

Boise State University  
**ScholarWorks**

---

Counselor Education Faculty Publications and  
Presentations

Department of Counselor Education

---

1-2019

## Age of Drinking Initiation as a Mediator of the Relationship Between Sensation Seeking and Heavy Drinking Among High School Seniors

Diana M. Dumas  
*Boise State University*

Rob Turrisi  
*Pennsylvania State University*

Raissa Miller  
*Boise State University*

Susan Esp  
*Boise State University*

Brian Flay  
*Boise State University*

# Age of Drinking Initiation as a Mediator of the Relationship Between Sensation Seeking and Heavy Drinking Among High School Seniors

**Diana M. Doumas, Ph.D.\***

Department of Counselor Education  
Institute for the Study of Behavioral Health and  
Addiction  
Boise State University  
Boise, ID  
dianadoumas@boisestate.edu

**Raissa Miller, Ph.D.**

Department of Counselor Education  
Institute for the Study of Behavioral Health and  
Addiction  
Boise State University  
Boise, ID

**Rob Turrisi, Ph.D.**

Department of Biobehavioral Health and Prevention  
Research Center  
The Pennsylvania State University  
University Park, PA

**Susan Esp, Ph.D.**

School of Social Work  
Institute for the Study of Behavioral Health and  
Addiction  
Boise State University  
Boise, ID

**Brian Flay, Ph.D.**

Initiative for Healthy Schools  
Boise State University  
Boise, ID

## Author Note

Correspondence concerning this article should be addressed to Diana Doumas at Institute for the Study of Behavioral Health and Addiction, Boise State University, 1910 University Drive, Boise, ID 83725. E-mail: dianadoumas@boisestate.edu Telephone: (208) 426-2646; Fax: (208) 426-4386.

This work was supported by the National Institute of General Medical Sciences under Grant number U54GM104944. The content is solely the responsibility of the authors and does not represent the official views of the National Institutes of Health.

## Abstract

Sensation seeking has been identified as a significant risk factor for adolescent alcohol use. Little is known, however, about the process by which sensation seeking impacts heavy alcohol use. The current study used structural equation modeling (SEM) to examine the relationships among sensation seeking, age of drinking initiation, and heavy alcohol use in a sample of high school seniors ( $N = 221$ ). Results supporting age of drinking initiation as a mediator of the relationship between sensation seeking and heavy alcohol use. Implications include providing personality-targeted prevention to adolescents who display sensation seeking traits to delay drinking initiation among these students.

**Keywords:** adolescent drinking; sensation seeking; age of drinking initiation

Underage drinking is a significant problem in the United States, with 61% of adolescents reporting alcohol use by their senior year (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2017). Among high school students, seniors have the highest rates of alcohol use, with 33% of seniors reporting alcohol use in the past 30 days, 16% reporting binge drinking in the past two weeks, and 46% reporting being drunk at least once in their lifetime (Johnston et al., 2017). Additionally, adolescent alcohol use is associated with significant negative consequences including academic problems, interpersonal problems, being a victim of dating violence, the use of other substances, and suicide attempts

(Arata, Stafford & Tims, 2003; Miller, Naimi, Brewer, & Jones, 2007). Adolescent alcohol use is also associated with impaired neuropsychological functioning including deficits in verbal memory, visuospatial ability, and psychomotor speed (Hanson, Medina, Padula, Tapert, & Brown, 2011; Nguyen-Louie et al., 2015). Further, heavy alcohol use in high school is associated with multiple, reoccurring alcohol-related problems during college (Scaglione et al., 2015) and with alcohol problems later in life, including alcohol dependence, work impairment, and premature death (Marshall, 2014).

Researchers have suggested that risky-decision making may be a primary contributor to high rates of alcohol use among adolescents (Albert & Steinberg, 2011; D'Amico, Elickson, Collins, Martino, & Klein, 2005). Research in the area of developmental neuroscience suggests that both structural and functional changes that occur in the brain during adolescence contribute to risk-taking behavior (Steinberg, 2008). Regions of the brain that are dominant in decision-making and impulse inhibition (e.g., ventral prefrontal cortex) mature at a slower rate than regions of the brain that are dominant in pleasure and reward seeking (e.g., nucleus accumbens) (Bava & Tapert, 2010; Casey, Getz, & Galvan, 2008). Additionally, patterns of dopamine activity seen in the adolescent brain may lead to heightened activation and reduced inhibition associated with adolescent risk-taking behavior (Matthews, Bondi, Torres, & Moghaddam, 2013; Siegel, 2013; Wahlstrom, Collins, White, & Luciana, 2010).

Risky-decision making and risk-taking behavior may be most pronounced in adolescents with a genetic predisposition for increased sensation seeking behavior (Casey et al., 2008). Sensation seeking is a biologically-based personality trait that is manifested in a tendency toward novelty-seeking, including risk-taking behavior (Zuckerman 1979; 1994). Researchers have identified sensation seeking as one of the most significant risk factors for adolescent alcohol use among disinhibitory traits (Strautz & Cooper, 2013). Several studies indicate that among adolescents, sensation seeking is associated with higher levels of alcohol use (MacPherson, Magidson, Reynolds, Kahler, & Lejuez, 2010; Sznitman & Engel-Yeger, 2017; Urban, Kokonyei, & Demetrovics, 2008), binge drinking and alcohol-related consequences (Doumas, Miller, & Esp, 2017), as well as other drug use (Martins, Storr, Alexandre, & Chilcoat, 2008). Sensation seeking has also been identified as a promising marker for the identification of adolescents who are at risk for initiating binge drinking (Sargent, Tanski, Stoolmiller, & Hanewinkel, 2010).

Sensation seeking is also associated the early onset of alcohol use (Jensen et al., 2017; Malmberg et al., 2012). This is particularly important as early initiation of alcohol use is associated with neurodevelopmental changes in cognition, brain structure, and function (Lisdahl et al. 2013). Further, early initiation of alcohol use is associated with higher rates of alcohol use and alcohol dependence in adulthood (Dawson, Goldstein, Chou, Juan, & Grant, 2008; Hingson, Heeren, & Winter, 2006; Moss, Chen, & Yi, 2014). Research has also reported that the initiation of alcohol use in late childhood (prior to age 11) is related to an increase in chronicity of adult alcohol dependence relative to initiation during early adolescence (ages 11-14) (Guttmanova et al., 2011). More recent research adds to these findings, indicating that early initiation of alcohol use is associated with alcohol-related health and social consequences (Donoghue et al., 2017), an increased risk of alcohol use and binge drinking later in adolescence (Aiken et al., 2017) and being classified in a high risk group of college students who report multiple and repeated alcohol-related consequences (Scaglione et al., 2015). Thus, delaying alcohol initiation is important to reduce the risk of heavy drinking and alcohol-related consequences both in adolescence and into adulthood.

Although the associations among sensation seeking, age of drinking initiation, and alcohol use among adolescents is well documented, how these constructs are related is unclear. The present study seeks to further examine these associations by examining age of drinking initiation as a mediator of the relationship between sensation seeking and alcohol use. Further, we chose to examine these relationship among high school seniors as the highest rates of drinking among high school students occurs during the senior year (Johnston et al., 2017). To achieve our aims, we used structural equation modeling (SEM) to test both direct and indirect effects within a mediational model. We hypothesized that there would be a direct relationship between sensation seeking and heavy alcohol use and that this relationship would be mediated by age of drinking initiation.

## **Method**

### **Participants**

The sample consisted of 221 high school seniors who were recruited from one high school in the Northwest as part of a larger study (Doumas, Esp, Flay, & Bond, 2017). Because the School District Research Board required parental consent for all students regardless of age, consent forms were sent to parents of all students (N = 488), including those

who were 18 years old. A total of 248 (51%) parents provided consent. Among students with parental consent, those who were in attendance at school ( $n = 226$ ) were given an opportunity to participate. Among these students, 221 (45.2% male, 54.8% female) provided assent. Participant ages ranged from 16 to 18 ( $M = 17.16$ ,  $SD = 0.45$ ). Participants were primarily Caucasian (81.2%), with 6.4% Hispanic, 4.6% Asian, 1.8% African-American, 1.4% American Indian/Alaskan Native, and 4.6% other.

## **Procedure**

All seniors registered at the high school were eligible to participate. Active consent was required by the students' parents in order to participate in the study. The active parental consent procedures are described in more detail in Doumas, Esp, et al. (2017). Participants who received parental consent were recruited during a common core class period and were asked to assent prior to participating in the research. Students with parental consent were taken to the school's computer lab to participate in the study. A member of the research team and a school counselor described the research study and invited the students to participate. Students who agreed to participate were given a URL to access the survey which took about 15 minutes to complete. All study procedures were approved by the University Institutional Review Board and the School District Research Board.

## **Measures**

***Sensation Seeking.*** The Zuckerman–Kuhlman Personality Questionnaire (ZKPQ; Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993) was used to assess sensation seeking. The ZKPQ is a 40-item forced choice questionnaire designed to measure five personality traits. For the purposes of this study, only the 19-item Impulsive Sensation Seeking (ImpSS) scale was used. The ImpSS items reflect a lack of planning (e.g. "I usually think about what I am going to do before doing it" reverse scored), a tendency to act impulsively (e.g., "I often do things on impulse"), a need for excitement and thrills (e.g. "I like to have new and exciting experiences and sensations even if they are a little frightening), a preference for unpredictability (e.g. "I enjoy getting into new situations where you can't predict how things will turn out"), and a need for novelty and change (e.g. "I tend to change interests frequently"). The ImpSS scale has been psychometrically validated with college students, with Cronbach's alpha ranging from .77 - .82 (Zuckerman et al., 1993). The ImpSS has also been used to validate shorter measures of sensation seeking for adolescents (Stephenson, Hoyle, Palmgreen, & Slater, 2003). The ImpSS scale Cronbach's alpha for this sample was  $\alpha = .77$ .

***Age of Drinking Initiation.*** Age of drinking initiation was assessed by asking participants the following question "How old were you the first time you drank alcohol (that is, more than a few sips)?" Response options included I have never drank alcohol, age 10 or younger, 11, 12, 13, 14, 15, or 16 or older."

***Heavy Alcohol Use.*** Peak drinking and frequency of drinking to intoxication were assessed using the Quantity/Frequency/Peak Questionnaire (QFP; Dimeff, Baer, Kivlahan, & Marlatt, 1999; Marlatt et al., 1998). Peak drinking quantity was assessed by the question "What is the most number of drinks that you have consumed on any given night in the past month?" Frequency of drinking to intoxication was assessed by the question "During the past 30 days (about 1 month), how many times have you gotten drunk, or very high from alcohol?" This item was rated on a 6-point scale with the anchors 0, 1 to 2, 3 to 4, 5 to 6, 7 to 8, or 9 or more times. Frequency of binge drinking was defined as consuming 5 or more drinks in a row for males (3 or more for females) in a 2 hour period during the last 2 weeks. The 5/3 quantity has been identified as appropriate for adolescents aged 16-17 based on BAC levels for this age group (Donovan, 2009).

## **Statistical Analysis**

Prior to analysis, variables were examined for normality. All variables were within the normal range for skew and kurtosis. Bivariate correlations between the variables in the model were also calculated prior to conducting the main analyses to test for multicollinearity (see Table 1). Although several of the correlations were significant at  $p < .01$ , the variance inflation factor (VIF) ranged from 1.2 – 3.5 with corresponding tolerance levels ranging from .35 - .85. These VIF levels are below the rule of thumb of  $VIF < 10$  (Norman & Streiner, 2008; Tabachnick & Fidell, 2007), suggesting acceptable levels of multicollinearity among the predictor variables. We also examined the data for missing values and imputed missing data using maximum likelihood (ML) estimation (Byrne, 2001). Missing data for each variable was minimal, with < 1% of items missing for sensation seeking, < 1% of items missing for age of drinking initiation, and < 2% of items missing for heavy drinking. We then evaluated model fit and examined direct and indirect

relationships between sensation seeking and heavy alcohol use through SEM using AMOS 25.0 with the maximum likelihood estimation method. We selected SEM as this method of analysis allows for the examination of direct and indirect paths between observed variables (Karadag, 2012). The model included three latent variables, sensation seeking, age of drinking initiation, and heavy alcohol use. Sensation seeking was indicated with one measure, age of drinking initiation was indicated with an individual item, and heavy drinking was indicated by three individual items (i.e., peak drinking, drinking to intoxication, and binge drinking). We used three goodness of fit indices to assess model fit: chi-square, the comparative fit index (CFI), and the root mean square error of approximation (RMSEA). Good model fit is demonstrated when the model chi-square is not significant, the CFI value is .95 or greater, and the RMSEA value is .06 or less (Hu & Bentler, 1999). We used an alpha level of  $p < .05$  to determine statistical significance for the paths in the model.

To test for mediation, we used the joint significance test of indirect paths from the predictor to the mediator (i.e., age of initiation), and from the mediator to the outcome (i.e., heavy alcohol use). MacKinnon and colleagues' (2002) examination of multiple mediation techniques revealed that compared with other methods, the joint significance test was the most powerful and had the most conservative Type I error rates. We used AMOS 25 to test the direct and indirect paths. We used bias-corrected bootstrapping in which indirect effects are estimated from multiple resampling from the data set. During the bootstrapping process, each sample is adjusted to correct for potential bias in the estimates (MacKinnon, 2008). When there is evidence for mediation, confidence intervals can be calculated to provide a range of estimates for the mediated effect (Shrout & Bolger, 2002). Confidence intervals that do not include zero indicate significance of the indirect effect (Preacher & Hayes, 2008). We derived confidence intervals using bootstrapping procedures, an approach that provides confidence interval estimates that do not depend upon assumptions of normality. In this study, we tested the indirect effect with 2,000 bootstrap samples and a 95% confidence interval (CI).

## Results

Figure 1 presents the results of the mediational model tested. Evaluation of the global fit statistics indicated that the tested model was a good fit for the data. The overall chi-square test of the model was statistically nonsignificant,  $\chi^2(4) = 5.21, p = .27$ , the CFI was .99, and the RMSEA was 0.04. Examination of the direct path coefficients revealed that the sensation seeking was significantly related to heavy alcohol use,  $\beta = .18, p = .01$ . Sensation seeking was also related to an earlier age of drinking initiation,  $\beta = -.21, p = .01$ , and earlier age of drinking initiation was significantly related to higher levels of heavy alcohol use,  $\beta = -.36, p = .001$ . Further, sensation seeking increased heavy alcohol use through the mediated effect of earlier age of drinking initiation,  $\beta = .08, p = .01, 95\% \text{ CI } [.03, .15]$ . These results offer evidence that age of drinking initiation partially mediated the relationship between sensation seeking and heavy alcohol use.

## Discussion

Alcohol use among high school seniors is concerning due to the high rates of heavy drinking and the negative associated consequences among this group of adolescents. Further, patterns of risky drinking established in high school are associated with alcohol-related problems in college (Scaglione et al., 2015) and later in life (Marshall, 2014). Sensation seeking has been identified as a significant risk factor for heavy alcohol use in adolescents, yet little is known about the process by which sensation seeking impacts drinking among high school seniors. The aim of the current study was to examine the relationship between sensation seeking and heavy alcohol use among high school seniors and to test a mediational model in which we hypothesized that age of drinking initiation would mediate the relationship between sensation seeking and heavy alcohol use.

The first aim of this study was to examine the direct effect of sensation seeking on heavy alcohol use among high school seniors. Results indicated sensation seeking was directly related to higher levels of heavy alcohol use, as well as indirectly related to heavy alcohol use through age of drinking initiation. These findings are consistent with research indicating high sensation seeking is associated with high rates of alcohol use (MacPherson et al., 2010; Sznitman & Engel-Yeger, 2017; Urban et al., 2008) and binge drinking (Doumas, Miller, et al., 2017; Sargent et al., 2010) among adolescents. Results suggest that among high school seniors, students who score higher on the personality trait sensation seeking are at risk for heavy alcohol use, including binge drinking.

Our second aim was to examine the mechanism by which sensation seeking is related to heavy alcohol use among high school seniors. Specifically, because sensation seeking is related to age of drinking initiation (Jensen et al., 2017; Malmberg et al., 2012) and age of drinking initiation is related to alcohol use and binge drinking among adolescents (Aiken et al., 2017), we hypothesized that early age of drinking initiation would provide a potential explanation for how sensation seeking is related heavy alcohol use among high school seniors. We found support for this hypothesis, as the mediational model indicated high sensation seeking was significantly associated with earlier age of initiation of drinking, which in turn, was related to higher levels of heavy alcohol use. These findings extend the current literature by demonstrating the process by which high sensation seeking is associated with heavy drinking among high school seniors and highlight the importance of delaying the onset of alcohol use among adolescents who are high sensation seekers.

### **Limitations and Directions for Future Research**

Although this study extends the literature on the relationship of sensation seeking and age of drinking initiation on heavy alcohol use among high school seniors, there are limitations. First, the sample was primarily Caucasian and recruited from one high school in the Northwest region, limiting generalizability. Generalizability is also limited by a relatively low response rate of approximately 50%. Although the response rate in this study is similar to other school-based research using active parental consent (30% - 60%) (Smith, Boel-Studt, & Cleeland, 2009), the issue of nonresponse bias should be considered in the interpretation of the results. School samples recruited with active parental consent procedures are generally less diverse, have fewer high-risk participants (Shaw, Cross, Thomas, & Zubrick, 2015; Smith et al., 2009), and have participants with lower rates of alcohol use (Doumas, Esp, & Hausheer, 2015) than those recruited with passive consent. Therefore, future research with more diverse samples and using additional recruitment methods to increase the response rate is recommended. A final limitation is adolescent self-reported alcohol use. The reliability and validity of self-reported use for this age group, however, have been demonstrated, and self-report is common practice used in studies examining adolescent alcohol use (Flisher, Evans, Muller, & Lombard, 2004; Lintonen, Ahlstrom, & Metso, 2004). We also took specific steps to minimize social desirability and response bias, including providing assurances regarding confidentiality during the student assent process.

### **Implications**

The findings of this study have important implications for prevention efforts targeting sensation seeking adolescents.

Because high sensation seeking is associated with early age of drinking initiation (Jensen et al., 2017; Malmberg et al., 2012), it is important for school personnel to be able to identify students who have high sensation seeking traits. High sensation seeking students often engage in high-risk activities (e.g., use of alcohol and drugs, high-risk sexual activities, gambling, fighting, and high-risk and extreme sports), are impulsive behaviorally, and are prone to high rates of boredom (Roberti, 2004). School personnel, including counselors, psychologists, and teachers, who become aware of these types of behaviors can identify these students who could then be referred for further assessment using tools such as the ZKPQ (Zuckerman et al., 1993).

Prevention strategies designed specifically for high sensation seeking students are also needed. Researchers have developed brief, personality-targeted interventions that focus on changing how adolescents manage their personality risk, including enhancing motivation and exploring new ways of coping (Conrod, Stewart, Comeau, & Maclean, 2006). These interventions, based on motivational interviewing and cognitive-behavioral therapy, effectively reduce alcohol use (Conrod, Castellanos-Ryan, & Mackie, 2011; Conrod, Castellanos-Ryan, & Strang, 2010; Conrod et al., 2013; Conrod et al., 2006), particularly among high sensation seeking adolescents (Conrod, Castellanos, & Mackie, 2008). Findings from recent research also indicate protective behavioral strategies (PBS) that change the manner of drinking (i.e, avoiding drinking games, shots, and gulping, avoiding mixing different types of alcohol, and not trying to out-drink others) buffered the impact of sensation seeking on heavy alcohol use, whereas strategies associated with planning (e.g. planning ahead of time not to exceed a certain amount of drinks, stopping drinking at a certain time, or leaving a party at a predetermined time) did not (Doumas, Miller, & Esp, 2017). Thus, training adolescents to use specific PBS that change how one drinks, together with personality-targeted interventions, may be helpful. To date, however, these types of interventions have not been tested as a prevention strategy to delay onset of alcohol use. A personality-specific approach to prevention, however, may be promising for sensation seeking adolescents.

## Conclusion

Risky drinking patterns established in high school are associated with significant negative consequences that extend into adulthood. The current study examined the relationships between sensation seeking, age of drinking initiation, and heavy alcohol use among high school seniors. This study demonstrated that high sensation seeking is related to heavy alcohol use and results supported age of drinking initiation as one explanation for how sensation seeking influences heavy alcohol use among high school seniors. These findings suggest personality-targeted prevention programs designed to delay the initiation of drinking may reduce heavy alcohol use among sensation seeking adolescents.

## Acknowledgements

The authors wish to thank Jaime Johnson, Kristen Shearer, Rhiannon Trull, and Laura Mundy for their assistance in participant recruitment and data collection.

## References

- Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. CA: US Sage Publications, Inc.
- Aiken, A., Clare, P. J., Wadolowski, M., Hutchinson, D., Najman, J. M., Slade, T., ... & Mattick, R. P. (2017). Age of alcohol initiation and progression to binge drinking in adolescence: a prospective cohort study. *Alcoholism: Clinical and Experimental Research*, *40*, 100-110. doi:10.1111/acer.13525
- Albert, D., & Steinberg, L. (2011). Judgment and decision making in adolescence. *Journal of Research on Adolescence*, *21*, 211-224. doi:10.1111/j.1532-7795.2010.00724.x
- Arata, C. M., Stafford, J., & Tims, M. S. (2003). High school drinking and its consequences. *Adolescence*, *38*, 567-579.
- Bava, S., & Tapert, S. F. (2010). Adolescent brain development and the risk for alcohol and other drug problems. *Neuropsychological Review*, *20*, 398-413. doi:10.1007/s11065-0109146-6
- Byrne, B. M. (2001). Structural equation modeling: Perspectives on the present and the future. *International Journal of Testing*, *1*, 327-334. doi:10.1080/15305058.2001.9669479
- Casey, B. J., Getz, S., & Galvan, A. (2008). The adolescent brain. *Developmental Review*, *28*, 62-77. doi:10.1016/j.dr.2007.08.003
- Conrod, P. J., Castellanos, J., & Mackie, C. (2008). Personality-targeted interventions delay the growth of adolescent drinking and binge drinking. *Journal of Child Psychology and Psychiatry*, *49*, 181-190. doi:10.1111/j.1469-7610.01826.x
- Conrod, P. J., Castellanos-Ryan, N., & Mackie, C. (2011). Long-term effects of a personality-targeted intervention to reduce alcohol use in adolescents. *Journal of Consulting and Clinical Psychology*, *79*, 296-306. doi: http://dx.doi.org/10.1037/a0022997
- Conrod, P. J., Castellanos-Ryan, N., & Strang, J. (2010). Brief, personality-targeted coping skills interventions and survival as a non-drug user over a 2-year period during adolescence. *Archives of General Psychiatry*, *67*, 85-93. doi:10.1001/archgenpsychiatry.2009.173
- Conrod, P. J., O'Leary-Barrett, M., Newton, N., Topper, L., Castellanos-Ryan, N., Mackie, C., & Girard, A. (2013). Effectiveness of a selective, personality-targeted prevention program for adolescent alcohol use and misuse: a cluster randomized controlled trial. *JAMA Psychiatry*, *70*, 334-342. doi:10.1001/jamapsychiatry.2013.651
- Conrod, P. J., Stewart, S. H., Comeau, N., & Maclean, A. M. (2006). Preventative efficacy of cognitive behavioral strategies matched to the motivational bases of alcohol misuse in at-risk youth. *Journal of Clinical Child and Adolescent Psychology*, *35*, 550-563.
- D'Amico, E. J., Elickson, P. L., Collins, R. L., Martino, S. K., & Klein, D. J. (2005). Processes linking adolescent problems to substance-abuse problems in late young adulthood. *Journal of Studies on Alcohol*, *66*, 766-775. doi:10.15288/jsa.2005.66.766
- Dawson, D. A., Goldstein, R. B., Chou, S. P., Ruan, W. J., & Grant, B. F. (2008). Age at first drink and the first incidence of adult-onset DSM-IV alcohol use disorders. *Alcoholism: Clinical and Experimental Research*, *32*, 2149-2160. doi:10.1111/j.1530-0277.2008.00806.x
- Dimeff, L. A., Baer, J. S., Kivlahan, D. R., & Marlatt, G. A. (1999). *Brief Alcohol Screening and Intervention for College Students (BASICS): A harm reduction approach*. New York: Guilford Press.

- Donoghue, K., Rose, H., Boniface, S., Deluca, P., Coulton, S., Alam, M. F., ... & McArdle, P. (2017). Alcohol consumption, early-onset drinking, and health-related consequences in adolescents presenting at emergency departments in England. *Journal of Adolescent Health, 60*, 438-446. doi:10.1016/j.jadohealth.2016.11.017
- Donovan, J. E. (2009). Estimated blood alcohol concentrations for child and adolescent drinking and their implications for screening instruments. *Pediatrics, 123*, 975-981. doi:10.1542/peds.2008-0027
- Doumas, D. M., Esp, S., Flay, B., & Bond, L. (2017). A randomized controlled trial testing the efficacy of a brief online alcohol intervention for high school seniors. *Journal of Studies on Alcohol and Drugs, 78*, 706-715. doi:10.15288/jsad.2017.78.706
- Doumas, D. M., Esp, S., & Hausheer, R. (2015). Parental consent procedures: Impact on response rates and nonresponse bias. *Journal of Substance Abuse and Alcoholism, 3*, 1031-1034.
- Doumas, D. M., Miller, R., & Esp, S. (2017). Impulsive sensation seeking, binge drinking, and alcohol-related consequences: Do protective behavioral strategies help high risk adolescents?. *Addictive Behaviors, 64*, 6-12. doi:10.1016/j.addbeh.2016.08.003
- Flisher, A. J., Evans, J., Muller, M., & Lombard, C. (2004). Brief report: Test-retest reliability of self-reported adolescent risk behavior. *Journal of Adolescence, 27*, 207-212. doi:10.1016/j.adolescence.2001.10.001
- Guttmanova, K., Bailey, J. A., Hill, K.G., Lee, J. O., Hawkins, J. D., Woods, M. L., Catalano, R. F. (2011). Sensitive periods for adolescent alcohol use initiation: Predicting the lifetime occurrence and chronicity of alcohol problems in adulthood. *Journal of Studies on Alcohol and Drugs, 72*, 221-231. doi:10.15288/jsad.2011.72.221
- Hanson, K. L., Medina, K. L., Padula, C. B., Tapert, S. F., & Brown, S. A. (2011). Impact of adolescent alcohol and drug use on neuropsychological functioning in young adulthood: 10-year outcomes. *Journal of Child & Adolescent Substance Abuse, 20*, 135-154. doi:10.1080/1067828X.2011.555272
- Hingson, R. W., Heeren, T., & Winter, M. R. (2006). Age at drinking onset and alcohol dependence: Age at onset, duration, and severity. *Archives of Pediatric Adolescent Medicine, 160*, 739-746. doi:10.1001/archpedi.160.7.739
- Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*, 1-55.
- Jensen, M., Chassin, L., & Gonzales, N. A. (2017). Neighborhood moderation of sensation seeking effects on adolescent substance use initiation. *Journal of Youth and Adolescence, 46*, 1953-1967. doi:10.1007/s10964-017-0647-y
- Johnston, L. D., O'Malley, P. M., Miech, R. A., Bachman, J. G., & Schulenberg, J. E. (2017). Monitoring the future national survey results on drug use, 1975-2016: Overview, key findings on adolescent drug use. *Ann Arbor: Institute for Social Research, The University of Michigan*. Retrieved from: <http://www.monitoringthefuture.org/pubs/monographs/mtf-overview2016.pdf>
- Karadag, E. (2012). Basic features of structural equation modeling and path analysis with its place and importance in educational research methodology. *Bulgarian Journal of Science and Education Policy, 6*, 194-212.
- Lintonen, T., Ahlstrom, S., & Metso, L. (2004). The reliability of self-reported drinking in adolescence. *Alcohol and Alcoholism, 39*, 362-368. doi:10.1093/alcalc/agh071
- Lisdahl, K. M., Gilbert, E. R., Wright, N. E., & Shollenbarger, S. (2013). Dare to delay? The impacts of adolescent alcohol and marijuana use onset on cognition, brain structure, and function. *Frontiers in Psychiatry, 4*, 1-19. doi:10.3389/fpsy.2013.00053
- MacKinnon, D. P. (2008). *Introduction to statistical mediation analysis*. New York, NY: Routledge.
- MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods, 7*, 83.
- MacPherson, L., Magidson, J. F., Reynolds, E. K., Kahler, C. W., & Lejuez, C. W. (2010). Changes in sensation seeking and risk-taking propensity predict increases in alcohol use among early adolescents. *Alcoholism: Clinical and Experimental Research, 34*, 1400-1408. doi:10.1111/j.1530-0277.2010.01223.x
- Malmberg, M., Kleinjan, M., Vermulst, A. A., Overbeek, G., Monshouwer, K., Lammer, J., & Engels, R. C. M. (2012). Do substance use risk personality dimensions predict the onset of substance use in early adolescence? A variable- and person-centered approach. *Journal of Youth and Adolescence, 41*, 1512-1525. doi:10.1007/s10964-012-9775-6
- Marlatt, G. A., Baer, J. S., Kivlahan, D. R., Dimeff, L. A., Larimer, M. E., Quigley, L. A.,... Williams, E. (1998). Screening and brief intervention for high-risk college student drinkers: Results from a 2-year follow-up assessment. *Journal of Consulting and Clinical Psychology, 66*, 604-615. doi:10.1037/0022-006X.66.4.604



- Martins, S. S., Storr, C. L., Alexandre, P. K., & Chilcoat, H. D. (2008). Adolescent ecstasy and other drug use in the National Survey of Parents and Youth: The role of sensation-seeking, parental monitoring and peers' drug use. *Addictive Behaviors, 33*, 919-933. doi:10.1016/j.addbeh.2008.02.010
- Matthews, M., Bondi, C., Torres, G., & Maghaddam, B. (2013). Reduced presynaptic dopamine activity in adolescent dorsal striatum. *Neuropsychopharmacology, 38*, 1344-1351. doi:10.1038/npp.2013.32
- Marshall, E. J. (2014). Adolescent alcohol use: risks and consequences. *Alcohol and Alcoholism, 49*, 160-164. doi:10.1093/alcalc/agt180
- Miller, J. W., Naimi, T. S., Brewer, R. D., & Jones, S. E. (2007). Binge drinking and associated health risk behaviors among high school students. *Pediatrics, 119*, 76-85. doi:10.1542/peds.2006-1517
- Moss, H. B., Chen, C. M., & Yi, H. Y. (2014). Early adolescent patterns of alcohol, cigarettes, and marijuana polysubstance use and young adult substance use outcomes in a nationally representative sample. *Drug and Alcohol Dependence, 136*, 51-62. doi:10.1016/j.drugalcdep.2013.12.011
- Nguyen-Louie, T. T., Castro, N., Matt, G. E., Squeglia, L. M., Brumback, T., & Tapert, S. F. (2015). Effects of emerging alcohol and marijuana use behaviors on adolescents' neuropsychological functioning over four years. *Journal of Studies on Alcohol and Drugs, 76*(5), 738-748. doi:http://dx.doi.org/10.15288/jsad.2015.76.738
- Norman, G. R., & Streiner, D. L. (2008). *Biostatistics: The bare essentials* (3rd ed.). Hamilton, Ontario: B.C. Decker, Inc.
- Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*, 879-891. doi:10.3758/BRM.40.3.879
- Roberti, J. W. (2004). A review of behavioral and biological correlates of sensation seeking. *Journal of Research in Personality, 38*, 256-279. doi:10.1016/S0092-6566(03)00067-9
- Sargent, J. D., Tanski, S., Stoolmiller, M., & Hanewinkel, R. (2010). Using sensation seeking to target adolescents for substance use interventions. *Addiction, 105*, 506-514. doi:10.1111/j.1360-0443.2009.02782.x
- Scaglione, N. M., Mallett, K. A., Turrise, R., Reavy, R., Cleveland, M. J., & Ackerman, S. (2015). Who will experience the most alcohol problems in college? The roles of middle and high school drinking tendencies. *Alcoholism: Clinical and Experimental Research, 39*, 2039-2046. doi:10.1111/acer.12846
- Shaw, T., Cross, D., Thomas, L. T., & Zubrick, S. R. (2015). Bias in student survey findings for active parental consent procedures. *British Educational Research Journal, 41*, 229-243. doi:10.1002/berj.3137
- Shrout, P. E., & Bolger, N. (2002). Mediation in experimental and nonexperimental studies: New procedures and recommendations. *Psychological Methods, 7*, 422-445. doi:10.1037//1082-989X.7.4.422
- Siegel, D. J. (2013). *Brainstorm: The power and purpose of the teenage brain*. New York, NY: Penguin Group.
- Smith, D. C., Boel-Studt, S., & Cleeland, L. (2009). Parental consent in adolescent substance abuse treatment outcome studies. *Journal of Substance Abuse Treatment, 37*, 298-306. doi:10.1016/j.jsat.2009.03.007
- Steinberg, L. (2008). A social neuroscience perspective on adolescent risk-taking. *Developmental Review, 28*, 78-106. doi:10.1016/j.dr.2007.08.002
- Stephenson, M. T., Hoyle, R. H., Palmgreen, P., & Slater, M. D. (2003). Brief measures of sensation seeking for screening and large-scale surveys. *Drug and Alcohol Dependence, 72*, 279-286. doi:10.1016/j.drugalcdep.2003.08.003
- Strautz, K., & Cooper, A. (2013). Impulsivity-related personality traits and adolescent alcohol use: A meta-analytic review. *Clinical Psychology Review, 33*, 574-592. doi:10.1016/j.cpr.2013.03.003
- Sznitman, S., & Engel-Yeger, B. (2017). Sensation seeking and adolescent alcohol use: Exploring the mediating role of unstructured socializing with peers. *Alcohol and Alcoholism, 52*, 396-401. doi:10.1093/alcalc/agx008
- Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston: Allyn and Bacon.
- Urbán, R., Kökönyei, G., & Demetrovics, Z. (2008). Alcohol outcome expectancies and drinking motives mediate the association between sensation seeking and alcohol use among adolescents. *Addictive Behaviors, 33*, 1344-1352. doi:10.1016/j.addbeh.2008.06.006
- Wahlstrom, D., Collins, P., White, T., & Luciana, M. (2010). Developmental changes in dopamine neurotransmission in adolescence: Behavioral implications and issues in assessment. *Brain and Cognition, 72*, 146-159. doi:10.1016/j.bandc.2009.10.013
- Zuckerman, M. (1979). *Sensation seeking: Beyond the optimal level of arousal*. Lawrence Erlbaum, Hillsdale, NJ.
- Zuckerman, M. (1994). *Behavioral expression and biosocial bases of sensation seeking*. Cambridge University Press, New York.
- Zuckerman, M., Kuhlman, D.M., Joireman, J., Teta, P., & Kraft, M. (1993). A comparison of three structural models for personality: The big three, the big five, and the alternative five. *Journal of Personality and Social Psychology, 65*, 757-768. doi:10.1037/0022-3514.65.4.757

Table 1

*Means, Standard Deviations, and Bivariate Correlations for Variables in the Model*

Measure	1	2	3	4	5
1. Sensation Seeking	—				
2. Age of Drinking Initiation	-.21**	—			
3. Peak Drinking	.17*	-.36**	—		
4. Drinking to Intoxication	.26**	-.38*	.75**	—	
5. Binge Drinking	.20**	-.30**	.71**	.79**	—
<i>M</i>	28.18	15.00	2.54	0.67	0.54
<i>SD</i>	3.77	1.30	4.04	0.95	1.08

\*  $p < .05$ , \*\*  $p < .01$ .

Figure Captions

Figure 1

*Age of drinking initiation as a mediator of sensation seeking and heavy alcohol use*

