Cannabis use and schizotypy: The role of social anxiety and other negative affective states

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A B S T R A C T

Emerging research suggests that cannabis use might be related to psychosis onset in people vulnerable to developing schizophrenia-spectrum disorders. Furthermore, individuals with high-positive and disorganized schizotypy traits report more cannabis use and cannabis-related problems than controls. Social anxiety, a frequently co-occurring schizotypal feature, is related to increased cannabis-related problems in the general population. Building on this research, we explored the impact of social anxiety, measured by the Social Interaction Anxiety Scale (SIAS), and depression and trait anxiety reported on the Brief Symptom Inventory (BSI), on the relationship of schizotypy, measured by the Schizotypy Personality Questionnaire-Brief Revised (SPQ-BR), to cannabis use (n=220 schizotypy, 436 controls) and frequent cannabis use and cannabis-related problems among users (n=88 schizotypy, 83 controls) in college undergraduates. Among cannabis users, social anxiety moderated the relationships of schizotypy to frequent cannabis use and more cannabis-related problems in the total schizotypy group, and across high-positive, negative, and disorganized schizotypy subgroups. Depression and trait anxiety also moderated the relationship of schizotypy to frequent cannabis use and more cannabis-related problems, but results varied across high-positive, negative, and disorganized schizotypy subgroups. Results suggest therapeutically targeting negative affective states may be useful in psychosocial intervention for cannabis-related problems in schizotypy.

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1. Introduction

Over the last decade, there has been a significant development in literature examining patterns and consequences of cannabis use among those with schizotypy, highlighting its clinical importance. We recently confirmed higher rates of cannabis use and cannabis-related problems among high-schizotypy college students (Cohen et al., 2010a). Social anxiety, which frequently co-occurs with schizotypy (Brown et al., 2008), appears to be uniquely related to cannabis-related impairment (Buckner et al., 2012a) in the general population. This paper expands on these findings by examining the moderating role of social anxiety, and other negative affective states (depression and trait anxiety), in the relationships of categorically-identified high-schizotypy to cannabis use and cannabis-related problems.

Among non-clinical young-adult populations, cannabis use is associated with higher rates of positive and disorganized, but not negative/interpersonal, schizotypy traits (Bailey and Swallow, 2004; Cohen et al., 2010a; Earleywine, 2006; Mass et al., 2001; Schiffman et al., 2005; Williams et al., 1996). More frequent cannabis use (Compton et al., 2007; Dumas et al., 2002; Esterberg et al., 2009; Gregg et al., 2007) and cannabis use of longer duration (Fridberg et al., 2011) are associated with higher levels of schizotypy traits, particularly positive and disorganization symptoms. Cannabis dependence is also related to high levels of self-reported psychotic symptoms among the general population (Fergusson et al., 2003). Additionally, individuals with elevated schizotypy symptoms report more psychosis-like symptoms during immediate cannabis use and unpleasant effects following use (Barkus and Lewis, 2008; Barkus et al., 2006; Stirling et al., 2008), and more cannabis-related problems (Cohen et al., 2010a). This high rate of cannabis-related problems in schizotypy is consistent with the “supersensitivity model” of substance use in schizophrenia, which posits that individuals with schizophrenia are more likely to experience negative substance use-related consequences than other groups due to inherent vulnerabilities such as impaired cognitive functioning and biological sensitivity to stress (Gregg et al., 2007; Mueser et al., 1998).

Given the social, cognitive, and emotion-processing deficits apparent in schizotypy — e.g., social cognition inaccuracies (Brown and Cohen, 2010), poor inhibition and emotional confusion (Kerns, 2006), and impaired emotional intelligence and social functioning (Aguirre et al., 2008) — one might expect schizotypal individuals to also experience greater cannabis-related problems.

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Furthermore, studies suggest that frequent cannabis use is associated with an increased likelihood of future development of psychosis (Arendt et al., 2005; Arseneault et al., 2002; Caspi et al., 2005; Hall et al., 2004; Henquet et al., 2005a; Sewell et al., 2009), and earlier onset of psychosis among cannabis users (Galvez-Bucyllini et al., 2012; Large et al., 2011). In fact, one meta-analysis of seven prospective studies found a pooled odds ratio estimate of 2.1 (95% CI: 1.7–2.5) for development of psychosis associated with prior cannabis use (Henquet et al., 2005a). However, cannabis use is thought to interact with other factors in the development and expression of psychosis such that it is not itself sufficient to cause a schizophrenia-spectrum disorder (Henquet et al., 2005b; Sewell et al., 2009).

The “relaxation of dysphoria” model of substance use motives in schizophrenia (Gregg et al., 2007) might also provide an explanation for why schizotypal young adults are more likely to use cannabis. As opposed to direct relief of schizophrenic symptoms, cannabis use in schizophrenia appears related to more generalized motives of relaxation and alleviation of depression, anxiety, or boredom (Addington and Duchak, 1997; Gregg et al., 2007). Despite higher trait anxiety and depression in schizotypy (Lewandowski et al., 2006), neither has yet been consistently shown to impact the relationship between cannabis use and schizotypy (Dumas et al., 2002; Nunn et al., 2001; Williams et al., 1996), although there has been indication that the relationship between some schizotypal traits (i.e., perceptual aberrations, magical thinking, and constricted affect) and cannabis non-use versus frequent use may be influenced by depression and anxiety among a non-clinical college population (Dumas et al., 2002). However, to our knowledge these relationships have not been examined using moderation models. Furthermore, there are good reasons to posit that social anxiety, as yet overlooked in this literature, may play an important role in this relationship.

First, in the general population there is a positive relationship between social anxiety and cannabis use disorder (Agosti et al., 2002; Buckner et al., 2008, 2012a; Lysney et al., 2002) and cannabis-related problems (Buckner et al., 2006a, 2006b, 2011; Buckner and Schmidt, 2008, 2009; Marmorstein et al., 2010). This relationship appears specific to social anxiety, remaining significant even after controlling for various other pathology, including other anxiety disorders and depression (Buckner et al., 2008, 2012a; Buckner and Schmidt, 2008, 2009) and alcohol use disorder (Buckner et al., 2006a, 2006b, 2012a). Second, there is significant positive association between schizotypy and social anxiety, which appears to be related to schizotypy through mechanisms that are distinct from social anhedonia or negative symptoms more generally (Brown et al., 2008; Cohen and Matthews, 2010; Cohen et al., 2010b). In fact, although social anxiety is often psychometrically assessed as a component of the “interpersonal” factor of schizotypy (e.g., Schizotypy Personality Questionnaire; Raine, 1991), it has been shown to be more strongly related to positive than negative symptoms (Brown et al., 2008). The Schizotypal Personality Questionnaire-Brief Revised (Cohen et al., 2010b) addresses this issue by parceling out social anxiety as a separate schizotypy factor, which may be conceptualized as secondary to core negative traits (Cohen and Matthews, 2010). Yet, despite the relationships between social anxiety and cannabis use/problems and between schizotypy and social anxiety, to our knowledge, existing research has not yet explored the impact of social anxiety on cannabis use and cannabis-related problems in schizotypy.

To determine whether cannabis use and use-related problems in categorically-identified high-schizotypal students are influenced by social anxiety, we reexamined data from Cohen et al. (2010a), considering the schizotypy group as a whole, as well as by elevation on separate positive, negative, and disorganized schizotypal trait factors. Specifically, we hypothesized that (i) schizotypal participants would report higher levels of social anxiety than controls; (ii) higher levels of social anxiety would be related to more frequent cannabis use and more cannabis-related problems; and (iii) controlling for influencing factors such as trait anxiety and depression, social anxiety would moderate the relationships of schizotypy with cannabis use frequency and cannabis-related problems, such that schizotypal individuals with elevated social anxiety would demonstrate more frequent cannabis use and more use-related problems than other participants. Finally, across each of these analyses, we expected that individuals with elevated positive and disorganized, but not necessarily negative, schizotypy traits would be more strongly associated with problematic cannabis use. To test the specificity of the impact of social anxiety, we tested these hypotheses while controlling for trait anxiety and depression. We also examined the impact of trait anxiety and depression on the relationships of schizotypy and schizotypy traits with cannabis use behaviors. Finally, given evidence that sex is important for understanding social anxiety (Sutterby et al., 2012), particularly in the context of the relationship of social anxiety to problematic cannabis use (Buckner et al., 2011, 2012a), we examined the impact of sex on these models.

2. Methods

2.1. Participants

Freshman and sophomore students at a large public Southeastern university (n = 7951) were approached via email to participate in an online survey, which has been shown to be a reliable and valid method for collecting self-report data, particularly about substance use patterns (McCabe et al., 2002; Rado et al., 2011), in exchange for a chance to win one of the 10 $25 prizes. Twenty-seven percent responded (n = 2145). Of these, 24% were discarded as incomplete (n = 493) or invalid (n = 79; endorsing > 1 of four infrequency items; Chapman, 1976). From the remaining pool, schizotypal participants were identified using the Schizotypal Personality Questionnaire-Brief Revised (SPQ-BR: Cohen et al., 2010b). The SPQ-BR has a super-ordinate four-factor solution (Cohen et al., 2010b), comprising Cognitive-Perceptual (ideas of reference/suspiciousness, magical thinking, unusual perceptions), Disorganized (eccentric behavior, odd speech), Negative (i.e., no close friends, constricted affect), and Social Anxiety traits. In light of evidence that the Social Anxiety factor is secondary to core negative schizotypy pathology (Cohen and Matthews, 2010; Cohen et al., 2010b), and to prevent circularity of analysis with regard to our social anxiety variable, we omitted the SPQ-BR Social Anxiety factor in determining schizotypy group membership. In addition, it is notable that the SPQ-BR omits two items of the SPQ-Brief (Raine and Benishay, 1996) that demonstrate a bias against cannabis users (Earleywine, 2006).

Participants were assigned to categorical high-schizotypy (> 95th percentile on the Cognitive-Perceptual, Disorganized, or Negative subscale of the SPQ-BR; n = 220, 88 of whom reported cannabis use) and control (< 50th percentile on all three subscales; n = 436, 83 of whom reported cannabis use) groups. In addition, in order to categorically examine the relationship of specific schizotypy traits to variables of interest, high-schizotypy trait subgroups were created for participants scoring above the 95th percentile on the Cognitive-Perceptual (n = 88 (40% of the total schizotypy group)), 51 reporting cannabis use; hereinafter referred to as the high-positive group). Negative (n = 105 (48% of the total schizotypy group), 34 reporting cannabis use), and Disorganized (n = 75 (34% of the total schizotypy group), 27 reporting cannabis use) subscales. Reflecting the heterogeneity of the schizotypy group, these high-trait subgroups were not mutually-exclusive. These participants were drawn from the same larger database examined in our prior study of cannabis use in schizotypy (Cohen et al., 2010a); however, selection criteria differed slightly between our prior study and the present one, as the prior study (schizotypy n = 95; control n = 857) identified schizotypal participants based on total SPQ-BR scores above the 95th percentile, and excluded participants endorsing > 2 infrequency items. This study was approved by the LSU Human Subject Review Board and all subjects provided informed consent.

2.2. Measures

2.2.1. Substance use Behaviors

Cannabis use frequency was assessed by an item adapted from the Core Institute’s Campus Assessment of Alcohol and Other Drug Norms (“How often do you typically use marijuana?”), used in prior research (Kilmer et al., 2006), Please cite this article as: Najolia, G.M., et al., Cannabis use and schizotypy: The role of social anxiety and other negative affective states, Psychiatry Research (2012), http://dx.doi.org/10.1016/j.psychres.2012.07.042.
with response options ranging from never to daily. Alcohol use frequency was also assessed using this format (Buckner et al., 2006a, 2006b). In light of the ordinal nature of this item and in line with prior research (Aarons et al., 2001; Buckner et al., 2010; Buckner et al., 2006a; Buckner and Schmidt, 2008), participants were categorized as non-users, infrequent users (less than weekly use), and frequent users (weekly or greater use) for purposes of regression analyses.

The Marijuana Problems Scale (MPS) was administered to assess negative social, occupational, physical, and personal consequences of cannabis use among users over the past 90 days (Stephens et al., 2006). The 19 items are rated as 0 (no problem), 1 (minor problem), or 2 (serious problem). Items endorsed as minor or serious were counted to calculate total number of cannabis-related problems. The measure was internally consistent in the current data set (α = 0.98; Buckner et al., 2010; Cohen et al., 2010a).

2.2.2. Anxiety and depression variables

Social anxiety was measured using the Social Interaction Anxiety Scale (SIAS; Mattick and Clarke, 1998), a 20-item scale employing Likert responses anchored from “Never” to “Extremely.” The SIAS has demonstrated strong construct validity (Mattick and Clarke, 1998), a 20-item scale employing Likert responses anchored from “Never” to “Extremely.” The SIAS has demonstrated strong construct validity (Mattick and Clarke, 1998), and was internally consistent in the present sample (α = 0.89).

Trait anxiety and depression were assessed by the Anxiety and Depression subscales of the Brief Symptom Inventory (BSI; Derogatis, 1993a), a self-report measure with good reliability and convergent validity, employing a 4-point Likert scale (Derogatis, 1993b; Derogatis and Melisaratos, 1983; Morlan and Tan, 1998). The BSI was internally consistent in this sample (α = 0.98).

2.3. Analyses

Analyses were conducted in five steps. First, demographic differences were analyzed using t-tests. Second, to test our first hypothesis, the high-schizotypy and control groups were compared on the main variables of interest (cannabis use frequency, cannabis use problems, and social anxiety), as well as potential confounding variables (alcohol use, trait anxiety, and depression) using t-tests and Mann-Whitney U tests. These data reflect a subset of data previously presented (Cohen et al., 2010a), but are reported here as relevant to the moderation analyses. Third, to test our second hypothesis, Spearman correlations were examined for the high-schizotypy and control groups among predictor and outcome variables. To test our third hypothesis, in analysis sets four and five, the moderating effect of social anxiety on high-schizotypy and number of cannabis-related problems among users was examined using hierarchical regression, controlling for trait anxiety and depression, and cannabis use frequency. Where significant moderation effects were found, significance of the slopes of regression lines created for schizotypy and control groups were tested to probe the nature of the interaction effect, following procedures set forth by Aiken and West (2000) and Holmbeck (2002). Analyses four and five were then repeated examining trait anxiety and depression as potential moderators to determine the specificity of social anxiety moderating effects. Finally, we examined the additional impact that sex on these models. All tests were two-tailed.

Due to significant positive skew of the BSI-Depression and BSI-Anxiety variables within the control group, and positive skew of the MPS in the total group, non-parametric tests were used for the second and third analyses. For regressions, BSI-Depression and BSI-Anxiety variables were square root transformed (skew following transformation ≤ 2.00). To maintain interpretability of regression results, the MPS was not transformed for use in the fifth analysis set, as regression residuals were normally distributed.

3. Results

3.1. Demographics

High-schizotypy participants and controls did not significantly differ on demographic variables (see Table 1). In addition, no schizotypy subgroup, as elevated in positive, negative, or disorganized traits, significantly differed from controls on any demographic variables (t < 1.54, Ps > 0.13).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Group differences (control vs. schizotypy) on demographic and analysis variables.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n</strong>: Total</td>
<td>436</td>
</tr>
<tr>
<td>Mean SPQ-BR score</td>
<td></td>
</tr>
<tr>
<td>Total score</td>
<td></td>
</tr>
<tr>
<td>Cognitive-perceptual subscale</td>
<td></td>
</tr>
<tr>
<td>Negative subscale</td>
<td></td>
</tr>
<tr>
<td>Disorganization subscale</td>
<td></td>
</tr>
<tr>
<td><strong>n</strong>: Cannabis users</td>
<td>83</td>
</tr>
<tr>
<td>% Malea</td>
<td>37%</td>
</tr>
<tr>
<td>Education (M ± S.D.)a</td>
<td>12.37 ± 1.09</td>
</tr>
<tr>
<td>Ethnicitya</td>
<td></td>
</tr>
<tr>
<td>% Caucasian</td>
<td>84%</td>
</tr>
<tr>
<td>% African American</td>
<td>6%</td>
</tr>
<tr>
<td>% Asian</td>
<td>4%</td>
</tr>
<tr>
<td>% Hispanic</td>
<td>4%</td>
</tr>
<tr>
<td>% American Indian</td>
<td>2%</td>
</tr>
<tr>
<td>Depression (M ± S.D.),b</td>
<td>8.07 ± 2.96 (Mdn = 7)</td>
</tr>
<tr>
<td>Social anxiety (M ± S.D.),b</td>
<td>14.23 ± 8.94</td>
</tr>
<tr>
<td>Alcohol usea</td>
<td></td>
</tr>
<tr>
<td>% Reporting use</td>
<td>88%</td>
</tr>
<tr>
<td>% Users reporting ≥ weekly use</td>
<td>52%</td>
</tr>
<tr>
<td>Cannabis usea</td>
<td></td>
</tr>
<tr>
<td>% Reporting use</td>
<td>19%</td>
</tr>
<tr>
<td>% Users reporting ≥ weekly use</td>
<td>24%</td>
</tr>
<tr>
<td>Cannabis-related problems among usersb</td>
<td>1.88 ± 2.66 (Mdn = 1)</td>
</tr>
</tbody>
</table>

a P ≤ 0.001.

b P ≤ 0.10.

a Group means or demographic percentages and t-statistic reported. For ethnicity comparison, due to large disparity in groups, t-test compared % Caucasians to % non-Caucasian.

b Group means, medians, and non-parametric Mann-Whitney U statistic reported.

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3.2. Schizotypy vs. control group comparisons

Members of the high-schizotypy group reported significantly more social anxiety, depression, and trait anxiety, higher likelihood of cannabis use, and more cannabis-related problems than the control group (Table 1). Consistent with the total schizotypy group, all schizotypy subgroups reported significantly more depression (Us > 3016.50, Ps < 0.001), trait anxiety (Us > 3234.50, Ps < 0.001), social anxiety (ts > –8.86, Ps < 0.001), cannabis use (ts > –2.69, Ps < 0.01), and cannabis-related problems (Us > 970.00, Ps < 0.05) than the control group (Results of t-test comparisons between controls and each of the schizotypy trait elevation subgroups may be found in the Supplementary Materials.). Among cannabis users, individuals in the total schizotypy group, as well as those with high positive and high disorganized traits (ts > –1.81, Ps < 0.07), were more likely to report weekly or greater use than controls at a trend level; however, consistent with prior research indicating that negative schizotypy traits may serve some protective purpose in connection with risk of cannabis use (e.g., Cohen et al., 2010a), individuals with high negative traits were not significantly more likely than controls to report weekly or greater use (t = –0.59, P = 0.55). Interestingly, while schizotypy groups reported a greater likelihood of cannabis use and more frequent use (with the exception of those in the high-negative group), the total schizotypy and control groups did not differ on reports of alcohol use or frequency of alcohol use, and only individuals with elevated positive traits were significantly more likely to use alcohol than controls (t = –2.13, P = 0.03). All other comparisons of alcohol use/frequency were nonsignificant (ts < 0.92, Ps > 0.36).

3.3. Correlations

Table 2 presents correlations between regression model predictor and outcome variables separately for high-schizotypy and control groups (Correlations among regression model predictor and outcome variables for each of the schizotypy trait elevation subgroups may be found in the Supplementary Materials.). Interestingly, different patterns emerged with regard to depression and anxiety variables. While social anxiety, trait anxiety, and depression were all associated with lower frequency of use among controls, they were not significantly associated with cannabis use frequency within the total schizotypy group, or for subgroups with elevations of positive, negative, or disorganized schizotypy traits. By contrast these variables were not significantly related to cannabis-related problems among controls; but greater cannabis-related problems were associated with social anxiety in the schizotypy group (and for individuals elevated in positive, r = 0.31, P = 0.03, negative, r = 0.47, P = 0.01, and disorganized, r = 0.56, P < 0.01, traits). Cannabis-related problems among schizotypal users were also positively associated with depression, apparently driven by its association with depression in the high-negative (r = 0.48, P < 0.01) and disorganized subgroups (r = 0.53, P < 0.01), and with trait anxiety in the total schizotypy group, although the effect size was small and this relationship did not reach statistical significance across schizotypy subgroups (r < 0.25, Ps > 0.07). Frequency of use was significantly associated with cannabis-related problems in both the control and schizotypy groups. Within the schizotypy group, frequency of use was significantly associated with cannabis-related problems in the high-positive (r = 0.38; P = 0.01) and disorganized (r = 0.43; P = 0.02), but not negative (r = 0.28; P = 0.11) subgroups. Again, this is consistent with prior research indicating that negative schizotypy traits may not share the same association with problematic cannabis use as positive and disorganization traits (e.g., Cohen et al., 2010a; Fridberg et al., 2011). No variables were associated with prediction of cannabis use vs. nonuse.

3.4. Moderation effects of social anxiety on schizotypy and cannabis use

Social anxiety did not significantly moderate the relationships between schizotypy group and cannabis use vs. non-use for the total schizotypy group or any schizotypy subgroups, with or without depression and trait anxiety added to the models (Block 3: Odds Ratios (ORs) < 1.02, P > 0.36). Neither depression nor trait anxiety, respectively, moderated the relationship between schizotypy status and use vs. non-use, when controlling for social anxiety and trait anxiety or depression, respectively (ORs < 0.89, Ps > 0.64). The main effect of sex, after controlling for depression and anxiety, was significant in the model examining the relationships of sex and social anxiety in predicting cannabis use vs. non-use (Block 2: ORs = 1.76, 95% CI: 1.22–2.55, P < 0.01); but the interaction between cannabis use and sex was non-significant (Block 3: ORs = 1.00, 95% CI: 0.97–1.02, P = 0.71).

In the second logistic regression model (predicting frequent vs. infrequent use among users), the main effect of social anxiety was not significantly related to cannabis use frequency and the main effect of schizotypy status was predictive of frequent use at a trend level; but social anxiety significantly moderated the relationship between schizotypy status and frequency of use, even after controlling for depression and trait anxiety (Table 3). However, depression also significantly moderated this relationship, controlling for social and trait anxiety (Block 3: ORs = 7.32, 95% CI: 1.15–46.69, P = 0.04), and trait anxiety moderated this relationship at a trend level, controlling for depression and social anxiety (Block 3: ORs = 9.23, 95% CI: 0.87–98.08, P = 0.07). When sex was added as an intermediate step to this model, there was a trend-level main effect for sex (Block 2: OR = 1.88, 95% CI: 0.96–3.68, P = 0.06), but no sex x social anxiety interaction (Block 3: OR = 1.00, 95% CI: 0.96–1.04, P = 0.95). Furthermore, the schizotypy x social anxiety interaction remained significant (Block 5: OR = 1.12, 95% CI: 1.02–1.23, P = 0.01). The schizotypy x sex x social anxiety interaction was not significant (Block 6: OR = 0.98, 95% CI: 0.84–1.13, P = 0.77).

Turning towards the influence of social anxiety on schizotypy subgroups in predicting cannabis use frequency, social anxiety significantly moderated the relationship between schizotypy and cannabis use frequency across all three models (Block 3: ORs > 1.12, Ps < 0.02). In addition, the main effect of schizotypy subgroups, entered in Block 2, was significant in the models comparing high-negative (OR = 1.12, 95% CI: 1.01–1.25, P = 0.05) and disorganized (OR = 0.18, 95% CI: 0.05–67, P = 0.01) subgroups to controls, but not the model comparing high-positive trait...
individuals to controls (OR = 0.41, 95% CI: 0.12–1.43, P = 0.16). The main effect of social anxiety, entered in Block 2, was not significant in any of these models (ORs < 1.01; Ps > 0.68). Logistic regression results for models entering comparison of controls to each of the schizotypy trait elevation subgroups may be found in the Supplementary Materials.

Depression also significantly moderated the relationship between schizotypy subgroups and cannabis use frequency in the models comparing the high-positive (Block 3: OR = 8.53, 95% CI: 1.20–61.36, P = 0.03) and disorganized (Block 3: OR = 11.48, 95% CI: 1.45–91.01, P = 0.02) subgroups to controls; but not in the model comparing the high-negative subgroup to controls (Block 3: OR = 3.48, 95% CI: 0.46–25.58, P = 0.23). Trait anxiety only significantly moderated the relationship between cannabis use frequency and positive traits (Block 3 for the model comparing controls to the high-positive subgroup: OR = 8.53, 95% CI: 1.20–61.36, P = 0.03; for models comparing controls to the high-negative and disorganized subgroups ORs < 7.37; Ps > 0.10).

Fig. 1 presents regression lines for all four significant models predicting frequency of use (Cohen and Cohen, 1983). Visual examination suggests that at lower levels of social anxiety, high-schizotypy participants were less likely to report frequent cannabis use than controls; but as social anxiety increased, the likelihood of frequent cannabis use decreased for controls and increased for schizotypal participants. However, post-hoc analysis of the slopes of the regression lines reached significance for only the control group in the models comparing controls to the total schizotypy group (Table 3) and the positive schizotypy subgroup (slope for schizotypy: W = 2.97, P = 0.09; slope for controls: W = 3.82, P = 0.05). Thus, although social anxiety significantly moderated the association between schizotypy status and frequency of cannabis use, the relationship appears driven by a significant decrease in cannabis use frequency among control participants as social anxiety increases, particularly in the model comparing controls to the positive schizotypy subgroup.

3.5. Moderation effects of social anxiety on schizotypy and cannabis-related problems

In the model comparing the total high-schizotypy group to controls on cannabis-related problems, after controlling for the significant influence of trait anxiety, depression, and cannabis-use frequency, there was a significant main effect of social anxiety, but not schizotypy status. Social anxiety significantly moderated

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the relationship between schizotypy and cannabis-related problems (Table 4). However, the moderating effects of depression (β = 0.28, Step 3: R²Δ = 0.02, P = 0.02) and trait anxiety (β = 0.33, Step 3: ΔR² = 0.02, P = 0.04) were also significant in these models, controlling for social anxiety, cannabis use, and trait anxiety or depression, respectively; thus, social anxiety may not be the only negative affective state that influences the relationship between schizotypy and cannabis-related problems. When sex was added as an intermediate step to this model, there was a significant interaction effect for sex × social anxiety (β = −0.61, Step 3: R²Δ = 0.04, P ≤ 0.01), with men, but not women, showing a significant increase in cannabis-related problems when going from low to high social anxiety (slope for men: t = 3.90, P < 0.001; slope for women: t = 0.29, P = 0.77; Holmbeck, 2002). Even controlling for these variables, the schizotypy × sex × social anxiety interaction remained significant in the next step (β = 0.30, Step 5: R²Δ = 0.02, P = 0.04), and there was no schizotypy × sex × social anxiety interaction (β = −0.47, Step 6: R²Δ < 0.91, P = 0.33).

Turning towards the influence of social anxiety on schizotypy subgroups, social anxiety significantly moderated the relationship between schizotypy and cannabis-related problems in the models comparing the high-negative (β = 0.58, Step 3: R²Δ = 0.05, P < 0.01) and disorganized (β = 0.55, Step 3: R²Δ = 0.09, P < 0.001) subgroups to controls, but moderated this relationship at only a trend level in the model comparing the high-positive subgroup to controls (β = 0.26, Step 3: R²Δ = 0.01, P = 0.09). There was also a main effect of social anxiety in all the three schizotypy subgroup models (βs > 0.25, Ps < 0.03), but not total schizotypy status (βs < −0.18, Ps > 0.20) (Hierarchical regression results for models comparing controls to each of the schizotypy trait elevation subgroups may be found in the Supplementary Materials.). Depression significantly moderated the relationship between schizotypy status and cannabis-related problems in the models comparing the high-negative (β = 0.51, Step 3: R²Δ = 0.08, P < 0.001) and disorganized (β = 0.39, Step 3: R²Δ = 0.05, P < 0.01) subgroups to controls; but not in the model comparing the high-positive subgroup and controls (β = 0.02, P = 0.91). Trait anxiety only significantly moderated the relationship between schizotypy status and cannabis use problems in the model comparing the high-negative subgroup to controls (β = 0.37, Step 3: R²Δ = 0.04, P = 0.01; for the high-positive and high-disorganized groups βs < 0.26, Ps ≥ 0.10).

Regression lines for frequent cannabis users are plotted in Fig. 2 (Cohen and Cohen, 1983). The slope of the regression line for the high-schizotypy, but not the control, group was significant (Table 4), such that high-schizotypy individuals with higher social anxiety reported more cannabis-related problems, even after controlling for depression, trait anxiety, and cannabis use frequency (Aiken and West, 2000; Holmbeck, 2002). This pattern was consistent across all the three supplemental analyses comparing controls to high-positive, negative, and disorganized subgroups (schizotypy subgroup slopes: ts > 2.86, Ps < 0.005; control subgroup slopes: ts < −0.64, Ps > 0.52). Thus, only within the schizotypy groups was social anxiety significantly related to number of cannabis-use problems. Visual examination of the regression lines suggests that while schizotypal traits are associated with fewer cannabis-related problems compared to controls at low levels of social anxiety across all schizotypy subgroups (especially those high in negative and disorganized traits), the presence of high social anxiety in schizotypy is associated with reports of

### Table 4

Summary of hierarchical regression predicting cannabis-related problems among users (controlling for trait anxiety, depression, and cannabis use frequency)*

<table>
<thead>
<tr>
<th>Step</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Depression</td>
<td>1.14</td>
<td>0.57</td>
<td>0.19**</td>
</tr>
<tr>
<td></td>
<td>Anxiety</td>
<td>2.37</td>
<td>0.68</td>
<td>0.33**</td>
</tr>
<tr>
<td></td>
<td>Weekly cannabis use</td>
<td>3.71</td>
<td>0.73</td>
<td>0.32**</td>
</tr>
<tr>
<td>Step 2</td>
<td>Schizotypy</td>
<td>−1.18</td>
<td>1.00</td>
<td>−0.11</td>
</tr>
<tr>
<td></td>
<td>Social anxiety</td>
<td>0.09</td>
<td>0.03</td>
<td>0.28***</td>
</tr>
<tr>
<td>Step 3</td>
<td>Schizotypy × social anxiety interaction</td>
<td>0.13</td>
<td>0.07</td>
<td>0.30*</td>
</tr>
</tbody>
</table>

** Significance of regression slope

<table>
<thead>
<tr>
<th>Schizotypy</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.48**</td>
<td>−0.25</td>
</tr>
</tbody>
</table>

* P ≤ 0.05.
** P ≤ 0.001.
*** P ≤ 0.001.

R² for Step 1 = 0.34, P < 0.001; ΔR² for Step 2 = 0.03, P < 0.001; ΔR² for Step 3 = 0.02, P = 0.05.

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Fig. 2. Cannabis-related problems among weekly users as moderated by social anxiety (controlling for use, depression, and trait anxiety) for schizotypy (Solid Line) and control (Dashed Line) Groups. Note: Total MPS is depicted on the y axis.
cannabis-related problems similar to, or in some instances in excess of, controls.

4. Discussion

In this study, we expanded on our recent study examining cannabis use in schizotypy (Cohen et al., 2010a) by examining the role of social anxiety, and other negative affective states (i.e., depression and trait anxiety) in that data set. The high-schizotypy group was significantly more likely to report cannabis use and more frequent cannabis use (i.e., weekly or greater) than controls. Among cannabis users, the high-schizotypy group reported three times the number of cannabis-related problems as controls. By contrast, the total high-schizotypy and control groups did not differ on reports of alcohol use or frequency of alcohol use, and only individuals with elevated positive traits were significantly more likely to use alcohol than controls, highlighting the unique relationship that cannabis might play in social and occupational dysfunction in schizotypy. Consistent with prior research, high-schizotypal individuals reported more social anxiety (Brown et al., 2008), depression, and trait anxiety (Lewandowski et al., 2006) than controls. Cannabis use frequency was significantly negatively correlated with these affective variables in the control group; whereas cannabis-related problems were significantly positively correlated with these variables in the schizotypy group. Examining relationships among these variables within subgroups of individuals with elevated positive, negative, and disorganized schizotypal traits, (i) social anxiety was significantly associated with cannabis-related problems across all three symptom presentations at medium to large effect sizes; (ii) depression was related to cannabis problems at medium to large effect sizes among individuals with high-negative and disorganized, but not positive traits; and (iii) trait anxiety was associated with cannabis-related problems at only small effect sizes. Taken together, these data suggest that emotional distress — particularly social anxiety and depression — plays an important role in the experience of cannabis-related problems, unique to cannabis users with schizotypal traits. Consistent with this indication, we found that social anxiety moderated the relationship between schizotypy and frequency of use and cannabis-related problems among cannabis users, even after controlling for depression and trait anxiety, across high-positive, negative, and disorganized trait subgroups. In addition, depression and trait anxiety moderated these relationships across some, but not all, schizotypal trait subgroups.

Contrary to our expectation, social anxiety did not moderate the relationship between schizotypy status and cannabis use vs. non-use; nor did depression or trait anxiety. However, among cannabis users, social anxiety significantly moderated the relationships between schizotypy status and use frequency, both within the total schizotypy group and across all the three schizotypy subgroups. This relationship appeared driven by a significant decrease in risk of frequent use among controls as social anxiety increased, particularly when compared to the high-positive schizotypy group. Interestingly, this pattern of cannabis use frequency decreasing as social anxiety increases has not been found in prior research on the relationship between social anxiety and cannabis use behavior in the general population; although some prior studies have found no relationship between social anxiety and cannabis use frequency, finding instead the relevant relationship is that between social anxiety and cannabis-related problems (e.g., Buckner et al., 2007). Our finding of a decrease in cannabis use frequency among non-schizotypal participants as social anxiety increases may be related to the fact that, to our knowledge, our study is the first to parse out the impact of schizotypal traits in such models. In interpreting these results, it should be recalled that our theoretical framework of interest considered the impact of social anxiety on cannabis-use behavior within high vs. low schizotypy groups, such that control group comprises individuals scoring below the 50th percentile on all the three schizotypy factors, and thus represent a unique low-schizotypy comparison group that may not be representative of the broader population of socially-anxious individuals. Given that cannabis use tends to occur in social situations (Buckner et al., 2012b), particularly among those with elevated social anxiety (Buckner et al., 2012c), it is possible that our high social anxiety, low schizotypy group avoids social situations and thus encounters fewer opportunities to use cannabis.

Social anxiety also significantly moderated the relationship between schizotypy status and cannabis-related problems. This relationship appeared to be driven by the relationship between social anxiety and high-negative and disorganized schizotypy traits; however, the slope for all schizotypy subgroups was significant, indicating that as social anxiety increases among individuals with schizotypy cannabis-related problems increase. Interestingly, while there were some indications that negative schizotypy traits were protective against certain problematic patterns of cannabis use (i.e., cannabis users with high-negative traits were not significantly more likely to engage in frequent use than controls, and use frequency was correlated with cannabis-use problems at only a non-significant small effect size among individuals with high-negative traits), once the moderating effect of social anxiety is added to the model, these protective mechanisms are no longer effective.

These results are consistent with the “supersensitivity” model, which posits that individuals with schizophrenia are more likely to experience negative substance use-related consequences due to vulnerabilities such as impaired cognitive functioning, and stress sensitivity (Barkus and Lewis, 2008; Barkus et al., 2006; Gregg et al., 2007; Mueser et al., 1998; Stirling et al., 2008). Similarly, in schizotypy, social, cognitive, and emotion-processing deficits — e.g., social cognition inaccuracies (Brown and Cohen, 2010), poor inhibition and emotional confusion (Kerns, 2006), and impaired emotional intelligence and social functioning (Aguirre et al., 2008) — may lead to more negative consequences among individuals who use cannabis to manage social anxiety. Future research should explore potential mechanisms, such as cannabis effect expectancies (Buckner and Schmidt, 2008), that may underlie these relationships.

Supplemental analyses testing the specificity of social anxiety’s moderating effects suggest that social anxiety is not the only negative affective state impacting the relationship between schizotypy and problematic cannabis use (i.e., frequency of use and resulting functional problems), as both depression and trait anxiety also moderated some of these relationships. However, across elevated schizotypy subgroup presentations, results were more variable for these negative affective states than for social anxiety, which moderated the relationship between schizotypy status and cannabis use frequency and related problems across all schizotypy subgroups. Depression significantly moderated the relationships between positive and disorganized (but not negative) subgroups with frequent use; and moderated the relationships of cannabis-related problems with negative and disorganized (but not high-positive) subgroups. Trait anxiety only significantly moderated the relationships between positive traits and cannabis use frequency, and between negative traits and cannabis-related problems. While supplemental to the initial conceptual focus of this study, these results resonate with research noting the relationship between negative affect in general and schizotypy symptoms, in both non-cannabis users and individuals with cannabis use disorders (Fridberg et al., 2011), and provides...
argument for future studies to examine application of the “alle-
viation of dysphoria” theory of schizophrenia substance use (Gregg et al., 2007) to schizotypy.

Several limitations of this study warrant mention. Its correla-
tional nature cannot address causality or direction of moderat-
on. Our substance use data was also limited to information about frequency of use, and did not reflect quantity or duration of use, which have been shown to be related to schizotypy symptoms (Fridberg et al., 2011), nor does our data reflect recency of use or whether current non-users have any history of past cannabis-use. However, frequency of use has been shown to be related to cannabis-related problems in prior research (Buckner et al., 2007; Buckner and Schmidt, 2008), and results addressing can-
nabis-related problems are focused on the issues arising with the 3-months prior to assessment. In addition, use of a college-based sample comprising 62% female participants may not be representa-
tive of the larger schizotypy population. However, while there was a significant main effect of sex in predicting frequent use among cannabis users and a significant sex × social anxiety interaction in predicting cannabis-related problems among users, the moderating effect of social anxiety on the relationships between schizotypy status and frequent cannabis use and canna-
bis-related problems remained significant even after controlling for these effects in the models, and there were no significant 3-way interaction effects among schizotypy status, sex, and social anxiety in any of the models. Furthermore, we did not collect data regarding other illicit substances, which may be relevant to cannabis use and psychosis (Van Dam et al., 2008); however, risk for psychosis development has been found to be specific to cannabis (Arseneault et al., 2002; Henquet et al., 2005b).

Notwithstanding these limitations, this study suggests therapeutic interventions that could mitigate psychosis-potentia-
ting behavior (i.e., problematic cannabis use) in schizotypy. In prior research, 85% of schizotypal frequent cannabis users indicated interest in general psychiatric/psychological treatment, whereas only 25% indicated interest in cannabis use treatment (Cohen et al., 2010a). Thus, cognitive behavioral therapy for social anxiety (e.g., Powers et al., 2008) could be used to restructure anxious and depressive thoughts, challenge socially-based and affectively-related cannabis use expectancies, identify alternative coping skills to address affective reasons for use, and improve drug refusal skills.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.psychres.2012.07.042.

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