

## Developmental Psychology

# Sexual Behavior and Substance Use in Adolescence and Young Adulthood: Non-specific Associations Between a Range of Sexual Behaviors and Alcohol, Nicotine, and Marijuana Use

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Sexual behaviors and substance use exhibit high rates of co-occurrence and similar patterns of age-related change, with typical initiation in middle adolescence followed by large increases in late adolescence and emerging adulthood. Because adolescent sexual behaviors are associated with negative health consequences including sexually-transmitted infections and substance use, adolescent sexual behaviors are often conceptualized within a health-risk framework. Sexual development, however, is a normative process important for healthy psychosocial adjustment, with the timing (early vs later initiation) and context (casual vs romantic partner) of sexual behaviors influencing their association with health risks. We tested whether seven common sexual behaviors could be conceptualized as markers along a continuum of sexual development (e.g., from kissing and making out to oral, vaginal, and anal sex) and then examined their associations with various measures of substance use in a sample of adolescents and young adults ( $N = 626$ ; ages 13-22 years old). We found a 2-parameter logistic item response theory model provided a good fit to the prevalence and covariance among the sexual behaviors, with each behavior holding a different location on a trait representing the progression of sexual development. Each sexual behavior was associated with greater substance use even after adjusting for an early initiation of sexual behavior, current age, biological sex, and socioeconomic status. The results indicate that even normative sexual behaviors have strong and non-specific associations with substance use in adolescence and emerging adulthood.

### Introduction

Participation in romantic and partnered sexual behaviors are normative aspects of psychosocial development that typically emerge in adolescence (Centers for Disease Control and Prevention, 2017; Halpern & Haydon, 2012). Initiation of substance use also most commonly occurs in adolescence followed by substantial increases in regular substance use in late adolescence and emerging adulthood (ages 18-25) (*National Survey of Drug Use and Health*, 2020; Young et al., 2002). Engagement in sexual behaviors is strongly associated with substance use, and this co-occurrence persists over time, indicative of co-developmental processes between sexual and substance use behaviors (Armour & Haynie, 2006). These behaviors emerge alongside significant neurobiological and psychosocial changes (Crone & Dahl, 2012; Suleiman et al., 2017), suggesting potential

bidirectional associations between normative adolescent development and health-risk behaviors like sexual intercourse and substance use. Here, we examine the associations between a variety of sexual behaviors and forms of substance use in adolescence and emerging adulthood.

### Adolescent Sexual Development

Participation in sexual behavior is an important component of pubertal and social development during adolescence, exhibiting normative age-related trends within a given sociocultural context. In the United States, 11-16% of 15 year olds report having engaged in sexual intercourse, which increases to about 41% by age 17 and 55-72% by age 18 (Centers for Disease Control and Prevention, 2017; Halpern & Haydon, 2012). Given that more young people report having engaged in sexual intercourse by age 18 than not, adolescent sexual behaviors are increasingly concep-

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tualized within a sex-positive framework that views sexuality as a normal and healthy developmental process in adolescence and emerging adulthood (Harden, 2014; Tolman & McClelland, 2011). Under this framework, sexual debut occurring at about ages 16–20 years old can be considered developmentally normative, especially in the context of an intimate or sexually exclusive relationship (Centers for Disease Control and Prevention, 2017; Halpern & Haydon, 2012; Harden, 2014; Zimmer-Gembeck & Helfand, 2008). Most studies examining the associations between normative sexual behaviors (e.g., dating, non-penetrative partnered sexual behavior, and normative timing of sexual intercourse) and negative health and behavioral outcomes have found only weak associations (Harden, 2014). In fact, there is some evidence that initiating sexual behavior later than age 15 is associated with better psychosocial adjustment such as more positive peer relationships and attitudes about school relative initiating at earlier ages (Bouchey & Furman, 2003; Golden et al., 2016; Zimmer-Gembeck & Helfand, 2008).

This sex-positive perspective is in contrast to a health-risk or deviancy model that conceptualizes adolescent sexual behavior as similar to other forms of non-normative or socially undesirable behaviors such as substance use and delinquency (Jessor et al., 1991; Jessor & Jessor, 1977; Tolman & McClelland, 2011). The conceptualization of adolescent sexual behavior within a deviancy framework is primarily due to the consistent associations between the early initiation of sexual intercourse (i.e., before age 15) and risky sexual behaviors (e.g., non-condom use) and negative health consequences (e.g., sexually transmitted infections, unwanted pregnancy) and adjustment problems (e.g., substance use, mental health problems, school problems) (Armour & Haynie, 2006; Cornelius et al., 2007). This association has been consistently replicated, and poses a concern for parents and health professionals alike.

There is some tension between the sex-positive and health-risk perspectives of adolescent sexuality in regards to what behaviors are considered normal and at what age. Importantly, adolescent sexuality entails a variety of behaviors and experiences other than heterosexual penile-vaginal intercourse, and the timing of when these behaviors emerge may help account for why the associations between adolescent sexual behavior and negative outcomes changes over time (Hensel & Fortenberry, 2014; O'Sullivan & Thompson, 2014). For example, most existing studies of adolescent sexual development focus on the early initiation of sexual intercourse, but fail to consider other relevant sexual behaviors and the developmental progression of sexuality more generally.

Recently, we showed that item response theory (IRT) models can be used to operationalize a conceptualization of adolescent sexual behaviors as existing along a continuum of “difficulty” defined by their prevalence, providing a quantitative measure of an individual’s level of sexual development (Clark et al., 2020). That is, less mature sexual behaviors such as kissing, petting, and dry sex will have lower difficulty values relative to more mature sexual behaviors that tend to occur at later ages such as oral, vaginal, and anal sex (Carver et al., 2003; Clark et al., 2020). For example, dating and kissing are relatively frequent romantic

behaviors by middle adolescence and have been associated with positive behavioral correlates (Carver et al., 2003). Thus, it may be that precocious engagement in more difficult sexual behaviors accounts for the associations between adolescent sexual behaviors and poor adjustment.

## Adolescent Substance Use

Substance use is another class of behaviors that tend to emerge in middle adolescence and are considered socially undesirable until adulthood. Common substances include tobacco, alcohol, and marijuana, with as high as 42% of U.S. high school students having used e-cigarettes, 36% having used marijuana, and 30% actively drinking alcohol in 2019 (Centers for Disease Control and Prevention, 2020). As with sexual behavior, it is important to consider age at first use of a substance and frequency of use. Regular use of a substance before age 18 is relatively rare and much less common than simply having ever tried a substance and occasional use (*National Survey of Drug Use and Health*, 2020; Young et al., 2002). For example, about 58% of 15 year-olds who have used alcohol report having only 1 to 5 alcoholic drinks in their lifetime (Young et al., 2002). Consistent with findings for an early sexual debut, an early initiation of substance use is associated with more risk factors such as conduct problems and environmental risk factors, and a higher likelihood of negative adult outcomes such as substance use disorders (Babor et al., 1992; Lewinsohn et al., 1996; McGue et al., 2001). Early sexual debut and early initiation of substance use are associated with similar risk factors, which might account for their co-occurrence. That is, sexual behaviors per se may not have a causal influence on substance use and vice versa, but rather may be common outcomes of broader developmental processes such as behavioral disinhibition (McGue et al., 2006; McGue & Iacono, 2005).

## Current Study

We examined a number of aspects of the associations between several normative sexual behaviors and substance use in a sample of adolescents and young adults (ages 13–22 years old). First, we fit an IRT model to account for the prevalence and covariance of seven common sexual behaviors (kissing, making out, petting or dry sex, penetration with fingers or sex toys, oral sex, vaginal sex, and anal sex) that varied in their difficulty or maturity along a continuum of sexual development.

Next, we tested whether these sexual behaviors were associated with several measures of substance use including alcohol, nicotine, marijuana, other drug use, and general substance use. Here, we were interested in whether more normative or low difficulty sexual behaviors (e.g., kissing) were as predictive of substance use as more mature or higher difficulty sexual behaviors (e.g., intercourse). We also examined if there was any specificity to the associations between the seven sexual behaviors and substance use measures, or if the associations were generally consistent across the different sexual behaviors and substance use measures. Also, because an early sexual debut is associated with more risk factors and adjustment problems in adolescence, we included an early age of sexual initiation (oral, vaginal, or anal sex before age 16) in all analyses. Therefore,

a given sexual behavior was only considered to be associated with a substance use measure if it exhibited a significant association above and beyond an early age of sexual initiation.

We also included other demographic variables in the analyses including age, biological sex, and socioeconomic status (SES). Age was included to rule out the possibility that associations between the sexual behaviors and substance use measures were simply due to the fact that the incidence of sexual behaviors and frequency of substance use increases substantially over the course of adolescence and emerging adulthood (Centers for Disease Control and Prevention, 2017). Biological sex was also included due to mean-level sex differences commonly observed in the use of some substances and findings for sex differences in the incidence and timing of certain sexual behaviors (Halpern & Haydon, 2012). SES was included for similar reasons, that is, differences in substance use and sexual behaviors across SES levels (Halpern & Haydon, 2012). Finally, we tested whether age or biological sex moderated the associations between any of the sexual behaviors and substance use measures, that is, whether the associations differed for younger versus older participants or across men and women (Meschke et al., 2000; Young et al., 2002; Zimmer-Gembeck & Helfand, 2008).

## Methods

### Sample Ascertainment

Data were collected from September 21 through September 29, 2020 using an actively managed, double-opt-in research panel using Qualtrics XM survey software. Recruitment was designed to ascertain a sample with equal representation of biological sex (50% male; 50% female) and age (33% 13-16; 33% 17-19; 33% 20-22) and a race/ethnicity split of 70% White and 30% non-White among people living in the United States. Quotas were created for each variable and monitored while the survey was in the field. Respondents were recruited using a dashboard-style web page on the Qualtrics website and cellphone app where participants see a list of surveys that they have the option to participate in. Recruitment was also conducted through emails sent to established panel members within the Qualtrics database. In all recruitment methods, potential participants received information on the estimated length of the survey and compensation for completing it. Specific details about the survey content were not available until the participants opted-in to avoid self-selection bias. Upon opting into the study, participants read and provided an electronic signature on a consent form containing an overview of the survey contents. Participation was voluntary and anonymous as no individually identifying information was collected. Contact information for the research team was provided if participants had questions about the survey. The University of Michigan Medical School Institutional Review Board reviewed all study protocols. The study design, hypotheses, and analytic plan were not pre-registered.

The survey was completed by 630 respondents. Data was manually checked and four respondents were excluded due to inconsistent and illogical responses, resulting in a final sample size of 626 respondents (312 males, 287 females,

25 that reported non-binary gender, and two that refused to answer). Single measures were excluded on a case by case basis if all other responses from that participant were within a plausible range of values. The final sample included responses from participants aged 13 to 22 years old ( $M = 18.09$  years,  $SD = 2.45$ ). The median response time for completing the survey was 29.8 minutes.

### Demographics

**Table 1** reports the demographic characteristics of the sample, which were close to the set quotas, though some differences occurred in gender and race due to the number of respondents reporting non-binary gender and mixed race. The sample had slightly more male than female participants (49.8% male, 45.8% female). The quota for the age distribution of the sample was met with the three age groups (13-16, 17-19, 20-22) being equal at 33.3%. Ethnicity (16.3% sample vs 18.5% US population Hispanic) and racial representation (73% vs 73.6% White, 9.4% vs. 13.4% Black, 6.9% vs 5.9% Asian, 4.6% vs 2.8% Mixed, 0.6% vs. 2.8% Native American, 5.4% other) in the sample were similar to the U.S. general population (U.S. Census Bureau QuickFacts). The plurality of participants were enrolled in either middle school (2.7%) or high school (42.2%); 38.3% were enrolled in college, and 16.1% of the sample reported not being currently enrolled in school.

Note. The following additional responses were also obtained for gender: 1.0% (6) Trans male/trans man, 0% (0) Trans female/trans woman, 2.7% (17) Gender Queer/Gender Non-Conforming, 0.3% (2) Different identity, 0.3% (2) Refuse to answer

In terms of sexual orientation, nearly two thirds (65.8%) of the participants reported being fully heterosexual. A quarter of the sample endorsed sexual fluidity (12.3% mostly heterosexual; 3.4% mostly homosexual; 9.6% bisexual). Only 3.8% rated their sexual orientation as totally homosexual, and the remainder reported their sexual orientation as questioning (1.9%) or asexual (1.4%), or refused to answer the question (1.8%). Almost half of the respondents reported a household income of under \$50,000 (12% <\$9,999; 11.8% \$10,000-\$24,999; 21.9% \$25,000-\$49,000). A third of the sample reported household income between \$50,000 and \$99,999 (19.3% \$50,000-\$74,999; 12.8% \$75,000-\$99,999), and the remaining 22.2% have an income over \$100,000 (12.6% \$100,000-\$149,999; 5.1% \$150,000-\$199,000; 4.5% \$200,000+). The median household income range was \$50,000-\$74,999, comparative to the U.S. median of \$68,703 (Semega et al., 2020). Given the low age of the sample, over half said that they are not currently working a paid job (52.6% not currently working; 6.4% working full-time; 41% working part-time).

### Measures

**Sexual behaviors.** Participants reported lifetime engagement in seven sexual behaviors (*Yes/No*) including kissing, making out (prolonged hugging and kissing), petting (feeling inside or outside the clothes) or dry sex (thrusting or rubbing your genitals against each other's bodies, but not having sex), partnered penetration with fingers or a sex toy, oral sex (a person puts his/her mouth on another person's

**Table 1. Demographics**

	Total (N = 626) % (n)	Male (n = 312) % (n)	Female (n = 287) % (n)
<b>Age</b>			
13-14	7.5 (47)	6.7 (21)	8.7 (25)
15-16	25.7 (161)	19.9 (62)	29.3 (84)
17-18	22.8 (143)	24.0 (75)	22.6 (65)
19-20	23.4 (147)	24.4 (76)	24.0 (69)
21-22	20.4 (128)	25.0 (78)	15.3 (44)
<b>Race</b>			
White	76.5 (479)	87.8 (274)	63.8 (183)
Black	11.2 (70)	5.4 (17)	17.4 (50)
Native American	1.8 (11)	1.0 (3)	2.1 (6)
Asian	9.9 (52)	4.8 (15)	11.8 (34)
Native Hawaiian	2.1 (11)	1.3 (4)	2.4 (7)
Don't know	1.0 (5)	0 (0)	1.4 (4)
Some other race	5.7 (30)	2.6 (8)	21 (7.3)
Hispanic- any race	16.3 (86)	7.4 (23)	20.6 (59)
<b>Current Education Level</b>			
7 <sup>th</sup> - 8 <sup>th</sup> grade	2.7 (17)	1.9 (6)	3.5 (10)
9 <sup>th</sup> - 10 <sup>th</sup> grade	15.3 (96)	16.3 (51)	14.3 (41)
11 <sup>th</sup> - 12 <sup>th</sup> grade	27.5 (172)	21.5 (67)	32.1 (92)
1 <sup>st</sup> - 2 <sup>nd</sup> year of college	22.8 (143)	23.1 (72)	23.7 (68)
3 <sup>rd</sup> - 4 <sup>th</sup> year of college	12.8 (80)	14.7 (46)	11.5 (33)
Beyond 4 <sup>th</sup> year of college	2.7 (17)	3.8 (12)	1.7 (5)
Not currently enrolled in school	16.1 (101)	18.6 (58)	13.2 (38)
<b>Sexual Orientation</b>			
100% Heterosexual	65.8 (412)	77.9 (243)	58.2 (167)
Mostly heterosexual	12.3 (77)	9.0 (28)	16.4 (47)
Bisexual	9.6 (60)	3.8 (12)	13.6 (39)
Mostly homosexual	3.4 (21)	2.2 (7)	3.1 (9)
100% Homosexual	3.8 (24)	3.8 (12)	3.5 (10)
Questioning	1.9 (12)	1.0 (3)	2.4 (7)
Asexual	1.4 (9)	0.6 (2)	1.4 (4)
Refuse to answer	1.8 (11)	1.6 (5)	1.4 (4)
<b>Annual Household Income</b>			
\$0-9,999	12.0 (75)	9.9 (31)	13.2 (38)
\$10,000-\$24,999	11.8 (74)	9.9 (31)	13.6 (39)
\$25,000-49,999	21.9 (137)	21.2 (66)	23.7 (68)
\$50,000-74,999	19.3 (121)	17.6 (55)	20.6 (59)
\$75,000-99,999	12.8 (80)	15.1 (47)	10.8 (31)
\$100,000-149,999	12.6 (79)	15.1 (47)	9.8 (28)
\$150,000-199,999	5.1 (32)	6.4 (20)	3.8 (11)
\$200,000+	4.5 (28)	4.8 (15)	4.5 (13)
<b>Hours Worked/Week</b>			
<5 hours	6.5 (41)	8.7 (27)	4.5 (13)
6-10 hours	8.8 (55)	7.1 (22)	11.5 (33)
11-15 hours	7.3 (46)	8.0 (25)	6.6 (19)

	Total (N = 626) % (n)	Male (n = 312) % (n)	Female (n = 287) % (n)
16-20 hours	8.8 (55)	8.3 (26)	9.8 (28)
21-25 hours	5.0 (31)	5.4 (17)	4.9 (14)
26-30 hours	4.6 (29)	4.5 (14)	4.5 (13)
>30 hours	6.4 (40)	8.3 (26)	4.9 (14)
Not currently working at a paid job	52.6 (329)	49.7 (155)	53.3 (153)

Note. The following additional responses were also obtained for gender: 1.0% (6) Trans male/trans man, 0% (0) Trans female/trans woman, 2.7% (17) Gender Queer/Gender Non-Forming, 0.3% (2) Different identity, 0.3% (2) Refuse to answer

sex organs), vaginal intercourse (inserting the penis into a vagina), and anal intercourse (penetration of the anus). A count of the number of sexual behaviors a participant reported engaging in was also calculated. Participants who reported engaging in oral, vaginal, and/or anal sex also reported the age they first engaged in that behavior. An *early age of sexual initiation* was defined as engaging in oral, vaginal, or anal sex before age 16 years-old (0 = no, 1 = yes).

**SES.** The mean z-score of mother's highest education level, father's highest education level, and total family income was used to calculate an SES variable.

**Nicotine use.** Participants reported frequency of smoking cigarettes, using smokeless tobacco, or e-cigarettes (*Never, once or twice, occasionally but not regularly, regularly in the past, regularly now*). Response options "*regularly in the past*" and "*regularly now*" were coded the same for the analyses. We utilized a single nicotine use variable which was the respondent's highest frequency reported among the three nicotine questions.

**Alcohol use.** Alcohol use was assessed using reports of the number of lifetime occasions of drinking alcoholic beverages (more than a sip) (*0, 1-2, 3-5, 6-9, 10-19, 20-39, 40 or more*), number of lifetime binges defined as consuming 5 or more standard drinks in a row (*0, 1-2, 3-5, 6-9, 10-19, 20-39, 40 or more*), and the greatest number of drinks consumed in a 24 hour period (*0, 1-2, 3-5, 6-9, 10-19, 20-39, 40 or more*). The mean z-score of the three alcohol consumption variables was used to calculate an alcohol use composite (mean  $r = .59$ ).

**Marijuana use.** Participants reported how many occasions they had used marijuana or hashish in their lifetime (*0, 1-2, 3-5, 6-9, 10-19, 20-39, 40 or more*).

**Other drugs and number of substances used.** Participants reported if they had ever used a variety of non-prescription drugs classes including *amphetamines, methamphetamine, sedatives, tranquilizers, cocaine, opiates, MDMA, PCP, psychedelics, inhalants, anabolic steroids, ketamine, cold or cough medicine*. We calculated a count variable of the number of different substance classes the participants had ever used (*nicotine, alcohol, marijuana, 15 non-prescription drugs*; range 0 to 7 or more).

**Substance use factor scores.** We also derived an aggregate measure of substance use by fitting a single-factor confirmatory factor analytic model (CFA) to the covariance among the nicotine use, alcohol use, and marijuana use variables. In this model, the latent substance use factor mean was fixed to 0, and the factor variance was fixed to

1. The model was fully saturated (i.e., degrees of freedom = 0) so that it provides a perfect fit to the data. The standardized factor loadings were  $\lambda = .79, .74, \text{ and } .80$  for nicotine, alcohol, and marijuana use, respectively. Factor scores were generated from this model using maximum a posteriori scoring (MacCallum, 2009).

### Data Analytic Strategy

First, the seven sexual behaviors were used as indicators of a latent factor in a 2 parameter logistic (i.e., 2PL) IRT model (de de Ayala, 2009). In these models, the latent sexual propensity trait was placed on a standard metric with a mean of 0 and variance of 1. The two parameters refer to discrimination and difficulty. The discrimination or *a* parameters are the maximum slope of an item's response function (i.e., the probability of endorsement given a person's level of the latent trait) and is analogous to the factor loadings in a CFA, and indexes how well a given behavior differentiates between persons higher or lower on the latent sexual propensity trait (i.e., their level of sexual behavioral development). To facilitate interpretability, discrimination values were converted into standardized factor loadings (de de Ayala, 2009). The difficulty or *b* parameters are reported in a z-score metric and denote the point along the latent continuum at which the endorsement likelihood of a given behavior is 50%. Put another way, youth with factor scores above the difficulty value are more than 50% likely to endorse a given behavior and vice versa.

The next set of analyses were a series of multiple regression models. Separate regression models were fit for each sexual behavior and substance use measure, wherein the substance use outcome was regressed on a given sexual behavior, early sexual initiation, age, biological sex, SES, and four interaction terms. The interaction terms included sexual behavior x age, sexual behavior x biological sex, age x biological sex and the three-way interaction term of sexual behavior x age x biological sex. Age was grand mean centered prior to the computation of the interaction terms (the other variables included in interaction terms were dichotomous). Biological sex was coded 0 = female, 1 = male. Early sexual initiation was included as a covariate to adjust for the fact that early initiation of sexual intercourse is specifically associated with substance use. All models were fit in Mplus version 8.4 (Muthén & Muthén, 2020) using full information maximum likelihood estimation. Confidence intervals were derived via nonparametric percentile boot-

strapping (1000 draws), which provides reliable assessments of parameter estimate precision across a variety of data conditions (Falk, 2018). We used  $p < .005$  for our threshold of statistical significance to reduce the probability of false positives given the number of statistical tests and to focus on the most robust and reliable effects. Model estimation was facilitated by the Mplus Automation Package (Hallquist & Wiley, 2018) in R (R Core Team, 2019) was also used to facilitate the analyses.

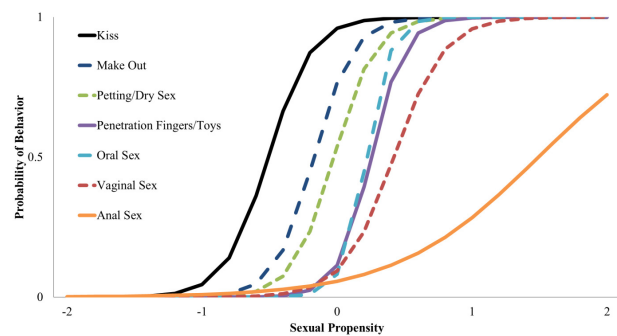
## Results

The lifetime prevalence of the sexual and substance use behaviors by age and gender are shown in Table 2, and correlations among the study variables are reported in Table 3 (see [https://osf.io/hfwyg/?view\\_only=6985a5d5305b42198d6ac5912ac5b3df](https://osf.io/hfwyg/?view_only=6985a5d5305b42198d6ac5912ac5b3df) for full data set). Age was moderately correlated with each sexual behavior ( $r$ 's = .18 to .38) such that less mature sexual behaviors (i.e., kissing, petting/dry sex, and sexual penetration) were more prevalent at an early age than more mature sexual behaviors (i.e., oral, vaginal, and anal sex). For example, among participants 13-14 years-old, over 50% of males and 30% of females had kissed, while only 14.3% of males and 4% of females had engaged in oral sex. However, nearly half of males and over one third of females 17-18 years-old had participated in oral sex. Sex differences in the prevalence of sexual behaviors were relatively small ( $r$ 's = .01 to .10), with the largest sex difference observed for oral sex (46.5% and 38.7% for males and females, respectively). These sex differences may have been due to the slightly lower mean age of female relative to male participants (Cohen's  $d = -0.28$ ). SES had small negative correlations with the sexual behaviors ( $r$ 's = -.05 to -.15) and substance use measures ( $r$ 's = .00 to -.15).

The correlations among the sexual behaviors were moderate to large in size ( $r$ 's = .25 to .84)<sup>1</sup>. Correlations among the substance use measures were large ( $r$ 's = .58 to .79). Correlations among the sexual behaviors and substance use measures were smaller but still at least moderate in size ( $r$ 's = .23 to .49), and relatively consistent across the different sexual behaviors and substance use measures.

### IRT model parameters of Sexual Behaviors

Estimates of the item parameters and information/reliability values at selected levels of the latent trait for each sexual behavior can be found in Table 4 and graphs of the item characteristic curve for each sexual behavior are provided in Figure 1 (see [https://osf.io/hfwyg/?view\\_only=6985a5d5305b42198d6ac5912ac5b3df](https://osf.io/hfwyg/?view_only=6985a5d5305b42198d6ac5912ac5b3df) for R scripts). The sexual behaviors were all highly discriminating of the propensity to participate in partnered sexual behaviors (all discrimination values above  $a = 1.00$ ; factor loadings above  $\lambda = .70$ ), indicating a high degree of covariation among behaviors. Estimates of the difficulty parameters steadily increased



**Figure 1. Item Characteristic Curves for Sexual Behaviors from 2PL Item Response Model.**

Sexual propensity factor scores on X axis in standard deviation units, probability of endorsement on Y axis.

from the “easiest” behavior of kissing followed by making out and so on until anal sex, the most difficult or least frequent behavior. The difficulty value for anal sex ( $b = 1.49$ ) indicates that the likelihood of having engaged in anal sex reaches 50% at 1.49 standard deviations above the mean of the sexual propensity trait. In contrast, even participants below average on the sexual propensity trait were likely to have kissed ( $b = -.51$ ) while people with an average propensity to engage in these partnered sexual behaviors had a 50% likelihood of engaging in petting or dry sex ( $b = -.02$ ). Consistent with the high discrimination values, each sexual behavior provided a considerable amount of information (consistently more than 5 logits) at the level of the latent trait consistent with their difficulty value. Given the range of difficulties included here, the sexual propensity factor was reliable to very reliable within one standard deviation of the mean. Reliability was lower outside of this range, however, suggesting that more sexual behaviors are required to more effectively measure the more extreme ends of sexual propensity.

### Multiple Regression Results Predicting Substance Use Variables

Results from the multiple regression models can be found in Tables 5 and 6.  $R^2$  values were relatively consistent across models with a mean  $R^2 = .26$  and range of .20 to .34, all  $p$ 's < .001. None of the age x biological sex two-way and sexual behavior x age x biological sex three-way interaction terms were significant at  $p < .005$ , and so are not reported in the tables. SES was only associated with nicotine use after adjusting for the other variables in the model, and only in the models that included kissing and making out (mean  $\beta = -.09$ ), and so was also excluded from the tables.

<sup>1</sup> The tetrachoric correlations among the sexual behaviors can be found in the online supplement; these correlations ranged from  $r = .66$  to .97. These correlations are basis for the IRT parameters Table 3 includes the correlations that formed the basis of the primary regression models in which the sexual behaviors entered as independent variables (i.e., in the primary models the sexual behaviors were entered as binary predictor variables).

**Table 2. Lifetime prevalence of sexual and substance use behaviors by age (N=626)**

	Male (n = 312)						Female (n = 287)					
	%						%					
	13-14	15-16	17-18	19-20	21-22	Total	13-14	15-16	17-18	19-20	21-22	Total
<b>Sexual Behaviors</b>												
Kissing	57.1	51.6	70.7	78.9	82.1	70.8	32.0	58.3	67.7	75.4	84.1	66.2
Making out	28.6	35.5	58.7	71.1	73.1	58.7	12.0	47.6	52.3	66.7	81.8	55.4
Light petting/dry sex	19.0	30.6	57.3	64.5	67.9	53.8	8.0	38.1	50.8	62.3	68.2	48.8
Penetration using finger/toys	19.0	14.5	42.7	55.3	61.5	43.3	4.0	29.8	33.8	50.7	65.9	39.0
Oral sex	14.3	19.4	48.0	60.5	61.5	46.5	4.0	25.0	35.4	52.2	68.2	38.7
Vaginal sex	9.5	9.7	38.5	46.1	52.6	36.5	4.0	21.4	30.8	44.9	68.2	34.8
Anal sex	4.8	9.7	10.7	21.1	15.4	13.8	0.0	7.1	9.2	18.8	31.8	13.6
<b>Substance Use Behaviors</b>												
Smoked cigarettes	14.3	9.8	22.7	22.4	28.2	20.8	0.0	15.5	10.8	15.9	40.9	17.1
Used chewing tobacco	9.5	4.8	12.0	10.5	15.4	10.9	0.0	5.6	1.5	11.6	11.4	6.6
Used e-cigarettes	23.8	25.8	38.7	42.1	43.6	37.2	16.0	36.9	35.4	43.5	54.5	39.0
Drank alcohol (more than a sip)	33.3	40.3	44.0	67.1	75.6	56.1	16.0	51.2	55.4	56.5	79.5	54.7
Binge drank alcohol	0.0	6.5	14.7	26.8	33.3	19.2	0.0	4.8	6.2	24.6	43.2	15.3
Used marijuana	19.0	19.4	41.3	43.4	41.0	35.9	8.0	27.4	30.8	42.0	59.1	34.8
Used other drugs	9.5	22.6	17.3	27.6	25.6	22.4	8.9	10.7	6.2	15.9	31.8	13.9

**Table 3. Descriptive Statistics and Correlations among Variables**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Kissing																	
2. Making out	.76																
3. Petting or dry sex	.65	.79															
4. Penetration fingers/toys	.55	.70	.76														
5. Oral sex	.58	.70	.78	.84													
6. Vaginal sex	.49	.60	.65	.76	.78												
7. Anal sex	.25	.30	.36	.39	.41	.38											
8. Sexual behaviors count	.76	.87	.89	.89	.90	.83	.51										
9. Early sexual initiation	.32	.39	.42	.48	.51	.46	.33	.51									
10. Nicotine use	.34	.36	.39	.40	.38	.37	.33	.45	.36								
11. Alcohol use	.36	.40	.42	.45	.45	.46	.23	.49	.30	.58							
12. Marijuana use	.30	.32	.37	.42	.41	.42	.25	.44	.32	.63	.59						
13. Count of drugs tried	.35	.37	.41	.45	.43	.42	.32	.48	.36	.79	.71	.74					
14. Substance use factor	.38	.42	.46	.49	.48	.48	.32	.53	.38	.87	.81	.89	.87				
15. Age	.26	.33	.32	.34	.38	.36	.18	.39	.02	.17	.39	.25	.29	.30			
16. Biological Sex	.06	.04	.05	.05	.10	.04	.01	.08	-.02	.01	.08	.08	.08	.06	.17		
17. SES	-.05	-.08	-.12	-.11	-.09	-.11	-.15	-.12	-.10	-.15	.00	-.10	-.11	-.10	-.10	.11	
Mean	.68	.56	.51	.41	.42	.35	.14	3.07	.18	.78	.00	1.24	1.90	.00	18.1	.50	-.02
SD	.47	.50	.50	.49	.49	.48	.34	2.68	.38	1.09	1.00	2.08	1.95	.91	2.45	.50	.81

SD = standard deviation. Biserial correlations presented for associations between dichotomous and continuous variables; Pearson correlations presented for associations between continuous variables. Mean values for dichotomous variables refer to frequency of endorsement. Biological sex is coded 0 = female, 1 = male.



**Table 4. Model Parameters from Sexual Behavior 2 Parameter Logistic (2PL) Item Response Model**

Behavior	<i>a</i>	$\lambda$	<i>b</i>	-2	-1.5	-1	-.5	0	.5	1	1.5	2
Kiss	6.24	.96	-.51	<.00	.15	1.66	8.68	1.50	.13	<.00	<.00	<.00
Make out	6.97	.97	-.17	<.00	.01	.15	6.79	8.70	.89	.01	<.00	<.00
Petting or dry sex	6.67	.97	-.02	<.00	<.00	.07	3.08	11.05	2.36	.05	<.00	<.00
Penetration fingers/sex toys	8.13	.98	.25	<.00	<.00	<.00	.32	6.65	11.78	.15	.01	<.00
Oral sex	11.03	.99	.22	<.00	<.00	<.00	.13	9.17	12.78	.02	<.00	<.00
Vaginal sex	5.40	.95	.42	<.00	<.00	.01	.34	2.48	7.27	1.17	.14	.01
Anal sex	1.88	.72	1.49	<.00	.02	.03	.10	.19	.36	.72	.88	.71
Test Information				1.01	1.18	2.93	20.44	40.74	36.57	3.13	2.03	1.72
Test Reliability				.01	.15	.66	.95	.98	.97	.68	.51	.42

*a* = discrimination;  $\lambda$  = standardized factor loading; *b* = difficulty. Information values presented at 9 levels of the latent trait; numbers denote latent trait level for information value. Test reliability estimates derived from test information values via the formula  $r_{xx} = 1 - (1/\text{information})$  (Thissen & Orlando, 2001).

**Table 5. Kissing, Making Out, Petting/Dry Sex, and Penetration with Fingers/Sex Toy (N= 626)**

	Nicotine		Alcohol		Marijuana		Number of Substances		Substance Use Factor	
	$\beta$	SE	$\beta$	SE	$\beta$	SE	$\beta$	SE	$\beta$	SE
<b>Kissing</b>	<b>.23</b>	.05	<b>.26</b>	.04	<b>.22</b>	.04	<b>.25</b>	.04	<b>.27</b>	.04
Early Sexual Initiation	<b>.28</b>	.05	<b>.24</b>	.04	<b>.26</b>	.05	<b>.28</b>	.04	<b>.30</b>	.04
Age	.08	.05	<b>.10</b>	.05	.04	.04	.09	.05	.08	.04
Bio Sex	.00	.05	.06	.04	<b>.09</b>	.05	.09	.05	.06	.04
Kissing x Age	.03	.07	<b>.28</b>	.06	<b>.22</b>	.06	<b>.16</b>	.07	<b>.19</b>	.07
Kissing x Bio Sex	-.01	.06	-.07	.06	-.06	.06	-.07	.07	-.06	.06
<b>Making Out</b>	<b>.29</b>	.05	<b>.27</b>	.05	<b>.22</b>	.05	<b>.27</b>	.05	<b>.30</b>	.05
Early Sexual Initiation	<b>.26</b>	.05	<b>.23</b>	.04	<b>.27</b>	.05	<b>.28</b>	.04	<b>.30</b>	.04
Age	.04	.04	<b>.10</b>	.04	.04	.04	<b>.12</b>	.05	.06	.04
Bio Sex	.07	.05	.06	.04	<b>.11</b>	.04	<b>.12</b>	.05	<b>.10</b>	.04
Making Out x Age	.02	.07	<b>.25</b>	.06	<b>.20</b>	.07	.10	.07	<b>.18</b>	.06
Making Out x Bio Sex	-.13	.07	-.08	.06	-.11	.06	-.14	.07	-.13	.06
<b>Petting/Dry Sex</b>	<b>.30</b>	.06	<b>.25</b>	.05	<b>.23</b>	.05	<b>.27</b>	.05	<b>.30</b>	.05
Early Sexual Initiation	<b>.25</b>	.05	<b>.22</b>	.05	<b>.25</b>	.05	<b>.27</b>	.05	<b>.28</b>	.05
Age	.03	.04	<b>.13</b>	.06	.05	.05	<b>.12</b>	.05	.08	.04
Bio Sex	.04	.04	.03	.04	.06	.04	.08	.05	.05	.04
Petting/Dry Sex x Age	.05	.08	<b>.25</b>	.06	<b>.21</b>	.07	.13	.07	<b>.19</b>	.07
Petting/Dry Sex x Bio Sex	-.10	.07	-.03	.06	-.04	.06	-.09	.07	-.07	.06
<b>Penetration with Fingers/ST</b>	<b>.26</b>	.06	<b>.26</b>	.06	<b>.26</b>	.06	<b>.29</b>	.06	<b>.30</b>	.06
Early Sexual Initiation	<b>.24</b>	.05	<b>.21</b>	.05	<b>.22</b>	.05	<b>.24</b>	.05	<b>.26</b>	.05
Age	.05	.04	<b>.12</b>	.05	.04	.03	<b>.10</b>	.04	<b>.08</b>	.04
Bio Sex	.00	.04	.05	.04	.06	.04	.08	.04	.04	.04
Penetration with Fingers/ST x Age	.04	.08	<b>.29</b>	.06	<b>.22</b>	.08	<b>.16</b>	.07	<b>.21</b>	.07
Penetration with Fingers/ST x Bio Sex	-.04	.07	-.07	.07	-.05	.07	-.08	.07	-.06	.06

Note.  $\beta$  = standardized regression coefficients; SE = standard error; Bio Sex coded 0 = female, 1 = male. Bold indicates  $p < .005$ .

We detected significant main effects for the seven sexual behaviors and a count of the number of sexual behaviors a participant reported engaging in for each substance use measure, except for non-significant associations between anal sex and alcohol ( $\beta = .05, p = .33$ ) and marijuana use ( $\beta = .15, p = .09$ ). That is, engaging in each sexual behavior was associated with greater use of alcohol, nicotine, marijuana, and substance use in general even after adjusting for an early initiation of sexual behavior, age, and biological sex. The size of these effects were relatively consistent across sexual behaviors and substance use outcomes: kissing (mean  $\beta = .25$ ), making out (mean  $\beta = .27$ ), petting/dry sex (mean  $\beta = .27$ ), penetration with fingers/sex toys (mean  $\beta = .27$ ), oral sex (mean  $\beta = .26$ ), vaginal sex (mean  $\beta = .30$ ), and the count of sexual behaviors (mean  $\beta = .36$ ). Anal sex was only significantly associated with nicotine use, the number different substances tried, and the substance use factor after adjusting for other variables in the model (mean

$\beta = .23$ ).

An early initiation of sexual behavior was associated with greater substance use in each model with effects similar to those for the individual sexual behaviors (mean  $\beta = .25$ ). For nicotine use, only the main effects for each sexual behavior and an early initiation of sexual behavior were significant predictors in each model. For alcohol use, the main effect for age (mean  $\beta = .17$ ) and the sexual behavior x age interaction term (mean  $\beta = .25$ ) was statistically significant in each model. That is, levels of substance use increased with age for participants who engaged in a given sexual behavior, while levels of substance use did not increase as a function of age for participants who had not engaged in a given sexual behavior. See [Figure 2](#) for a visualization of the interaction between age and oral sex predicting alcohol use.

For marijuana use, age had a smaller main effect that was statistically significant in six of the eight models (mean  $\beta = .08$ ), and the sexual behavior x age interaction term (mean

**Table 6. Oral, Vaginal, and Anal Sex (N= 626)**

	Nicotine		Alcohol		Marijuana		Number of Substances		Substance Use Factor	
	$\beta$	SE	$\beta$	SE	$\beta$	SE	$\beta$	SE	$\beta$	SE
<b>Oral Sex</b>	<b>.22</b>	.07	<b>.25</b>	.06	<b>.29</b>	.07	<b>.26</b>	.06	<b>.30</b>	.06
Early Sexual Initiation	<b>.26</b>	.05	<b>.23</b>	.05	<b>.22</b>	.06	<b>.27</b>	.05	<b>.27</b>	.05
Age	.01	.05	<b>.10</b>	.05	.02	.04	.07	.05	.04	.04
Bio Sex	.01	.04	.05	.04	<b>.10</b>	.04	<b>.10</b>	.04	.07	.04
Oral Sex x Age	.11	.08	<b>.31</b>	.06	<b>.23</b>	.08	<b>.19</b>	.07	<b>.24</b>	.07
Oral Sex x Bio Sex	-.06	.07	-.09	.07	-.10	.07	-.13	.07	-.10	.07
<b>Vaginal Sex</b>	<b>.26</b>	.07	<b>.29</b>	.06	<b>.32</b>	.07	<b>.29</b>	.06	<b>.34</b>	.06
Early Sexual Initiation	<b>.25</b>	.05	<b>.20</b>	.04	<b>.19</b>	.04	<b>.25</b>	.05	<b>.25</b>	.05
Age	.05	.05	<b>.14</b>	.05	.05	.04	<b>.10</b>	.05	<b>.09</b>	.04
Bio Sex	.03	.04	.06	.04	<b>.10</b>	.04	<b>.11</b>	.04	<b>.08</b>	.04
Vaginal Sex x Age	.02	.08	<b>.22</b>	.06	<b>.16</b>	.08	<b>.13</b>	.06	<b>.15</b>	.07
Vaginal Sex x Bio Sex	-.09	.08	-.08	.07	-.07	.08	-.14	.07	-.09	.07
<b>Anal Sex</b>	<b>.26</b>	.07	.05	.06	.15	.09	<b>.24</b>	.07	<b>.19</b>	.07
Early Sexual Initiation	<b>.29</b>	.05	<b>.28</b>	.05	<b>.29</b>	.05	<b>.30</b>	.05	<b>.33</b>	.05
Age	.09	.05	<b>.29</b>	.05	<b>.17</b>	.05	<b>.22</b>	.05	<b>.21</b>	.05
Bio Sex	.03	.04	.04	.04	<b>.08</b>	.04	<b>.07</b>	.04	.06	.04
Anal Sex x Age	.01	.07	<b>.19</b>	.05	.14	.10	.02	.07	.12	.07
Anal Sex x Bio Sex	-.10	.07	-.04	.06	-.13	.08	-.15	.07	-.11	.07
<b>Count of Sex Behaviors</b>	<b>.37</b>	.06	<b>.33</b>	.05	<b>.33</b>	.06	<b>.37</b>	.06	<b>.40</b>	.05
Early Sexual Initiation	<b>.16</b>	.05	<b>.18</b>	.05	<b>.19</b>	.05	<b>.21</b>	.05	<b>.21</b>	.05
Age	.01	.06	<b>.28</b>	.05	<b>.15</b>	.06	<b>.15</b>	.05	<b>.16</b>	.05
Bio Sex	-.03	.04	.01	.04	.05	.04	.03	.04	.01	.04
Count x Age	.01	.05	<b>.20</b>	.04	<b>.15</b>	.06	.09	.05	<b>.13</b>	.05
Count x Bio Sex	-.07	.05	-.06	.05	-.08	.06	-.11	.05	-.08	.05

Note.  $\beta$  = standardized regression coefficients; SE = standard error; Bio = Biological. Bio Sex coded 0 = female, 1 = male. Bold indicates  $p < .005$ .

$\beta = .25$ ) was significant for each sexual behavior except anal sex. Biological sex also had a small effect on marijuana use that was statistically significant in five of the eight models (mean  $\beta = .08$ ), with male sex being associated with slightly greater marijuana use.

For the number of different substances tried, age also had a small main effect that was statistically significant in six of the eight models (mean  $\beta = .09$ ), and the sexual behavior x age interaction term also had a small effect that was significant in four of the eight models (mean  $\beta = .12$ ). Biological sex had a small main effect that was significant in four of the eight models (mean  $\beta = .09$ ), and the sexual behavior x biological sex interaction term also had a small effect that was statistically significant in three of the eight models (mean  $\beta = -.11$ ). This interaction indicated that the differences in levels of substance use between participants who had versus had not engaged in a given sexual behavior

was greater for female relative to male participants.

For the general substance use factor, age had a small main effect that was significant in four of the eight models (mean  $\beta = .10$ ), and the sexual behavior x age interaction term was significant in seven of the eight models (mean  $\beta = .18$ ). Biological sex had a small effect that was statistically significant in two of the eight models (mean  $\beta = .07$ ). The sexual behavior x biological sex interaction term also had a small effect (mean  $\beta = -.09$ ) that was only significant for the model with making out (same interpretation as previously discussed).

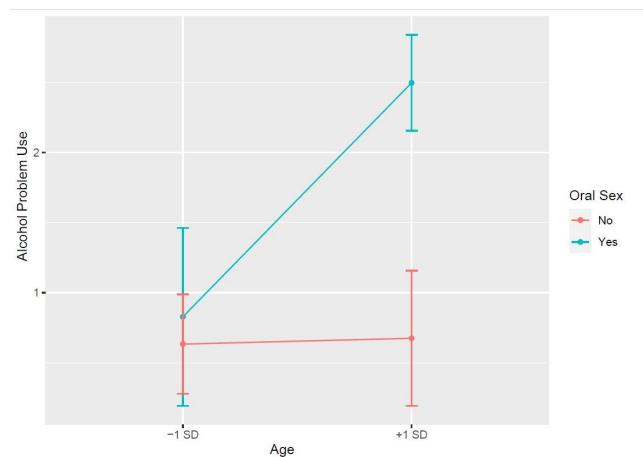
## Discussion

We examined the co-occurrence between sexual behavior and substance use in adolescence and young adulthood wherein seven sexual behaviors of varying prevalence or normativeness were conceptualized as markers along a con-

tinuum of sexual maturity. The emphasis of our analyses was on testing the specificity versus generality of the associations between less mature behaviors (i.e., more prevalent such as kissing, making out, petting/dry sex) and more mature (i.e., less prevalent such as penetration using fingers/sex toys, oral sex, vaginal sex, anal sex) sexual behaviors and several substance use outcomes (alcohol, nicotine, marijuana, and general substance use). We found that engaging in each sexual behavior was consistently associated with greater substance use even after accounting for age, an early initiation of sexual behavior, biological sex, and SES. This association remained significant for each of the seven sexual behaviors and each substance use outcome with the exception of anal sex and alcohol and marijuana use, which may be accounted for by moderators not explored in the current analysis like sexual orientation. These findings are strong evidence for a general—rather than behavior or substance-specific—association between current sexual activity and substance use in adolescence and young adulthood.

We also found that a 2PL IRT model provided a good fit to the prevalence rates and covariance among the sexual behaviors, which supports the validity of our conceptualization that these sexual behaviors can serve as markers along a continuum of sexual maturity. The good fit of the IRT model was due to the following observations. One, there were high correlations among the sexual behaviors, evidence of a latent sexual propensity trait, that is, a common process associated with the likelihood of engaging in each sexual behavior. Two, the prevalence of the sexual behaviors varied in a progressive fashion from kissing (68.2%; the most common behavior) to anal sex (13.6%; the least common behavior). Therefore, the sexual behaviors could be arrayed along a dimension of difficulty scaled to the latent sexual propensity trait. That is, participants with an average or even below low average level of the sexual propensity trait were likely to have engaged in the less difficult behaviors (kissing, making out, petting/dry sex), while only participants with an above average level of the sexual propensity trait were likely to have engaged in the more difficult behaviors (penetration with fingers/sex toys, oral sex, vaginal sex, anal sex). Third, the prevalence of each sexual behavior increased with age. Together, these observations and model results suggest that engagement in these sexual behaviors represents a progression of sexual development (e.g., that engaging in more difficult behaviors is dependent upon or at least very likely to follow engaging in less difficult behaviors) and provide a quantitative estimate of sexual maturity, at least as behaviorally defined.

It is important to interpret the associations between the sexual behaviors and substance use outcomes in the context of the covariates used in the analysis, in particular, age and early sexual initiation. Given that the rates of each sexual behavior and type of substance use increased with age, their associations could be an artifact of increasing age. After adjusting for age, however, we still detected associations between each sexual behavior and substance use, even for common or relatively less mature sexual behaviors, suggesting a more direct association between sexual behavior and substance use. We also identified a consistent interaction between age and each sexual behavior for alcohol use, marijuana use, and general substance use, where



**Figure 2. Association between oral sex and alcohol problem use.**

Simple slopes are plotted +1 and -1 standard deviation from the mean for oral sex and age.

substance use among older participants who endorsed engaging in sexual behaviors was greater than the younger participants that had engaged in these sexual behaviors. These results point toward co-development processes between sexual behaviors and substance use, and suggest engagement in these sexual behaviors tends to precede normative increases in substance use in late adolescence and emerging adulthood, while people who do not engage in these sexual behaviors are less likely to exhibit increases in substance use during this time.

Associations between the sexual behaviors and substance use were also robust after adjusting for an early age of sexual debut (before age 16). This is important because of the strong association between early sexual behavior and substance use, especially an early initiation of substance use and substance use disorders (Armour & Haynie, 2006; Cornelius et al., 2007; Jessor & Jessor, 1977; McGue et al., 2006; McGue & Iacono, 2005). The link between early sexual initiation and substance use problems is largely due to a variety of common risk factors present in childhood and early adolescence including conduct problems, parent-child relationship problems, low parental monitoring, academic difficulties, and deviant peer affiliation. That is, the co-occurrence among early sexual initiation and substance use is primarily due to developmental processes that begin prior to adolescence, most likely processes that contribute to general behavioral disinhibition (Iacono et al., 2008). Our results, however, indicate that each sexual behavior was associated with substance use after adjusting for early sexual initiation, which served as a proxy for these pre-existing risk factors. This suggests a different set of processes are operating in adolescence and emerging adulthood that also contribute to the co-occurrence between these sexual behaviors and substance use.

## Neurobiological and Social Changes in Adolescence

What then accounts for the link between sexual behavior and substance use in adolescence and emerging adulthood?

Our hypothesis is that the co-occurrence of sexual behavior and substance use is due a constellation of neurobiological and psychosocial changes that occur in adolescence. Among the neurobiological changes are reward-related brain processes such as increased density and distribution of dopaminergic receptors (Galván, 2013). Dopamine is critical for approach motivation and positive emotions such as excitement and pleasure, and these changes in the brain's dopaminergic architecture may bias behaviors toward more immediate rewards and pleasure, even in the context of risk (e.g., risk of sexually transmitted infections) (Wahlstrom et al., 2010).

Social environments also change substantially in adolescence, specifically, there is a movement away from parents and family and a greater emphasis on spending time with similarly aged peers and potential romantic partners (Nelson et al., 2016). Relative to adults, adolescents report peer acceptance and rejection are more strongly associated with their subjective well-being and self-esteem, and peer attitudes are more important in guiding their behavior (Nelson et al., 2016). Also, rather than a preference for same-sex friends in childhood, adolescents become motivated to include mixed sex peers in their social circles, potentially facilitating increased opportunities for engagement in male-female sexual behavior (Connolly, Craig, Goldberg & Pepler, 2004; Molloy, Gest, Feinberg & Osgood, 2014). These changes suggest that peers are especially salient stimuli in adolescence, and may evoke reward-related brain processes increasing motivation to engage in pleasurable and potentially risky behaviors.

This perspective is supported by neuroimaging studies that find adolescents—but not adults—make riskier decisions while in the presence of peers relative to when they are alone. The mechanism for the increase in risk-taking while in the presence of peers seems to be increased activation in brain structures associated with reward-related processes (e.g., ventral striatum; Chein et al., 2011). Further, this peer enhancement effect in reward-related brain activation is present even during the passive receipt of reward, additional evidence that the mere presence of peers enhances reward-related brain processes during adolescence, which may then bias behavior toward more exciting and risky activities.

These processes may also help account for the consistent finding that the strongest correlate of an adolescents' problem behaviors (delinquency, substance use) is the level of problem behaviors in their friends (Cornelius et al., 2007). As these friend groups coalesce, they can begin to establish norms that reinforce more frequent and extreme forms of deviance (Choukas-Bradley et al., 2014; Suleiman & Dardorff, 2014). Integration into sexually experienced peer groups is likely to have a similar effect in promoting engagement in sexual behaviors. A potential romantic partner then could be conceptualized as an especially salient peer, as nearly all stages of romantic relationship formation offer excitement and anticipation of reward including emotional and social aspects in addition to the opportunity to engage in partnered sexual behaviors (Crone & Dahl, 2012; Suleiman et al., 2017).

In sum, a combination of normative social and neurobiological developmental processes unique to adolescence

likely help account for the emergence and co-occurrence between sexual behavior and substance use in adolescence and emerging adulthood. These processes are distinct from pre-existing risk factors associated with general behavioral disinhibition (such as conduct problems, impulsivity, a variety of environmental risk factors, and precocious sexual behavior), which makes an independent contribution to the co-occurrence between sexual behaviors and substance use. However, these novel reward-related processes associated with peers, friendships, and romantic partner relationships are likely what accounts for the large *normative increase* in socially undesirable behaviors during adolescence.

## Limitations and Future Directions

All our analyses were cross-sectional, so prospective data is necessary to make stronger inferences about developmental change (i.e., within-person change not between-person differences among people of different ages) as well as any causal influences between sexual behavior and substance use. Future research should test for directional effects between sexual behaviors and substance, over and above common causes (e.g., behavioral disinhibition). For example, substance use may decrease inhibitions and impulsivity which then influences engagement in sexual behavior. Thus, while we suggest a number of plausible causal factors, other mechanisms accounting for the relationship between sexual behavior and substance use (e.g., directional effects, developmental cascades; etc.) should be examined.

The sample also lacked adequate diversity to test for differences between racial, ethnic, and sexual orientation groups, an important topic given that engagement in sexual behavior is likely varied among demographic subgroups (e.g., prevalence of anal sex in heterosexual vs non-heterosexual males). These subgroup variables should also be explored as moderators of both the structural effects in the regression models and item parameters in IRT models. The results of the IRT model also revealed low information at both the low and high ends of the sexual propensity. Expanding the number of low (e.g., masturbation) and high (e.g., multiple partners) difficulty sexual behaviors could help increase measurement precision across the continuum of sexual development. Furthermore, age should be directly incorporated into the IRT analyses as the definition of normative sexual experience will be strongly correlated with age. Additionally, the analyses did not assess the potential moderating or mediating effects of peer risk behavior, including peer and partner substance use. Peer risk behavior is a reliable correlate of the adolescent's own behavior, and thus should be explored in future research.

Next, our study conceptualized sexual behavior as existing on a normative continuum of development. We did not, however, explore the fit of substance use on such a continuum. Future exploration into this topic should consider "normative" patterns of substance use, including the use of alcohol and nicotine before and after the legal age of use. This line of study must also consider that, unlike sexual behavior, sufficiently heavy use of almost all substances pose some potential negative health risk. Finally, our hypotheses regarding the role of normative changes

in neurobiology and social environments that then influence reward-related brain processes are speculative. Empirical tests of these conjectures will require the assessment of reward-related brain processes (e.g., using neuroimaging methods), the impact of peers and romantic partners on those processes, and how each then influences sexual behavior and substance use, ideally in the context of a longitudinal design to make stronger inferences about the direction of the effects (e.g., brain→ peers or peers→ brain). We hope such research is pursued in the future to help answer these questions.

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### Contributions

Conception and design: Brian M. Hicks, Carter Sherman, Claire Kalina, Hannah Roberts.

Data acquisition: Carter Sherman, Claire Kalina, Hannah Roberts.

Data analysis and interpretation: Brian M. Hicks, D. Angus Clark.

Manuscript writing: Brian M. Hicks, Hannah Roberts,

Carter Sherman, Claire Kalina, D. Angus Clark.

Manuscript revisions: Mary M. Heitzeg, Ph.D.

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### Competing Interests

None.

### Data Accessibility Statement

Data and R scripts are uploaded as online supporting information through the Open Science Framework (OSF), and can be accessed using this link: [https://osf.io/hfwyg/?view\\_only=6985a5d5305b42198d6ac5912ac5b3df](https://osf.io/hfwyg/?view_only=6985a5d5305b42198d6ac5912ac5b3df)

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## SUPPLEMENTARY MATERIALS

### Peer Review History

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