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Gender- and age-varying associations of sensation seeking and substance use across young adulthood

Rebecca J. Evans-Polce, Ph.D^a, Megan S. Schuler, Ph.D^b, John E. Schulenberg, Ph.D^{a,c}, and Megan E. Patrick, Ph.D^a

^aInstitute for Social Research, University of Michigan, Ann Arbor, MI

^bRAND Corporation, Boston, MA

^cDepartment of Psychology, University of Michigan, Ann Arbor, MI

Abstract

Introduction: Sensation seeking is associated with elevated risk for substance use among adolescents and young adults. However, whether these associations vary across age for young men and women is not well characterized.

Methods: Using data from the Monitoring the Future (MTF) panel study, we examine the age-varying associations of sensation seeking and three types of substance use behavior (binge drinking, cigarette use, and marijuana use) across ages 18 to 30 using time-varying effect modeling. Analyses include participants in the eleven most recent MTF cohorts (12th-graders in 1994-2004), who are eligible to respond through age 29/30 (N=6,338 people; 30,237 observations).

Results: While sensation seeking levels and substance use are lower among women, the magnitude of the association of sensation seeking with binge drinking and with marijuana use among women exceeds that of men in the later 20s. Differential age trends were observed; among men, the associations generally decreased or remained constant with age. Yet among women, the associations decayed more slowly or even increased with age. Specifically, the association of sensation seeking with marijuana use among women increased during the late 20s, such that the association at age 30 exceeded that in the early 20s.

Conclusions: The significantly stronger associations of sensation seeking with binge drinking and marijuana use observed among women compared to men during the mid- to late-20s suggests divergent risk factors across genders for substance use during young adulthood, with sensation seeking remaining a strong risk factor for women but not men.

Keywords

sensation seeking; substance use; gender; young adults; time-varying effect models

1. Introduction

Sensation seeking is characterized by the pursuit of varied, novel and intense sensations and experiences, and the willingness to take risks for the sake of these experiences (Zuckerman, 1994). Sensation seeking varies across development, typically increasing with the onset of adolescence, peaking in mid-adolescence, and declining in early adulthood (Casey, Jones, & Somerville, 2011; Luna, 2009; Spear, 2000; Steinberg, 2008). Similarly, substance use behaviors increase across adolescence, peak in early young adulthood, and then decline (Chen & Jacobson, 2012; Evans-Polce, Vasilenko, & Lanza, 2015; Patrick et al., 2011; Patrick et al., 2016; Schulenberg, Maslowsky, & Jager, in press; Schulenberg et al., 2017).

A large body of research has identified both cross-sectional and longitudinal associations between higher levels of sensation seeking and a greater likelihood of substance use and consequences, including alcohol use (Arnett, 1996; Kaynak et al., 2013; MacPherson et al., 2010; Patrick & Schulenberg, 2010; Schulenberg et al., 1996), cigarette use (Malmberg et al., 2012), and marijuana use (Arnett, 1996; Crawford et al., 2003; Keyes et al., 2015; Miles et al., 2001). It has been hypothesized that sensation seeking is associated with elevated substance use due to a higher level of physiological reward response for substance use behaviors (Bardo, Donohew, & Harrington, 1996; Kaynak et al., 2013) due to immaturity of the prefrontal regions responsible for cognitive control. Additionally, earlier initiation of substance use has been posited to mediate the association between sensation seeking and substance use in later adolescence and adulthood (Charles et al., 2016; Steinberg, 2008). Studies examining sensation seeking and substance use longitudinally have found that increases in sensation seeking are associated with increases in substance use during adolescence (Crawford et al., 2003; MacPherson et al., 2010) and young adulthood (Knafo et al., 2013). This suggests that the developmental trajectories of both sensation seeking and substance use are linked during adolescence and young adulthood. While positive associations have been identified in both adolescence and adulthood, how these associations change across age is not well understood.

Developmental changes during the transition from adolescence to adulthood, including brain maturation, social development, and environmental/contextual changes (Institute of Medicine, 2014; Schulenberg & Maggs, 2002) influence changes in both sensation seeking and substance use, and may induce variation in their association across age. In addition, as the nature of substance use changes across development (i.e., from more experimental to more regular and dependent use; Benowitz, 2010; Wagner & Anthony, 2002), so might the salience of risk factors for substance use. Only one study to date has examined age-specific estimates, specifically with regard to sensation seeking and cigarette use. The authors found a stronger link in adolescence compared to young adulthood, suggesting sensation seeking may be a developmentally limited risk factor with particular salience in adolescence (Lydon-Stanley & Geier, 2017). Studies have not yet examined if this is also true for other substances such as binge drinking and marijuana use. Given developmental differences in timing of peak use of these substances (e.g., Chen and Jacobson, 2012), in perceptions and motivations for their use (Patrick et al., 2016; Patrick et al., 2017), and in the social and environmental context of substance use from adolescence to young adulthood, there may be

important differences in how sensation seeking risk varies across age for binge drinking compared to cigarette or marijuana use.

Previous research has demonstrated gender differences in rates of both substance use and sensation seeking. Sensation seeking is higher, on average, among men than women (Keyes et al., 2015; Nolen-Hoeksema, 2004; Steinberg, 2008); men and women show parallel decreases across young adulthood, suggesting that gender differences are largely constant across age (Steinberg, 2008). On the other hand, substance use is higher for men than women across young adulthood and the degree of this gender difference varies across adolescence and young adulthood (Evans-Polce et al., 2015). Previous studies that have examined gender differences in cross-sectional associations between sensation seeking and substance use have yielded mixed findings, with some finding a stronger association for alcohol use among men (Nolen-Hoeksema, 2004) and other studies showing a stronger association for women for both alcohol and other drugs (Keyes et al., 2015). Stronger associations for women have also been found when examining lower thresholds of alcohol use (DeHann, Egberts, & Heerdink, 2015). To date, studies have not explored if there are different associations across development between sensation seeking and substance use for men and women.

Our study seeks to build on previous literature by examining gender differences in the magnitude of the associations between sensation seeking and substance use behaviors (binge drinking, cigarette use, and marijuana use) across age during young adulthood (age 18 to 30). We aim to elucidate at what ages sensation seeking presents a particularly heightened risk for substance use and how this may differ by gender, which may further explicate the developmental link between sensation seeking and substance use. Understanding how risk changes across development is critical for developing tailored interventions to reach young adults in ways that are most salient and likely to reduce future negative consequences.

2. Methods

2.1. Sample

Data for this study come from the longitudinal panel portion of the Monitoring the Future (MTF) study, an ongoing national study of adolescents and adults in the U.S. (Schulenberg et al., 2017). Each spring MTF conducts school-based surveys in a nationally representative sample of approximately 15,000 high school seniors. Approximately 130 schools are selected to participate each year using a multi-stage random sampling design with replacement and are provided a monetary incentive for participation. Twelfth grade students in participating schools are asked to complete a paper and pencil self-report questionnaire that is administered in classrooms by study staff. Participation in the study is voluntary; parents of students are notified in advance of the study and provided the opportunity to decline their child's participation.

Annually, approximately 2,400 of those students are randomly (oversampling for drug users) selected to be followed longitudinally. Follow-up surveys are staggered such that a random half of each cohort is assessed one year after high school and the other half is assessed two years after high school. Individuals are then surveyed every two years through age 29/30,

such that assessments are completed at modal ages 18, 19/20, 21/22, 23/24, 25/26, 27/28, and 29/30. Follow up surveys are mailed in the spring with an incentive payment to participants homes. Additional details of the data collection procedure are available elsewhere (Bachman et al., 2015; Miech et al., 2017; Schulenberg et al., 2017).

Because of noted historical variation in substance use and sensation seeking/risk preference among high school seniors in MTF (Keyes et al., 2015) we limit the current analysis to individuals from the eleven most recent MTF cohorts eligible to be followed through age 30 (12th graders in 1994-2004), who completed at least one follow-up survey post high school in which they provided data on sensation seeking and substance use measures (N=6,338 people; 30,237 observations). Thus, everyone provided data at a minimum of baseline and one additional time point. On average participants provided data at 5 of the 7 time points. The number of participants included in the analysis from any given follow up wave ranged from n=5623 (83% at age 19/20) to n=3760 (56% at age 29/30). Those who provided at least one wave of follow-up data were more likely to be female, White and have parents with a high school education, and were less likely to report past 30-day cigarette, alcohol, and marijuana use during 12th grade, compared to those who were selected for follow-up but did not respond. However, these differences were small in magnitude (all $R^2 < 0.02$); use of attrition weights is discussed below.

2.2. Measures

2.2.1. Substance use.—At each wave, participants reported whether they had engaged in any *binge drinking* (5 or more drinks in a row) in the past two weeks, any *cigarette use* in the past 30 days, and any *marijuana use* in the past 30 days.

2.2.2. Sensation seeking.—Participants reported their level of agreement on a five-point scale (disagree to agree; Mean [SD] = 2.8 [1.5]) for the following two statements: “I get a real kick out of doing things that are a little ‘dangerous’” and “I like to test myself every now and then by doing something a little risky.” A mean of the two items (Dever et al., 2012; Keyes et al., 2015; Patrick & Schulenberg, 2010) was used to create a *sensation seeking* scale ($\alpha = 0.83$ indicating good scale reliability). These items also correlated with risk behaviors including substance use and conduct problems (r ranged from 0.11 to 0.34) providing evidence for construct validity.

2.2.3. Plan of Analysis—Analyses were conducted using time-varying effect models (TVEM) (Li et al., 2015; TVEM SAS Macro, 2015), a statistical method that estimates regression coefficients as a function of time using non-parametric spline regression. We estimated the age-varying association of sensation seeking with three substance use behaviors: binge drinking, cigarette use, and marijuana use for men and women. To test for gender differences in the associations, we specified TVEMs with age-varying main effects for both sensation seeking and gender, as well as an age-varying interaction of sensation seeking and gender while controlling for race/ethnicity (White non-Hispanic, Black non-Hispanic, Hispanic, and Other), parent(s) highest level of education (a high school degree or less, some college (Reference), or college degree), and the other two substance use behaviors (e.g. analyses with binge drinking as the outcome controlled for cigarette use and marijuana

use). All TVEM models were run in SAS 9.4 using the TVEM macro (TVEM SAS Macro, 2015). All models were estimated using the B-spline method (Li et al., 2015); pseudo-likelihood information criteria were used for model selection, as outlined in Shiyko et al. (2012). All analyses incorporated age-specific weights to account for oversampling drug users and attrition at follow-up waves.

3. Results

3.1. Descriptives.

Table 1 provides time-invariant sample characteristics overall and by gender. Just over half the sample were men (55%). Three quarters of the sample were White non-Hispanic with the remaining individuals roughly split between Black non-Hispanic, Hispanic, and Other. Over half of respondents had at least one parent with a college degree.

3.2. Sensation seeking and substance use behaviors across age by gender

Men have a consistently higher level of sensation seeking at all ages compared to women. Mean sensation seeking declines steadily for both men and women from age 18 to 30. Among men, sensation seeking is highest at age 18 with a mean of 3.6 (out of 5) and declines by age 30 to 3.0. For women, the highest level of sensation seeking is 3.0 at age 18 and declines through age 30 to 2.2. Across all three substances, men have consistently higher rates of substance use than women. The highest prevalence of binge drinking for men is 53% at age 23. The highest prevalence of binge drinking for women occurs earlier at age 22 (34%). The prevalence of cigarette use is highest for men and women at age 18 when approximately 36% of both men and women report cigarette use. Similar to cigarette use, marijuana use peaks for both men and women at age 18 (33% and 23% for men and women, respectively).

3.3. Age-varying association of sensation seeking with substance use by gender

We find evidence for gender differences in the association between sensation seeking and substance use, while controlling for race, parental education, and other substance use. The association of sensation seeking with cigarette use is not significantly different between men and women at any age; however, a significantly stronger association with sensation seeking among women emerges in the mid-20s for binge drinking and marijuana use. Figures 1, 2, and 3 depict these age-varying associations for men and women, and in the case of binge drinking and marijuana use denotes the specific ages at which there are significant gender differences.

The association between sensation seeking and binge drinking is similar in strength for men and women from age 18 to 24 (Figure 1). For example, for both men and women at age 18, each unit increase in sensation seeking is associated with 1.4 times greater odds of binge drinking (95% CI: 1.2, 1.5 for men and 95% CI: 1.3, 1.5 women). The association between sensation seeking and binge drinking is significantly stronger for women from age 24 to 28, compared to men at the same ages (e.g., at age 26, OR: 1.2 [95% CI: 1.1, 1.3] for men and OR: 1.3 [95% CI: 1.3, 1.4] for women).

The association between sensation seeking and cigarette use for men and women is not significantly different from ages 18 to 30 (Figure 2). However, men and women exhibit distinct trends across age and peaks in association. For women, the association decreases from age 18 to 24 (OR: 1.3 [95% CI: 1.2, 1.4] at age 18 and OR: 1.1 [95% CI: 1.0, 1.2] at age 24) and then increases slightly through age 30. For men, the association strengthens slightly from ages 18 to 20 and then decreases, becoming nonsignificant at ages 24 to 30.

We found the most pronounced gender differences when examining marijuana use (Figure 3). From age 25 to 30, the link between sensation seeking and marijuana use is significantly stronger for women than men. For example, at age 29 each unit increase in sensation seeking is associated with 1.6 times greater odds of marijuana use for women (95% CI: 1.4, 1.8) and 1.2 times greater odds for men (95% CI: 1.1, 1.4). For men, the association between sensation seeking and marijuana use is strongest at age 18 and remains fairly constant through age 30; for women, in contrast, this association strengthens from age 21 to 30 and is strongest at age 30 (OR=1.6, 95% CI: 1.3, 1.9).

4. Discussion

This study is novel in that we examine the age-specific associations between sensation seeking and three substance use behaviors (binge drinking, cigarette use, marijuana use) in a US national sample of individuals ages 18 to 30. We find that while there generally remains a positive association of sensation seeking with binge drinking, cigarette use, and marijuana use throughout young adulthood for both men and women, the strength of associations vary across age. Thus, our findings reveal that the strength of sensation seeking as a risk factor for substance use is strongest during late adolescence, providing needed insight into developmentally graded risk factors (Schulenberg et al., in press) and suggesting that substance use prevention strategies that provide or help facilitate alternative outlets (e.g., competitive sports; D'Silva et al., 2001; Zakletskaia et al., 2009) for sensation seeking other than substance use may be most effective for adolescents compared to older young adults.

One potential explanation for the weakening of the association between sensation seeking substance use in the late 20s is that substance use at this age may be more established and more closely linked to using substances to cope. Sensation seeking may be more important for using to experiment (which often occurs in adolescence and young adulthood), but is likely overshadowed with age by a coping function of substance use, as well as any progression toward substance use disorder. Indeed, we find that sensation seeking has a weaker association with binge drinking and cigarette use in the late 20s compared age 18. In particular, cigarette use (compared with binge drinking and marijuana use) has the weakest association with sensation seeking in the late 20s. This may be due to the fact that there is a higher risk of dependence among cigarette users who ever initiate compared to marijuana or alcohol (Benowitz, 2010; Wagner & Anthony, 2002), and thus smokers (at any age) are more likely to be using for addiction-related reasons. Furthermore, cigarette use is unique compared to alcohol and marijuana use in that cigarette use initiation rates are very low in the mid- and late-20s; almost all current cigarette users (88%) initiate use at or before age 26 (USDHHS, 2012). Thus, by age 30 many cigarettes users are established users and likely nicotine dependent, reflected in the attenuated overall association with sensation seeking. As

we did not find any significant gender differences in cigarette use, the relative impact of dependence versus sensation seeking appear to be equally attenuated for both men and women across young adulthood.

Another important consideration regarding age variation is the concurrent developmental and social changes occurring in young adulthood. The transition to adulthood is a critical time for brain maturation, with executive functioning increasing, as well as changes in social roles and contexts (Institute of Medicine, 2014; Schulenberg & Maggs, 2002). As individuals make the transition to adulthood, they experience maturation at multiple levels and their risk-taking declines; consequently, the functions and purposes of substance use may change such that substance use is less a matter of seeking novelty. The adoption of familial social roles for instance, is common in young adulthood and associated with a “maturing out” of substance use (e.g., Dawson, Gran, Stinson, & Chou, 2006; Leonard & Windle, 1991) while college attendance, particularly in early young adulthood is associated with greater risk of binge drinking (Evans-Polce et al., 2017; Staff et al., 2010; White et al., 2006) and marijuana use (Miech et al., 2017). Thus, these social roles may be important confounders or mediators in the association between sensation seeking and substance use. For instance, those with higher levels of sensation seeking may be less likely to get married or become a parent (Arnett, 1998) and a lack of familial social roles (marriage and parenthood) is associated with risk of substance use in the later 20s (e.g., Dawson et al., 2013; Staff et al., 2014). Previous research examining the related construct of impulsivity found familial social roles to mediate the association between impulsivity and problematic drinking (Lee, Ellingson, & Sher, 2015). Examining potential mediators and moderators of the age-varying sensation seeking-substance use association may be an important area of future research to further understand the mechanisms behind age-graded risk.

While significant gender differences were not observed for cigarette use, men and women did exhibit distinct age-varying associations of sensation seeking with binge drinking and marijuana use. For both substances, these associations were significantly stronger for women than for men in the later 20s. This suggests the importance of examining gender moderation in risk factors across development. The strengthening of the association between sensation seeking and marijuana use, in particular, across young adulthood among women may be due to the relative rarity of use in the mid- and late-20s among women (e.g., approximately 9% of women report past 30-day marijuana use at age 30 compared to 17% of men at this age). There is likely a changing composition of marijuana users with age across the 20s, with those more risk prone continuing to use and those more involved for social or experimental reasons discontinuing use. Men also have greater prevalence of marijuana use disorders and more severe marijuana use disorders than women suggesting addiction may be a greater factor for men rather than sensation seeking, contributing to the diminishing association (Hasin et al., 2015; Hernandex-Avila, 2004).

Limitations should be taken into account while considering implications of the findings. First, the sample is limited to youth who graduated from high school and thus may not be generalizable to high school dropouts. Second, MTF assesses sensation seeking with two items; while this sensation seeking measure has been used in multiple previous studies (Dever et al., 2012; Keyes et al., 2015; Patrick & Schulenberg, 2010), it may not capture all

dimensions of sensation seeking. At the same time, the use of US-national panel data spanning ages 18 through 30 is an important strength; the application of TVEM analyses produces a set of generalizable findings about the age-varying associations between sensation seeking and substance use among young adults in the US.

As we show, both sensation seeking and substance use decline across the transition to adulthood, accompanied by a general diminution in the association between sensation seeking and substance use. Nevertheless, the associations vary across substances and across gender. Furthermore, patterns of substance use across age vary by other sociodemographic characteristics, including race/ethnicity (e.g., Evans-Polce et al., 2015) suggesting there may be additional heterogeneity in the substance use risk factors including sensation seeking. Expanding age-varying risk for substance use to include additional moderators such as race/ethnicity may be an important next step in this research. Understanding heterogeneity in the associations between sensation seeking and substance use across young adulthood may help to broaden our understanding of the role of sensation seeking in perpetuating substance use and to identify groups especially at risk, including those for whom sensation seeking remains high well into the 20s. This may be useful for prevention interventions in determining who, what, and when to target substance use prevention strategies.

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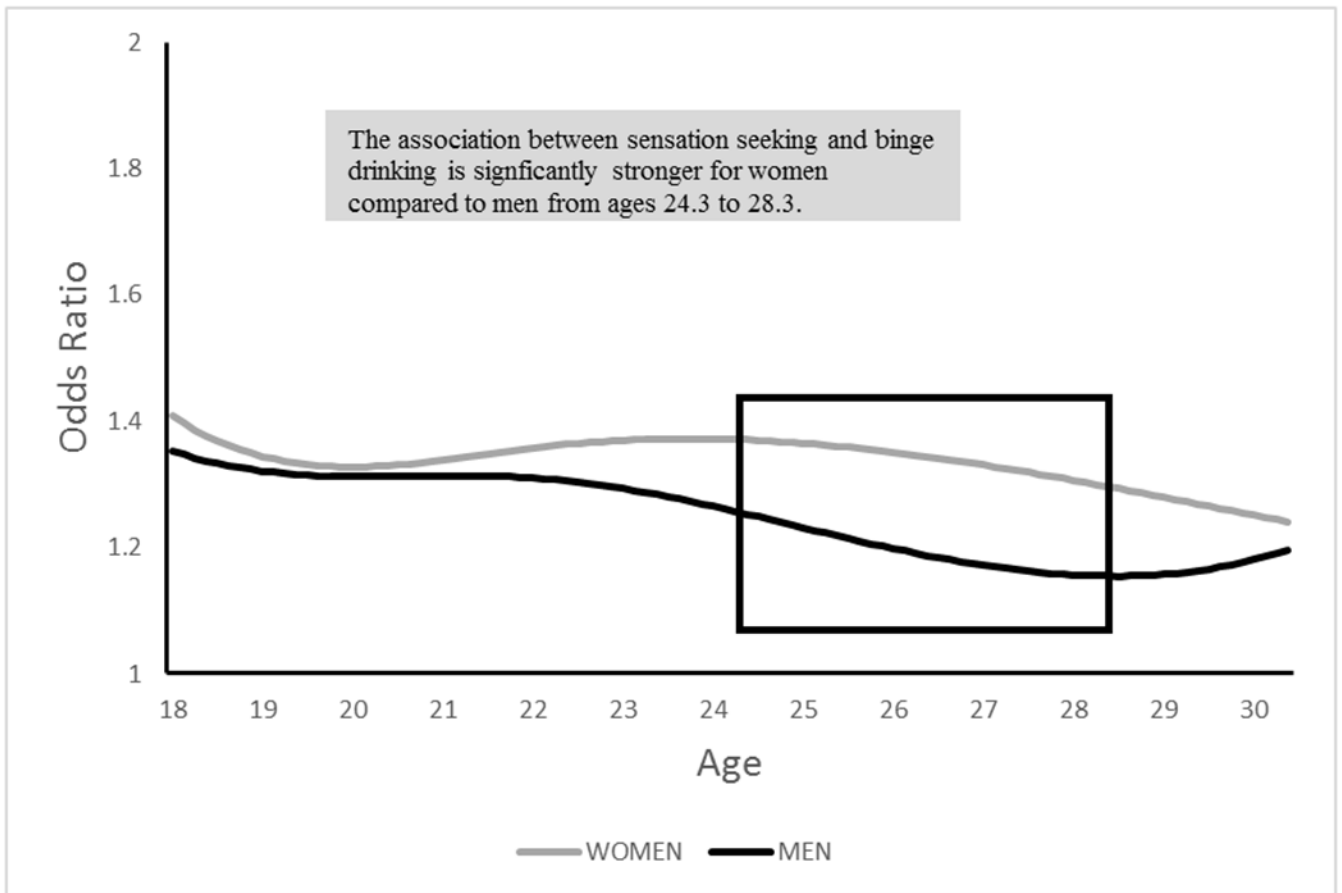


Figure 1. Age-varying association of sensation seeking with binge drinking across ages 18 to 30: gender differences

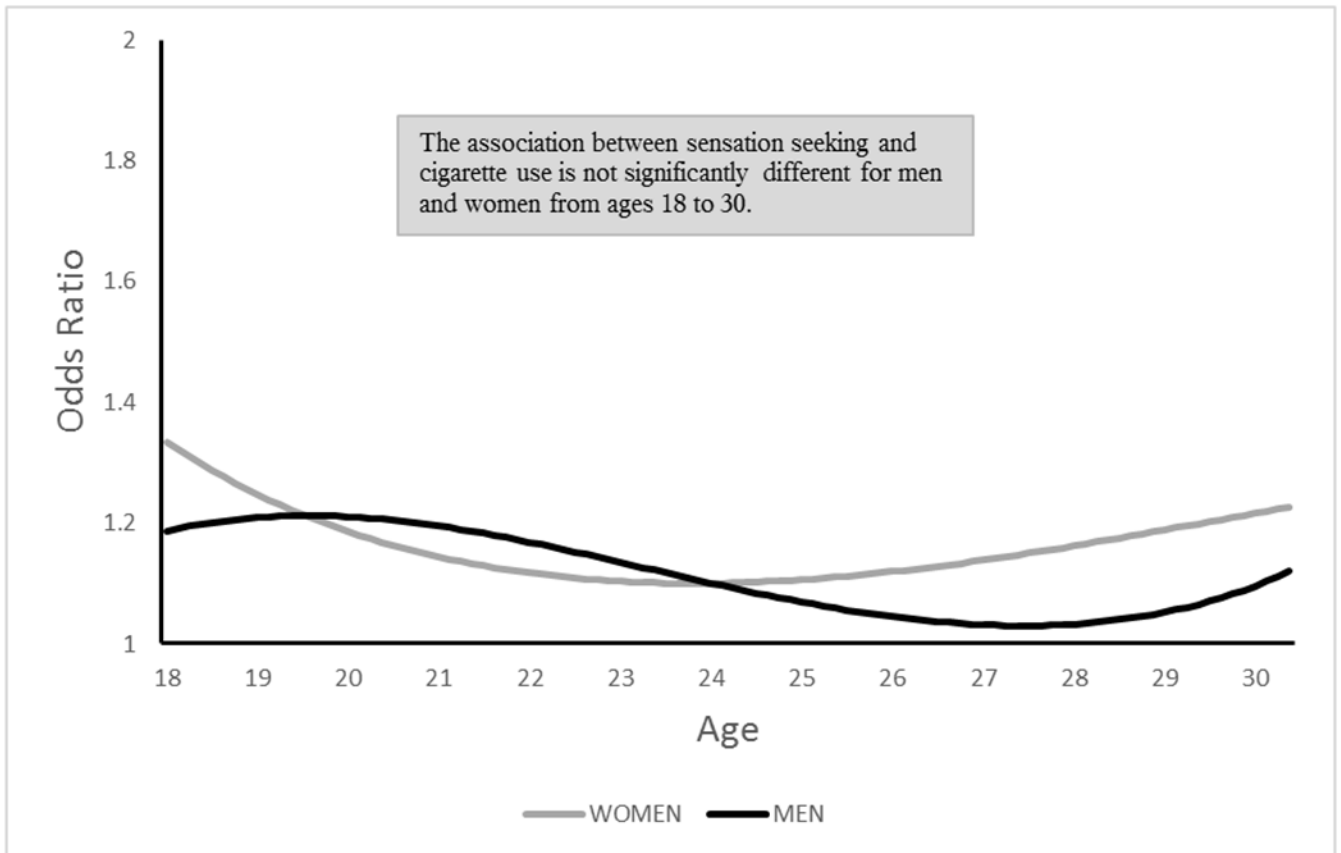


Figure 2. Age-varying association of sensation seeking with cigarette use across ages 18 to 30: Gender differences

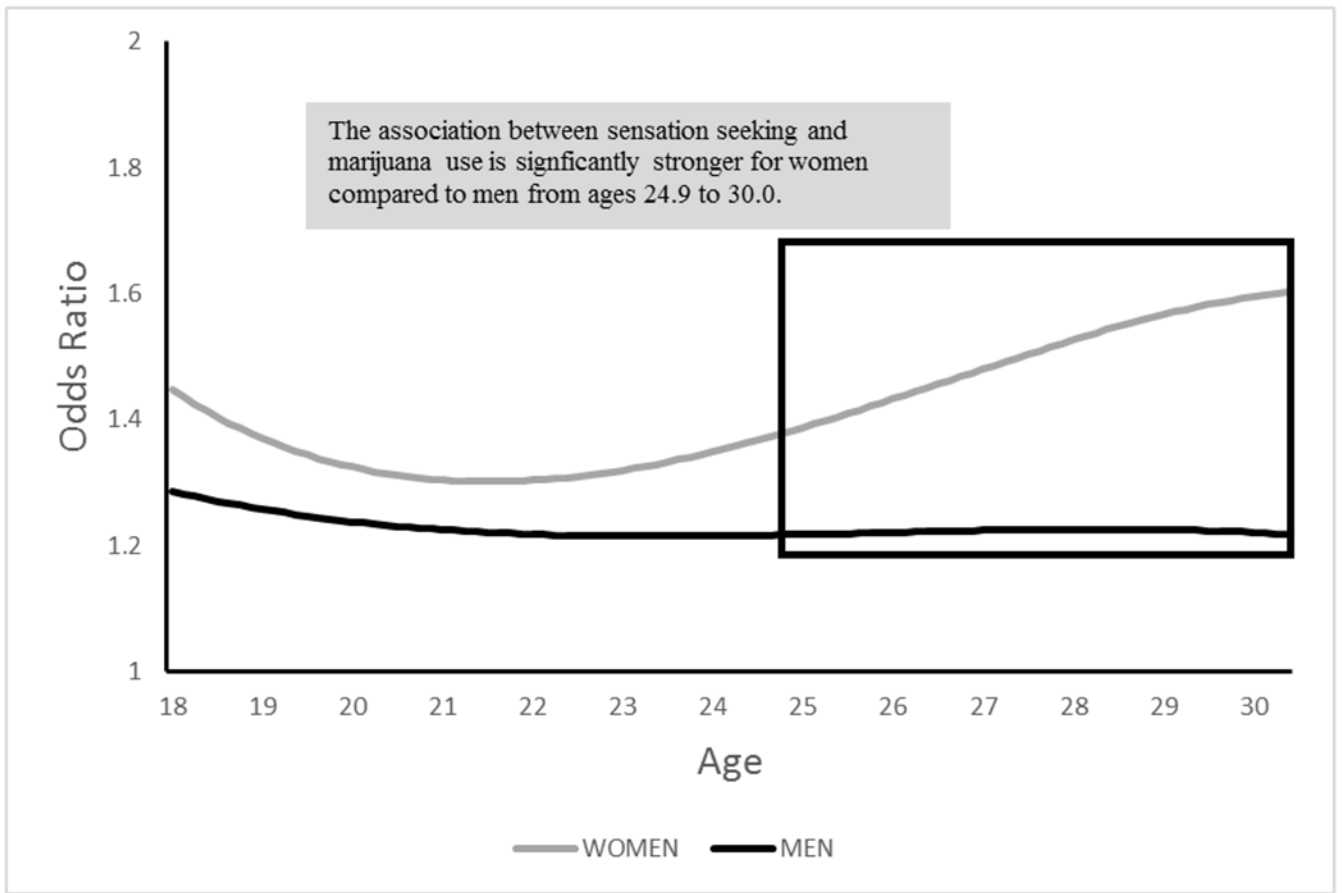


Figure 3. Age-varying association of sensation seeking with marijuana use across ages 18 to 30: gender differences

Table 1.

Weighted sample characteristics (N=6,338)

	Men (54.5%)	Women (45.5%)
Race/ethnicity		
White non-Hispanic	76.4%	73.8%
Black non-Hispanic	7.1%	9.3%
Hispanic	7.1%	8.9%
Other	9.5%	8.0%
Highest Parent Education		
HS diploma	26.2%	29.0%
Some college	20.7%	22.3%
College degree	53.1%	48.7%

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