

RUNNING HEAD: Psychostimulant Use Among College Students

**Psychostimulant Use Among College Students During Periods of High and Low Stress:
An Interdisciplinary Approach Utilizing Both Self-Report and Unobtrusive Chemical
Sample Data**

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ABSTRACT

This study quantified psychostimulant use patterns over periods of high and low stress from both self-report measures and chemical wastewater analyses and identified possible predictors of psychostimulant abuse on a college campus. Self-report data were collected at three times of varying stress levels throughout one college semester: during the first week of school ($N = 676$), midterms ($N = 468$), and shortly before final exams ($N = 400$). Campus wastewater samples were collected over 72-hour periods during the same time frames as the surveys. The metabolites of Adderall and Ritalin were quantified through solid phase extraction and liquid chromatography-tandem mass spectrometry (LC-MS/MS). Samples were normalized with creatinine. Evidence was found to suggest an increase in psychostimulant use during periods of stress, with significant differences found from self-report data between the first week and midterms and from chemical data between these same two assessment periods as well as between the first week of classes and finals. Key predictors of lifetime non-prescriptive psychostimulant use included self-reported procrastination and poor time-management, use of other substances (especially nicotine/tobacco, alcohol, and cocaine), and students' perception of non-prescriptive psychostimulant use as normative on campus. The findings shed further light on psychostimulant use patterns among college students, particularly as a function of stress; the study also highlights the benefit of utilizing an interdisciplinary approach that uses both subjective and objective empirical data. The results have implications for prevention/intervention programs on college campuses designed to reduce stress and facilitate healthier coping.

Keywords Psychostimulants, Adderall, Ritalin, wastewater analysis, stress, coping

1. Introduction

The internal and external demands experienced by college students can create significant pressure to consistently perform at one's best. With these demands increasing over time, overall stress levels of college students have shown an increase from previous decades (Hudd et al., 2000; Pryor, Hurtado, DeAngelo, Blake & Tran, 2011; Sax, 1997, 2003). More so than in previous decades, psychostimulant drugs that can help individuals focus and increase performance for hours at a time are easily obtained (DeSantis, Webb, & Noar, 2008; Substance Abuse and Mental Health Services Administration [SAMHSA], 2012). Popularly known as "Study Buddies" or "Smart Drugs," prescription drugs designed to treat attention-deficit hyperactivity disorder (ADHD) are now being used by some students as study aids to increase academic performance (Arria et al., 2008; Arria et al., 2012; Carroll, McLaughlin, & Blake, 2006; Farah et al., 2004; Robach, 2011).

There are two main classes of psychostimulant drugs: amphetamine-containing salts (e.g. Adderall and Vyvanse) and methylphenidate (e.g. Ritalin, Focalin, and Concerta). Dexamphetamine-based drugs are yet another class of psychostimulants, comprised of only the dextrorotary, or right-handed, stereoisomer (Dextroamphetamine and amphetamine, 2013). Amphetamine salts, methylphenidate compounds, and dexamphetamine-based drugs increase the neurotransmitters dopamine and noradrenaline by either stimulating their release or inhibiting their reuptake (Sulzer, Sonders, Poulsen, & Galli, 2005; Volkow et al., 2001). The increase of neurotransmitters boosts attention, focus, learning, and impulse control.

Whether prescribed by a doctor or bought from a friend, psychostimulant drugs are easy to obtain free of charge or for a price (DeSantis et al., 2008; Robach, 2011; SAMHSA, 2012). Easier access to pharmaceutical stimulants is due in part to the increased diagnosis of ADHD in the past decade, with a recent study reporting a 66% increase in diagnosis during physician outpatient visits from 2000 to 2010 (Garfield et al., 2012). Production of methylphenidate has also risen, showing an almost three-fold increase worldwide between 2000 and 2009 (International Narcotics Control Board, 2010). Even with increased diagnosis and production, individuals who misuse psychostimulants often obtain the pills illegally. On a college campus, students can buy the pills from friends or acquaintances who are prescribed the drug, with prices often increasing at high-stress periods such as midterms and finals (McCabe, Teter, & Boyd, 2006; Trudeau, 2009). Studies indicate that anywhere from 23-84% of students with psychostimulant prescriptions have been asked about selling, trading, or giving away their medication (Advokat, Guidry, & Martino, 2008; Boyd, McCabe, Cranford, & Young, 2007).

Although psychostimulants can be beneficial for individuals with ADHD when taken as prescribed, non-prescriptive use can have dangerous side effects and have high potential for abuse (Dextroamphetamine and amphetamine, 2010). Psychostimulants affect the sympathetic nervous system, increasing heart rate, blood pressure, and respiration. Over time, the increased activity of the sympathetic nervous system can lead to detrimental changes in cardiac function (Vetter et al., 2008). Bypassing a doctor's prescription also decreases awareness of potential risks and increases the likelihood of other problems associated with misuse. For example, studies indicate that psychostimulant misuse is associated with increased use of alcohol and other illicit substances, and individuals who misuse psychostimulants are more likely to misuse and combine use with other drugs, which may increase toxicity (Barrett, Darredeau, Bordy, & Pihl, 2005; McCabe & Teter, 2007; SAMHSA, 2009).

Surveys conducted at undergraduate universities indicate variable rates of psychostimulant use and misuse on college campuses. Low and Gendaszek (2002) reported a lifetime amphetamine use of over 35% for students from a small college, Babcock and Byrne (2000) found a lifetime methylphenidate use of more than 16% for students at a liberal arts college, and Teter, McCabe, Cranford, Boyd, and Guthrie (2005) reported a lifetime prescription stimulant use of over 8% from a random sample of undergraduate students. In a national survey of 119 four-year undergraduate institutions, McCabe et al. (2005) found a 6.9% lifetime illicit use of prescription stimulants and a 2.1% use in the past 30 days. Of the previous studies, none investigated the independent use of both methylphenidate and amphetamine in the same study; rather, the two were grouped together or only one of these compounds was studied. Despite differing percentages of lifetime use of amphetamine and methylphenidate, research indicates that college students are more than twice as likely to report non-prescriptive psychostimulant use than their counterparts in the general population (Kaye & Darke, 2012). Further, young adults aged 18-25 show a higher percentage of nonmedical use of psychotherapeutic drugs than youths aged 12-17 and adults aged 26 and older (SAMHSA, 2012). Such findings suggest a need for further research to clarify the rates of non-prescriptive use for both Adderall and Ritalin. Additional research is also needed to examine predictors of psychostimulant use and misuse, especially among college students.

Surveying and interviewing students can be a useful way to gather psychostimulant use data, but these methods can lead to underreporting (Del Boca & Noll, 2000; Harrell, Kapsak, Cisin, & Wirtz, 1997; Sloan, Bodapati, & Tucker, 2004). When paired with objective measures, however, self-report data can be a valuable complement, facilitating increased confidence in the obtained data, particularly when findings from both objective and subjective measures converge. When it comes to investigating substance use, one objective method that has been applied successfully involves the use of chemical wastewater sampling. Over the past few decades, sampling aquatic environments for illicit drug metabolites has been used increasingly, and this procedure has demonstrated utility in answering questions about human population substance abuse (Banta-Green et al., 2009; Castiglioni et al., 2006; Castiglioni, Zuccato, & Fanelli, 2011; Van Nuijs et al., 2011). As with other substances for which this procedure has been applied, psychostimulants can be identified in wastewater from their known metabolites. The metabolite of Adderall is a combination of l-amphetamine and d-amphetamine, whereas Vyvanse is excreted specifically as d-amphetamine. Ritalin/Focalin/Concerta are excreted as α -phenyl-2-piperidine acetic acid, commonly known as ritalinic acid.

To investigate the use patterns of psychostimulants on a college campus, this study utilized both self-report measures of psychostimulant use as well as objective, chemical data derived from unobtrusive campus wastewater samples. For both types of methods, data were collected at three points throughout the semester that accounted for varying levels of stress: during the first week of classes (Time 1), midterms (Time 2), and shortly before final exams (Time 3). Results were compared between the self-report and wastewater sample data, and predictors of psychostimulant use were investigated.

2. Methods

2.1 Self-report data

The self-report measures consisted of three anonymous web-based surveys administered to undergraduate students at a private, liberal arts college in the Pacific Northwest with an undergraduate population of approximately 2,600 students. Surveys were designed by the researchers but administered through the university's Office of Institutional Research. Students who completed the first survey at the start of the semester ($N = 627$ respondents) were eligible to take the second survey at midterms ($N = 468$) and the third survey shortly before final exams ($N = 400$). Participation was compensated by entries into a raffle to win an Apple iPad2. Given the inclusion of human participants, approval by the university's Institutional Review Board was obtained prior to conducting the surveys. The survey questions that were the focus of the present study were presented to participants in the context of a broader study of *Stress, Wellness, and Coping*, which included a variety of questions on respondents' subjective stress and the factors that they believe contribute to their stress, questions regarding the students' physical and mental health, and survey items on a wide variety of coping strategies (both healthy and unhealthy) that respondents have used in the past and/or that they use currently. Copies of the complete survey questions are available from the first author, upon request. Anonymity of the participants to the researchers was maintained by the Office of Institutional Research, which stripped the database of any identifying information (e.g., student identification numbers, which were used to link participant data across the three survey administrations and to identify the iPad2 raffle winner at the end of the study). This safeguard meant that it was impossible for researchers to identify participants who had completed the study.

2.1.1 Sample demographics

The mean age of respondents was 20.14 ($SD = 2.04$), and all four class ranks were fairly equally represented (27.0% freshmen, 21.6% sophomores, 25.1% juniors, and 25.6% seniors). Consistent with the overall undergraduate population at this university, the majority of the sample was female (65.2%) and White (non-Hispanic; 80.3%); other races/ethnicities represented included Hispanic (5.9%), Asian (5.3%), and Mixed Race (6.7%). Less than 1 percent of the sample was African-American, Native Hawaiian, or American Indian/Native Alaskan. The mean cumulative GPA of respondents was 3.23 ($SD = 0.49$). In terms of employment status, 53.1% of the sample reported that they worked part-time, 2.5% worked full-time, and 44.3% were not employed (i.e., full-time students).

2.1.2 Psychostimulant use

Psychostimulant use was assessed with a series of questions, beginning with the prompt: "How often, if ever, have you used any of the substances below?" Participants were then asked to rate their usage level for Adderall, Ritalin, or other ADHD medication. Given the equivalence of their respective metabolites, Adderall/Dexedrine/Vyvanse were grouped together, as were Ritalin/Focalin/Concerta. By far, the most common substance used was Adderall, followed by Ritalin. Respondents were asked to rate their usage on the following scale: 1 = "Never Used;" 2 = "Used, but not in past 12 months;" 3 = "Used, but not in past 30 days;" 4 = "Used, but not in past 2 weeks;" 5 = "Used in the past 2 weeks." If respondents indicated that they had used ADHD medication, they were asked to indicate whether the medication was prescribed for them (*Yes* or *No*) and, if yes, whether the amount taken was higher than the prescribed dose (*Yes* or *No*). Participants' past and current use of several other substances at Time 1—including nicotine/tobacco, alcohol, marijuana, and cocaine—were assessed with the exact same questions

and scales as noted above for psychostimulants, except that participants were not asked whether these substances were prescribed for them.

2.1.3 Other measures of interest

In addition to basic background variables (e.g., gender, race/ethnicity, GPA), other sets of questions were included to identify additional predictors of non-prescriptive psychostimulant use. Using a scale ranging from 1 (“very little”) to 10 (“very much”), participants reported the extent to which “procrastination or poor time management” affected their overall stress level. Additionally, participants were asked to estimate the percentage of students on campus (ranging from 0-100%) that they thought had *ever used* non-prescribed Adderall or Ritalin, as well as the percentage of students on campus who they thought had used these substances non-prescriptively *during the past 2 weeks*.

2.2 Chemical sample data

Wastewater samples were collected from an on-campus sampling location representing four residence halls with a known population of 476 undergraduate students. Samples were collected for 72-hour periods at 1-hour intervals; more detailed information about sampling has been reported elsewhere (Burgard, Fuller, Becker, Ferrell, & Dinglasan-Panlilio, 2013). The timing of the wastewater sample collection was coordinated with that of the survey administration, such that samples were obtained at the same three times during the semester as the surveys described above.

Following collection of the samples, wastewater was filtered and the metabolites extracted via solid phase extraction. Quantitative analysis was performed via liquid chromatography tandem mass spectrometry (LC-MS/MS). Recovery was accounted for using methamphetamine-D9 as a method surrogate, and the sample was normalized with creatinine. Following these procedures, the concentrations of amphetamine and ritalinic acid (the metabolites of Adderall/Dexedrine/Vyvanse and Ritalin/Focalin/Concerta, respectively) were obtained and the average concentrations for each of the three sampling periods over the course of the semester were calculated. The final measures for the chemical data are the average concentrations of amphetamine and ritalinic acid (in ng) per mg of creatinine. Additional details on the analysis have been reported by Burgard et al. (2013).

3. Results

3.1 Patterns of psychostimulant use across periods of low vs. high stress

The patterns of use for Adderall (and the related compounds of Vyvanse and Dexedrine) as well as Ritalin (and the related compounds of Focalin and Concerta) were compared across all three assessment periods during the semester.¹ From this point on, the terms *Adderall* and *Ritalin*

¹ A repeated-measures analysis of variance (ANOVA) on self-reported stress level of participants (assessed on a Likert scale from 1 to 10) revealed that stress levels were significantly different across these assessment periods, $F(2, 377) = 143.62, p < 0.001$. Follow-up paired-samples t tests indicated that, as expected, self-reported stress levels were statistically significantly higher at both midterms ($M = 6.88; SD = 1.78$) and before final exams ($M = 6.79; SD = 1.89$), relative to the first week of classes ($M = 4.92; SD = 2.13$).

are used to refer to these different sets of related compounds. Table 1 summarizes the results of the data for both the surveys as well as the unobtrusive chemical sample data.

3.1.1 *Self-report data*

Although the actual frequencies were low (with cell sizes ranging from 5 to 15), the percentage of participants who reported non-prescriptive use of Adderall increased four-fold from the first week of classes to midterms. Similarly, non-prescriptive use was more than 3 times higher at finals vs. the first week of classes. The descriptive results for non-prescriptive use of Ritalin were similar for the first week vs. midterms, revealing a steep increase in the percentage of participants reporting non-prescriptive use. Unlike Adderall, reported non-prescriptive use of Ritalin was only slightly higher at finals vs. the first week of classes. Across all three assessment periods, results for both Adderall and Ritalin revealed very small and relatively stable percentages of participants (< 2%) reporting that they used either class of substances prescriptively, and almost no participants reported that they used Adderall or Ritalin with a prescription but *not* as directed. Throughout the semester, the majority of the participants denied psychostimulant use in the past 2 weeks.

To examine statistically significant differences in non-prescriptive use (relative to non-use) at the high vs. low periods of stress during the semester, a series of McNemar's exact tests (McNemar, 1947) were conducted. McNemar's exact test is a nonparametric test, specifically designed to examine differences between correlated proportions or percentages. Similar in some respects to 2x2 Chi-square test (used for *independent* observations), McNemar's test is appropriate for paired categorical data where any of the cell sizes are small ($n < 5$; Conover, 1999; Daniel, 1990; McNemar, 1947). Results of these tests revealed that non-prescriptive use (relative to non-use) was significantly higher for both Adderall ($p = 0.004$) and Ritalin ($p = 0.002$) at midterms vs. the first week of classes. Although non-prescriptive use of Adderall was higher at finals vs. the first week of the semester, this difference was not statistically significant with a two-tailed alpha level of 0.05.

3.1.2 *Chemical sample data*

As shown in Table 1, the average concentration of amphetamine (AMP) was over 3 times higher at midterm vs. the first week of classes, while the average concentration at finals was 1.5 times higher than at the first week. The average concentration of ritalinic acid (RIT) was nearly 5 times higher at midterms and more than 8 times higher at finals, relative to the first week. Paired-samples *t* tests indicated that each of these four contrasts were statistically significantly different (*t* values ranged from -10.61 to -26.63, with all $ps < 0.01$).

Of note, the data reported above and in Table 1 for the average metabolite concentrations include only estimates of analytical uncertainty. The field of "wastewater epidemiology" for detection of drug use is less than ten years old and recent research in this field suggests that sampling uncertainty should also be considered (Mathieu, Rickermann, Berset, Schürch, & Brenneisen, 2011; Ort, Lawrence, Reungoat, & Mueller, 2010; Ort, Lawrence, Rickermann, & Joss, 2010). Although often more difficult to quantify than the drug levels themselves, determining sampling uncertainty gets at the question of the representativeness of the samples obtained and what target substances may potentially be missed in the course of the sampling procedure. The maximum sampling uncertainty for the chemical data in the present study is detailed elsewhere (Burgard et al., 2013). While there is reason to think that the true level of

sampling uncertainty in the present study is less than this maximum amount², if we apply these maximally conservative estimates, the results of the chemical sample data still indicate statistically higher concentrations of both AMP and RIT at midterms vs. the first week of the semester. For comparison between the original and maximum levels of uncertainty, two sets of error bars are included in Figure 1, which depicts the average concentrations of AMP and RIT for all three periods of assessment.

3.2 Self-reported lifetime substance use

The survey results for lifetime substance use (Figure 2) reveal that the most common substances reported were alcohol and marijuana (78.8% and 50%, respectively), followed by nicotine/tobacco (31.2%). A total of 11.7% reported using Adderall non-prescriptively at some point in their life, followed by 8.5% reporting non-prescriptive use of Ritalin. The lowest lifetime substance use rate was cocaine (7%).

3.3 Predictors of lifetime non-prescriptive psychostimulant use

Logistic regression was used to examine predictors of having ever used non-prescriptive ADHD medication (relative to reporting having never used psychostimulants). A stepwise analysis (summarized in Table 2) was conducted in order to examine the incremental contribution of specific variables. In Step 1, five demographic variables were entered into the equation: gender, race/ethnicity, parents' education level (as a rough proxy of SES), cumulative GPA, and Greek membership. At this stage, these variables accounted for roughly 3% of the variance, with lower GPA emerging as the only statistically significant predictor of non-prescriptive use ($p < 0.01$). In Step 2, procrastination/poor time management accounted for an additional 3% of the variance and was a significant predictor ($p < 0.01$). The extent to which participants perceived non-prescriptive psychostimulant use as normative (added in Step 3) robustly predicted non-prescriptive use ($p < 0.001$) and accounted for a significant incremental proportion of variance ($R^2 = .129$). Finally, in Step 4, use of other substances was added. In this final step, the entire set of variables accounted for a nearly 30% of the variance in lifetime non-prescriptive psychostimulant use ($R^2 = .297$). Use of all of the substances *except* marijuana significantly predicted non-prescriptive use of psychostimulants ($ps < 0.01$). In the final regression equation, the perception of non-prescriptive psychostimulant use as normative remained a significant predictor ($p < 0.01$), while procrastination/poor time management was marginally significant ($p < .10$).

4. Discussion

4.1 Patterns of psychostimulant use

² This is related to the fact that the estimate of maximum sampling uncertainty is based on the assumption that the observed increases in AMP and RIT are accounted for solely by *prescribed* use of psychostimulants among the students living in the dorms represented by the wastewater samples. Given the close correspondence between the trends of wastewater sampling and self-reported *non-prescriptive* psychostimulant use in the present study, this assumption seems too conservative in this case.

The results of the present study generally revealed increased use at high- vs. low-stress periods during the semester, with significantly higher self-reported non-prescriptive use at midterms vs. the first week of classes for both Adderall and Ritalin. The wastewater analysis indicated higher average concentrations of both AMP and RIT at midterms and finals (relative to baseline). When factoring in the maximum degree of potential sampling uncertainty, the differences between first week and midterms remained significant, indicating that we can have the greatest confidence that the average concentrations at these two assessment periods were different.

Although this is the first study of which we are aware to examine psychostimulant use longitudinally over the course of a semester, the results of the present study are consistent with reports from popular media indicating that college students may be more likely to use psychostimulants as “academic steroids” during periods of higher stress (DeSantis et al., 2008; Robach, 2011). Our findings are also generally consistent with previous research examining prevalence of psychostimulant use on college campuses (Johnston, O’Malley, Bachman, & Schulenberg, 2012; McCabe et al., 2005; McCabe et al., 2006; Teter et al., 2005; Teter, McCabe, LaGrange, Cranford, & Boyd, 2006).

In contrast to the Adderall findings, which showed remarkably close correspondence between self-report and the chemical sample data in the observed trends, the results for Ritalin showed somewhat less correspondence, at least for the assessment right before final exams. This could indicate that Ritalin use is not as closely connected to academic stress, relative to Adderall. Alternatively, the highest concentration of RIT at finals could potentially be accounted for by high-dosage use by a smaller number of participants at this assessment period.

When considering the findings in this study of increased psychostimulant use during periods of higher stress later in the semester (midterms and finals), an alternative interpretation of these data is worth mentioning. Since the only low-stress period of data collection (at least for self-report data) occurred at the beginning of the semester, this leaves open the possibility that the higher use of psychostimulants later in the semester could be accounted for, at least in part, by increased access to these substances as the semester progressed, as opposed to higher stress, *per se*. In other words, during the first week of classes—relative to later in the semester—fewer students on campus may have known where (or from whom) to obtain non-prescriptive psychostimulants. Although additional survey data were not available at any additional low-stress period besides the first week of classes, we would note that chemical sampling data collected during the week *following* midterms—a low-stress period later in the semester—revealed trends that were fully consistent with the findings reported in this study for Adderall, suggesting a drop in use of this drug, on par with the level observed during the first week of classes (these findings are reported by Burgard et al., 2013). Also consistent with the findings reported here, data collected on the concentration of ritalinic acid over the course of two semesters indicated that Ritalin use did not show a consistent pattern as a function of stress (Burgard et al., 2013). Taken together, these findings suggest that higher psychostimulant use, at least for Adderall and related compounds, was indeed related to higher academic stress, as opposed to merely increased access to non-prescriptive psychostimulants later in the semester. Nevertheless, it would be helpful for future studies to include both self-report and chemical sampling data at additional low-stress data collection periods besides the first week of classes to provide further evidence for the unique association between academic stress and psychostimulant use.

4.2 Lifetime and current non-prescriptive use rates

The lifetime non-prescriptive use rates of Adderall and Ritalin in this study were fairly comparable to previous estimates (Johnston et al., 2012; McCabe et al., 2005; McCabe et al., 2006; Teter et al., 2005; Teter et al., 2006). However, the reported lifetime non-prescriptive use rates were notably higher than the current non-prescriptive use rates in this study, even at the high-stress periods, which could indicate some degree of selective under-reporting of *current* psychostimulant use on the collected surveys. Alternatively, it could be that some of the non-prescriptive users were lost to attrition. It is possible that a high proportion of college students have tried psychostimulants non-prescriptively, but further research is needed to ascertain the prevalence of “single-trial” users, compared to individuals who engage in chronic non-prescriptive psychostimulant use.

4.3 Predictors of non-prescriptive psychostimulant use

In contrast to some previous research (Herman-Stahl, Krebs, Kroutil, & Heller, 2007; McCabe et al., 2005; McCabe et al., 2006; SAMHSA, 2012; Teter et al., 2006), demographic variables did not emerge as strong predictors of non-prescriptive psychostimulant use in the present study. This discrepancy may be due to the limited variability of the sample for some of these variables, as well as the fact that the study was conducted solely in the context of a liberal arts college.

Consistent with previous research (Arria et al., 2008; Herman-Stahl et al., 2007; McCabe et al., 2005; SAMHSA, 2012), participants who reported using other substances (i.e., nicotine/tobacco, alcohol, and cocaine) were more likely to report lifetime non-prescriptive psychostimulant use (relative to non-users). In contrast to some previous findings (Arria et al., 2008; Arria et al., 2012; DeSantis, Noar, & Webb, 2009; Herman-Stahl et al., 2007; McCabe et al., 2005), marijuana use was not a significant predictor of lifetime non-prescriptive psychostimulant use.

This study revealed two other predictors of lifetime non-prescriptive psychostimulant use, namely procrastination/poor time management (as a reported source of stress) and the perception of non-prescriptive psychostimulant use as normative on campus. Both of these variables accounted for a substantial proportion of variance beyond demographic variables, and both could have important implications for prevention and intervention programs targeting non-prescriptive psychostimulant use among college students. The latter normative-perception finding is consistent with the *false-consensus effect* (Bauman & Geher, 2002; Marks & Miller, 1987), whereby an individual's overestimation of the extent to which others are engaging in a particular behavior increases the likelihood of engaging in this same behavior. An alternative interpretation of this latter finding is that, at least for some participants, the reported prevalence of non-prescriptive psychostimulant use on campus could potentially reflect an *accurate* perception of use within those students' social networks, if the level of drug use is high among these respondents' group of friends and acquaintances. Further research is needed to clarify the extent to which the perception of non-prescriptive psychostimulant use on campus reflects global, inflated prevalence estimates, as opposed to accurate, “local” ones, based on observations of drug usage for one's social group.

Given the correlational nature of the data in this study, we cannot conclude that there is necessarily a causal relationship between either of the two predictors noted above and non-prescriptive psychostimulant use. However, further research is warranted to examine the potential mechanisms of association for these variables. For example, it would be helpful to identify what factors might determine whether procrastinating students turn to psychostimulants as a way to cope, and to examine whether attempts to improve time management may decrease the risk for psychostimulant abuse. Similarly, if further research confirms the importance of the false-consensus effect in non-prescriptive psychostimulant use, this would suggest that educating college students regarding the actual rates of non-prescriptive psychostimulant and disabusing them of inflated perceptions of this behavior's occurrence might help to curb non-prescriptive psychostimulant use.

4.4 Limitations of the study

There are several limitations of this study. First, the fact that the sample was unrepresentative of the broader population of college students in some respects (particularly gender and ethnic composition) raises questions about the generalizability of these findings. Second, although the overall sample of survey respondents was relatively large, the limited number of participants who reported current non-prescriptive psychostimulant use at each of the three assessment periods precluded prediction of *current* use rates over time. Similarly, despite increases in reported non-prescriptive use of more than 300% from the low-stress baseline during the first week of classes to the follow-up assessment(s) at midterm and/or final exams, these high-percentage increases reflected very small increases in terms of actual *numbers* of participants. Although analyses specifically designed for small cell sizes enabled significance testing, larger cell sizes would undoubtedly inspire greater confidence in the observed trends of non-prescriptive psychostimulant use. Lastly, despite the advantages for the chemical sample data of not being susceptible to self-report bias, one limitation of these data in particular is that they are unable to provide specific information on frequency or dosage of use for the substances detected.

5. Conclusions

To our knowledge, this is the first study that has employed both self-report and unobtrusive chemical sample data to examine psychostimulant use longitudinally over the course of a semester during periods of low and high academic stress. As such, despite the limitations of the study, we believe that this preliminary investigation highlights the value of utilizing an interdisciplinary, multi-method approach to study psychostimulant use, especially among college students. Although additional research is clearly needed with larger and more diverse samples, this investigation offers an integrative model for future research on this topic, which we hope will advance our knowledge of psychostimulant use among college students and also guide research on prevention/intervention programs designed to address psychostimulant misuse and abuse among this population.

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Table 1 Current Adderall & Ritalin Use Across all 3 Assessment Periods
Based on Self-Report & Unobtrusive Chemical Sample Data

Dependent Variable	Time of Assessment		
	1 st Week	Midterms	Finals
	% (<i>n</i>)	% (<i>n</i>)	% (<i>n</i>)
Adderall Use			
Non-prescriptive use	0.8% (5)	3.2% (15)	2.8% (11)
Prescribed as directed	1.8% (11)	1.5% (7)	1.3% (5)
Prescribed but not taken as directed	0.0% (0)	0.0% (0)	.3% (1)
Non-use	97.4% (609)	95.3% (448)	95.7% (376)
Ritalin Use			
Non-prescriptive use	.3% (2)	3.4% (16)	.8% (3)
Prescribed as directed	1.3% (8)	1.1% (5)	.8% (3)
Prescribed but not taken as directed	0.0% (0)	.2% (1)	.3% (1)
Non-use	98.4% (614)	98.1% (459)	98.2% (385)
Chemical Sample Data			
ng AMP/mg Creatinine	ng/mg (<i>SD</i>) 74 (7)	ng /mg (<i>SD</i>) 240 (60)	ng /mg (<i>SD</i>) 111 (6)
ng RIT / mg Creatinine	36 (4)	170 (40)	310 (40)

Note. Assessment periods: 1st week of classes, at midterm, and immediately before final exams. Chemical samples were obtained from campus wastewater collected for 72 hours during the same periods as survey data collection.

AMP = amphetamine, the metabolite of Adderall/Dexedrine/Vyvanse. RIT = ritalinic acid, the metabolite of Ritalin/Focalin/Concerta.

Table 2:

Logistic Regression Analysis Results: Prediction of Lifetime Non-Prescriptive Psychostimulant Use

<i>Predictors</i>	Have ever used Non-Rx Psychostimulants (<i>n</i> = 89) vs. Never used Psychostimulants (<i>n</i> = 513)					<i>R</i> ²
	<i>B</i>	<i>SE</i>	<i>Wald</i>	<i>Exp(B)</i>	<i>95% CI</i>	
Step 1						.032
Gender	-.28	.24	1.41	.75	.47 to 1.20	
Race/Ethnicity	-.18	.32	.31	.84	.64 to 2.21	
Parents' Education	.14	.08	2.83 [†]	1.15	.98 to 1.35	
GPA	-.53	.22	5.55**	.59	.38 to .92	
Greek Membership	.08	.32	.06	1.08	.50 to 1.73	
Step 2						.059
<i>Added:</i> Procrastination/Poor Time Management	.15	.05	9.04**	1.16	1.05 to 1.28	
Step 3						.129
<i>Added:</i> Perception of Campus Non-Rx Psychostimulant Use as Normative	.60	.12	25.16***	1.82	1.44 to 2.29	
Step 4						.297
Gender	.17	.29	.36	1.19	.68 to 2.08	
Race/Ethnicity	.14	.36	.17	1.16	.58 to 2.32	
Parents' Education	.08	.10	.77	1.09	.90 to 1.32	
GPA	-.29	.28	1.10	.75	.44 to 1.28	
Greek Membership	-.47	.37	1.59	.63	.30 to 1.30	
Procrastination/Poor Time Management	.10	.06	3.29 [†]	1.11	.99 to 1.24	
Perception of Campus Non-Rx Psychostimulant Use as Normative	.38	.13	8.46**	1.47	1.13 to 1.90	
<i>Added: Use of Other Substances</i>						
Nicotine/Tobacco Use	.27	.10	8.13**	1.31	1.09 to 1.58	
Alcohol Use	.36	.13	7.23**	1.44	1.10 to 1.89	
Marijuana Use	.07	.10	.54	1.08	.89 to 1.31	
Cocaine Use	.59	.19	9.48**	1.81	1.24 to 2.64	

Note. The formula for the Wald statistic is $(B/SE)^2$ and is a test of significance based on a Chi-Square distribution. *Exp(B)* is the odds ratio. *95% CI* = 95% Confidence Interval for *Exp(B)*. Each predictor has 1 *df*. *R*² = Nagelkerke *R*².

† *p* < .10 * *p* < .05 ** *p* < .01 *** *p* < .001

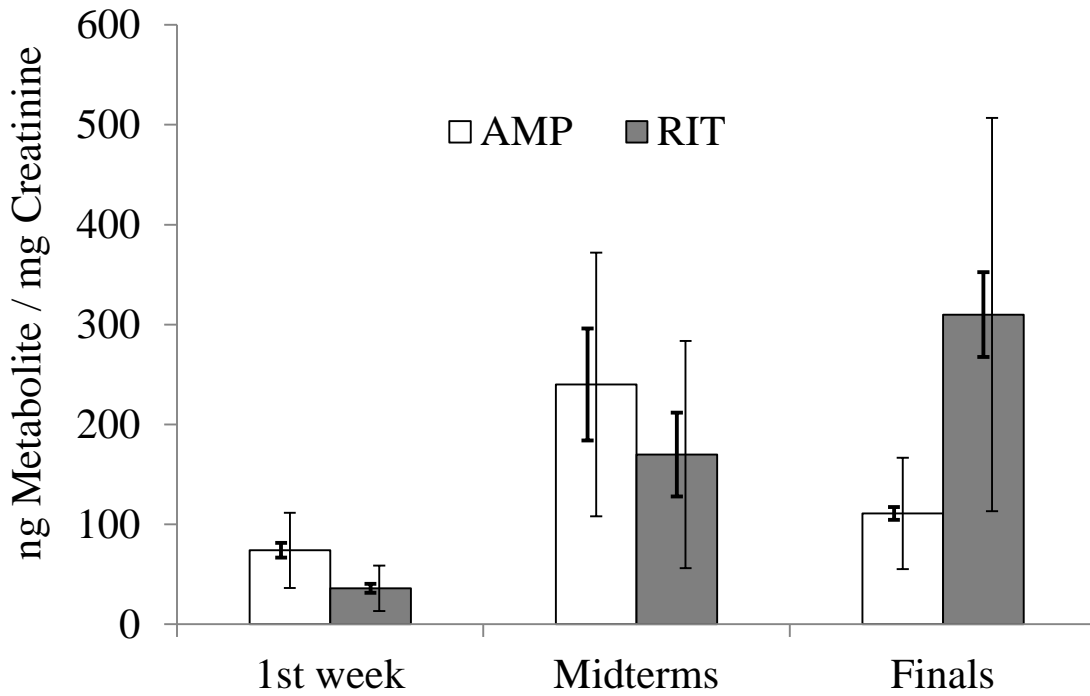


Figure 1

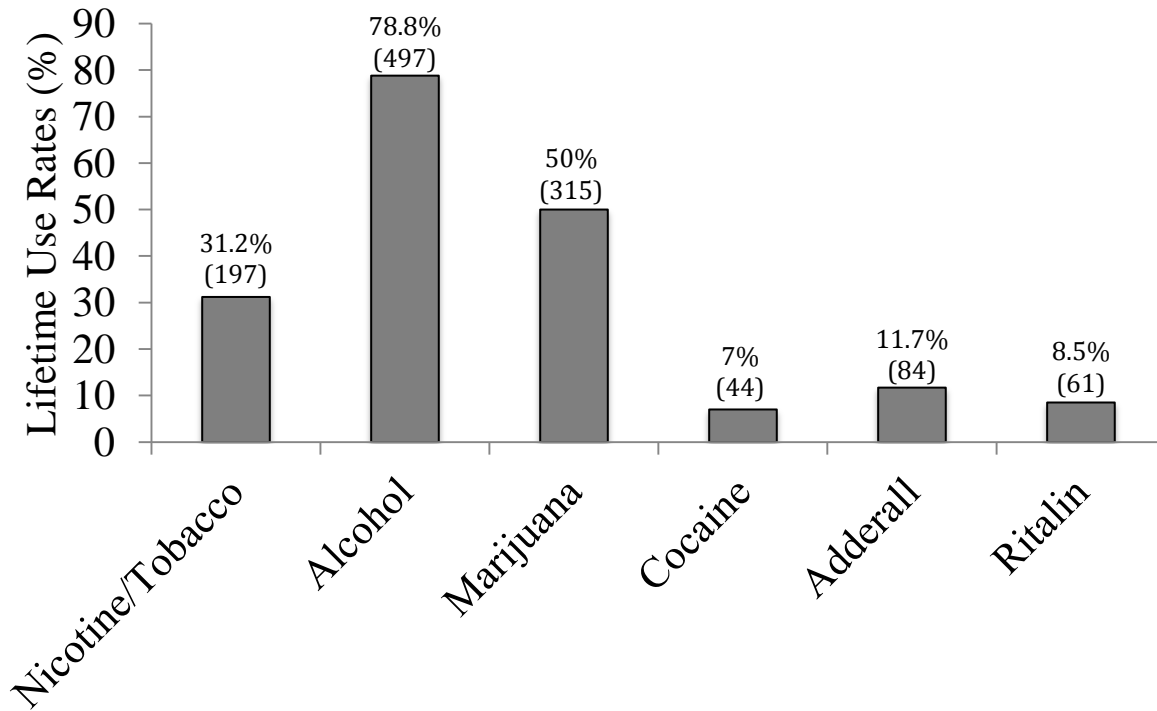


Figure 2

Figure 1 Average concentrations of amphetamine (AMP) and ritalinic acid (RIT) for the first week of classes, midterms, and the week before final exams. Two sets of error bars are included to denote the original standard deviations (*SDs*, left and bold) in the data and the maximum *SDs* (on the right) when factoring in the highest possible level of sampling uncertainty from the wastewater analysis.

Figure 2 Percentages and frequencies of self-reported lifetime substance use and non-prescriptive use for Adderall and Ritalin.