

umented empirically in the laboratory using various cue-reactivity paradigms (Carter & Tiffany, 1999).

Drug craving has been described most frequently as one component of drug dependence, leading to continued drug use and relapse after treatment or during periods of drug abstinence (Pickens & Johanson, 1992; American Psychiatric Association, 1994). Little research has focused on craving for marijuana, perhaps because most people who smoke marijuana do not develop marijuana dependence (Anthony, Warner & Kessler, 1994). However, the dependence potential of marijuana is not trivial. Recent surveys in the United States estimate 11 million current (past month) marijuana users (Substance Abuse and Mental Health Services Administration, 1999), and non-human primates reliably self-administer intravenous injections of delta-9-tetrahydrocannabinol (THC), the psychoactive ingredient in marijuana (Tanda, Munzar & Goldberg, 2000).

Individuals seeking treatment for marijuana dependence presented with considerable psychiatric and psychosocial distress (Stephens, Roffman & Simpson, 1993). Moreover, marijuana withdrawal has been documented in adolescents and adults seeking treatment for marijuana dependence (Crowley *et al.*, 1998; Budney, Novy & Hughes, 1999), in frequent marijuana users not seeking treatment (Wiesbeck *et al.*, 1996) and in human laboratory studies (Haney *et al.*, 1999). Although few of these studies assessed craving, Budney *et al.* (1999) reported that 93% of marijuana-dependent adults seeking treatment reported experiencing mild craving for marijuana, and 44% rated their past craving as severe. These studies suggest that marijuana withdrawal and craving significantly impact the clinical course of marijuana dependence and its successful treatment.

A deficiency in the assessment of drug craving is the reliance on single-item measures, such as rating average intensity of craving during the past week on a 10-point scale (Halikas *et al.*, 1991). As Tiffany (1992) noted, single items often have low reliability, and unless other craving items are concurrently measured, single-item reliability is impossible to calculate. Further, single items do not assess the varied nature of craving experienced by individuals in various stages of drug dependence under widely different environmental conditions. Single-item questions also do not reflect the different theoretical perspectives on the nature of drug urges and craving (Wise, 1988; Tiffany, 1990; Robinson & Berridge, 1993; Verheul *et al.*, 1999). Given the dearth of research on marijuana craving and the lack of any psychometrically valid instrument with which to measure it, we developed a multi-dimensional questionnaire to assess marijuana craving.

The development of the Marijuana Craving Questionnaire (MCQ) was based on the model of the Questionnaire on Smoking Urges (Tiffany & Drobes, 1991) and the Cocaine Craving Questionnaire (Tiffany *et al.*, 1993). Items on the MCQ were drawn from five theoretical conceptualizations of craving. The conceptual categories were expected to aid in the interpretation of factors that emerged from analyses, but were not expected to emerge as factors themselves. The five categories were: (1) desire to use marijuana, (2) anticipation of positive outcomes from marijuana use, (3) anticipation of relief from withdrawal symptoms or negative mood, (4) intention and planning to use marijuana and (5) lack of control over marijuana use.

We administered the MCQ to 217 current marijuana smokers who were not attempting to quit or reduce their marijuana use. Results were analyzed with exploratory and confirmatory factor analyses to determine the factor structure of the questionnaire. Demographic variables, marijuana use history and current mood were also assessed as measures of concurrent validity and for interpretation of factor structure.

Method

Participants

Two hundred and seventeen marijuana smokers participated in the study as part of recruitment efforts for ongoing research studies at the National Institute on Drug Abuse, Baltimore, Maryland (123 participants, 57%) and Wake Forest University School of Medicine, Winston-Salem, North Carolina (94 participants, 43%). Inclusion criteria were: at least 18 years old, use of marijuana at least once in the past month, and not seeking treatment to reduce or quit marijuana use. The Institutional Review Board of each institution approved the study. Participants provided written informed consent and were paid $20 for their participation.

Participants ($n = 217$) averaged 31.4 (SD 7.5)

years of age; 79% were male; 50% were African American and 44% were Caucasian; 71% were single; and 80% had completed high school or beyond. Participants reported first marijuana use at age 15.3 (SD 3.9), use of marijuana on 17.5 (SD 9.2) days in the past month, and 91% reported marijuana use at least once a week during the past 6 months. The Baltimore and Winston-Salem samples differed significantly on the following demographic variables: gender, ethnicity, marital status, education and employment (all ps < 0.001). With respect to marijuana use, Winston-Salem participants reported greater life-time use ($p < 0.05$), past month use ($p < 0.001$), and fewer were planning to quit smoking marijuana in the next 6 months ($p < 0.05$) compared with the Baltimore sample. A greater percentage of the Winston-Salem sample also reported using marijuana within the past 24 hours ($p < 0.001$).

Because of the demographic and drug use differences between the samples, we conducted several tests to determine whether combining the samples was justified. A correlational pattern hypothesis test for equality of correlation matrices indicated that the groups could be combined, χ^2 (136) = 149.31, $p = 0.21$. Separate correlational pattern hypothesis tests were also conducted to determine whether there were sample differences with regard to gender, age, ethnicity, education, work and marijuana and other drug use. The largest χ^2 (all df = 136) was 148.61 ($p = 0.20$) and the smallest χ^2 was 108.92 ($p = 0.96$), indicating that the factor structure was unaffected by differences in demographics and drug use.

Questionnaire development
The individual items of the MCQ were constructed based on the items of the Cocaine Craving Questionnaire (Tiffany *et al.*, 1993). Nine items from each of the five conceptualizations of craving described in the Introduction were used. Items in the relief from withdrawal/negative mood category were based on descriptions of marijuana withdrawal found in the literature (e.g. Wiesbeck *et al.*, 1996; Budney *et al.*, 1999). A sixth category, Consistency, containing two items was added to the MCQ to assess the consistency with which subjects completed the questionnaire. Eighteen of the 47 items were negatively worded (3–4 items from each content

category and one item from the Consistency category) to reduce variance due to acquiescence. Each item was rated on a seven-point Likert-type scale from "strongly disagree" to "strongly agree". The complete MCQ may be obtained from the first author.

Procedure
Participants were administered individually a packet of forms that included, in this order, a marijuana history questionnaire, a two-factor mood form (Diener & Emmons, 1984) and the MCQ. Information on demographics, marijuana use history, marijuana craving (frequency, duration, definition and single-item questions in various rating formats), experience in quitting marijuana, treatment episodes and use of other drugs was obtained from the marijuana history questionnaire. Single-item craving measures were adapted from scales reported in the drug abuse literature (Kozlowski & Wilkinson, 1987; Halikas *et al.*, 1991; Tiffany, 1992; Childress *et al.*, 1999). The mood form contained nine adjectives rated on a seven-point scale that were averaged to indicate current positive (four items) and negative (five items) mood. Before completing the MCQ, participants were read explicit instructions about completing the questionnaire and answered 10 practice items taken from the MCQ, which were checked to ensure that participants understood the rating scale. They then completed the MCQ with respect to how they were currently thinking or feeling. Before they left, participants completed an evaluation form on the questionnaire. Average duration of testing was 39 minutes.

Data analysis
Demographic and marijuana history data of the two samples (Baltimore and Winston-Salem) were compared using chi-square tests for dichotomous variables and Student's *t*-test for continuous variables. Only one subject failed to respond to one item of the MCQ (response rate $> 99.9\%$); the missing response was replaced by the item mean. Raw scores on negatively worded items were inverted to ensure positive correlations among items. The structure of the 45-item MCQ (the two items from the Consistency category were excluded) was examined by exploratory factor analyses using principal axis

extraction to detect simple structure (STATIS-TICA; StatSoft, 1995). Extraction of factors continued as long as (1) the minimum eigen-value, how much variance the factor explained, exceeded 1.0 (Kaiser's criterion; Kaiser, 1960) and (2) the minimum change in communalities (proportion of item variance due to common factors) was less than 0.01. A plot of eigenvalues (Cattell's scree test; Cattell, 1966) was also visu-ally inspected for correspondence with the Kaiser criterion. Because the factor structure of the Cocaine Craving Questionnaire (Tiffany *et al.*, 1993) contained one secondary factor with substantial intercorrelations among primary fac-tors, hierarchical analysis of oblique rotations of extracted factors was performed. The resulting factor model was verified by a series of confirmatory factor analyses (CFA). All CFA were analyzed using structural equation model-ing (SEPATH, STATISTICA; StatSoft, 1995).

First, CFA were conducted on several struc-tural models to determine whether the overall factor structure was affected by differences in demographics or patterns of marijuana and other drug use between the two samples. CFA model parameters were generated from generalized least-squares estimates and evaluated by chi-square pattern hypothesis tests of the differences between correlation matrices (Steiger, 1980). A small and non-significant chi-square value indi-cates that differences between correlation ma-trices are negligible. Secondly, CFA were used to compare the structural model of three-, four- and five-factor solutions. In general, more parsi-monious models (those with fewer parameters) tend not to fit as well as more complex models. Multiple indices were used to assess goodness-of-fit and parsimony: comparative fit index (CFI; Bentler, 1990), root mean squared error of ap-proximation (RMSEA; Steiger, 1980), and sin-gle-sample cross-validation index (CVI; Browne & Cudeck, 1990). After adjusting for parsimony in a set of competing models, a larger CFI indicates that the model has accounted for a greater proportion of the variance, with satisfac-tory fit indicated by values above 0.90. Smaller RMSEA and CVI values indicate better good-ness-of-fit.

Results
Factor analysis of MCQ
Kaiser criteria and the Cattell scree test sug-gested a four-factor solution accounting for 52.2% of the total variance. The four factors had eigenvalues of 8.0, 3.0, 3.8 and 8.8 that ac-counted for 17.7%, 6.7%, 8.4% and 19.5% of the variance, respectively. Multiple indices indi-cated that the four-factor solution (CFI = 0.89, RMSEA = 0.07, CVI = 1.5) was more appropri-ate than either a five-factor (CFI = 0.84, RM-SEA = 0.08, CVI = 8.5) or three-factor (CFI = 0.79, RMSEA = 0.09, CVI = 9.5) sol-ution. Hierarchical analysis of the oblique factors yielded one secondary factor loading on the four primary factors. A CFA was performed to com-pare the four-factor solution with the one-factor solution based on the 40 items with significant loadings (0.30 and above) on the secondary fac-tor. Results suggested that the four-factor sol-ution was still more appropriate than the secondary-factor solution (CFI = 0.76, RM-SEA = 0.11, CVI = 10.7).

Table 1 presents the item loadings for the four primary factors. We replicated procedures used in development of the Cocaine Craving Ques-tionnaire (Tiffany *et al.*, 1993) in retaining only items that loaded above 0.30 on a given factor and less than 0.30 on any other factor, which resulted in 17 items. Factor-based scale scores were derived by summing the raw scores for items on each factor and dividing by the total number of items for that factor. A General factor scale was developed by summing all items and dividing by 17. Resulting factor scale means (SD) were 2.9 (1.2), 5.1 (1.6), 4.1 (1.5), 4.3 (1.7), and 3.9 (1.0) for Factors 1, 2, 3, 4 and the General factor, respectively. A CFA was per-formed to compare the four-factor solution with the General-factor solution and showed that the four primary factors better reproduced the ob-served data than the General factor (CFI = 0.61, RMSEA = 0.15, CVI = 2.7). Table 2 presents intercorrelations of MCQ factor scales. There were no significant correlations for Factor 2 with either Factor 1 or Factor 3. The remaining fac-tors exhibited low to moderate, positive intercor-relations.

Reliability of MCQ
Table 3 presents standardized alpha coefficients and mean inter-item correlations of each factor scale for the entire sample and various subsam-ples based on demographic and drug use vari-ables. The reliability coefficient for Factor 3 in

Table 1. *MCQ factor structure*

Factor/item	Factor loading
Factor 1 (Compulsivity)	
16.[a] If I smoked a little marijuana right now, I would not be able to stop using it (L)[b]	0.59
19. I would do almost anything for a joint (I)	0.55
25. It would be difficult to turn down a joint right this minute (L)	0.50
26. Starting now, I could go without smoking marijuana for a long time[c] (L)	0.40
31. I would not be able to control how much marijuana I smoked if I had some here (L)	0.64
35. I could easily limit how much marijuana I smoked right now[c] (L)	0.63
36. I do not need to smoke marijuana right now[c] (D)	0.72
Factor 2 (Emotionality)	
9. I would feel more anxious if I smoked marijuana right now[c] (R)	0.60
13. I would feel less in control of things right now if I could smoke marijuana[c] (R)	0.68
28. If I smoked marijuana right now, I would feel more tense[c] (R)	0.63
34. I would feel more restless if I smoked marijuana right now[c] (R)	0.57
Factor 3 (Expectancy)	
14. Smoking marijuana would help me sleep better at night (R)	0.45
39. If I were smoking marijuana right now, I would feel less nervous (R)	0.65
41. Smoking marijuana would not make me content[c] (P)	0.36
Factor 4 (Purposefulness)	
2. Smoking marijuana would not be pleasant right now[c] (P)	0.51
12. Right now, I am not making any plans to use marijuana[c] (I)	0.46
32. It would be great to smoke marijuana right now (P)	0.77

[a] Position of item on MCQ. [b] Content category of item: desire to use marijuana (D), anticipation of positive outcomes from marijuana use (P), anticipation of relief from withdrawal symptoms or negative mood (R), intention and planning to use marijuana (I), and lack of control over marijuana use (L). [c] Negatively-worded item.

those using marijuana less than 100 times in their life was small and negative in direction (-0.06). Correlations between individual items and the factor scale score showed that item 41 (Smoking marijuana would not make me content) was responsible for the lack of homogeneity of items on Factor 3 for infrequent marijuana users (inter-item $r = -0.21$). For all other comparisons, there were no appreciable differences in internal consistencies between any subsample.

Validity of MCQ

Concurrent validity. Forward stepwise multiple regression analyses were conducted on each factor individually to determine the subset of demographic and marijuana use variables that best predicted that factor scale score. Only variables having significant ($p < 0.05$) zero-order correlations with a specific factor were entered into the analysis, and only variables with significant ($p < 0.05$) Beta weights were retained. The variable having the highest partial correlation with each scale score made the most unique contribution to that factor. Less confidence in the ability to quit marijuana for 1 year (partial $r = -0.38$),

lower positive mood (partial $r = -0.23$), expectation of the positive benefits of marijuana use (partial $r = 0.22$), positive mood (partial $r = 0.17$) and less confidence in the ability to quit marijuana for 1 year (partial $r = -0.47$) were the best and most unique predictors of Factors 1–4 and the General factor, respectively.

Construct validity. A common method of establishing the validity of a new measure is to correlate scores with other measures that tap the same construct, such as the single-item craving measures. The same forward stepwise multiple regression analyses described above for concurrent validity were conducted. The following measures of marijuana craving and liking were the best and most unique predictors of Factors 1–4 and the General factor, respectively: current craving rated on a Likert-type scale (partial $r = 0.19$), current craving rated on a scale from 0 (not at all) to 10 (most imaginable) (partial $r = 0.21$), average past month craving rated on a visual analog scale (partial $r = 0.19$), current liking rated on a visual analog scale (partial $r = 0.31$) and current craving rated on a Likert-type scale (partial $r = 0.35$).

Table 2. *Intercorrelations of MCQ factor scales*

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 2	0.01			
Factor 3	0.37★	0.12		
Factor 4	0.58★	0.23★	0.39★	
General factor	0.80★	0.48★	0.62★	0.79★

★$p < 0.001$.

Definition of craving. On the marijuana history questionnaire, participants were asked to choose between two definitions of craving for marijuana. Results indicated that 49% defined craving as "any urge or desire to use marijuana, even a weak one" and 51% defined craving as "only a strong urge or desire". There were no significant differences between the two response groups on any of the MCQ factor scales or on any demographic or marijuana use variables.

Frequency and duration of craving
Participants were asked to indicate the average frequency (number of times per day) and duration (length in minutes) of their marijuana craving during the past week according to categories reported by Halikas *et al.* (1991). Most subjects (83%) reported craving marijuana 1–5 times per day, and 82% reported that each craving episode lasted 30 minutes or less. Figure 1 shows mean factor scale scores as a function of craving frequency and duration. Multivariate analysis of variance (MANOVA) was used to test the hypothesis that craving was affected by the differences in frequency and duration. The test of significance was based on Wilks' Lambda and was converted to an F value (Rao's R) by means of a set of procedures developed by Rao (1951). A significant multivariate test was followed by univariate F tests for each variable to interpret the respective effect. The MANOVA indicated significant increases in factor scores as a function of increasing frequency and duration, Rao's R $(4,179) = 470.06$, $p < 0.001$. Univariate tests revealed a main effect of frequency for Factor 1, F $(6,182) = 9.99$, $p < 0.001$ and Factor 4, F $(6,182) = 6.20$, $p < 0.001$. A main effect of duration was observed for Factor 3, F $(7,182) = 2.50$, $p < 0.05$. *Post hoc* tests (Tukey's HSD) indicated that participants who craved twice daily had significantly higher scores on

Factors 1 and 4 than those who craved less often. The intensity of craving on Factors 1 and 4 rose with increased frequency and peaked among subjects who craved more than 20 times a day. Factor 3 increased significantly among subjects who craved 30–60 minutes. There were no differences between factor scale means for persons who craved more than five times a day or for longer than 45 minutes.

MCQ evaluation
Questionnaire evaluation form. The testing conditions were rated as satisfactory by 96% of all participants. The vast majority of respondents reported that the instructions (100%) and questions (96%) were clear, precise and understandable, that the items were appropriate for the subject of craving (88%) and that other people like themselves would understand the questions if they were participating in this research (99%). Some participants experienced physical discomfort (7%) or felt emotionally upset (2%) while answering the questions, and 5% found the items to be personally offensive, insulting or embarrassing. Seven per cent reported that they omitted questions. Seventy-three individuals (34%) stated that they would like to make changes in the questionnaire, with 10 of 73 (14%) dissatisfied with the repetitiveness of some items. On a scale of 0 (very unsatisfactory) to 7 (very satisfactory), participants' mean rating of satisfaction with the questionnaire was 5.9 (range 3–7, SD 1.0).

Craving during completion of questionnaire. Twenty per cent of participants reported that they craved marijuana more than usual while completing the MCQ. Participants with a greater baseline intensity of current craving (Likert-type scale) and who reported feeling emotionally upset while answering the questions craved mari-

Group/variable	Factor 1	Factor 2	Factor 3	Factor 4	General
Sample					
Total ($n = 217$)	0.82[a](0.40)[b]	0.78 (0.47)	0.55 (0.29)	0.68 (0.42)	0.81 (0.21)
Baltimore ($n = 123$)	0.80 (0.37)	0.71 (0.39)	0.51 (0.26)	0.68 (0.42)	0.80 (0.19)
Winston-Salem ($n = 94$)	0.84 (0.44)	0.83 (0.56)	0.61 (0.36)	0.70 (0.44)	0.83 (0.23)
Gender					
Male ($n = 171$)	0.82 (0.40)	0.76 (0.45)	0.54 (0.28)	0.71 (0.45)	0.80 (0.20)
Female ($n = 46$)	0.81 (0.40)	0.83 (0.55)	0.60 (0.34)	0.56 (0.30)	0.83 (0.24)
Age					
< 32 years ($n = 110$)	0.83 (0.41)	0.74 (0.42)	0.60 (0.33)	0.77 (0.53)	0.81 (0.21)
≥ 32 years ($n = 107$)	0.82 (0.39)	0.81 (0.52)	0.51 (0.26)	0.58 (0.31)	0.80 (0.20)
Ethnicity					
Caucasian ($n = 96$)	0.80 (0.37)	0.82 (0.54)	0.54 (0.29)	0.72 (0.46)	0.78 (0.18)
Minorities ($n = 121$)	0.85 (0.45)	0.72 (0.40)	0.56 (0.30)	0.62 (0.35)	0.84 (0.24)
Education					
HS grad ($n = 172$)	0.81 (0.38)	0.82 (0.53)	0.56 (0.30)	0.62 (0.35)	0.80 (0.20)
Not HS grad ($n = 45$)	0.84 (0.43)	0.57 (0.26)	0.52 (0.27)	0.85 (0.66)	0.81 (0.21)
Employment					
Employed ($n = 137$)	0.84 (0.43)	0.82 (0.54)	0.54 (0.28)	0.68 (0.41)	0.81 (0.21)
Unemployed ($n = 80$)	0.78 (0.34)	0.76 (0.34)	0.59 (0.32)	0.70 (0.44)	0.79 (0.19)
Last month marijuana use					
1–17 days ($n = 98$)	0.81 (0.35)	0.77 (0.46)	0.52 (0.27)	0.62 (0.35)	0.80 (0.19)
18–30 days ($n = 119$)	0.84 (0.41)	0.78 (0.47)	0.56 (0.30)	0.70 (0.44)	0.78 (0.18)
Life-time marijuana use					
< 100 times ($n = 26$)	0.83 (0.43)	0.69 (0.37)	-0.06 (-0.01)	0.50 (0.25)	0.71 (0.14)
≥ 100 times ($n = 191$)	0.82 (0.41)	0.79 (0.48)	0.60 (0.34)	0.70 (0.44)	0.82 (0.21)

[a] Standardized alpha coefficient. [b] Mean inter-item correlation.

juana more than usual while completing the MCQ (adjusted $R^2 = 0.34$, $p < 0.001$). Experiencing emotional discomfort was the strongest and most unique predictor of craving during the completion of the MCQ (partial $r = 0.18$).

Consistency check. A consistency check score was developed using the two items from the Consistency category and four items from other categories. It is a summative index of inconsistency in responding to paired positively worded equivalent items, equivalent reversed items and negatively-worded similar items. Scores greater than 1 SD beyond the mean were considered a "red flag" for inconsistent responding. The score revealed that 85% of all respondents answered within acceptable limits of accuracy. Following the same procedures described above, a forward stepwise multiple regression was conducted to examine inconsistent responding. Inconsistency in answering positively worded items, craving marijuana more than usual while completing the questionnaire, not considering quitting in the next 6 months, more episodes of outpatient treatment for marijuana use and use of mari-

juana less than 100 times in life-time were significantly related to inconsistent responding (adjusted $R^2 = 0.18$, $p < 0.001$). Craving marijuana more than usual while completing the MCQ was the strongest and most unique predictor of inconsistency (partial $r = 0.21$).

Craving and inconsistency. A MANOVA was conducted to explore further the mutual influence of inconsistent responding and craving during questionnaire administration on factor scale scores. Results indicated significant increases in MCQ factor scale scores attributable to craving, Rao's R (4,204) = 4.52, $p < 0.01$, but not to inconsistent responding, Rao's R (4,204) = 1.74, $p = 0.14$. Univariate tests revealed a main effect of craving for Factor 1, F (1,207) = 16.07, $p < 0.001$ and Factor 4, F (1,207) = 8.04, $p < 0.01$.

Discussion
Marijuana craving was defined by examining the content of items within each factor and the correlation between factor scale scores and demo-
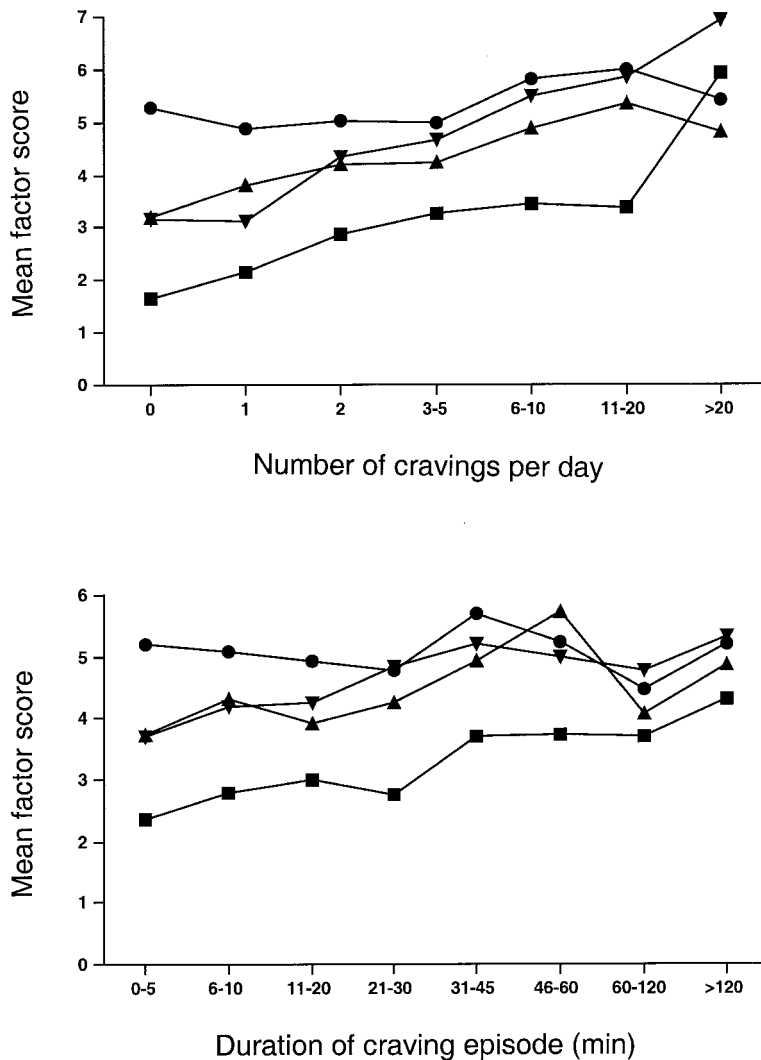
Figure 1. *Mean score for Factor 1 (compulsivity, ■), Factor 2 (emotionality, ●), Factor 3 (expectancy, ▲) and Factor 4 (purposefulness, ▼) of Marijuana Craving Questionnaire as a function of self-reported frequency of daily cravings (top panel) and duration of average craving episode (bottom panel) during the past week. For craving frequency, the number of subjects in each response category were: 0 (n = 18), 1 (n = 38), 2 (n = 72), 3–5 (n = 70), 6–10 (n = 12), 11–20 (n = 2), and > 20 (n = 5). For craving duration, the number of subjects in each response category were: 0–5 (n = 76), 6–10 (n = 46), 11–20 (n = 33), 21–30 (n = 22), 31–45 (n = 6), 46–60 (n = 5), 60–120 (n = 14), and > 120 (n = 15).*

graphic variables, marijuana use history, current mood and single-item measures of craving. Four specific constructs were found to characterize craving for marijuana: (1) *compulsivity*, an inability to control marijuana use; (2) *emotionality*, use of marijuana in anticipation of relief from withdrawal or negative mood; (3) *expectancy*, anticipation of positive outcomes from smoking

marijuana; and (4) *purposefulness*, intention and planning to use marijuana for positive outcomes.

Multidimensional nature of marijuana craving
The majority of items (five of seven) that loaded on Factor 1 were from the lack of control over use category. The Factor 1 scale score was uniquely correlated with current craving and less

confidence in the ability to quit smoking marijuana for 1 year, a criterion for sustained remission from abuse or dependence (American Psychiatric Association, 1994). For these reasons, we suggest that Factor 1 taps *compulsivity*. Lack of control over drug use is also an important feature of the Cocaine Craving Questionnaire (Tiffany *et al.*, 1993) and the Obsessive Compulsive Drinking Scale (Anton *et al.*, 1995). These findings support the idea that compulsive craving is a hallmark feature of drug dependence. During initial experimentation, drug use is thought to be under voluntary control. If progression to dependence ensues, the drug now controls much of behavior, such that addicts exhibit compulsive, repetitive drug-seeking and drug use in spite of negative consequences to themselves and society. The development from initial drug use to dependence (compulsive craving) and the underlying changes in brain structure and function are areas of active research (Nestler & Aghajanian, 1997; Ahmed & Koob, 1998).

All items in Factor 2 came from the anticipation of relief from withdrawal symptoms or negative mood category. The negative mood content of Factor 2 items (anxious, tense, restless) are symptoms of marijuana withdrawal (Wiesbeck *et al.*, 1996; Crowley *et al.*, 1998; Budney *et al.*, 1999), and Factor 2 scores were uniquely associated with low positive mood. Thus, we name Factor 2 *emotionality*. Negative mood can serve as a cue to elicit craving (Maude-Griffin & Tiffany, 1996; Taylor *et al.*, 2000). Thus, anticipating relief from dysphoric states would be an expected component of emotional craving. The desire to use drugs, including marijuana, for relief from negative mood or withdrawal may explain, in part, why drug use persists in the absence of self-reported drug liking (Tiffany, 1990; Robinson & Berridge, 1993) and despite adverse health consequences, such as pulmonary injury caused by smoked drugs (Fligiel *et al.*, 1997).

Factor 3 was comprised of two items from the relief from withdrawal or negative mood category and one item from the anticipation of positive outcome category. Factor 3 was uniquely correlated with average past month craving and expectation of the positive benefits of marijuana use. Thus, Factor 3 is named *expectancy* or craving in anticipation that smoking marijuana will have beneficial results. Expectations play a

significant role in the subjective response to a drug. For example, Kirk, Doty & de Wit (1998) found that subjects who expected to receive a cannabinoid reported greater positive effects (liking, euphoria) to oral THC than subjects who did not have this expectancy. Further support for an expectancy component in craving comes from brain imaging studies. Volkow *et al.* (1999) reported that increased cocaine craving induced by methylphenidate was correlated with activation of the right orbitofrontal cortex, which has been implicated in the expectation of a reinforcing stimulus (London *et al.*, 2000).

Factor 4 included two items from the positive outcome category and one item from the intention and planning category. Factor 4, named *purposefulness*, was uniquely correlated with liking marijuana and positive mood. The identification of a purposefulness factor is consistent with reports of craving for tobacco (Tiffany & Drobes, 1991) and cocaine (Tiffany *et al.*, 1993) and supports Tiffany's (1990) cognitive theory, which predicts that craving is coupled with intention and planning to use a drug. There is evidence that sensory stimulation contributes to the satisfaction of cigarette smoking (Rose, Behm & Levin, 1993). Whether this conditioned response maintains long-term drug use is unclear. Because of its association with marijuana liking and positive mood, Factor 4 may account for the observation that craving may be increased immediately after drug use that is pleasurable (Singleton & Gorelick, 1998), thereby increasing the chance of taking another puff (short-term) rather than smoking a joint the next day (long-term).

Characteristics of marijuana craving

Kozlowski and colleagues (Kozlowski & Wilkinson, 1987; Kozlowski *et al.*, 1989) proposed that the term "craving" should refer only to intense desires and urges to use drugs. An equal number of subjects in this study defined craving for marijuana as "any urge or desire" and "only a strong urge or desire". Subjects endorsing one definition or the other did not differ with respect to demographic or marijuana use variables and MCQ factor scale scores. These findings are consistent with responses from cocaine users (Tiffany *et al.*, 1993), alcoholics (Kozlowski *et al.*, 1989) and tobacco smokers (Kozlowski *et al.*, 1989; Taylor *et al.*, 2000). These results do not

support the proposal that craving should be reserved for only strong urges and desires. We have shown that ratings of tobacco craving varied directly as a function of the intensity of the craving cue (Taylor *et al.*, 2000), suggesting that "low" and "high" craving can be determined empirically and that craving can be viewed as a motivational continuum (cf. West, 1987).

Hughes (1987) proposed that temporal measures of urge or craving are important in addition to intensity. Halikas *et al.* (1991) characterized craving for cocaine with respect to frequency, duration and intensity. To our knowledge, this is the first report of the frequency and duration of marijuana craving episodes. On average, subjects reported craving marijuana twice daily, with each episode lasting 6–10 minutes. Scores on Factor 1 (*compulsivity*) increased as a function of frequency and duration of craving episodes, suggesting that lack of control contributes more to marijuana use in individuals who crave very frequently and longer than those who crave infrequently and briefly. In contrast, Factor 2 (*emotionality*) scores were at high levels regardless of craving frequency and duration. In individuals who crave more than 20 times a day and for periods of more than 2 hours, all factor scores were at or near maximum and roughly equivalent, suggesting that their craving experience is intense and perhaps uncontrollable.

Psychometric issues and future research
The validity and reliability of the MCQ was determined in a sample of marijuana users who reported relatively heavy recent use and who were not attempting to quit marijuana use. The subjective experience of craving may differ among individuals who are experimenting with a drug, those who are addicted, those attempting to quit use and former users who are now abstinent. Hence, further testing of the MCQ with these distinct populations is needed to address issues of concurrent, predictive and divergent validity. Further testing may also identify a different factor structure. The four-factor solution obtained in this study was dependent on the MCQ items, the procedures and the population and thus may not represent all aspects of marijuana craving.

Because all Factor 2 (*emotionality*) items were negatively worded, a "negative-item" bias may have been responsible for the formation of this factor (cf. Sweeney, Pillitteri & Kozlowski, 1996). The rationale for including positively and negatively worded items was to avoid acquiescence bias (a "yes" response set). Because negatively worded items can be confusing, we presented detailed instructions on rating the items and included a preliminary practice test that contained negatively worded items. Factor 2 (*emotionality*) was positively correlated with Factor 3 (*expectancy*), which contained all positively worded items. If negative wording were responsible for the factor structure of *emotionality*, then *expectancy* and *emotionality* would have been inversely correlated. We also developed a consistency check score to evaluate accurate responding. The majority of subjects responded within acceptable limits of accuracy. Further, the consistency check score revealed that the primary source of inconsistency was responding to positively worded, not negatively worded items. Thus, we feel that use of negatively worded items neither compromised accurate responding on the MCQ nor substantially contributed to the structure of Factor 2 (*emotionality*).

The consistency check score indicated that about 15% of the sample scored at least one standard deviation beyond the mean consistency score. When these inconsistent responders were removed from the analysis, there were slight increases in the reliability coefficients and average inter-item correlations for the four factors and the General factor, as expected. However, mean factor scale scores were not affected. Craving while completing the questionnaire was the strongest predictor of inconsistent responding and was also correlated with emotional discomfort. The consistency check score appeared to tap into a subgroup of subjects who reported increased craving and being emotionally upset during the questionnaire. Because we were unable to demonstrate the utility of the consistency check score solely with respect to inconsistent responding, we included all subjects in the analyses.

The average time to complete the MCQ was 7 minutes, which should allow its use in research and clinical settings. We do not recommend using the 17-item factor structure (Table 1) as a short form until the factor structure of the 45-item MCQ has been validated in an independent sample. Also, we do not recommend use of the General factor score because if craving is truly a

multi-dimensional construct, averaging the factors to obtain a single score is inappropriate.

The multi-dimensional MCQ appears ideally suited as a correlate in studies suggesting that different brain regions and neurochemical systems mediate craving. For example, brain imaging studies have shown that cue- or drug-elicited cocaine craving was correlated with activation (increased glucose metabolism or blood flow) in the (1) amygdala and anterior cingulate (Childress *et al.*, 1999), limbic structures involved in emotionality; (2) dorsolateral prefrontal cortex (Grant *et al.*, 1996), an area of working memory (see Wise, 1988 for a discussion of the role of memory in craving); and (3) orbitofrontal cortex (Volkow *et al.*, 1999), which is implicated in compulsive behavior, expectation of rewarding stimuli and impaired judgement (London *et al.*, 2000). These distinct neural correlates of craving suggest that drug craving is a complex, multiply-determined phenomenon that is measured optimally by a multi-dimensional questionnaire.

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