Methamphetamine Use in a Rural College Population: Associations With Marijuana Use, Sensitivity to Punishment, and Sensitivity to Reward

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This study examined predictors of methamphetamine use in a 6-month prospective study of 2,270 rural young adults. Sensitivity to punishment (SP), sensitivity to reward (SR), and gender were exogenous variables in an observed variable path analysis with 3 endogenous criteria: Time 1 (T1) marijuana use and methamphetamine use at T1 and Time 2 (T2). SP was negatively associated with marijuana use at T1, and this association was attenuated by SR. Male gender was positively associated with marijuana use. T1 marijuana use and SR were positively, and male gender negatively, associated with T1 methamphetamine use. T1 methamphetamine use, T1 marijuana use, and SP were positively associated with T2 methamphetamine use. Methamphetamine use prevalence and the role of distal predictors and proximal indicators of drug involvement are discussed.

Keywords: behavioral inhibition system (BIS), behavioral activation system (BAS)

Methamphetamine use among young adults is a significant public health concern (Iritani, Hallfors, & Bauer, 2007; Rawson, Gonzales, McCann, & Ling, 2007; Substance Abuse and Mental Health Services Administration [SAMHSA], 2006). Use in rural areas has been elevated relative to many other parts of the country (Grant et al., 2007; Sloboda & Kozel, 1999). Though the prevalence of methamphetamine use during the past year is low, ranging from 0.3% in the Northeast to 1.6% in the West among individuals 12 years and over, it accounts for a high percentage of substance use treatment admissions (SAMHSA, 2006, 2007b). For example, methamphetamine is a drug of abuse for 32% of substance use treatment admissions among 18- to 25-year-olds in the most rural counties and 26% of admissions in the most urban counties (SAMHSA, 2006). A recent study indicated that rural participants began regular methamphetamine use at an earlier age and were more likely to use it intravenously relative to urban participants (Grant et al., 2007). The high percentage of treatment admissions for methamphetamine despite its relatively low prevalence is indicative of its particularly rapid course from use to dependence (Castro, Barrington, Walton, & Rawson, 2000). Thus, examining predictors of methamphetamine use initiation is important.

Previous research has identified, in addition to the variability of methamphetamine use across geographic regions and between rural and urban areas, several demographic and contextual factors associated with risk of methamphetamine use. For example, methamphetamine use among young adults is positively associated with White or Native American race, poverty, having an ever-incarcerated father, use of other illicit drugs, and not attending college (Herman-Stahl, Krebs, Kroutil, & Heller, 2007; Iritani et al., 2007). Gender associations have been somewhat mixed, with multivariate models indicating risk of past-year use being higher in young adult women (Herman-Stahl et al., 2007) in the National Survey on Drug Use and Health (NSDUH) sample, while prevalence was higher in young adult men (Iritani et al., 2007) in the National Longitudinal Study of Adolescent Health. Psychological risk factors have also been identified. For example, sensation-seeking motives are commonly endorsed reasons for use initiation (Brecht, O’Brien, von Mayrhauser, & Anglin, 2004). Sensation seeking and psychological distress have been linked to past-year methamphetamine use (Herman-Stahl et al., 2007; Iritani et al., 2007), though findings have been mixed in multivariate analyses (Herman-Stahl et al., 2007). In a treatment sample, impulsivity has been associated with severity of methamphetamine abuse symptoms (Simons, Oliver, Gafer, Ebel, & Brummelts, 2005).

Behavioral activation system (BAS) and behavioral inhibition system (BIS) are theoretical brain systems that guide approach and avoidance behavior, respectively (Gray, 1987). The BIS is hypothesized to be sensitive to cues of punishment (SP) and nonreward and is instrumental in causing behavioral output. The BAS is hypothesized to be sensitive to reward (SR) and is instrumental in goal-directed behaviors. These brain systems are hypothesized to be largely orthogonal, and the activity in these systems is thought to underlie individual difference characteristics such as trait anxiety and impulsivity (Carver & White, 1994; Gray, 1987; Torrubia, Ávila, Molto, & Caseras, 2001).

Previous research has found significant associations between psychological measures of BAS and BIS levels and alcohol, marijuana, and other drug use (Franken, Muris, & Georgieva, 2006; Johnson, Turner, & Iwata, 2003; Knyazev, 2004; Knyazev, Sloboedskaya, Kharchenko, & Wilson, 2004; O’Connor & Colden, 2005; Pardo, Aguilar, Molineuvo, & Torrubia, 2007; Simons & Arens, 2007). For example, the fun seeking and drive dimensions of Carver’s BAS scale are positively associated with illicit drug use disorders (Franken et al., 2006; Johnson et al., 2003). Simi-
larly, SR is associated with problematic alcohol consumption patterns (O’Connor & Colder, 2005) and marijuana use (Simons & Arens, 2007) among young adults. Associations between BIS indicators and substance use have been less consistent. However, research has found significant negative associations between SP and the probability of marijuana use (Simons & Arens, 2007) as well as frequency and quantity of alcohol use (Pardo et al., 2007). In addition to these main effects, interactive effects have been found. For example, the negative association between SP and marijuana use is attenuated by SR (Simons & Arens, 2007).

Previous research has not examined associations between methamphetamine use and measures of BIS/BAS functioning. Methamphetamine use is a risk behavior that may pose both strong positive approach cues (e.g., euphoric effects) as well as strong inhibitory cues (e.g., health problems, legal risks; American Psychiatric Association, 2000; SAMHSA, 2006). Thus, individual differences in methamphetamine use may be associated with indicators of BIS/BAS functioning such as SR and SP. Effects may be a combination of direct effects on methamphetamine use and indirect effects via associations with more commonly used illicit drugs such as marijuana (Fergusson, Boden, & Horwood, 2006a). For example, SP and SR may be associated with methamphetamine use by increasing the likelihood of individuals being in social contexts and environments where the drug may be available.

The current study examined lifetime and recent use of methamphetamine in a young adult sample in a 6-month prospective design. Lifetime marijuana use frequency, lifetime methamphetamine use, and methamphetamine use during the follow-up period were the criterion variables in an observed variable path analysis. Due to the low prevalence of use, methamphetamine use was a dichotomous variable (use/no use). SP and SR, gender, and use of marijuana were examined as predictors. SR was hypothesized to be positively associated and SP negatively associated with both marijuana and methamphetamine use. SR was hypothesized to attenuate the association between SP and both marijuana and methamphetamine use. The invariance, meaning, and causal significance of hypothesized drug use sequences (i.e., gateway hypothesis) remains an active area of debate and research (Fergusson et al., 2006a; Fergusson, Boden, & Horwood, 2006b; Kandel, Yamaguchi, & Klein, 2006; Tarter, Vanyukov, Kirisci, Reynolds, & Clark, 2006; Zimmer & Morgan, 1997). Nonetheless, marijuana use is most commonly initiated prior to methamphetamine and other illicit drugs (Brecht, Greenwell, & Anglin, 2007; Fergusson et al., 2006a; Zimmer & Morgan, 1997). Thus, we hypothesized a positive effect from lifetime marijuana use to the probability of methamphetamine use. On the basis of previous research with this population, we hypothesized that women would be more likely to use methamphetamine but less likely to use marijuana, relative to men (Simons & Arens, 2007; Simons, GaBer, Correa, & Bush, 2005).

Method

Participants

Participants were 2,270 college students recruited from a state university in a rural area in the Midwest. Given the primary geographic areas served by the school, students come from largely rural areas. Women made up 64% of the sample. The sample ranged in age from 18 to 25 years (M = 19.59, SD = 1.51). Ninety-four percent of the sample were White, 1% Asian, 1% Black, 1% Native American/Alaskan Native, and 3% other or did not respond. Participants were recruited through e-mail, flyers, and advertisements in the student newspaper. All enrolled undergraduates were eligible for recruitment. Eighty-seven percent returned for a 6-month follow-up, and 94% of returning participants were successfully matched with their Time 1 (T1) data. One previous article has been submitted for publication from this dataset (Simons, Carey, & Wills, 2007).

Measures

**Methamphetamine and marijuana use.** Lifetime use of each drug was assessed by 7-point anchored rating scales. The rating scale was adapted from the National Household Survey of Drug Abuse (SAMHSA, 2000) and includes the following anchors: 0 (never used), 1 (1–2 days), 2 (3–11 days), 3 (12–50 days), 4 (51–100 days), 5 (101–300 days), and 6 (>300 days). Frequency of use of each drug in the past 6 months was assessed with 9-point anchored rating scales ranging from 0 (no use) to 8 (more than once a day).

**Sensitivity to Punishment and Sensitivity to Reward Questionnaire (Torrubia et al., 2001).** This is a 48-item two-factor scale with a dichotomous (yes/no) response format. For the current study, we used a factor solution obtained by O’Connor, Colder, and Hawk (2004). The SR scale has 17 items (α = .78), one sample of which is, “Do you generally give preference to those activities that imply an immediate gain?” The SP scale has 18 items (α = .85), of which one item is, “Do you often refrain from doing something because of your fear of being embarrassed?” Construct validity of these scales as indicators of BIS and BAS is supported by expected relationships with other individual difference measures (Caseras, Ávila, & Torrubia, 2003; O’Connor et al., 2004; Pardo et al., 2007; Torrubia et al., 2001).

Procedure

Participants completed questionnaires online under the supervision of a research assistant. Participants had adequate space to protect their privacy and provided informed consent for participation. Responses were identified by a user-defined code, thus ensuring participants’ anonymity. Participants received $20 for the baseline assessment and $30 for a 6-month follow-up assessment. Average time interval was 203 days (SD = 50.35). Attrition analyses indicated that methamphetamine use was associated with study attrition. Thirty-three percent of individuals who reported using methamphetamine at baseline did not return for the follow-up (or were not able to be matched to baseline data), compared with 17.51% who reported never having used methamphetamine, χ²(1, N = 2259) = 17.17, p < .001.

Results

Descriptive Statistics

Approximately 5% (n = 112) of participants reported using methamphetamine at least once in their lifetime, and 1.6% (n = 36) reported using it in the past 6 months at T1. Table 1 contains the distribution of lifetime methamphetamine and marijuana use. Of the individuals with data at both time points who had reported never having used methamphetamine at T1, only 1% reported...
initiating use during the follow-up period. A past-year prevalence estimate in the sample is 2.2% (i.e., endorsed using methamphetamine in the past 6 months at either T1 or T2). Bivariate analyses comparing lifetime users and nonusers at T1 indicated that individuals who had tried methamphetamine reported greater SR \((M = 10.13, SD = 3.33 vs. M = 8.55, SD = 3.73), t(2248) = -4.33, p < .001\). Cohen’s \(d = 0.45\), and more lifetime marijuana use \((M = 4.99, SD = 1.46 vs. M = 1.26, SD = 1.71), t(2252) = -22.62, p < .001\). Cohen’s \(d = 2.35\), but did not differ on SP \((M = 8.34, SD = 4.79 vs. M = 8.84, SD = 4.50), t(2249) = 1.13, p = .129\). Degrees of freedom vary due to missing data. Though lifetime marijuana use was strongly associated with methamphetamine use at T1. Likelihood of having tried methamphetamine did not vary by gender, with 5.19% of men and 4.83% of women reporting having tried methamphetamine in their lifetime, \(\chi^2(1, N = 2259) = 0.15, p = .702\).

A correlation matrix is presented in Table 2. SP was modestly negatively associated with T1 marijuana but not methamphetamine use. In contrast, SR was positively associated with both T1 marijuana and T1 methamphetamine use. Male gender was positively associated with marijuana use but not methamphetamine use. Neither SP nor SR was significantly correlated with T2 methamphetamine use. There were moderate positive correlations between T2 methamphetamine use and both T1 marijuana and T1 methamphetamine use. The size of correlations with T1 and T2 methamphetamine use should be interpreted in consideration of the low base rate of use, which decreases the sizes of correlations (McGrath & Meyer, 2006).

**Path Analysis**

We conducted an observed variable path analysis in Mplus 4.2 (L. K. Muthén & Muthén, 2006) with the maximum likelihood robust estimator, which is appropriate for analyzing both the skewed continuous and dichotomous criterion variables in the model. The path analysis with full information maximum likelihood estimation allowed us to include cases with missing data and to simultaneously estimate the equations. Data is presumed to be missing at random. The initial model was a saturated model designed to examine the hypothesized associations rather than test the fit of the model.

The model was estimated on 2,256 cases (14 could not be analyzed due to missing all data on either the predictors or crite-

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td>Gender</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Sensitivity to punishment</td>
<td>-.16</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Sensitivity to reward</td>
<td>.22</td>
<td>.02*</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>T1 Marijuana use</td>
<td>.19</td>
<td>-.11</td>
<td>.18</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>T1 Methamphetaminea</td>
<td>.01*</td>
<td>-.02</td>
<td>.09</td>
<td>.43</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>T2 Methamphetamineb</td>
<td>.00*</td>
<td>.04</td>
<td>.04*</td>
<td>.20</td>
<td>.28</td>
<td>—</td>
</tr>
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**Note.** \(N\)s range from 1,839 to 2,270. Gender code: 1 = male, 0 = female. T1 = Time 1; T2 = Time 2.

*a* T1 Methamphetamine is a dichotomous indicator of lifetime use.

*b* T2 Methamphetamine is a dichotomous indicator of use during the 6-month follow-up period.

**Nonsignificant; all other correlations are significant at \(p < .0001\).**

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
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<td>—</td>
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**Table 2**

**Correlation Matrix of Variables**

<table>
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<tr>
<th>Usage</th>
<th>Methamphetamine</th>
<th>Marijuana</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n)</td>
<td>(%)</td>
</tr>
<tr>
<td>No use</td>
<td>2,147</td>
<td>95.04</td>
</tr>
<tr>
<td>1-2 days</td>
<td>38</td>
<td>1.68</td>
</tr>
<tr>
<td>3-11 days</td>
<td>26</td>
<td>1.15</td>
</tr>
<tr>
<td>12-50 days</td>
<td>16</td>
<td>0.71</td>
</tr>
<tr>
<td>51-100 days</td>
<td>11</td>
<td>0.49</td>
</tr>
<tr>
<td>101-300 days</td>
<td>14</td>
<td>0.62</td>
</tr>
<tr>
<td>&gt; 300 days</td>
<td>7</td>
<td>0.31</td>
</tr>
</tbody>
</table>

**Note.** \(N = 2,270\).
Ordinary least square $R^2$ values are not available for the logistic portions of the model, Mplus reports an alternative, or pseudo $R^2$, value (L. K. Muthén & Muthén, 2006). Pseudo $R^2$ for the lifetime methamphetamine use equation was .54. Methamphetamine use at T2 was associated with T1 methamphetamine use ($b = 1.63$, $p < .01$), T1 marijuana use ($b = 0.60$, $p < .001$), and SP ($b = 0.11$, $p < .05$). Pseudo $R^2$ for the T2 methamphetamine use equation was .89.

**Discussion**

The results of this study generally supported the hypotheses. SR is associated with increased approach toward potentially rewarding behaviors, including marijuana and methamphetamine use. SP, in contrast, was negatively associated with marijuana use. Contrary to hypothesis, SP exhibited a positive association with T2 methamphetamine use in the multivariate model and was not directly associated with T1 methamphetamine use in the bivariate or multivariate analyses. SP and SR interacted with each other in predicting marijuana use, but interactions in predicting methamphetamine use were not significant.

SR exhibited the most consistent associations with substance use, being positively associated with both methamphetamine and marijuana use in the multivariate analyses as well as exhibiting a moderate bivariate association with T1 methamphetamine use. Direct prospective associations with methamphetamine use after controlling for the T1 association were not significant, however, in this brief longitudinal study. The associations with marijuana use replicate and extend previous research on alcohol and marijuana (O’Connor & Colder, 2005; Simons & Arens, 2007). The current study extends these findings to the use of methamphetamine.

Consistent with previous research, SP was negatively associated with marijuana use, and this association was attenuated by SR. At higher levels of SR the negative association between marijuana use and SP was not significant. In conjunction with previous research, this finding emphasizes the relevance of considering the interactive effects of these dimensions in understanding associations with behavior. Contrary to hypothesis, SP was positively associated with methamphetamine use at T2. This positive association was significant in the multivariate model, while the bivariate correlation was also positive in sign but not significant. This is somewhat surprising given the association between SP, harm avoidance, and behavioral inhibition. SP is positively associated with anxiety and neuroticism (Torrubia et al., 2001). Increased levels of negative emotions could provide a stimulus for seeking the euphoric effects
of methamphetamine. Though seeking a stimulant may seem counterintuitive in individuals characterized by heightened anxiety, previous research has indicated significant positive associations between negative affectivity and club drug use (Simons, Gaier, et al., 2005). Alternatively, BAS activity may also be connected to components of impulsivity (Newman & Wallace, 1993; Whiteside & Lynam, 2001). Future research examining this unexpected finding in samples with a higher proportion of users is warranted.

The strongest correlate of methamphetamine use was lifetime marijuana use. Marijuana use exhibited both cross-sectional associations with methamphetamine use at T1 and a prospective association with methamphetamine use at T2 when controlling for methamphetamine initiation at T1. Most individuals who use marijuana do not progress to using methamphetamine. Nonetheless, higher rates of marijuana use were strongly associated with the likelihood of using methamphetamine. Marijuana use may be an indicator of multiple distal risk factors for methamphetamine use, including individual differences in SP and SR as well as variables not included in this study (e.g., sensation seeking, antisocial behavior). In addition, frequent use of marijuana may expose individuals to contexts in which methamphetamine is used or may serve to decrease the perceived risk of methamphetamine. Future research examining the mechanism by which this effect manifests is warranted (Fergusson et al., 2006a).

Methamphetamine use clearly has severe negative consequences and has had a major impact on use of treatment resources in some parts of the country including the rural Midwest (Grant et al., 2007; Rawson, Gonzales, & Ling, 2006; Simons, Oliver, et al., 2005; SAMHSA, 2006). Nonetheless, it should be emphasized that current use of this drug is low in absolute terms. For example, in 2005 only 1.5% of 18- to 25-year-olds reported any use in the past year, and 0.6% reported use in the past 30 days (SAMHSA, 2007a). Among youth ages 12–17 years, 2.3% reported using methamphetamine in the past year in South Dakota, the highest prevalence in the country based on NSDUH estimates from 2002 to 2005 (Office of Applied Studies, 2006). Estimated past-year prevalence for young adults in this region is comparable (2.14%–2.91%) but less than some other regions such as Wyoming, Arkansas, or Minnesota (Office of Applied Studies, 2006). Though previous research indicates that college attendance is associated with lower methamphetamine prevalence (Herman-Stahl et al., 2007) the rate in the current sample (2.2% past-year prevalence) is reasonably comparable to epidemiological estimates for this region. Expressing concern about methamphetamine use to the public should be balanced against creating a false impression (and norm) that it is an epidemic and use is rampant. Such false norms can potentially have the undesirable effect of encouraging use and experimentation (Martens et al., 2006).

Several limitations should be noted. This was a sample of primarily White college students, and generalizability of the findings to other samples with different demographic characteristics remains a question for further research. In addition, the follow-up period was relatively brief and the rates of methamphetamine use relatively low. Thus, we were unable to examine associations between the constructs and rates of use and escalation over extended periods among users. Nonetheless, given the addictive potential of methamphetamine and severity of negative consequences predicting any use is of importance.

In summary, the present study examined associations between methamphetamine use, marijuana use, SP, and SR. SP and SR (and the interaction between these dimensions) explained a small amount of variance in lifetime marijuana use. Lifetime marijuana use, in turn, exhibited a strong association with methamphetamine use. Marijuana use was associated with both the likelihood of having used methamphetamine at T1 and prediction of use during the follow-up period, after controlling for use at T1. SR exhibited small to moderate positive associations with methamphetamine use at T1 in both bivariate (Cohen’s $d = 0.45$) and multivariate analyses. SP exhibited an unexpected positive prospective association with methamphetamine use during the follow-up period in the multivariate analysis. However, bivariate associations between SP and methamphetamine use were not significant. The study adds to a growing body of literature connecting substance use to individual differences in behavioral inhibition and activation systems.

References


